Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

CMD 25-H12.1-Ref6

Date: 2025-10-15

Reference from NexGen Energy Ltd.

In the matter of

NexGen Energy Ltd.

Licence application to prepare a site for and construct its Rook 1 uranium mine and mill project

Commission Public Hearing
Part 1

November 19, 2025

Référence de NexGen Energy Ltd.

À l’égard de

NexGen Energy Ltd.

Demande de permis concernant la préparation de l’emplacement et la construction de son projet de mine et d’usine de concentration d’uranium Rook I

Audience publique de la Commission
Partie 1

Le 19 novembre 2025

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Canada

Volume 2: Rook I Project Environmental Impact Statement

Rook I Project

Environmental Impact Statement

Section 10 Surface Water Quality and Sediment Quality

Submitted to:
Canadian Nuclear Safety Commission
Saskatchewan Ministry of Environment

Submitted by:
NexGen Energy Ltd.
3150-1021 W Hastings St
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November 2024

Executive Summary

Section Purpose

Section 10 of the Environmental Impact Statement (EIS) provides a comprehensive assessment of potential effects of the Rook I Project (Project) on surface water quality and sediment quality. This assessment included consideration of both potential effects from the Project and cumulative effects from the Project and other reasonably foreseeable developments (RFDs). The surface water quality and sediment quality assessment used widely accepted scientific practices and incorporated Indigenous and Local Knowledge.

Surface water quality and sediment quality represented intermediate components in the Environmental Assessment (EA); the selection was based on how changes in surface water quality and sediment quality could influence the health of fish, plants, wildlife, and the people that use natural resources. The surface water quality and sediment quality assessment provided information that was used to support valued component (VC) assessments such as fish and fish habitat, vegetation, and wildlife and wildlife habitat. Intermediate components, such as surface water quality and sediment quality, were not assessed for significance.

Setting

At a regional scale, the Project would be located within the southern Athabasca Basin adjacent to Patterson Lake, along the upper Clearwater River system, approximately 40 km east of the Saskatchewan-Alberta border and 640 km northwest of the city of Saskatoon.

The surface water quality and sediment quality assessment focused on a local study area (LSA), which is in the area of the proposed Project where direct environmental effects would be most likely to occur, and a regional study area (RSA), where cumulative effects may occur. The LSA is the portion of the Clearwater River watershed extending from its headwaters to the outlet of Naomi Lake, representing a surface area of 685 km^2. The RSA includes the LSA and is defined by the portion of the Clearwater River watershed extending from its headwaters to its confluence with the Mirror River, representing a surface area of 1,076 km^2. Broach Lake is located in the northwest corner of both study areas and is considered to be the headwaters of the Clearwater River. The Clearwater River flows through a series of lakes including Patterson Lake to Naomi Lake. From Naomi Lake, the Clearwater River flows another 20 km southeast before reaching the Mirror River confluence. The LSA and RSA used for the assessment of surface water quality and sediment quality are the same spatial boundaries as those used for other aquatic environment components (e.g., hydrology, fish and fish habitat).

Existing Conditions (Section 10.3)

The conditions for surface waterbodies in the LSA were determined from baseline studies conducted between 2015 and 2020. The water quality of the waterbodies and watercourses in the LSA is consistent with typical lakes located in the Canadian Shield in that the water quality:

- exhibits high water clarity, due to low amounts of total suspended solids;
- has near-neutral pH; and
- has wide-ranging surface water temperatures that vary seasonally.

Surface waters in the LSA were consistently low in dissolved solids, with the dominant major ions being calcium and bicarbonate. Generally, the concentrations of ions and total metals in surface waters, particularly those identified as constituents of potential concern (COPCs), were below water quality guideline levels. Some ions and metals were identified in quantities exceeding guidelines, which reflect naturally occurring elevated concentrations of these COPCs in the waterbodies and watercourses in the LSA.

The existing sediment quality conditions for surface waterbodies in the LSA were determined from baseline studies conducted between 2018 and 2019. The composition of the sediment showed that the top layer (i.e., 0 cm to 2 cm) consisted of a mixture of coarse sand, fine sand, and silt, with some variance in the proportion of these fractions among waterbodies.

In Patterson Lake, there was notable variability in sediment composition between basins and study years. Generally, sediment concentrations of metals and radionuclides in waterbodies in the LSA were low and below environmental thresholds.

Potential Effects and Proposed Mitigations (Section 10.4)

An analysis was completed to evaluate Project components and activities and associated effects pathways that could potentially affect surface water quality and sediment quality. The evaluation also considered similar combined effects from the Fission Patterson Lake South Property, the identified RFD for the surface water quality and sediment quality assessment.

Project activities that would have the potential to affect surface water quality and sediment quality during the Project lifespan and the far future include:

- handling and storage of waste rock and special waste rock and ore;
- runoff and seepage from the waste rock storage areas (WRSAs);
- groundwater flow from underground workings, including the underground tailings management facility (UGTMF);
- Project criteria air contaminant emissions that would deposit to the local watershed;
- discharge of treated effluent; and
- discharge of treated sewage.

Similar activities during the Project lifespan and far future period that could affect surface water quality and sediment quality would be expected to occur for the Fission Patterson Lake South Property, except for potential effects associated with the underground disposal of tailings, as the Fission Patterson Lake South Property has been designed with an above-ground tailings management facility.

As part of the pathways analysis, proposed environmental design features and mitigation measures were considered to determine whether effects on the environment could be avoided or reduced to negligible levels, thereby removing the pathway. Project environmental design features such as the UGTMF and the cemented paste tailings backfill were designed to minimize the Project’s effects on surface water quality and sediment quality. In addition, the Project would design, construct, and operate infrastructure such as the effluent treatment plant and diffuser and sewage treatment plant and outfall to reduce the load of COPCs to the aquatic environment and promote dispersion rapidly in the receiving environment. Proposed mitigations such as the recycling and reuse of process water, robust site water management procedures, and the implementation of Project-specific management plans would also reduce effects on surface water quality and sediment quality.

Similar mitigation and operational management practices would also be expected to be implemented by the Fission Patterson Lake South Property.

After mitigation measures were considered, the pathways screening analysis determined that some of the potential pathways from the Project to the environment could be removed from the assessment, especially those for potential effects to sediment quality. However, it was identified that the Project could still adversely affect surface water quality from the following pathways:

- deposition of fugitive dust emissions (e.g., particulate matter, metals, radionuclides) on local and regional waterbodies and watercourses;
- deposition of criteria air contaminants emissions (e.g., particulate matter, sulphur, nitrogen oxides) on local and regional waterbodies and watercourses;
- direct discharge of treated effluent during Construction, Operations, and Closure to Patterson Lake;
- direct discharge of treated sewage during Construction, Operations, and Closure to Patterson Lake;
- seepage from the WRSAs during Construction and Operations to groundwater that may flow into Patterson Lake; and
- runoff and seepage from the WRSAs and groundwater flow from the underground workings (including the UGTMF) to Patterson Lake after Closure.

Only surface water quality pathways were carried forward into the residual effects analysis as no pathways were identified for potential sediment quality effects.

Residual Effects Analysis (Section 10.5)

A residual effects analysis was conducted to determine the potential effects on surface water quality under two assessment cases: effects of the Project (i.e., Application Case), and combined effects of the Project and the Fission Patterson Lake South Property (i.e., RFD Case). The focus of the surface water assessment for the Project was to predict changes in surface water quality in the receiving environment from direct discharges from the Project, deposition of Project air emissions during the Project lifespan, and post-closure Project effects in the far future (e.g., runoff from the reclaimed Project footprint, groundwater inflows). Air deposition effects to the receiving environment would be limited to the lifespan of the Project and were not assessed in the far-future projection. A sensitivity scenario that included effects from the Project, Fission Patterson Lake South Property, and climate change was also assessed.

The residual effects analysis for surface water quality considered three measurement indicators:

- constituent concentrations associated with water quality (i.e., those constituents that apply to the protection to aquatic and terrestrial life);
- drinking water quality (i.e., those constituents that apply to the suitability of drinking water); and
- productivity status (i.e., the ability of a waterbody to support an aquatic food web).

For each measurement indicator, the various surface water constituent concentrations measured were compared to the respective thresholds.

During the lifespan of the Project in the Application Case and the RFD Case, overall COPC concentrations would increase locally, though the predicted concentrations would not result in any threshold exceedances in any measurement indicators during the Project lifespan. Similarly, air deposition effects during the Project lifespan in the Application Case and RFD Case would also result in minor, localized changes to the surface water COPC concentrations; however, such changes in COPC concentrations would not result in any COPC threshold exceedances.

In the Application Case and RFD Case far-future projections, seepage from the potentially acid generating (PAG) WRSA would cause a long-term continuous period of extremely slow migration of COPC metals and radionuclides to the receiving environment via shallow groundwater. The COPC concentrations in the far-future projection would be greater than peak concentrations for many of the COPCs modelled during the Project lifespan, because active water treatment was not assumed to continue after Closure. Under this scenario, concentrations of cobalt and copper were predicted to exceed surface water quality thresholds.

To minimize the potential for effects to the receiving environment (e.g., aquatic habitat), source control measures would be implemented for the PAG WRSA. This mitigation would be expected to result in reductions in the mass loading of cobalt and copper, and other COPCs, to Patterson Lake.

The productivity status of waterbodies in the Application Case and RFD Case during the Project lifespan and in the far-future projection would remain oligotrophic (i.e., having low productivity due to low nutrient concentrations), which is consistent with existing conditions.

The cumulative effects for the Project and Fission Patterson Lake South Property, and cumulative effects for these two projects plus climate change, were predicted to be similar during the Project lifespan and the far-future projection. Although there is inherent uncertainty associated with climate change predictions, the similarity indicates that climate change would have a minor effect on surface water quality.

Prediction Confidence and Uncertainty (Section 10.6)

Overall, there is a high degree of confidence in the predictions related to the surface water quality and sediment quality assessment in that the assessment has not underestimated potential effects of the Project. Uncertainty was primarily and appropriately addressed by making assumptions that conservatively overestimated rather than underestimated potential effects (i.e., a precautionary assessment), and using model inputs that were based on conservative assumptions. Monitoring would be used to address residual uncertainty during all phases of the Project.

Monitoring and Follow-Up (Section 10.7)

The Environmental Protection Program, Environmental Monitoring Plan, Effluent and Emissions Plan, and associated environmental monitoring would be implemented to verify effects predictions and effectiveness of mitigation on protection of the aquatic environment, identify unanticipated effects, and apply adaptive management.

Surface water quality monitoring for the Project is anticipated to consist of site water management monitoring, which would include waters within the Project footprint before and after treatment and/or discharge and in the surface water receiving environment. Key components of monitoring and follow-up would be the ongoing management of the site water management infrastructure components and the continuation and adaption of the receiving environment water quality monitoring program established during the baseline studies. A key element would include monitoring of runoff and seepage from WRSAs and seepage from the underground workings during Operations and into Closure to determine the potential for additional source control and adaptive management.

Surface water quality monitoring would be developed in accordance with the Metal and Diamond Mining Effluent Regulations, the federal *Fisheries Act*, and conditions established through Project authorizations issued by the Canadian Nuclear Safety Commission and Saskatchewan Ministry of Environment.

Abbreviations and Units of Measure

Abbreviation	Definition
BC MOE	British Columbia Ministry of Environment and Climate Change Strategy
BNDN	Birch Narrows Dene Nation
BRDN	Buffalo River Dene Nation
CAC	criteria air contaminant
CCME	Canadian Council of Ministers of the Environment
CNSC	Canadian Nuclear Safety Commission
COPC	constituent of potential concern
CRDN	Clearwater River Dene Nation
EA	Environmental Assessment
EIS	Environmental Impact Statement
ERA	environmental risk assessment
ETMF	exposure and toxicity modifying factor
ETP	effluent treatment plant
IKTLU	Indigenous Knowledge and Traditional Land Use
ISQG	interim sediment quality guideline
JWG	Joint Working Group
LEL	lowest effect level
LSA	local study area
MDMER	Metal and Diamond Mining Effluent Regulations
MN-S	Métis Nation – Saskatchewan
NE2	no-effect (sediment quality)
NexGen	NexGen Energy Ltd.
NFWQM	near-field water quality model
NPAG	non-potentially acid generating
PAG	potentially acid generating
RSWQM	regional surface water quality model
PEL	probable effect level
pH	potential of hydrogen
Project	Rook I Project
REF	reference (sediment quality)
RFD	reasonably foreseeable development
RMZ	regulatory mixing zone
RSA	regional study area
SEL	severe effect level
STP	sewage treatment plant
SWWBM	site-wide water balance and water quality model
TDS	total dissolved solids
TSD	technical support document
TSP	total suspended particulates
TSS	total suspended solids
UGTMF	underground tailings management facility
VC	valued component
WRSAs	waste rock storage areas

Unit	Definition
#	number
%	percent
°C	degrees Celsius
<	less than
≤	less than or equal to
µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per litre
Bq/L	becquerels per litre
g/yr	grams per year
kg/m^3	kilograms per cubic metre
km	kilometre
km/h	kilometres per hour
km^2	square kilometre
m	metre
m^2	square metre
m/s	metres per second
mg/L	milligrams per litre

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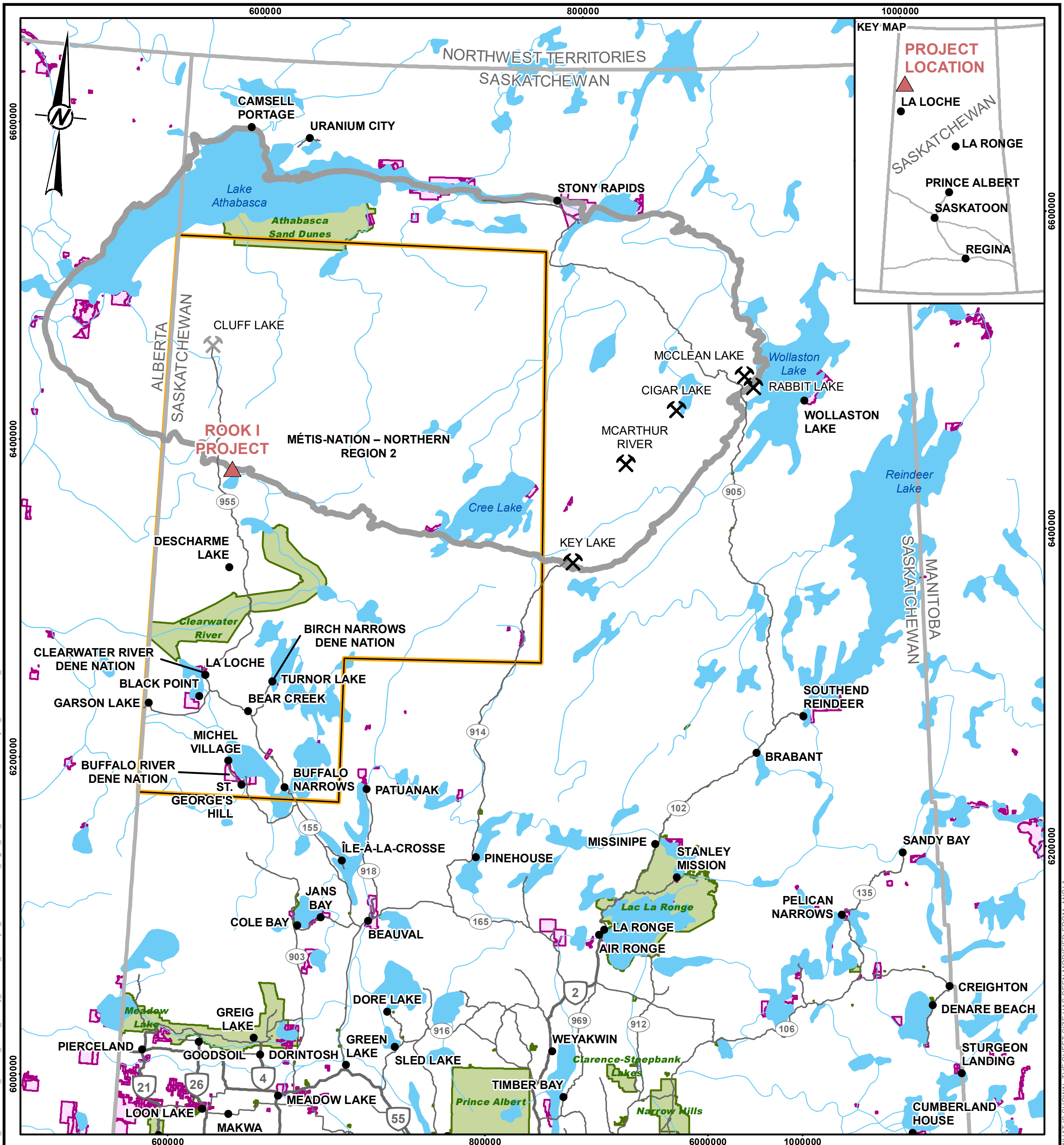
10 SURFACE WATER QUALITY AND SEDIMENT QUALITY

10.1 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 Northern Village of La Loche, and 640 km northwest of the city of Saskatoon (Figure 10.1-1). 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. Patterson Lake is at the interface of the Boreal Shield and Boreal Plain ecozones. Access to the Project would be from an existing road off Highway 955 (Figure 10.1-2), with on-site worker accommodation serviced by fly-in/fly-out access.

Section 10, Surface Water Quality and Sediment Quality, of the Environmental Impact Statement (EIS) characterizes the potential residual effects of the Project on surface water quality and sediment quality, which are attributes or components of the aquatic environment. Surface water quality and sediment quality represent intermediate components for the Environmental Assessment (EA). The Project has the potential to cause adverse effects on the surface water quality and sediment quality of waterbodies and watercourses primarily through drainage and discharge of water that has come into contact with areas where waste rock and ore would be mined, processed, and stored. Drainage from other areas (e.g., site roads and airstrip; Section 9, Hydrology) deposition of fugitive dust emissions on local and regional waterbodies (Section 7, Air Quality, Noise, and Climate Change), and erosion (Section 12, Terrain and Soils) also have the potential to affect surface water quality and sediment quality.

Changes in surface water quality and sediment quality could influence the health of fish, plants, and wildlife, and the people that use natural resources. The Birch Narrows Dene Nation (BNDN), Buffalo River Dene Nation (BRDN), Clearwater River Dene Nation (CRDN), Métis Nation – Saskatchewan (MN-S), and Ya'thi Néné Lands and Resources have all expressed ties to the land and water in the area for the use of water, fishing, trapping, hunting, gathering, and cultural practices (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; CRDN 2019a,b; TSD VI: YNLR; YNLRO 2019). For these reasons, the surface water quality and sediment quality assessment provides information that is used to support the assessments of other valued components (VCs), specifically, fish and fish habitat VCs (Section 11, Fish and Fish Habitat), vegetation VCs (Section 13, Vegetation), wildlife and wildlife habitat VCs (Section 14, Wildlife and Wildlife Habitat), human health (Section 15, Human Health), Indigenous land and resource use (Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use), and other land and resource use (Section 17, Other Land and Resource Use). A simplified linkage diagram, Figure 10.1-3, illustrates how proposed Project activities could result in a direct or indirect effect on surface water and sediment quality and the VCs that could be influenced through changes to surface water and sediment quality.



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

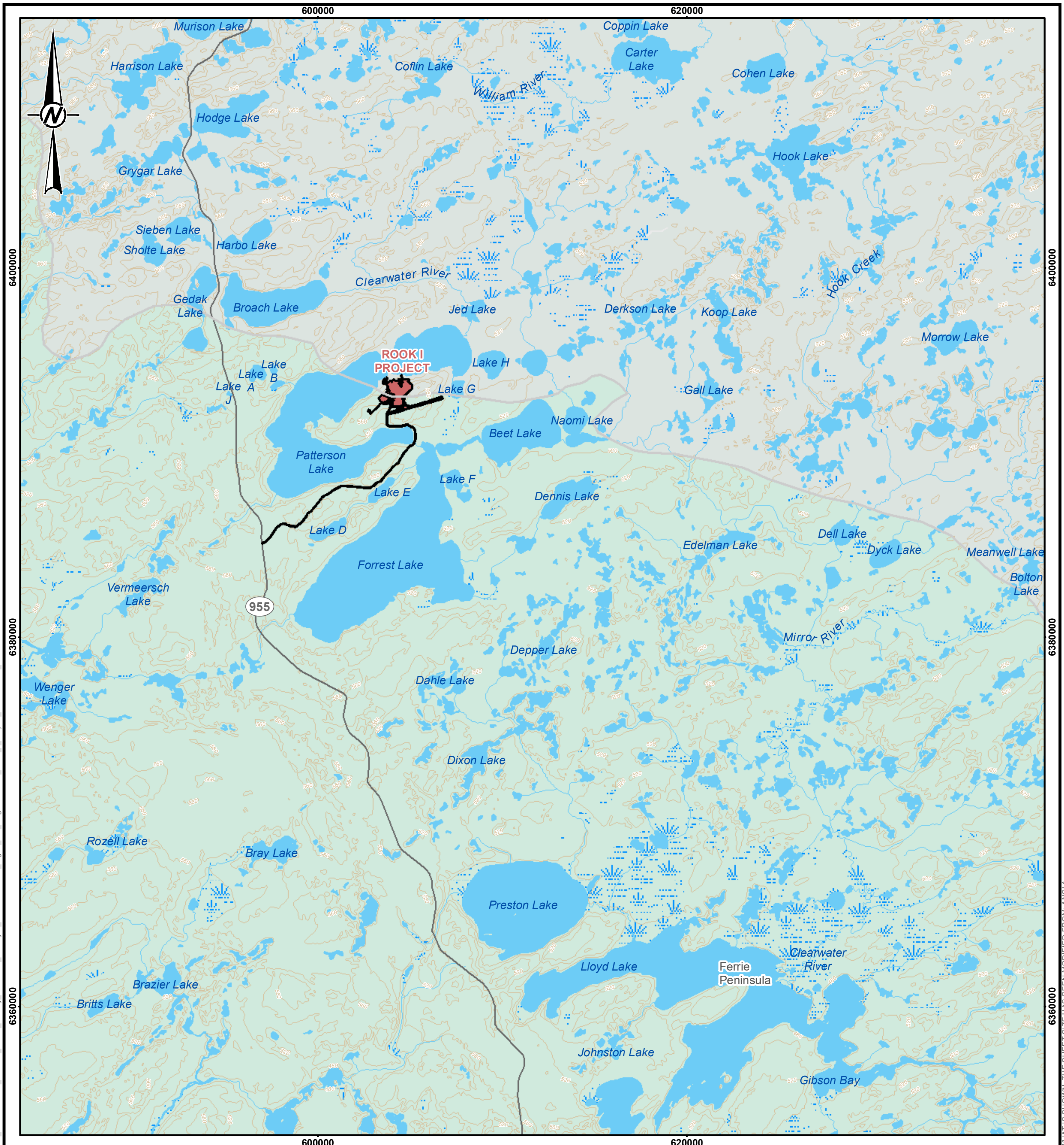
LOCATION OF THE ROOK I PROJECT

CONSULTANT

wsp

PROJECT	20144150	SCALE AS SHOWN	REV. 0

FIGURE 10.1-1



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

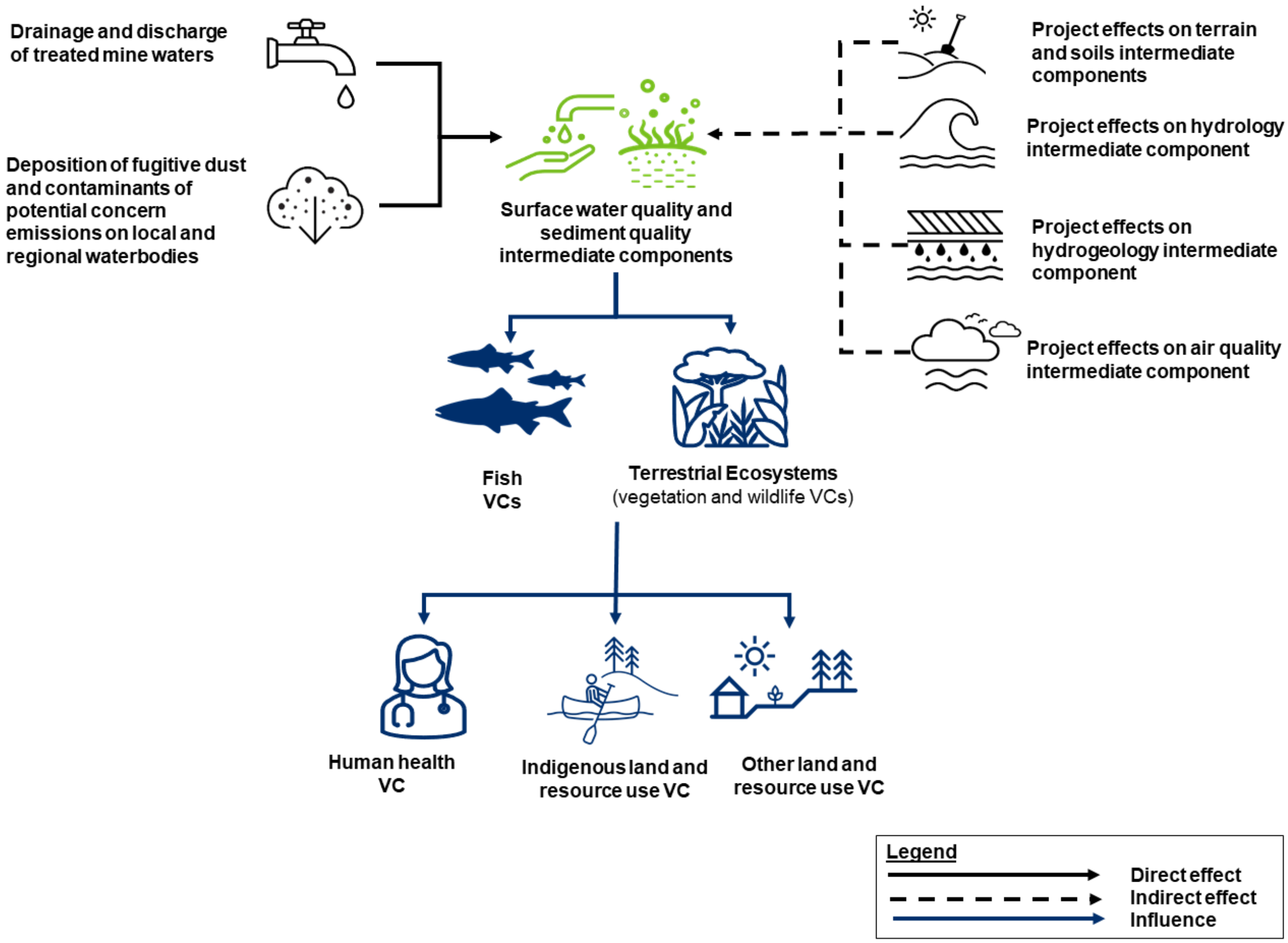
PROJECT
NexGen Energy Ltd.
ROOK I PROJECT

TITLE
REGIONAL AREA OF THE ROOK I PROJECT

CONSULTANT
wsp

PROJECT	20144150	SCALE AS SHOWN	REV. 0
FIGURE 10.1-2			

Figure 10.1-3: Linkage Diagram of Project Effects on Surface Water Qualtiy and Sediment Quality and Influenced Valued Components



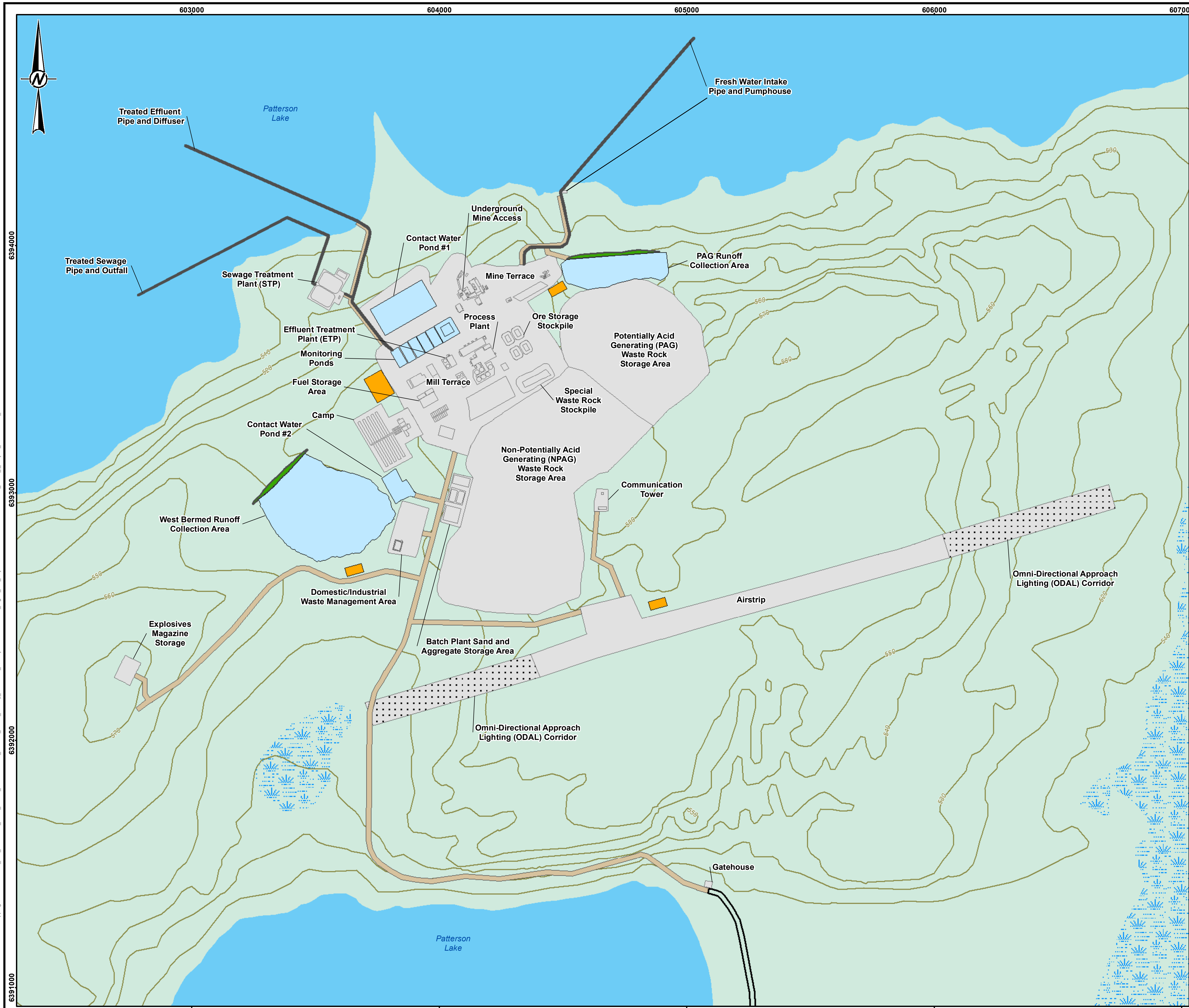
VC = valued component.

10.1.1 Project Summary

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 10.1-4):

- underground mine development;
- process plant buildings, including uranium concentrate packaging facilities;
- paste tailings distribution system;
- underground tailings management facility (UGTMF);
- potentially acid generating (PAG) waste rock storage area (WRSA);
- non-potentially acid generating (NPAG) WRSA;
- special waste rock[1] and ore storage stockpiles;
- surface and underground water management infrastructure, including water management ponds, effluent treatment plant (ETP), and sewage treatment plant (STP);
- 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.

[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.



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	SCALE AS SHOWN	REV. 0

FIGURE 10.1-4

10.1.2 Purpose and Approach to the Assessment

The purpose of Section 10 is to provide a detailed and comprehensive assessment of all potential Project-specific effects and cumulative effects from the Project and other previous, existing, and reasonably foreseeable developments (RFDs), if applicable, on surface water quality and sediment quality. This section meets the Terms of Reference for the Project submitted to the Saskatchewan Ministry of Environment and the Canadian Nuclear Safety Commission (CNSC) *Generic Guidelines for the Preparation of an Environmental Impact Statement – Pursuant to the Canadian Environmental Assessment Act, 2012* (Appendix 1A, Concordance Tables). The assessment of surface water quality and sediment quality followed the overall EA approach and methods (Section 6, Environmental Assessment Approach and Methods) and includes the following primary steps:

Step 1 – Define the component-specific methods (Section 10.2): presents the specific approaches, methods, and description of the water quality models used to measure and assess the effects of the Project on surface water quality and sediment quality as well as cumulative effects from the Project, other previous and existing projects and activities, and RFDs, if applicable.

Step 2 – Characterize existing conditions (Section 10.3): describes and characterizes existing conditions to provide context and a basis for evaluating potential changes to surface water quality and sediment quality caused by the Project.

Step 3 – Evaluate Project interactions and mitigations (Section 10.4): identifies Project components and/or activities with the potential to affect surface water quality and sediment quality and provides mitigation policies and actions committed to by NexGen to avoid or minimize potential adverse effects. A pathways analysis was used to focus further assessment on key interactions between the Project and surface water quality and sediment quality by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual adverse effects. Primary pathways anticipated to result in residual adverse effects after incorporation of mitigation are carried forward to Step 4 for further analysis. Where potential adverse effects are adequately mitigated and thus not forwarded for further analysis (i.e., where mitigation results in negligible effects or avoids the pathway altogether), the reasons for concluding the assessment at this stage are provided.

Step 4 – Analyze and classify residual effects (Section 10.5): evaluates and describes the potential Project effects on surface water quality and sediment quality that are anticipated to occur through the primary pathways. The residual effects analysis is presented as an integrated narrative that describes the effects of the Project over time and highlights predicted effects at the point when adverse effects of the Project are expected to be greatest. This step also includes an analysis of residual cumulative effects from the Project, other previous and existing projects and activities, and RFDs. Residual effects are classified and tabulated using the criteria direction, magnitude, geographic extent, duration, reversibility, and frequency to provide structure and comparability across all VCs and intermediate components in the EA.

Step 5 – Describe uncertainty and define prediction confidence (Section 10.6): identifies key uncertainties and explains how these uncertainties have been addressed to achieve a conservative, precautionary assessment. The implications of the approaches used to address uncertainties and the level of confidence in the residual effects analysis are discussed.

Step 6 – Identify monitoring and follow-up (Section 10.7): outlines the proposed actions to verify predicted residual effects. The purpose of these actions is to evaluate effectiveness of planned mitigation designs, policies, and practices, and address key sources of uncertainty.

10.2 Component Methods

10.2.1 Incorporation of Indigenous and Local Knowledge

Indigenous and Local Knowledge included in the assessment of surface water quality and sediment quality was shared by potentially affected First Nations and Métis Groups (collectively referred to as Indigenous Groups) and local priority area (LPA)[2] community members through the Project engagement process. The overall approach and methods for the incorporation of Indigenous and Local Knowledge into the EA is discussed in detail in Section 3, Indigenous and Local Knowledge. Issues and concerns related to surface water quality and sediment quality raised by Indigenous Groups and LPA community members, and how these comments were addressed, are summarized in Appendix 2B, Summary of Issues and Concerns Identified by Indigenous Groups, and identified and addressed in this assessment, where applicable.

A key source of Indigenous and Local Knowledge is the Project-specific studies completed by Indigenous Groups, including Traditional Land Use and Occupancy studies, Traditional Knowledge and Use studies, Indigenous Rights and Knowledge studies (henceforth referred collectively as IKTLU Studies). The IKTLU Studies that were reviewed and referenced in the EIS as technical support documents (TSDs) are listed below:

- TSD II (BNDN), Birch Narrows Dene Nation Traditional Knowledge and Use Study Specific to NexGen Energy Limited's Proposed Rook I Project;
- TSD III (BRDN), Buffalo River Dene Nation Traditional Knowledge and Use Study Specific to NexGen Energy Limited's Proposed Rook I Project;
- TSD IV (MN-S), Métis Nation – Saskatchewan Northern Region 2 Traditional Land Use & Diet Study for The NexGen Rook 1 Project;
- TSD V.1 (CRDN), Preliminary Identification of Issues and Concerns Related to the Proposed NexGen Energy Ltd. Rook 1 Project in the Patterson Lake Area; A Review; Clearwater River Dene Nation; Traditional Land Use and Occupancy Mapping Interviews; 2010 – 2016;
- TSD V.2 (CRDN), Clearwater River Dene Nation Indigenous Rights and Knowledge Survey Related to the Proposed NexGen Energy Ltd. Rook 1 Project in the Patterson Lake Area;
- TSD V.3 (CRDN), Socio-economic and Harvest Study; Clearwater River Dene Nation; NexGen Rook 1 Project; and
- TSD VI (YNLR), Provision of Athabasca Denesųłiné Traditional Knowledge, Land Use and Occupancy Information for the NexGen Rook I Project Environmental Assessment.

Another key source of Indigenous and Local Knowledge was information shared by Indigenous Group representatives during Joint Working Group (JWG) meetings. The JWGs represent an agreed-upon primary engagement mechanism as outlined in the Study Agreements signed by each Indigenous Group and NexGen. More details regarding the JWGs can be found in Section 2, Indigenous, Regulatory, and Public Engagement, and Section 3, Indigenous and Local Knowledge. There are four JWGs with the Project's primary Indigenous Groups (Section 2.4.1, Identification of Indigenous Groups for Engagement):

- Clearwater River Dene Nation (CRDN) JWG;

[2] The LPA consists of the local communities closest to the Project that would experience most of the Project effects and for which NexGen would prioritize local training, employment, and business opportunities for the Project. These communities are located along, or accessed via, Highways 155 and 955 north of the intersection of Highways 155 and 925.

- Métis Nation – Saskatchewan (MN-S) JWG representing MN-S Northern Region 2 (NR2);
- Birch Narrows Dene Nation (BNDN) JWG; and
- Buffalo River Dene Nation (BRDN) JWG.

The leadership of each Indigenous Group selected their JWG participants with consideration of group diversity; where possible, members included Elders, youth, different genders, a range of ages, and land users around Patterson Lake.

In addition to the IKTLU Studies and JWGs, Indigenous and Local Knowledge shared during specific engagement activities undertaken through the EA development process was incorporated into the assessment, where appropriate. These engagement activities included, but were not limited to:

- community information sessions held in four locations in 2019 (NexGen 2019);
- site tours;
- comments from the CRDN (2019b) on the Cluff Lake Mine licence renewal;
- other formal and informal meetings;
- workshops with specific groups (e.g., Fur Block N-19 trapper's workshop); and
- environmental and socio-economic baseline data collection.

Comments submitted by Indigenous Groups on the Project Description (CRDN 2019a; MN-S 2019; YNLRO 2019; ACFN 2019; CNSC 2019) were also reviewed for applicable Indigenous and Local Knowledge.

Indigenous and Local Knowledge related to surface water quality and sediment quality was incorporated into the assessment by viewing the information as complementary and influential alongside scientific information. Where possible, knowledge from each potentially affected Indigenous Group or LPA community member was described separately and cited accordingly. Where information is described for multiple potentially affected Indigenous Groups, they are collectively referred to as "Indigenous Groups" throughout the assessment.

Indigenous and Local Knowledge was included in the surface water quality and sediment quality assessment in the following ways:

- **Component Methods-Valued Components and Intermediate Components:** Indigenous and Local Knowledge was considered in the selection of the intermediate component of surface water quality and sediment quality and reflects the importance of water to Indigenous Groups and LPA communities as a source of drinking water, for supporting harvesting activities and contributing to community well-being and health. The importance of water was also reflected in the holistic perspective of Indigenous and Local Knowledge related to the interconnectedness of rivers, lakes and other waterways, and the relationship of water to aquatic and terrestrial environmental health. The value of Patterson Lake and the Clearwater River as an interconnected system and freshwater resource was highlighted (Section 10.2.2.1).
- **Component Methods-Spatial Boundaries:** The approach used to select spatial boundaries (i.e., the Clearwater River watershed), which includes a portion of the Clearwater River system and connecting waterbodies, is supported by Indigenous and Local Knowledge. Feedback from Indigenous Groups highlighted the interconnectedness of the region's waterways, and the Clearwater River as a holistic river system with many large lakes that are connected and integral to the river and cannot be viewed in isolation (Section 10.2.3).

- **Component Methods-Existing Conditions:** While Indigenous and Local Knowledge was primarily received after the aquatic environmental baseline program was underway, the waterbodies sampled were identified as culturally important to Indigenous Groups and LPA communities for harvesting activities, drinking water, occupancy, and travel. The Patterson Lake area in particular was identified as a culturally significant area where traditional activities have been practiced for generations. Therefore, the locations used to represent existing conditions generally align with Indigenous and Local Knowledge (Section 10.2.6.1).
- **Component Methods-Residual Effects Analysis:** Constituents of Potential Concern that were identified through Indigenous and Local Knowledge were included in the residual effects analysis (Section 10.2.8.2).
- **Existing Conditions-Surface Water Quality:** Indigenous and Local Knowledge was shared about the quality of the surface water in the Clearwater River, Patterson Lake, and other large waterbodies in the LSA, including changes in water quality, and to fish, vegetation, and wildlife health observed over time. (Section 10.3.1).
- **Project Interactions and Mitigation:** Indigenous and Local Knowledge helped to inform the scoping of Project interactions, pathway analysis, and consideration of mitigation measures (Section 10.4). This includes observations and experiences of land users related to the cumulative effects of changes in water quality and contamination from industry, including mining activities, and on aquatic and terrestrial environmental health.
- **Monitoring, Follow-Up, and Management:** Feedback provided by Indigenous Groups during engagement, including recommendations, were considered in the development of monitoring and follow-up activities (Section 10.7). In addition, it is planned that ongoing feedback from Indigenous Groups on the effectiveness of mitigations would be considered when updating monitoring programs and management plans. Independent Indigenous Monitors chosen by each primary Indigenous Group would have opportunities to participate in environmental monitoring programs for the proposed Project.

Specific references to Indigenous and Local Knowledge, and Project comments and concerns related to surface water quality and sediment quality raised by Indigenous Groups and LPA community members, are included in the applicable subsections of this assessment.

10.2.2 Valued Components, Intermediate Components, and Measurement Indicators

10.2.2.1 Valued Components and Intermediate Components

Valued components are aspects of the biophysical, cultural, and socio-economic environments that are considered to have scientific, social, cultural, economic, historical, archaeological, or aesthetic importance (Beanlands and Duinker 1983; CNSC 2021a). Intermediate components include physical attributes of the biophysical environment or media upon which VCs rely, such as air quality, terrain and soils, hydrology, and water and sediment quality (Section 6.3.3, Intermediate Components). Valued components and intermediate components are assessed using the same steps; however, unlike VCs, intermediate components do not have assessment endpoints or significance criteria. Instead, the significance of changes in intermediate components is evaluated in the context of related influences to VCs, which are the ultimate receptors.

Surface water quality and sediment quality were selected as intermediate components based on their connection to human use and healthy and functioning aquatic and terrestrial ecosystems, such as fish and fish habitat and wildlife (Table 10.2-1). Intermediate components, such as surface water and sediment quality, are critical to the EIS assessment as changes to intermediate components must be understood in order to facilitate assessment of various effect pathways to VCs. Changes to surface water and sediment quality can only be evaluated in the context of the related influences on a VC, which is the ultimate receptor of concern. As an example, changes in surface water quality by a predicted amount (i.e., magnitude) for a period of time (i.e., duration) cannot be evaluated without the context of what these changes would mean to fish and fish habitat, wildlife and wildlife habitat, human health, and cultural and heritage resources and Indigenous land and resource use.

Changes in surface water quality or sediment quality are considered in the following VC-specific assessments:

- Section 11, Fish and Fish Habitat, which describes and assesses potential changes to fish and fish habitat from changes to water quality and considers the results of the ecological risk assessment;
- Section 13, Vegetation, which describes and assesses potential changes to vegetation from water quality;
- Section 14, Wildlife and Wildlife Habitat, which describes and assesses potential changes to wildlife and wildlife habitat from water quality and considers the results of the ecological risk assessment;
- Section 15, Human Health, which describes and assesses potential changes to human health from water quality, and considers results of the human health risk assessment;
- Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use, including the IKTLU assessment, which describes and assesses potential changes to drinking water and cultural uses; and
- Section 17, Other Land and Resource Use, which describes and assesses potential changes to commercial and recreational uses derived from the natural environment.

Indigenous Groups have described the fundamental importance of water for all forms of life and supporting traditional land use activities, including harvesting and travel. For the CRDN, “respect for water is at the core of Denesųłiné teachings and practices because clean water is the fundamental requirement for all life . . . . Clean water is therefore inextricably connected to CRDN livelihoods, practices, customs and spirituality” (TSD V.2: CRDN). The Ya’thi Néné Lands and Resources commented on the importance of water to the community “I want this for the future generations. Water should be monitored, it should be kept clean, water is sacred for us” (TSD VI: YNLR). The BNDN noted that “Water is the most important thing, vital to life” (BNDN-JWG 2019). Water is central to BNDN and BRDN culture, community well-being and health (TSD II: BNDN; TSD III: BRDN).

> Drinking water is . . . a number one medicine. [Without] drinking water, you can't live . . . . And there's so many things around the lake . . . . like [medicines] in the water that you can get . . . . [including] all along the shore. (TSD II: BNDN)

LPA community members also frequently noted water quality and the protection of water as one of the most important components of the environment (NexGen 2019).

Showing respect for, and giving thanks to the water and resources through prayer and ceremonies is an important part of cultural practice (TSD III: BRDN; TSD V.2: CRDN; MN-S-JWG 2019a). For example, at harvesting cultural camps, CRDN Elders and teachers make offerings to the water prior to fishing (TSD V.2: CRDN). The care and protection of the lands and waters is considered a sacred responsibility to the CRDN, which is passed on through the generations.

> The teachings I received from my Grandmother when I was small – what she had told me was to respect the water or the fish will die. There will be no food if the environment is disturbed, like going through the bush. I never know what it meant. She said, 'When I'm gone you can pass this on. Don't throw garbage in water it will affect the fish. Pick out twigs floating in the water . . . . Pray for the lake. Use trees [branches], tobacco, holy water to make offerings. Do not let the water be disturbed.' We don't want anything happening to the water. The first thing [traditional] people, families say [to the lake on arrival] 'We did not come to disturb'. We make a prayer offering, take a small branch, twig, tobacco and speak to the water. 'Not here to disturb or disturb me'. (TSD V.2: CRDN)

Occupancy, travel, and harvesting activities are often centred around water, where cabins and camp sites serve as base camps from which traditional activities extend and waterways are utilized for travel. Lakes, rivers, and other waterways support fishing, trapping for aquatic and other furbearers, hunting for moose, the gathering of medicinal plants, and are a source of drinking water (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YNLR). The Patterson Lake area, including the complex of waterbodies connected to the Clearwater River, is culturally important to Indigenous Groups (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN); it is "historically and currently recognized as a 'good for everything' harvesting area which may have sustained CRDN members through time beyond living memory" (TSD V.1: CRDN), and described as paramount to MN-S members, and their lifeblood (TSD IV: MN-S). Knowledge of the lands and waters in the Patterson Lake area has been passed down through the generations.

Indigenous Groups have highlighted the relationship between water quality and aquatic and terrestrial environmental health, and commented on contamination of surface water and groundwater, bioaccumulation, food safety and human health, and long-term effects on water quality (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; BRDN-JWG 2021b; CRDN-JWG 2021; MN-S-JWG 2019a).

> Most important thing . . . because we drink that water and the fish lives on water. Creatures, they drink the water. You know, like moose, caribou, everything, you know. That's the most important thing . . . we drink a lot of water ourselves, you know. (TSD II: BNDN)

> It just ties back to everything. I think of all the plants that we use for medicinal purposes. You know, like all the trees and stuff like that. And then the other animals that come to that lake [Patterson] to drink. And those are the animals we hunt and we eat. You know what I mean? Like that's a big area where people go moose hunting and everything in the fall time. I think that should be something that they [regulators and the Crown] have to consider. (TSD V.2: CRDN)

The ability to practice traditional activities depends on having access to a healthy land base, and availability of abundant and high-quality resources, including clean air and water (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN).

Indigenous and Local Knowledge clearly links the importance of water quality to several users of water including local community members, plants, wildlife, and fish. This affirms the necessity to include surface water quality and sediment quality as an intermediate component in the EA used to inform assessments for fish and fish, habitat, vegetation, wildlife and wildlife habitat, human health, Indigenous land and resource use, and other land and resource use VCs.

10.2.2.2 Measurement Indicators

Measurement indicators are used to characterize changes to attributes of the environment from the Project, other human developments, and natural factors. The changes in measurement indicators are used to predict overall effects on VCs and intermediate components (Section 6.3.2, Assessment Endpoints and Measurement Indicators). Four measurement indicators were identified and used for the surface water quality and sediment quality assessment (Table 10.2-1).

Measurement indicators for surface water quality are defined as follows:

- **Water quality constituent concentrations (i.e., risk to aquatic and terrestrial life):** includes nutrient, major ion, trace metal, and radionuclide concentrations in waterbodies and watercourses, which are compared to water quality thresholds (e.g., guidelines, objectives, standards) that apply to the protection of aquatic life and terrestrial life.
- **Drinking water quality constituent concentrations:** includes major ion, trace metal and radionuclide concentrations in waterbodies and watercourses, which are compared to Canadian drinking water quality thresholds.
- **Productivity status constituent concentrations:** includes total phosphorus concentrations in waterbodies and watercourses, which are compared to Canadian waterbody trophic status[3] thresholds.

Measurement indicators for sediment quality are defined as follows:

- **Sediment quality constituent concentrations (i.e., risk to aquatic life):** includes trace metal and radionuclide concentrations in waterbodies and watercourses, which are compared to sediment quality thresholds (e.g., guidelines, objectives, standards) that apply to the protection of aquatic life and terrestrial life.

The measurement indicator constituent concentrations were compared to thresholds that have been developed for the Project, which are presented in Section 10.2.8.3, Development of Thresholds. For the Project, specific water quality and sediment quality constituents were selected from a broad range of water quality and sediment quality parameters for each measurement indicator. This group of constituents, referred to as constituents of potential concern (COPCs), represent a focused list of conventional water quality parameters, nutrients, major ions, metals, and radionuclides that have the potential to pose a risk to aquatic and terrestrial life and/or human

[3] Trophic status describes and classifies waterbodies and watercourses (e.g., lakes and rivers) based on their ability to support aquatic ecosystems (i.e., primary productivity). The ability of a lake to support aquatic biota, such as plants and algae, is dependent on nutrient concentrations and physical conditions, primarily phosphorus and nitrogen nutrients and water clarity, respectively. In Canadian waters, particularly waterbodies on the Canadian Shield, phosphorus is characterized as the principal limiting factor (i.e., limiting nutrient) for primary productivity (CCME 2004).

health should they increase as a result of the Project. For each COPC, a Project-specific threshold was determined for each measurement indicator, as necessary. The Project-specific thresholds were concentration limits intended to delineate an upper bound concentration limit where, if COPC concentrations remain below these thresholds, aquatic and terrestrial life, human health, and Indigenous land and resource use would be protected. The screening and selection process is described in Section 10.2.8.2, Constituents of Potential Concern. The selection of measurement indicators, and their specific COPCs, for surface water quality and sediment quality aligned with Indigenous and Local Knowledge and community concerns regarding the potential effects of degrading water quality on ecosystems, the ability to consume fish and wildlife, and the importance of high-quality drinking water for human consumption.

Table 10.2-1: Rationale and Measurement Indicators for the Surface Water and Sediment Quality Intermediate Components

Intermediate Component	Rationale	Measurement Indicators
Surface water quality	▪ Key attribute of healthy and functioning aquatic and terrestrial ecosystems ▪ Important to human use and health ▪ Indigenous and other land users may use local waterbodies and watercourses for recreational or cultural practices	▪ Water quality constituent concentrations ▪ Drinking water quality constituent concentrations ▪ Productivity status constituent concentrations
Sediment quality	▪ Key attribute of healthy and functioning aquatic ecosystems ▪ Important to human use and health ▪ Indigenous and other land users may use local waterbodies and watercourses for recreational or cultural practices	▪ Sediment quality constituent concentrations (i.e., risk to aquatic life)

10.2.3 Spatial Boundaries

The spatial boundaries selected for the surface water quality and sediment quality assessment support a description of the existing environment in sufficient detail to identify, understand, and assess potential Project interactions with the surface water quality and sediment quality intermediate components, including the contribution of the Project to residual effects (Table 10.2-2). The spatial boundaries for surface water quality and sediment quality consisted of a regional study area (RSA) and local study area (LSA) (Figure 10.2-1). In accordance with CEA Agency guidance (CEA Agency 2018), the selection of the assessment study areas considered intermediate component-specific attributes and hydrological boundaries, and the potential spatial extent of Project effects and other existing and future activities/developments.

The RSA for surface water quality and sediment quality is defined by the Clearwater River watershed boundary upstream of the Mirror River confluence. This study area represents a surface area of approximately 107,600 ha (1,076 km^2) (Figure 10.2-1) and is consistent with the RSA used by other water-related assessments in the EIS (i.e., hydrology, fish and fish habitat). The rationale for selecting the extent of this study area was that the Clearwater River just above the Mirror River confluence represents a point in the watershed where greater-than-negligible water quality changes from the Project would not be expected given the additional dilution provided by the Mirror River (Section 9.2.3, Spatial Boundaries). This assumption would be confirmed by more detailed analysis (Section 10.6) and through follow-up monitoring (Section 10.7).

The LSA for surface water quality and sediment quality lies within the RSA and is defined by the Clearwater River watershed boundary to just downstream of the Naomi Lake outlet (Figure 10.2-1). The key waterbodies in the LSA are along the mainstem of the Clearwater River: Broach Lake, Lake G, Lake H, Patterson Lake, Forrest Lake, Beet Lake, and Naomi Lake. This study area represents a surface area of 68,530 ha (685 km^2) and is consistent with the LSA used by other water-related assessments in the EIS (i.e., hydrology, fish and fish habitat). The LSA comprises two large lakes, Forrest and Patterson lakes, as well as a number of smaller waterbodies and wetlands interconnected by watercourses of various lengths. Due to the size of Forrest and Patterson lakes, existing conditions and Project effects on these lakes were assessed in discrete sub-regions: Patterson Lake comprises the North Arm – East Basin, the North Arm – West Basin, and the South Arm, and Forrest Lake comprises the North Basin and the South Basin (Figure 10.2-2). The rationale for selecting the extent of the LSA was that it includes waterbodies and watercourses where direct Project-related changes would be expected and likely to be measurable (i.e., the receiving environment). Therefore, the receiving environment represents the waterbodies and watercourses or watershed around the Project, where Project-related effects through site runoff, discharges, and air deposition would occur and could be expected to be measured.

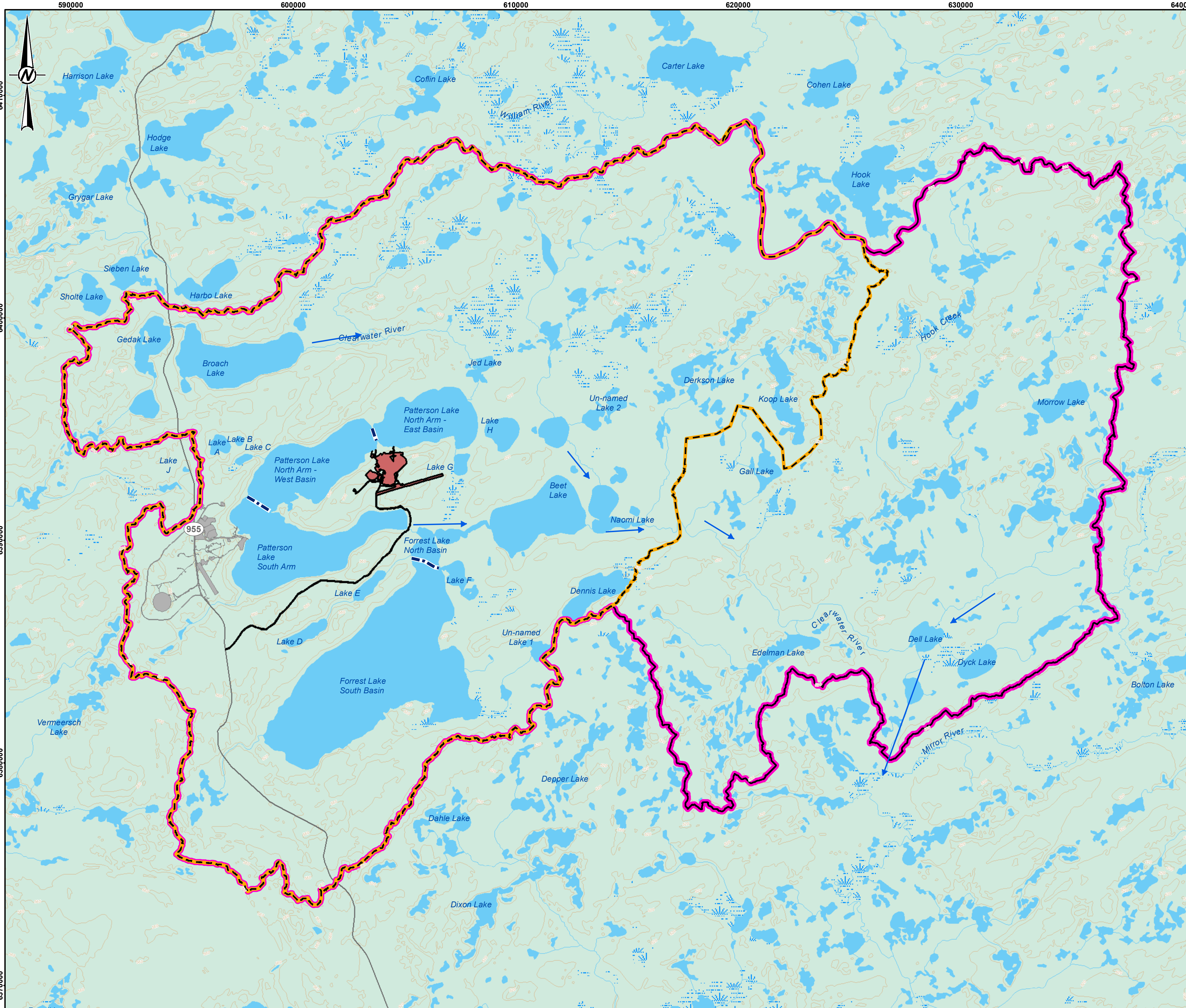
The approach used to select spatial boundaries supports Indigenous and Local Knowledge shared by Indigenous Groups about the interconnectedness of the region's waterways, and how rivers and lakes cannot be viewed in isolation (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.2: CRDN; BNDN-JWG 2021b; BRDN-JWG 2019a; BRDN-JWG 2020). For example, the CRDN describe the Clearwater River as a holistic river system in which Patterson Lake, Forrest Lake, and downstream lakes (e.g., Beet Lake) are intrinsically connected to and integral to the river (TSD V.2: CRDN). Similarly, Patterson Lake and other lakes are viewed by the CRDN as connected to the network of waterbodies and watercourses in the area, rather than as discrete and separate waterbodies (TSD V.2: CRDN; CRDN-JWG 2021). The MN-S described the importance of Patterson Lake because it is central to the river system for the entire area and feeds the lakes to the south, affecting all the waterways that members use (TSD IV: MN-S).

It is understood through Indigenous and Local Knowledge that Patterson Lake, Forrest Lake, Clearwater River, and other waterbodies and watercourses in the region are culturally important to Indigenous Groups and LPA communities for the use of: water, fish, plants and wildlife; cultural connections to the land, and community well-being (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YNLR; MN-S 2019; CRDN 2019a,b; YNLRO 2019). Patterson Lake, Forrest Lake, and the Clearwater River to downstream of the Naomi Lake outlet were included within the LSA.

Table 10.2-2: Spatial Boundaries for Assessment of Surface Water Quality and Sediment Quality

Study Area	Area	Description/Rationale
LSA	68,530 ha (685 km^2)	▪ Clearwater River watershed to just downstream of the Naomi Lake outlet ▪ Defines the expected extent of the direct and indirect effects from the Project ▪ Provides local context for assessing the residual effects
RSA	107,600 ha (1,076 km^2)	▪ Watershed draining to the Clearwater River above the Mirror River confluence ▪ Provides broader scale context to capture and assess Project effects and is linked to terrestrial and aquatic-related exposure pathways in the ecological health risk assessment ▪ Provides broader scale context for Project effects and assess cumulative effects, if applicable

LSA = local study area; RSA = regional study area.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- FLOW DIRECTION
- LAKE BASIN DIVISION
- SECONDARY HIGHWAY
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED AREA
- PROPOSED PROJECT FOOTPRINT
- FISSION PATTERSON LAKE SOUTH PROPERTY FOOTPRINT
- SURFACE WATER AND SEDIMENT QUALITY LOCAL STUDY AREA
- SURFACE WATER AND SEDIMENT QUALITY REGIONAL STUDY AREA

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
2. FISSION (FISSION URANIUM CORP.) OBTAINED FROM 2019 TECHNICAL REPORT ON THE PRE-FEASIBILITY STUDY OF THE PATTERSON LAKE SOUTH PROPERTY USING UNDERGROUND MINING METHODS.
3. 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

WATER AND SEDIMENT QUALITY STUDY AREA

CONSULTANT

wsp

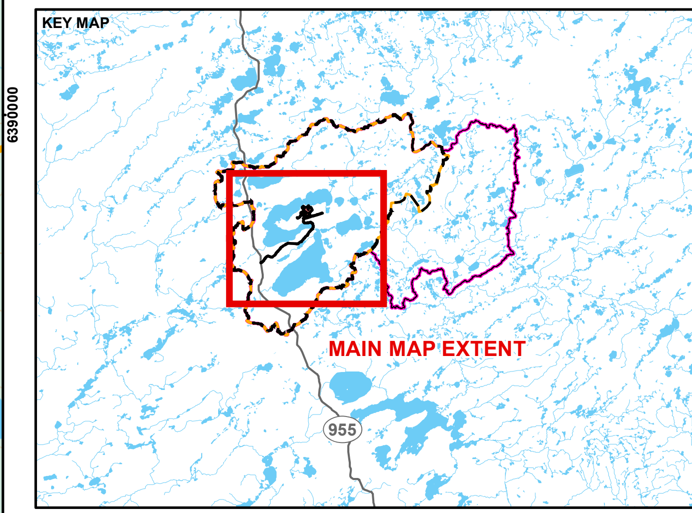
PROJECT		20144150	PHASE	3106 - 3
DESIGN	IC	2021-05-17	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-07	**FIGURE 10.2-1**	
CHECK	IC	2023-02-07		
REVIEW	GVA	2023-02-07		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

LEGEND

- BATHYMETRY CONTOUR ELEVATION (10m INTERVAL)
- ELEVATION CONTOUR (20 m INTERVAL)
- FLOW DIRECTION
- LAKE BASIN DIVISION
- SECONDARY HIGHWAY
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED AREA
- PROPOSED PROJECT FOOTPRINT
- SURFACE WATER AND SEDIMENT QUALITY LOCAL STUDY AREA
- SURFACE WATER AND SEDIMENT QUALITY REGIONAL STUDY AREA

KEY MAP



0 2 4
1:80,000 KILOMETRES

REFERENCE(S)
1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
2. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
3. FORREST LAKE BATHYMETRY CONTOURS DERIVED FROM JUNE 2019 BATHYMETRY SURVEY DATA. PATTERSON LAKE BATHYMETRY CONTOURS DERIVED FROM DATA COLLECTED BY NEXGEN, 2016.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT
NexGen Energy Ltd.
ROOK I PROJECT

TITLE
PATTERSON LAKE AND FORREST LAKE SUB-BASINS

CONSULTANT
wsp

PROJECT		20144150	PHASE	3106 - 3
DESIGN	IC	2021-05-17	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-07		
CHECK	IC	2023-02-07	**FIGURE 10.2-2**	
REVIEW	GVA	2023-02-07		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

10.2.4 Temporal Boundaries

The temporal scope of the assessment 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 (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 required 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 CNSC licence would be submitted to the CNSC 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.

For certain potential Project effects, snapshots (i.e., fixed in time or steady-state) were used to simulate processes rather than simulating Project effects over continuous time frames. Snapshots are used when the modelling platform does not have the ability to represent changing conditions over time (e.g., gradual changes in lake water quality). For example, various assessment snapshots of Project effects were considered in the near-field (i.e., within 200 m of the treated effluent diffuser) water quality modelling completed to assess dilution and mixing characteristics of the treated effluent and treated sewage discharge locations. The snapshots for the near-field water quality assessment were chosen deliberately to provide assessments at key times during the lifespan of the proposed Project that represented bounding conditions (i.e., combinations of background plus Operations discharge, which occurred just after the commencement of Project discharges at the start of Operations and five years before the end of Operations). These bounding conditions are expected to represent the upper and lower limits of the water quality conditions during the period of Operations discharge, respectively.

The temporal scope of the surface water quality assessment also considered water quality effects that may occur from the Project following Closure (i.e., in the far future). Far-future effects were included in the water quality assessment because, for surface water quality, the duration of effects from the Project could occur well beyond Closure. The far-future effects considered the potential for the long-term, extremely slow migration of COPCs from the underground workings (including the UGTMF) and WRSAs via the groundwater pathway to the receiving environment. While it is not possible to accurately predict potential effects thousands of years into the future, the temporal extent and mass loading inputs of the far-future assessment have been developed so that the modelled results provide a reasonable, conservative representation of the maximum potential changes to surface water quality in Patterson Lake and the downstream environment. The assessment of effects in the far future includes the assumption of limited source control associated with the WRSAs and the underground workings, where the WRSAs would be covered, and oxygen ingress would be limited. It is assumed that the PAG WRSA liner would not function in the far future and all infiltration and seepages through and from the WRSAs and underground workings would generate mass loading via contact with waste rock and tailings and carry the loads to surface waters via groundwater pathways. It also includes the conservative assumption that all contact material from the PAG WRSA is consistent with PAG material sources, with no source depletion (i.e., decreasing loading or concentrations) over time.

The assessment of surface water quality effects for the far future was based on surface water quality modelling that spanned 400 years, including the 43-year project timeline and 357 years after Closure. The post-closure timeframe is defined as the far-future projection and the modelled time period represents multiple climate cycles where mass loading inputs from the WRSAs and underground are assumed to be as predicted and at a maximum, respectively. Further details about these time frames and ways that precautionary measures were applied in the assessment are provided in Section 10.2.8.1.3 and Appendix 10A, Surface Water Quality Modelling Report.

Indigenous Groups noted the importance of preserving water quality, and aquatic and terrestrial habitat, for future generations. For example, concerns surrounding the interaction of groundwater, and ultimately surface water, with the tailings, have been raised by the CRDN, MN-S, BNDN, and BRDN (Section 10.4.3), including concerns related to long-term effects in general that may affect future generations (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; BNDN-JWG 2019; BNDN-JWG 2020; BNDN-JWG 2021a; BRDN-JWG 2020; BRDN-JWG 2021a; CRDN-JWG 2020; CRDN-JWG 2021; MN-S-JWG 2019a). By considering the far future as described, such that potential long-term changes to surface water quality in Patterson Lake, and downstream, were included, the assessment addresses the desire to protect the environment and provide for future generations. The far-future projection timeframes and modelling details are described in Section 10.2.8, Residual Effects Analysis.

The temporal boundaries applied to cumulative effects assessments include the duration of residual effects from previous and existing developments that overlap with residual effects from the Project, and the period during which the residual effects from RFDs overlap with the Project.

10.2.5 Assessment Cases

The concept of assessment cases was applied to the surface water quality and sediment quality assessment to estimate the incremental and cumulative effects from the Project and other developments (Section 6.5, Assessment Cases). 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. There are no known approved (but not yet constructed) projects in the LSA and RSA for surface water quality and sediment quality. Assessment cases for the Project included a Base Case, Application Case, and RFD Case.

Base Case for surface water quality and sediment quality is represented by existing conditions. The Base Case describes the existing environment in the LSA before application of the Project to provide an understanding of the current conditions that may be influenced by the Project. The temporal boundary of the Base Case includes the combined effects from previous and existing human disturbances and natural factors (e.g., fire, floods, drought) on the environment and surface water quality and sediment quality. As such, existing conditions represent the cumulative effects of historical and current environmental pressures that have influenced the observed condition and patterns of surface water quality and sediment quality (CEA Agency 2018).

Application Case for surface water quality and sediment quality represents predictions of the combined effects of the previous and existing projects/activities and natural factors in the Base Case plus the effects from the Project. This case was also used to identify and assess incremental, Project-specific changes that are predicted to occur to surface water quality during the lifespan of the Project as well as in the far-future projection. For sediment quality, the assessment of Project-specific effects was limited to the lifespan of the Project because direct effects of the Project (i.e., direct discharge and deposition of air emissions to the receiving environment) are limited to this period.

Reasonably Foreseeable Development Case for surface water quality includes the Base Case, Application Case, and RFDs that have not yet been approved. An RFD Case was not considered for sediment quality. Reasonably foreseeable developments are defined as projects and activities that fit any of the first three and both of the last two criteria from the list below:

- are currently under regulatory review or have officially entered a formal regulatory application process;
- have been publicly disclosed by other proponents;
- may be induced by the Project;
- have the potential to change the Project or the effects predictions; and
- occur in the spatial assessment boundary defined by surface water quality.

A key criterion for selecting other projects to include in the RFD Case was that the projects must cause similar effects on water quality influenced by the Project (Hegmann et al. 1999). The Fission Patterson Lake South Property, which is planned by Fission Uranium Corp. (Fission 2019, 2021), was included in the RFD Case for surface water quality (Figure 10.2-3). Public information describes a projected three-year construction period and seven-year operating period (production and processing) (Fission 2019, 2021). The anticipated start of construction and duration of active decommissioning at the Fission Patterson Lake South Property were not publicly available at the time this assessment was completed. For the assessment, it was assumed that the duration of active decommissioning for the Fission Patterson Lake South Property would be similar to the Active Closure Stage for the Project (i.e., five years; Section 6.5.3, Reasonably Foreseeable Development Case).

The CRDN and MN-S specifically mentioned the risk of cumulative effects from the Project and the nearby proposed Fission Patterson Lake South Property (CRDN 2019a; MN-S-JWG 2020; CRDN-JWG 2021).

The RFD Case also considered how natural factors (e.g., climate) may interact with the Project and other developments to affect surface water quality (Section 6.5.3). Potential climate change influences on surface water quality in the RFD Case were considered as a sensitivity scenario during the Project lifespan based on average hydrological forecasts (e.g., precipitation, evaporation) provided by the hydrology assessment (Section 9, Hydrology).

Indigenous Groups indicated concerns about cumulative effects from industrial development, government policies and climate change (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; MN-S 2019; CRDN 2019a,b; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YNLR; YNLRO 2019).

The surface water quality assessment includes a quantitative and qualitative analysis of predicted changes on measurement indicators and associated effects from the Fission Patterson Lake South Property on surface water quality. In addition, potential changes from natural disturbance factors and climate change are qualitatively discussed for surface water quality.

LEGEND

	ELEVATION CONTOUR (10 M INTERVAL)		FISSION PATTERSON LAKE SOUTH PROPERTY FOOTPRINT
	SECONDARY HIGHWAY		PATTERSON LAKE SOUTH PROPERTY HYPOTHETICAL MAXIMUM DISTURBANCE AREA
	WATERCOURSE		PROPOSED PROJECT FOOTPRINT
	WATERBODY		
	WETLAND		
	WOODED AREA		

0 1 2
1:50,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021.
2. FISSION (FISSION URANIUM CORP.) OBTAINED FROM 2019 TECHNICAL REPORT ON THE PRE-FEASIBILITY STUDY OF THE PATTERSON LAKE SOUTH PROPERTY USING UNDERGROUND MINING METHODS.
3. 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
DEVELOPMENTS INCLUDED IN THE REASONABLY FORESEEABLE DEVELOPMENT CASE

CONSULTANT
wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	JH	2023-02-07	SCALE AS SHOWN	REV. 0
GIS	LB/VMB	2023-02-07	**FIGURE 10.2-3**	
CHECK	IC	2023-02-07		
REVIEW	GVA	2023-02-07		

PATH: I:\CLIENTS\NexGen\20144150\Mapping\Products\FINAL_EIS_FIGURES_WSP_LOGO_UPDATED\10_Surface_Water_Quality_Sediment_Quality\20144150_Fig10_2-3_Developments_included_in_RFD_Case_Rev0.mxd PRINTED ON: 2023-02-07 AT: 2:09:57 PM

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25mm

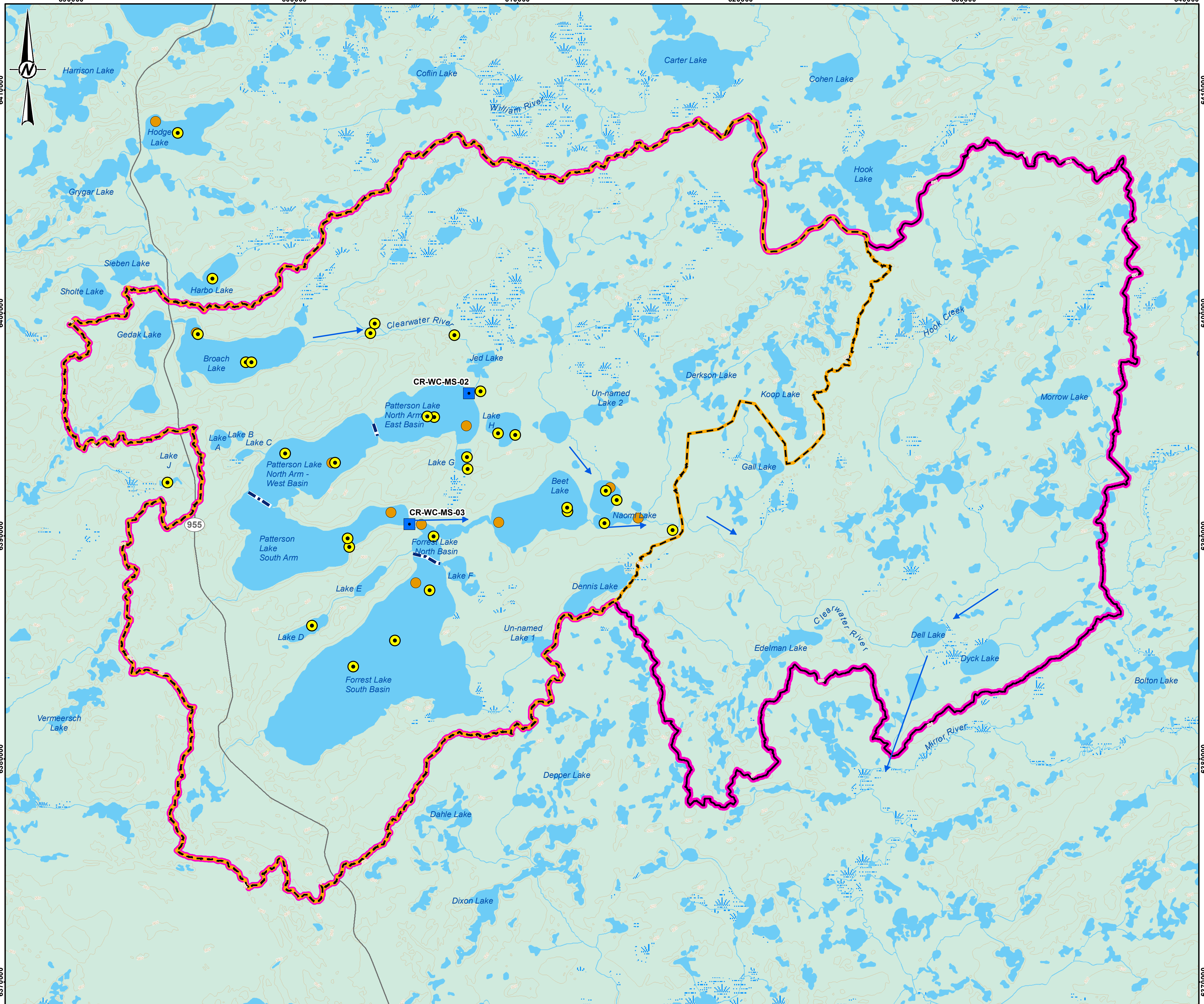
10.2.6 Existing Conditions

Existing conditions for surface water and sediment quality were used to provide a basis of understanding upon which residual effects could be assessed based on projected change. Indigenous and Local Knowledge played a key role in understanding current perspectives on water quality, as the waterbodies and watercourses have supported the livelihood, culture, and community well-being of Indigenous Groups in the area of the Project for many generations, and the intimate knowledge of the land and water has been passed down from generation to generation. To date, there has been little Indigenous and Local Knowledge explicitly expressed on sediment quality; the focus has been largely on surface water quality.

From a quantitative standpoint, data and information collected primarily at the local scale (i.e., LSA) provide detailed and precise measurements of existing conditions to allow the prediction of Project-related changes to measurement indicators for surface water quality and sediment quality. This information included in situ water quality measurements and the laboratory analysis of collected water and sediment samples. Summary data derived from the existing conditions characterization were used to develop the surface water quality conditions for the Base Case in the assessment, which were used as the environmental setting in the regional surface water quality modelling.

10.2.6.1 Surface Water Quality

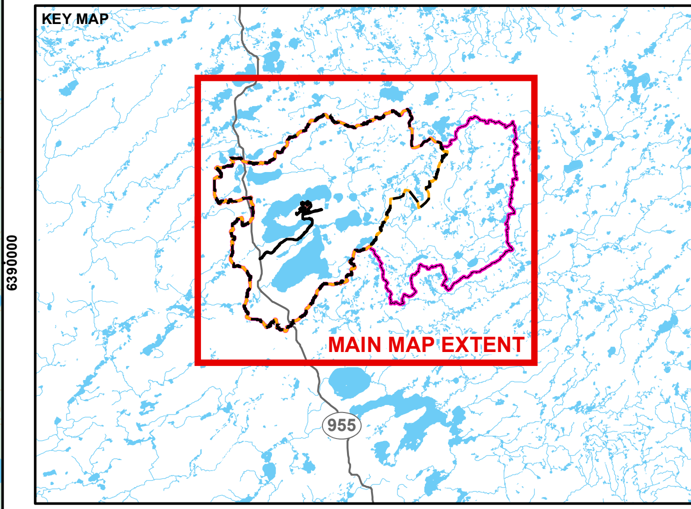
To assess existing conditions for surface water quality, field surveys were carried out to characterize existing surface water and sediment quality within the LSA and RSA. For water quality, a total of 13 field surveys were carried out between November 2015 and October 2020 by PGL Environmental and Canada North Environmental Services (Annex V.1, Aquatic Environment Baseline Report). Sampling locations are identified in Figure 10.2-4. Four lakes outside of the Clearwater River flow path (i.e., Harbo Lake, Hodge Lake, Lake D, and Lake J) were sampled to characterize the reference lake water quality. The reference lake water quality represents small lakes within the LSA that are outside of the influence of proposed Project discharges to assess potential air deposition effects. Between 2017 and 2020, quarterly field surveys were conducted to capture seasonal variation. Over the monitoring period, field measurements and water samples were collected from a total of 14 waterbodies and watercourses, with the two largest lakes, Patterson Lake and Forrest Lake, sampled in their individual sub-basins. Field measurements included physico-chemical (i.e., physical- and chemistry-related parameters) water column profiles of temperature, dissolved oxygen, pH, and specific conductivity in waterbodies or spot measurements of temperature, dissolved oxygen, pH, specific conductivity, and turbidity in watercourses. Field-measured data were obtained using hand-held meters and probes (i.e., water quality sensors, such as YSI-branded multi-probe sondes) that were lowered into the water at each sampling location. Collected water samples were analyzed in accredited commercial laboratories for a wide variety of parameters including inorganic ions, nutrients, metals, and radionuclides (Table 10.2-3). Laboratory analysis was conducted by ALS Environmental (2015) and SRC Group Environmental Analytical Laboratories (2016 to 2020).



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- FLOW DIRECTION
- LAKE BASIN DIVISION
- SECONDARY HIGHWAY
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED AREA
- GAUGE STATION
- WATER QUALITY SAMPLING LOCATION
- SEDIMENT QUALITY SAMPLING GENERALIZED LOCATION
- SURFACE WATER AND SEDIMENT QUALITY LOCAL STUDY AREA
- SURFACE WATER AND SEDIMENT QUALITY REGIONAL STUDY AREA

KEY MAP



0 5 10

1:175,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
2. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
3. FORREST LAKE BATHYMETRY CONTOURS DERIVED FROM JUNE 2019 BATHYMETRY SURVEY DATA. PATTERSON LAKE BATHYMETRY CONTOURS DERIVED FROM DATA COLLECTED BY NEXGEN, 2016.

PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

ROOK I PROJECT BACKGROUND SURFACE WATER QUALITY SAMPLING LOCATIONS

CONSULTANT

wsp

PROJECT		20144150	PHASE 3106 - 3
DESIGN	IC	2021-05-17	SCALE AS SHOWN REV. 0
GIS	NO	2024-02-06	
CHECK	IC	2024-02-06	FIGURE 10.2-4
REVIEW	GVA	2024-02-06	

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Table 10.2-3: Laboratory Analyzed Surface Water Quality Constituents included in the Baseline Studies, 2015 to 2020

Constituent Category	Constituent
Physical / general parameters	Specific conductivity, turbidity, TSS, TDS, hardness, alkalinity, pH
Major ions	Sodium, potassium, calcium, magnesium, fluoride, bicarbonate/carbonate, chloride, sulphate, cyanide
Nutrients	Total nitrogen, nitrate, nitrite, ammonia, total phosphorus, and reactive phosphorus or ortho-phosphate, organic dissolved and total carbon, total Kjeldahl nitrogen
Total and dissolved metals	Aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, cesium, chromium, cobalt, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, tellurium, thallium, tin, uranium, vanadium, zinc, zirconium
Radionuclides	Lead-210, polonium-210, radium-226, thorium-230, caesium-137

TDS = total dissolved solids; TSS = total suspended solids.

The waterbodies sampled in the aquatic environment baseline study, including Broach, Patterson, Forrest, Beet, and Naomi lakes, as well as the Clearwater River are culturally important to Indigenous Groups and used for harvesting activities, drinking water, occupancy, and travel (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN). Clearwater River was identified as an ancestral water route that is still used presently to access traditional use areas (TSD IV: MN-S; TSD V.2: CRDN). The CRDN reported that the Patterson Lake, Forrest Lake, Beet Lake, and other lakes further downstream are intrinsically connected and integral to the Clearwater River (TSD V.2: CRDN), and the MN-S highlighted Patterson Lake as being central to the river system for the entire area because it feeds the lakes to the south (TSD IV: MN-S).

> It's all connected together . . . . Not just me; a lot of people are saying that . . . . That's all one river. Patterson, through Forrest, Beet Lake. The river starts here . . . to Clearwater. (TSD V.2: CRDN)

The Patterson Lake and Forrest Lake area is particularly significant to the CRDN and has sustained CRDN members for generations (TSD V.1: CRDN; TSD V.2: CRDN). The MN-S have described the Patterson Lake area as being paramount to its members and their lifeblood (TSD IV: MN-S). The BRDN and BNDN have also reported practising traditional activities in the Patterson Lake area (TSD II: BNDN; TSD III: BRDN). The CRDN view Patterson Lake and Forrest Lake as one large lake with a narrow constriction, rather than two separate waterbodies (TSD V.1: CRDN, TSD V.2: CRDN).

The physicochemical surface water quality data collected in waterbodies and watercourses during the baseline studies were supplemented by in situ temperature monitoring performed at the gauge stations at the inlet and outlet of Patterson Lake as part of a hydrometric monitoring program conducted between August 2018 and September 2020 (Appendix 10A, Attachment 10A-1, Background Surface Water Quality Characterization; Annex IV.2, Hydrometric Monitoring Characterization Report). This monitoring was completed using Solinst Leveloggers installed between 0.5 m and 1.0 m beneath the water surface. These loggers collected continuous water temperature measurements during open-water and ice-covered conditions. The locations of the logger stations are shown in Figure 10.2-3.

Further discussion on the field survey methods is provided in Appendix 10A, Attachment 10A-1.

All available surface water quality data were compiled by waterbody and statistically analyzed. For each waterbody, the average, 25th percentile, 95th percentile, minimum, and maximum metrics were calculated for each constituent (Appendix 10A, Attachment 10A-1). Where sample constituent results were reported as less than the detection limit, the value used in the statistical analysis was set as equal to the reported detection limit for all statistics, except the average where a value equal to one half of the reported detection limit was used.

To ascertain the baseline un-ionized ammonia concentration in Patterson Lake to support the regional surface water quality modelling effort, monthly mean fractions of un-ionized ammonia were computed using average monthly in situ temperatures and average seasonal pH. Seasonal average pH in Patterson Lake was determined from the field pH data measured from the three basins of Patterson Lake. As a reported pH represents the negative logarithm of the hydrogen ion concentration, the field pH data were converted to corresponding hydrogen ion concentration, averaged based on season, and then converted back to a pH value to provide a seasonal average (Appendix 10A, Attachment 10A-1).

The surface water quality data were compared to the Project COPC thresholds for each measurement indicator for each waterbody in the LSA (i.e., water quality constituent concentrations for the protection of aquatic life and terrestrial life, drinking water quality constituent concentrations, and productivity status constituent concentrations). Additional information on threshold development is provided in Section 10.2.8.3.

10.2.6.2 Sediment Quality

Sediment quality samples were collected in the LSA in 2018 and 2019. In 2018, sediment samples were collected in eight lakes (i.e., Broach Lake, Hodge Lake, Patterson Lake, Forrest Lake, Lake G, Lake H, Beet Lake, and Naomi Lake) and in the Clearwater River below Naomi Lake within the LSA. Patterson Lake and Forrest Lake were sampled in each of their sub-basins. At each station, five replicate stations separated by a minimum distance of 20 m were sampled in each area to improve statistical power. The generalized area of the replicate stations is shown in Figure 10.2-4. The sediment quality sampling was conducted in the same general location as the benthic invertebrate community sampling to provide correlating sediment quality data to the benthic invertebrate community and biomass results (Annex V.1). In 2019, fall and winter sediment sampling was conducted in Naomi Lake, Patterson Lake, and Forrest Lake.

The sediment samples were analyzed for major ions and nutrients, total metals and radionuclides, particle size, total organic carbon, and moisture. Particle sizes were categorized based on the Wentworth Scale (Wentworth 1922) as recommended in *Metal Mining Technical Guidance for Environmental Effects Monitoring* (Environment Canada 2012). Sediment quality data were compared to the selected Project thresholds for sediment quality; these thresholds are presented in Section 10.2.8.3.4, Sediment Quality Thresholds.

10.2.7 Project Interactions and Mitigations

Interactions (i.e., linkages) between Project components or activities, and the corresponding potential changes to measurement indicators, were identified by a pathway analysis that was then used to inform the residual effects analysis for surface water quality and sediment quality (Section 6.7, Pathways Analysis). The first part of the analysis was to identify all potential effects pathways for all phases of the Project (Section 6.7.1, Identification of Project Interactions). Each pathway was initially assumed to have a linkage to potential effects on surface water quality and sediment quality.

Potential pathways from Project activities to surface water quality and sediment quality were identified using the following:

- review of the Project description (Section 5) and potential effect scoping by the project development, environmental, and socio-economic teams for the Project;
- input from Indigenous, regulatory, and public engagement (Section 2) and Indigenous and Local Knowledge (Section 3);
- scientific knowledge;
- previous experience with mining projects; and
- consideration of potential effects identified from the Terms of Reference (Section 1, Appendix 1A).

Potential adverse effects of the Project were then identified, and practicable mitigation was applied to avoid, minimize, and/or rehabilitate adverse effects on surface water quality and sediment quality (Section 6.7.2, Identification of Mitigation). Avoidance and minimization are widely recognized as the most important approach for biodiversity conservation (BBOP 2021). Avoidance designs and actions integrated into the Project were developed iteratively between the Project's environmental and project development teams. Minimization techniques and technology were also identified and implemented collaboratively between Project teams.

Each potential effect pathway was evaluated using proposed mitigation to predict whether the pathway had the potential to cause residual adverse effects (Section 6.7.3, Pathway Screening). A screening-level assessment was applied using Indigenous and Local Knowledge, scientific knowledge, logic, experience with similar developments, and an understanding of the effectiveness of mitigation (i.e., level of certainty that mitigation would work) to assign each pathway to one of the following categories:

- **No pathway:** Analysis reveals that the pathway could be removed (i.e., the effect is avoided) by mitigation so that the Project would result in no measurable environmental change relative to existing conditions or guideline values and, therefore, would have no residual effect on surface water quality or sediment quality.
- **Secondary pathway:** The pathway could result in a measurable but minor environmental change relative to existing conditions or guideline values, but this change is sufficiently small that it would have a negligible residual effect on surface water quality or sediment quality. Therefore, the pathway is not expected to contribute to effects of RFDs to cause a significant effect.
- **Primary pathway:** The pathway is likely to result in an environmental change relative to existing conditions or guideline values and could cause a greater than negligible effect on surface water quality or sediment quality.

Project interactions determined as no pathway or secondary pathway were not carried forward for further assessment (Section 6.7.3). Pathways that may result in changes to the environment and one or more associated measurement indicators and have the potential to cause a greater than negligible effect on surface water quality or sediment quality were carried forward to the residual effects analysis and residual effects classification (Section 10.5, Residual Effects Analysis).

10.2.8 Residual Effects Analysis

The residual effects analysis measures and describes the effects of the proposed Project on surface water quality and sediment quality relative to existing conditions and thresholds. The residual effects analysis was conducted using the spatial boundaries (Section 10.2.3) and temporal boundaries (Section 10.2.4, Temporal

Boundaries) identified for the assessment. Residual effects are described for each of the measurement indicators for the primary pathways identified for surface water quality and sediment quality in the LSA and RSA (Section 10.4.3, Primary Pathways). The residual effects analysis was completed for the Application Case and the RFD Case (Section 6.8, Residual Effects Analysis).

For the primary pathways identified for surface water quality in the LSA, residual effects were described for each of the measurement indicators (Section 10.4.3, Primary Pathways):

- **Water quality constituent concentrations:** provides a comparative assessment of the changes in COPC nutrient, major ion, trace metal, and radionuclide concentrations in the LSA with respect to water quality thresholds for the protection of aquatic and terrestrial life (Section 10.2.8.3.1, Water Quality Thresholds).
- **Drinking water quality constituent concentrations:** provides a comparative assessment of the changes in COPC major ion, trace metal, and radionuclide concentrations in the LSA with respect to drinking water threshold values (Section 10.2.8.3.2, Drinking Water Quality Thresholds).
- **Productivity status constituent concentrations:** provides a comparative assessment of the changes in total phosphorus concentrations in the LSA with respect to waterbody trophic status (Section 10.2.8.3.3, Productivity Status Thresholds).

For any primary pathways identified for sediment quality in the LSA, residual effects were described for the measurement indicator (Section 10.4.3):

- **Sediment quality constituent concentrations:** provides a comparative assessment of the changes in trace metal and radionuclide in the LSA with respect to sediment quality thresholds for the protection of aquatic and terrestrial life (Section 10.2.8.3.4).

The emphasis of the surface water quality assessment was the comparison of modelled water quality COPC concentrations in the receiving environment for Construction, Operations, and Closure and the far-future projection relative to existing conditions (i.e., Base Case) and established water quality thresholds for the Project. This process provided the opportunity to evaluate the extent and duration of the predicted changes to surface water quality. The models developed to support the water quality assessment are described in Section 10.2.8.1, Water Quality Model Development and Integration, and in more detail in Appendix 10A. The list of COPCs considered in this assessment includes those typically used to evaluate and monitor project-related effects on water and sediment quality from similar regional uranium mine operations (e.g., Rabbit Lake Mine; Cameco 2019; CNSC 2021b).

After modelling was complete, the modelled COPCs were screened on the basis that, if elevated above baseline conditions in the receiving environment occurred as a result of the Project, they may potentially pose a risk to aquatic and terrestrial life or drinking water use, or change productivity status (i.e., shift in trophic state). The methods used to determine the COPCs and to develop the Project-specific thresholds are summarized in Section 10.2.8.2 and Section 10.2.8.3. The COPCs that were screened into the assessment were analyzed in detail for their potential to cause adverse effects as described in Section 10.4 and Section 10.5.

The analysis of potential changes to sediment quality parameters was conducted through a qualitative evaluation of proposed Project-related direct discharges and deposition of site air emissions to the receiving environment and the modelled interaction of the sediment-water interface based on projected water quality changes as part of TSD XXI, Environmental Risk Assessment.

The residual effects were subsequently summarized and classified as described in Section 10.2.9, Residual Effects Classification.

10.2.8.1 Water Quality Model Development and Integration

The residual effects analysis was conducted through the development and integration of three water quality models: a site-wide water balance and water quality model (SWWBM), a near-field water quality model (NFWQM), and a regional surface water quality model (RSWQM).The purpose of the SWWBM was to predict the quality of water leaving the Project site (i.e., runoff and treated effluent discharges) and entering the receiving environment, including the effects of the deposition of aerial emissions from the Project. The results of the SWWBM provided modelled inputs to the NFWQM, which predicted effects on surface water quality in the near-field area of the discharge locations, and to the RSWQM, which predicted effects on surface water quality in the downstream receiving environment.

The purpose of the NFWQM was to assess potential effects on water quality in a localized area surrounding the discharge locations in Patterson Lake (i.e., within 200 m of the point of discharge) for the ETP diffuser and STP outfall. The NFWQM used predictions from the RSWQM to describe ambient conditions and the SWWBM (TSD XVIII, Site-Wide Water Balance and Water Quality Modelling Report) to describe treated effluent characteristics so that mixed concentrations of these waters could be calculated.

The purpose of the RSWQM was to assess the expected magnitude, extent, and duration of Project effects in the waterbodies downstream of the Project in the LSA on a lake-wide or basin-wide scale. The RSWQM used modelled predictions from the SWWBM and from two models developed by other disciplines in support of the EA: the air quality dispersion model (Section 7.2.5, Residual Effects Analysis) and the groundwater solute transport model (Section 8.5, Residual Effects Analysis).

Summary descriptions of the SWWBM, NFWQM, and RSWQM are provided in Section 10.2.8.1.1, Site-Wide Water Balance and Water Quality Model; Section 10.2.8.1.2, Near-Field Water Quality Model; and Section 10.2.8.1.3, Regional Surface Water Quality Model, respectively. A detailed description of each of the models is provided in Appendix 10A. However, the results of the SWWBM are not presented in the surface water quality assessment as the modelled results are limited to the Project site and not the receiving environment; this model and its results are described in detail in TSD XVIII.

Results from the water quality models supported the water quality assessment for the Application Case and RFD Case. Sensitivity scenarios were also included to provide a measure of the uncertainty associated with these assessment cases. The sensitivity scenarios included a reasonable upper bound scenario for the Application Case and a climate change scenario for the RFD Case. Since the surface water quality assessment included the integration of modelling inputs from other discipline assessments (i.e., hydrology, hydrogeology, and air quality), each modelling case and scenario used specific modelled scenarios from these integrated discipline models as the inputs; the inputs from these integrated models to the surface water quality assessment and RFD Case, and their sensitivity scenarios, are summarized in Table 10.2-4.

Table 10.2-4: Summary of Integrated Component Inputs to the Surface Water Quality Assessment Cases and Scenarios

Project and Associated Assessment Case	Input Data	Data Source	Input Data Sensitivity Scenarios from each Data Source
Rook I Project: ▪ Application Case ▪ RFD Case	▪ Treated effluent ▪ Treated sewage ▪ Site runoff ▪ Atmospheric deposition ▪ Groundwater seepage	▪ SWWBM ▪ STP design information, SWWBM ▪ SWWBM ▪ Air dispersion modelling ▪ Groundwater solute transport model	▪ Average and reasonable upper bound ▪ Average and reasonable upper bound ▪ Average and reasonable upper bound ▪ Application Case[(a)] ▪ Average and reasonable upper bound
Fission Patterson Lake South Property: ▪ RFD Case	▪ Treated effluent ▪ Treated sewage ▪ Site runoff ▪ Atmospheric deposition	▪ project treated effluent quality ▪ Project treated sewage discharge quality ▪ Project treated effluent quality ▪ Air dispersion modelling	▪ Average and with climate change ▪ Average and with climate change ▪ Average and with climate change ▪ Cumulative effects case[(a)]

a) Due to the conservatism associated with the air dispersion modelling, supplemental sensitivity scenarios were not required from this data source.

RFD = reasonably foreseeable development; SWWBM = site-wide water balance and water quality model; STP = sewage treatment plant.

10.2.8.1.1 Site-Wide Water Balance and Water Quality Model

The SWWBM was developed in the generalized systems dynamic modelling platform GoldSim. The SWWBM provides a mass-conservative representation of water quality (i.e., specifically water chemistry), and water movement and mixing on site during all Project phases, as well as the far-future projection (TSD XVIII). Water quality inputs (i.e., source terms) were linked to each flow that represented a water transfer on the Project site, meaning that a water chemistry (i.e., concentration of all COPCs) was assigned to each flow based on the flow's origin in the SWWBM. For flows that were derived from multiple sources in the SWWBM, mixed water concentrations were calculated where these water volumes interact. The interactions included defined surveillance points on the Project site (e.g., settling pond, sumps collecting stockpile runoff) and at the discharge points to Patterson Lake (i.e., ETP diffuser and STP outfall). A detailed description of the SWWBM is provided in TSD XVIII.

Source term inputs in the SWWBM were used to represent water quality for undisturbed runoff, contact water (i.e., water that comes into contact with exposed material such as WRSAs and ore storage stockpiles), runoff from areas effected by construction activities at surface, groundwater, treated effluent water, and treated sewage discharge. These inputs were derived from various sources, including geochemical testing and modelling, groundwater and surface monitoring data, proxy data from comparable project sites, and preliminary process modelling (e.g., process plant and treatment efficiency of the ETP). Source term inputs provided by other disciplines (e.g., ore stockpile and WRSAs source terms from geochemistry, baseline groundwater quality from hydrogeology) were assumed to be appropriate and representative for direct use in the SWWBM. Additional details regarding the SWWBM source term inputs are described in Appendix 10A.

The SWWBM provides constituent concentrations for treated effluent discharge, treated sewage discharge, and direct site runoff to the RSWQM for all Project phases. In the far-future projection, the SWWBM results provide constituent concentrations of direct site runoff to Patterson Lake. As this model represents on-site predictions for conditions that do not currently exist, no calibration was required. However, certain aspects of the water quality results were validated by comparing the results to available proxy data from similar developments. For example, predicted concentrations of nitrogen species in the treated effluent from blasting activities were validated with comparison to proxy data from uranium mines in northern Saskatchewan (Cameco 2019).

The SWWBM for the Application Case projected water quality and water balance conditions for the Project using historical climate and expected source term inputs. Several sensitivity scenarios were also completed whereby various source term inputs were modified to understand the influence on the assessment model results to provide an understanding of modelling uncertainty and source influence:

- a reasonable upper bound sensitivity scenario (i.e., historical climate and upper bound source term inputs);
- a low treatment efficiency sensitivity (i.e., two scenarios using the Application Case and the reasonable upper bound scenario for source term inputs, with a lowered effluent treatment efficiency); and
- a waste rock design sensitivity (i.e., waste rock source terms sensitivity).

Of these sensitivity scenarios, the results from the SWWBM for the Application Case and the reasonable upper bound scenario were carried forward into the RSWQM. Further detail on the sensitivity scenarios included in the SWWBM is provided in Appendix 10A.

10.2.8.1.2 Near-Field Water Quality Model

The NFWQM was developed using a Cornell Mixing Zone Expert System (CORMIX) model, a physically based mixing zone modelling platform (Doneker and Jirka 2007). The CORMIX model, recognized by the United States Environmental Protection Agency for mixing zone analysis, was used to conduct the assessment of treated effluent discharge and treated sewage discharge and mixing processes to quantify the dilution and mixing characteristics in the vicinity of the discharge.

The NFWQM was developed to assess the potential water quality effects from discharges from the ETP diffuser and STP outfall to Patterson Lake within 200 m of each discharge point during Operations, which is when these Project discharges are planned to occur.

The NFWQM projected the treated effluent mixing and dilution potential within a defined near-field mixing zone; the outer bound was 200 m around each discharge point, with the inclusion of a 100 m boundary that represented an expected regulatory mixing zone (RMZ) for both the ETP diffuser and STP outfall. An RMZ is a defined column of water surrounding a discharge point where exceedances of water quality thresholds are permitted through an approved water licence for a project, provided that the exceedances do not extend beyond the edge of the RMZ (WSA 2015; Doneker and Jirka 2007). For the NFWQM, the 100 m RMZ was assumed for the ETP diffuser and STP outfall based on a review of regulatory documents and guidance regarding the size of allowable RMZs (Appendix 10A, Section 10A6.2, Assessment Cases and Model Scenarios).

The NFWQM was developed for the ETP and STP discharge locations, independently, to meet the following objectives:

- Predict the concentration of each COPC at the edge of the proposed RMZ (i.e., within 100 m of either discharge point).
- Predict the distance the plume must travel from the discharge location before the threshold of each COPC is met.
- Evaluate the performance of the ETP and STP discharge designs in terms of dilution provided at the edge of the RMZ under a variety of ambient conditions (e.g., current speeds, ice cover).

The NFWQM was developed considering water depth and lake currents that affect mixing of the treated discharges with receiving water, ambient and discharge temperature and quality (i.e., total dissolved solids [TDS]) that affect the water and discharge densities, predicted COPC source term inputs for the treated discharges from the SWWBM, the configuration of the diffuser and outfall, and design flow and range of velocities. Based on a review of ambient conditions (Appendix 10A, Section 10A8.2, Near-Field Water Quality Model), the NFWQM considered the following ambient physical conditions in Patterson Lake:

- **Ice-cover conditions:** total water depth at the discharge locations reduced by 1 m during ice-covered periods to account for expected ice thickness of 1 m on Patterson Lake[4], with current speed[5] of 0.001 m/s, and lake water temperature of 0°C.
- **Open water with no stratification:** three ambient current speeds (i.e., 0.009 m/s, 0.042 m/s, and 0.079 m/s), and four different lake water temperatures (i.e., 5°C, 10°C, 15°C, and 20°C).
- **Open water with vertical stratification (applicable only to the ETP diffuser location):** three ambient current speeds (i.e., 0.009 m/s, 0.042 m/s, and 0.079 m/s) and three different stratification interface depths from the lake water surface (i.e., 4 m, 5 m, and 6 m). For this ambient condition, the surface water temperature and bottom water temperature at the discharge location were assigned 20°C (density of 998.26 kg/m³) and 6°C (density of 999.99 kg/m³), respectively. The three stratification depths (i.e., 4 m, 5 m, and 6 m) were simulated to test the sensitivity of diffuser performance to the depth of stratification.

A total of 35 scenarios were used to evaluate the performance of the ETP diffuser design and 26 scenarios to define the STP discharge design (TSD XIX, Conceptual Diffuser Design Report; TSD XX Downstream Use and Impact Study for Proposed Treated Sewage Discharge Report) in terms of dilution provided at the edge of the RMZ under a variety of ambient conditions. The dilution factors were used to calculate mixed concentrations based on the relative proportions of treated effluent concentrations from the SWWBM and background concentrations from the RSWQM. A detailed description of the modelling scenarios is provided in Appendix 10A, Section 10A8.2.

In addition to modelling the fate of COPCs in the near field for treated discharges from the ETP and STP, a separate analysis of the effects of the discharges to total suspended solids (TSS), water temperature, and dissolved oxygen was completed through the NFWQM. This analysis was conducted because these three constituents were not directly modelled in the SWWBM or RSWQM. Assumptions of TSS and dissolved oxygen concentrations and water temperature in winter and summer conditions were made for the mixing zones based on baseline data for Patterson Lake (Attachment 10A-1) and for the treated effluent discharge (i.e., TSS [WSA 2012], temperature [TSD XIX], and dissolved oxygen [Wells 2019]). Further details regarding this analysis are provided in Appendix 10A, Section 10A7.2, Model Scenarios and Input Data.

The NFWQM was run for the Application Case and the reasonable upper bound sensitivity scenario.

10.2.8.1.3 Regional Surface Water Quality Model

The RSWQM was also developed using GoldSim and was developed in parallel with the regional surface hydrology model (Section 9.2.10.1, Hydrological Modelling of Water Surface Elevation and Flow Rates; Appendix 9A, Hydrological Modelling Summary Report). The model is a mass-conservative (i.e., no mass lost from chemical reactions) representation of water quality, water movement, and mixing in the receiving environment during the lifespan of the Project and far-future projection. The receiving environment for the

4 Ice thickness measured to be approximately 1 m on Patterson Lake during 2019 winter surveys (Annex V.1, Aquatic Environment Baseline Report).

5 At the proposed ETP diffuser discharge location, 0.009 m/s was the lowest ambient current speed that achieved stable results in CORMIX. At the proposed STP discharge location, the ambient current speed of 0.001 m/s was applied as it is the lowest current speed allowed as an input into CORMIX.

RSWQM consisted of the upstream and downstream watersheds of the LSA, which included the waterbodies along the mainstem of the Clearwater River (i.e., Broach Lake, Lake G, Lake H, Patterson Lake, Forrest Lake, Beet Lake, and Naomi Lake).

The objectives of the RSWQM were as follows:

- Characterize the existing surface water quality conditions at the initiation of the Project and capture natural seasonal variation.
- Characterize the magnitude, spatial extent, and duration of changes in surface water quality at key waterbodies in the downstream environment in the LSA to assess the effects of Project activities (e.g., discharges of treated effluent and treated sewage, site runoff, groundwater inflows) on the receiving environment.
- Characterize the magnitude, spatial extent, and duration of effects of atmospheric deposition associated with Project emissions on the water quality of small waterbodies in close proximity to the Project and in waterbodies in the LSA immediately upstream and downstream of the Project.

In addition to evaluating effects during the Project lifespan, the RSWQM also considered effects that may occur in the far future (i.e., well past Closure). The water quality modelling extended 357 years after Closure and modelled two time periods in the far future. The first time period was 157 years in duration and included the natural hydrological and hydrogeological processes from the site following Closure, such as seepage from the UGTMF and seepages from the WRSAs as modelled by the solute transport model for this period of time, and surface runoff from the covered and reclaimed areas of the Project to Patterson Lake North Arm – West Basin. The first modelled time period for the far future included a minimum of three repeating climate cycles; one cycle is represented by 43 years of climate data: either the historical record or projected climate due to climate change. The Application Case, including the reasonable upper bound sensitivity scenario, and the RFD Case utilized the historical climate data record in the far-future projection; the RFD plus climate change sensitivity scenario utilized projected climate data in the far future to assess the potential effects of climate change to water quality.

The second modelled time period for the far future extended for 200 years past the first modelled time period and included natural hydrological and hydrogeological processes that account for maximum mass COPC loadings associated with solute transport via the groundwater model applied to Patterson Lake North Arm – West Basin over the entire temporal extent of the model (i.e., 357 years). The modelling of the migration of UGTMF-affected groundwater by the groundwater solute transport model demonstrated that the time for this groundwater to reach the surface water occurs over a very large temporal scale (i.e., hundreds of thousands of years; Section 8, Hydrogeology), and that the maximum COPC loadings generally occurred towards the end of the solute transport modelling period (i.e., up to 400,000 years). However, computational limits with the RSWQM precluded the use of a temporal scale consistent with the solute transport model. Therefore, to evaluate the potential for effects on surface water quality, the maximum loadings (i.e., those reached towards the end of the solute transport model) were applied to the period of 157 years to 357 years past Closure (i.e., the far future was effectively fast-tracked to the maximum loadings time period). This approach allows for a much shorter modelling timeframe to project the maximum potential changes to surface water quality in Patterson Lake in the far future and conservatively assumes that the UGTMF loadings that occur hundreds of thousands of years in the future overlap with loadings from the WRSAs.

The RSWQM was calibrated by running the Base Case (i.e., no Project effects), which is characterized by historical climate conditions and existing water quality conditions. The modelled water quality at each waterbody was assessed via a trend analysis for alignment with measured baseline water quality data. Overall, the Base

Case results produced an acceptable alignment with the measured baseline water quality data over time. A calibration factor was applied for iron to improve the alignment between modelled projection and baseline concentration. This calibration was only necessary for water transferred between the Patterson Lake basins because the baseline iron concentration in the North Arm – East Basin was an order of magnitude greater than the baseline concentration in the North Arm – West Basin and South Arm. Further detail regarding the RSWQM calibration is provided in Appendix 10A.

The RSWQM was run for the Application Case and RFD Case. As discussed in Section 10.2.5, Assessment Cases, the Application Case is characterized by Base Case conditions with Project effects, namely, Application Case source term inputs from the SWWBM, the air quality dispersion model, and the groundwater solute transport model. Although an inherent uncertainty is associated with all source term and model predictions, the Application Case results are generally assumed to represent a best estimate of surface water quality projections in the receiving environment from Project effects, and confidence in the overall model setup and baseline characterization is increased by calibrating multiple COPCs.

A sensitivity scenario was developed for the Application Case that was representative of reasonable upper bound, or 95th percentile, conditions. The purpose of this scenario was to examine a highly conservative estimation for water quality predictions to bound the uncertainty associated with the model input data. This scenario was characterized by Base Case conditions and Project effects, using reasonable upper bound source term inputs from the SWWBM and groundwater solute transport model (Appendix 10A). The air quality dispersion model was fundamentally developed as a reasonable upper bound due to the inherent conservatism associated with its configuration; therefore, the model inputs were the same as the inputs used for the Application Case. For example, the air quality dispersion model made the conservative assumption that emission sources from each piece of emitting equipment emit simultaneously and continuously, wherein it is unlikely that all of these sources would emit at the same time. This assumption leads to higher than actual predicted deposition rate. Most emitting sources were also simulated in the air quality dispersion model under their maximum possible emissions rate (Section 7.2.2.8, Residual Effects Analysis, Appendix 7A, Air Dispersion Modelling Report). Though the reasonable upper bound scenario results aid in the assessment potential Project effects, the assessment was conducted using adjusted input data; therefore, results from this scenario are presented in a separate subsection (Section 10.5.2.1).

The RFD Case was characterized by the Application Case, plus effects from the Fission Patterson Lake South Property (Fission 2019, 2021). The RFD Case considered the cumulative effects of the Project as well as air deposition, treated effluent discharge, treated sewage discharge, and non-contact site runoff to Patterson Lake South Arm from the planned Fission Patterson Lake South Property (Figure 10.2-3) during its construction and operations periods. The RFD case also considered uncontrolled discharge to Patterson Lake South Arm from the Fission Patterson Lake South Property from its assumed active decommissioning and into the far-future. As project-specific source term inputs for these discharges from the Fission Patterson Lake South Property were not yet defined at the time of model analysis, input assumptions were derived from Project inputs (Appendix 10A).

A sensitivity scenario was also considered within the RFD Case that was representative of climate change based on hydrological processes (i.e., increased precipitation and evaporation during the lifespan of the Project). Site-specific future climate projections were developed for the Project through analysis of available projections from a multi-model ensemble. The multi-model ensemble consists of available regional scale projections from several climate models representing different future climate scenarios (e.g., level of greenhouse gas emissions). The mean changes of projections for 2041 to 2070 relative to the period from 1981 to 2010 were applied to the historical climate record compiled for the Project. The period from 2041 to 2070 presents a conversative estimate in terms of climate change during the Project timeline. Adjusting the historical climate record based on this approach accounts for changes due to climate change, incorporates seasonality, and maintains the integrity of climate cycles that may continue as the climate changes (Appendix 9A, Appendix 10A, and Appendix 22A, Climate Change Dataset Summary Report).

10.2.8.1.3.1 Atmospheric Deposition

Results from the air quality dispersion model (Section 7.2.5) were also used as inputs in the RSWQM to assess the incremental effects from Project-related atmospheric deposition on waterbodies in the LSA during the lifespan of the Project. Additionally, the effects were assessed for four waterbodies located within the LSA upstream of the Clearwater River and of any Project-specific direct discharge to isolate atmospheric effects. The lakes are Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2. Since baseline water quality data were not available for these lakes, the water quality from the reference lakes (i.e., Harbo Lake, Hodge Lake, Lake D, and Lake J [Appendix 10A, Attachment 10A-1]) was used to represent the Base Case. As with Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2, the lakes used for the reference lake water quality characterization are also not directly connected to the Clearwater River. Following an evaluation of the baseline surface water quality dataset, average COPC measurements from reference lake baseline data were assumed to be a reasonable analogue for this assessment (Appendix 10A, Attachment 10A-1).

As part of the evaluation of atmospheric deposition to lakes in the LSA, a desktop analysis was conducted to estimate the average annual incremental increase in TSS due to the aerial deposition of total suspended particulates (TSP) emitted from the Project. The analysis was conducted on four small lakes (i.e., Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2) within the LSA, which lie outside of the Clearwater River flow path and outside of the direct influence of the Project through surface water and groundwater discharges (Figure 10.2-1), to determine the incremental increase from air deposition sources only. The analysis was performed on small lakes as the air deposition effects from the Project are anticipated to be more pronounced in lakes with a small surface area and volume. These lakes were included in the RSWQM to estimate their annual inflows and outflows.

The air dispersion modelling results for Construction and Operations were used to estimate the total annual air deposition of TSP (i.e., g/yr) into each lake based on surface area (Section 7.2.5). The average annual TSS concentration increase was estimated by dividing the predicted mass of TSP deposited per year by the average annual outflow. More detail regarding this analysis is provided in of Appendix 10A, Section 10A6.4.1.4.

10.2.8.2 Constituents of Potential Concern

The COPCs are a focused list of constituents determined through a screening process that potentially pose a risk to aquatic and terrestrial life and/or human health. The screening process and COPC selections for surface water quality and sediment quality are described in the following subsections.

10.2.8.2.1 Surface Water Quality Constituents of Potential Concern

The first step of the COPC screening process involved developing a comprehensive list of constituents for consideration. The comprehensive list of constituents included:

- **Conventional parameters:** TSS and dissolved organic carbon.
- **Nutrients:** total ammonia, nitrate, nitrite, and phosphorus.
- **Major ions:** chloride, fluoride, sulphate, calcium, magnesium, and sodium.

- **Total metals:** aluminum, arsenic, barium, beryllium, boron, cadmium, cesium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, strontium, thallium, tin, titanium, uranium, vanadium, and zinc.
- **Radionuclides:** lead-210, polonium-210, radium-226, thorium-230, and uranium-238.

Indigenous Groups identified the following constituents as being of concern:

- hydrocarbons and drilling fluids, either from drilling barges on Patterson Lake or seeping from the site (TSD II: BNDN; TSD II: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN);
- methane, from pipeline leaks in the muskeg (TSD IV: MN-S);
- mercury (TSD III: BNDN);
- radon emissions (TSD IV: MN-S; BNDN-JWG 2020; BNDN-JWG 2021c);
- uranium leaching from windblown dust (TSD II: BNDN; TSD IV: MN-S; MN-S-JWG 2019b);
- uranium leaching from tailings (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; BNDN-JWG 2019; BNDN-JWG 2020; BNDN-JWG 2021a; CRDN-JWG 2020; MN-S-JWG 2019a; NexGen 2019); and
- thorium leaching from tailings (TSD IV: MN-S).

Hydrocarbons and methane were not included as it is not typical industry practice to include these constituents in water quality modelling; Project discharges would not release material quantities of these substances. This exclusion does not diminish the importance of these constituents and their potential effect on the environment. To mitigate their potential influence on surface water quality or sediment quality, the Project would be required to adhere to regulations regarding their management and would prepare a number of management plans that would describe the means to monitor for, and mitigate, if necessary, their release from the Project to the environment.

Radon was also not included in the comprehensive list for screening as radon is not expected to meaningfully affect the chemistry of surface waters. Since radon released to the atmosphere from Project emissions does not readily precipitate out on land and has low solubility in water, it does not enter water easily and would likely escape from water to air. However, radon is included in the air quality dispersion modelling and residual effects analysis (Section 10.5) and the environmental risk assessment (TSD XXI).

The comprehensive list of constituents was subsequently reduced based on the following screening questions:

- Are there applicable water quality guidelines, objectives, standards, or other thresholds?
- If yes, are there potential sources of the constituent to the receiving environment because of Project Construction and Operations?
- If yes, are source terms and proxy data from baseline studies and other components (e.g., geochemistry, hydrogeology) available for the EA, such that the constituent can be assessed with confidence?
- If there are no applicable water quality guidelines, objectives, standards, or other thresholds, are associated data available to support calculating guidelines? For example, calcium and magnesium do not have guidelines but are used to calculate hardness, which supports the calculation of guidelines that are hardness dependent.

The screening process and resulting lists are illustrated further in Figure 10.2-5. Constituents that were removed from the comprehensive list based on answers to these screening questions, along with the rationale for their removal, are listed below:

- Conventional parameters:
  - **Total suspended solids:** Assumptions used to supplement the NFWQM and the residual effects pathway analysis were based on baseline data (i.e., 1 mg/L average) for lake-wide background concentrations and on the understanding that TSS in treated discharges from the ETP would be regulated consistent with the Metal and Diamond Mining Effluent Regulations (MDMER) to a maximum allowable TSS concentration of 15 mg/L. For the STP, the discharge limits for TSS would be 25 mg/L, which conforms to the Saskatchewan Waterworks and Sewage Works Regulations, where treated effluent from a sewage treatment facility discharges or will discharge to water frequented by fish.

    On a larger scale, Annex IV.3, Geomorphology Characterization Report, established that there are portions of both the Patterson Lake shoreline and Clearwater River below Patterson Lake that are subject to active sediment transport regimes and may be susceptible to future erosion. This potential erosion would depend on changes to the water surface elevation of Patterson Lake, which would influence wave action and resultant shoreline erosion. Water surface elevation changes may also influence the flow regime in the Clearwater River below Patterson Lake, which may alter sediment transport regimes between the lakes. Hydrological modelling (Section 9) of the RSA and fluvial sediment transport modelling (Appendix 9B, Hydraulic and Sediment Transport Modelling Summary Report) for the Clearwater River below Paterson Lake indicate that the changes in water surface elevation and sediment transport are unlikely to be measurable relative to existing conditions. Additionally, the implementation of the environmental design features and mitigation associated with construction activities and operational discharges from the ETP and STP to Patterson Lake, as outlined in Section 9, Table 9.5-2, would minimize the potential erosion effects of the Project and consequently, result in negligible increases in TSS within the Project footprint and the receiving environment. However, although removed as a COPC, TSS was considered for further assessment in the pathways analysis associated with discharge from the ETP and STP to the receiving environment, specifically related to the potential effects of any TSS in the regulated discharge to water quality and sediment quality in the vicinity of the discharge locations.
- Nutrients:
  - **Dissolved organic carbon:** no material source of organic carbon in Project discharge, no applicable guideline, and not currently required to calculate or modify any of the thresholds applicable to the Project.
  - **Nitrite:** nitrogen species would be present in two Project sources during the lifespan of the Project: explosives residues and treated sewage effluent.

    For explosives residues, little to no source term data exist for a complete range of nitrogen species on the Project site. This lack of data is typical of undeveloped sites that have not yet experienced any blasting. In these cases, it is common practice to estimate ammonia and nitrate concentrations based on explosives product details and projected production rates. These calculations do not account for nitrite species, as nitrite is not typically reported as a component of explosives products. It is also anticipated that any nitrite that forms as a result of the blasting process would oxidize to nitrate. Nitrite concentrations reported for contact water collected from piezometers near, and as seepage from, blasted material stockpiles at similar sites were non-detectable (Ecometrix 2015; Cameco 2018).

For treated sewage effluent, it is anticipated that the concentrations of nitrite and nitrate would be very low based on measured data from other lagoon systems (USEPA 2011) and information provided by Stantec (Stantec 2021).

- Major ions:
  - **Fluoride:** Not elevated in local groundwater or surface waters (Section 8.3.5, Groundwater Quality), and not anticipated to be sourced from the milling process. Additionally, source terms were not available for all site-specific inputs to the SWWBM.
- Total metals:
  - **Barium:** Baseline concentrations were consistently low (i.e., non-detectable), and initial model estimates of concentrations in the treated discharges were below applicable thresholds.
  - **Beryllium:** Baseline concentrations were consistently low (i.e., non-detectable), and initial model estimates of concentrations in the treated discharges were below applicable thresholds. Additionally, source terms not available for all site-specific inputs to the SWWBM.
  - **Boron:** Baseline concentrations were consistently low (i.e., non-detectable), and initial model estimates of concentrations in the treated discharges were below applicable thresholds.
  - **Cesium:** No current applicable guideline for threshold development, and there is no material source of cesium in Project discharge. Additionally, it is not needed to support calculation of guidelines or thresholds, and source terms not available for all site-specific inputs to the SWWBM.
  - **Thallium:** Baseline concentrations were consistently low (i.e., non-detectable), and initial model estimates of concentrations in the treated discharges were below applicable thresholds[6].
  - **Tin:** No current applicable guideline for threshold development, and it is not needed to support calculation of guidelines or thresholds.
  - **Titanium:** No current applicable guideline for threshold development. Additionally, source terms not available for site-specific inputs to the SWWBM.

The resulting COPC list for the surface water quality assessment is therefore as follows:

- **Major ions:** chloride and sulphate.
- **Nutrients:** total ammonia, un-ionized ammonia, nitrate, and phosphorus.
- **Total metals:** aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, strontium, uranium, vanadium, and zinc.
- **Radionuclides:** lead-210, polonium-210, radium-226, thorium-230, and uranium-238.

The COPC list includes constituents being regulated at similar mine sites in northern Saskatchewan.

With respect to nutrients, un-ionized ammonia is included with total ammonia as a COPC in the assessment. In aquatic environments, the total ammonia concentration incorporates the sum of the concentrations of the un-ionized ammonia (i.e., NH_3) and ionized ammonia (i.e., NH_4^+) species, with both existing in equilibrium. The un-ionized form of ammonia represents all forms of ammonia in water except for the ammonia ion. Most freshwater water quality guidelines (e.g., CCME 2023) include thresholds for total ammonia and un-ionized

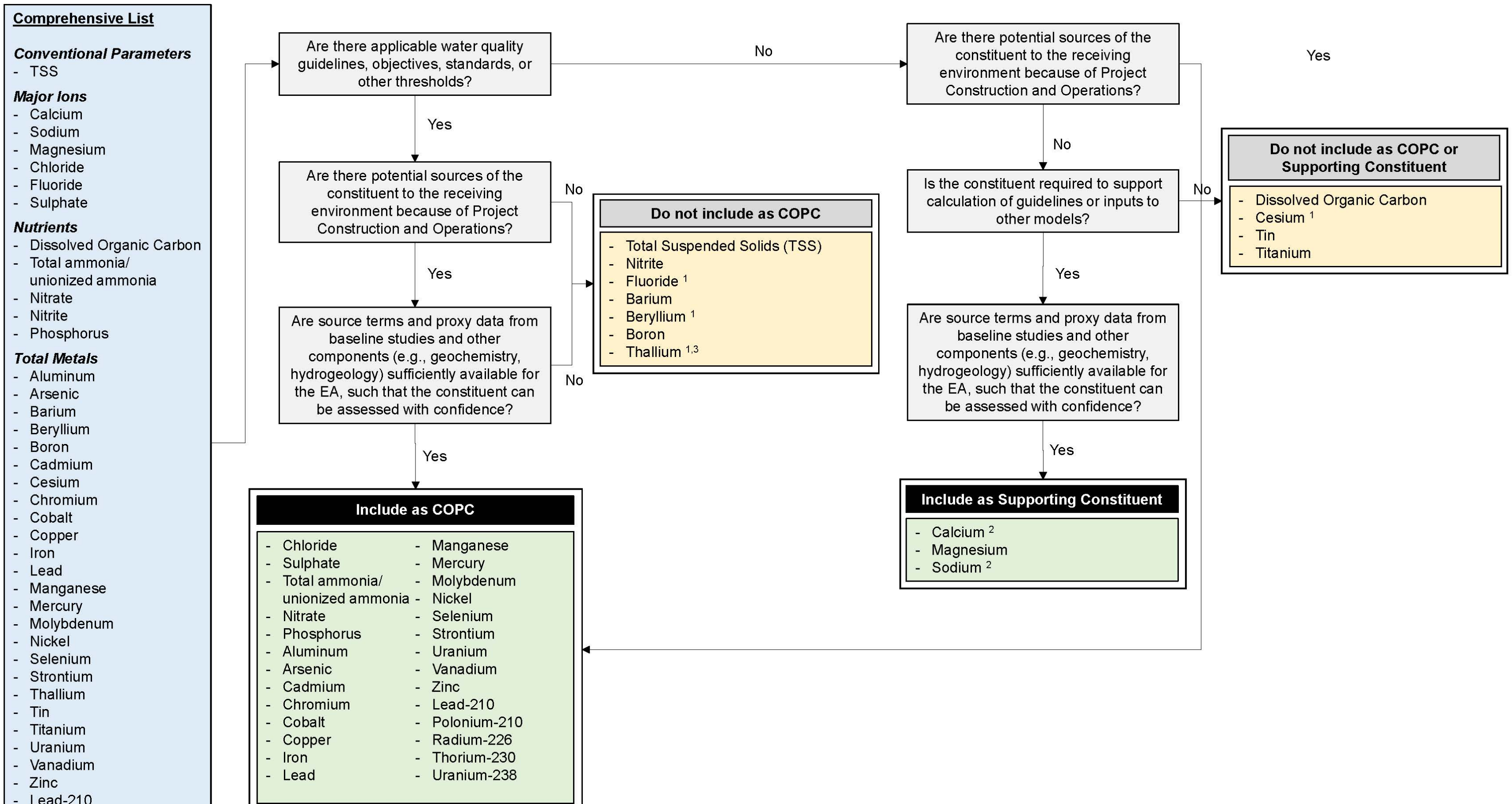
6 Screening conducted for the Project EA was validated by ongoing analytical work conducted between 2021 and 2023, as described in Appendix 10B, Thallium Supplement.

ammonia, which are based on pH and temperature. The proportion of un-ionized ammonia increases with increasing pH and temperature. As this increasing proportion of un-ionized ammonia also increases the potential toxicity, the threshold for total ammonia accounts for the variability of ambient conditions in its derivation. As a result, guidelines or thresholds for total ammonia represent a range of values based on the range of measured or projected pH and temperatures in a specific waterbody. Of note, pH is considered to be the most important exposure and toxicity modifying factor (ETMF) influencing ammonia toxicity (CCME 2010). For the existing condition characterization of the waterbodies in the LSA and RSA and the modelled COPC projections within the assessment, the un-ionized proportion of total ammonia was included based on measured or assumed ambient water temperature and pH conditions. Therefore, both total ammonia and un-ionized ammonia concentrations are presented in this subsection.

Additionally, calcium, magnesium, and sodium were included in the surface water quality modelling, despite not being screened in as COPCs. These constituents were added for the calculation of TDS and to facilitate the calculation of certain hardness-dependent thresholds. Ambient hardness reduces the potential bioavailability of certain water quality constituents by aquatic life; in these cases, the ambient hardness is an ETMF. This relationship means that the toxicity of the COPC is reduced in the presence of the ions that make up hardness (i.e., primarily calcium and magnesium). The result is that higher concentrations of COPCs with hardness-dependent guidelines can be present in the water before potentially affecting aquatic life.

The surface water quality assessment carried through this focused list of screened COPCs as they were identified to have the potential for increasing in concentration in the receiving environment due to proposed Project activities and the potential for resulting in adverse effects on aquatic and terrestrial life, drinking water quality, and productivity status. Constituents that did not screen in as COPCs were not anticipated to incrementally change in the receiving environment from baseline concentrations due to non-detectable or low concentrations in site-specific source terms in the SWWBM or because any Project-related change in the receiving environment was not expected to result in adverse effects to water uses or VCs. Surface water quality monitoring for the Project would be expected to include a larger set of constituents (Section 10.7).

Figure 10.2-5: Constituent of Potential Concern Screening Logic Diagram



Notes:
1. Additionally, source terms and proxy data from baseline studies and other components (e.g., geochemistry, hydrogeology) not sufficiently available for the EA, such that constituent cannot be assessed with confidence.
2. Additionally, potential source of constituent to receiving environment because of Project Construction and Operations identified through model development.
3. Screening conducted for the Project EA was validated by ongoing analytical work conducted between 2021 and 2023, as described in Appendix 10B, Thallium Supplement.

10.2.8.2.2 Sediment Quality

Sediment quality COPCs were selected by screening available sediment guidelines and reference values that have been identified as constituent of interest in Canadian uranium mining and milling operations, and those that possess Canadian sediment quality guidelines. For the Project, three sources of guidelines and reference values for sediment quality are applicable and are listed below with their included focused sediment quality constituents:

- Saskatchewan reference values for uranium operations (Burnett-Seidel and Liber 2013): arsenic, chromium, copper, lead, molybdenum, nickel, selenium, uranium, and vanadium;
- Uranium mining and milling industry in Canada reference values (Thompson et al. 2005): arsenic, copper, lead, molybdenum, nickel, selenium, uranium, lead-210, polonium-210, and radium-226; and
- Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life (CCME 1999): arsenic, cadmium, copper, lead, and zinc.

For the sediment quality assessment, the sediment COPCs were screened via two steps. First, if a focused sediment quality constituent had a corresponding water quality constituent that was identified in the water quality screening as having the potential to exceed baseline values in the receiving environment, it was carried to step two. Step two included an evaluation of the constituent in the environmental risk assessment (ERA) where sediment concentrations of the constituent were modelled from the predicted surface water quality concentrations of the constituent in Patterson Lake using the IMPACT model (TSD XXI; Ecometrix 2021) to determine its potential to exceed reference values or guidelines. The constituents that were predicted to exceed reference values or guidelines were then considered sediment COPCs for quantitative assessment in the ERA (TSD XXI; Ecometrix 2021). The list carried forward into the ERA for IMPACT modelling included:

- **Total metals:** arsenic, cadmium, copper, lead, molybdenum, nickel, selenium, uranium, and zinc.
- **Radionuclides:** lead-210, polonium-210, and radium-226.

The ERA included some additional constituents in their quantitative assessment: cobalt and all radionuclides in the uranium-238 decay series (i.e., uranium-238, uranium-234, thorium-230, radium-226, lead-210, and polonium-210). Cobalt was included, despite there being no sediment quality reference value or guideline for cobalt, because cobalt was identified as a notable COPC in surface water, especially in the far-future projections. The uranium-238 decay series were included because lead-210 and polonium-210 were predicted to exceed screening level LEL values (TSD XXI; Ecometrix 2021).

The resulting list of sediment quality COPCs is:

- **Total metals:** arsenic, cadmium, cobalt, copper, lead, molybdenum, nickel, selenium, uranium, and zinc.
- **Radionuclides:** uranium-234, uranium-238, thorium-230, radium-226, lead-210, and polonium-210.

The reference values and guidelines for the focus sediment quality constituents and the selected sediment quality COPC thresholds for the Project are described in Section 10.2.8.3.4.

10.2.8.3 Development of Thresholds

The thresholds for each of the COPCs selected for the surface water quality and sediment quality assessment were developed to align specifically to each of the measurement indicators: water quality constituent concentrations, drinking water quality constituent concentrations, productivity status constituent concentrations for surface water quality, and sediment quality constituent concentrations. Thresholds were set to identify if projected surface water quality and sediment quality during the lifespan of the Project and the far-future projection had the potential to adversely affect aquatic and terrestrial life, drinking water quality, and waterbody productivity health. The basis for the selection of the thresholds for each of the measurement indicators is provided in the following subsections.

10.2.8.3.1 Water Quality Thresholds

The Project-specific thresholds for COPCs for the water quality constituent concentrations measurement indicator were selected following a review of applicable guidelines for the COPCs. Project-specific thresholds were developed as both provincial and federal guidelines apply to the Project. The selected thresholds consisted of the most stringent chronic (i.e., long-term) water quality guidelines for the protection of aquatic life sourced from either the Canadian Environmental Quality Guidelines for the protection of aquatic life (CCME 2023) or the Saskatchewan's provincial objectives (WSA 2015, 2017), unless otherwise noted (e.g., where consideration of other factors, such as ETMFs, were considered appropriate). Where no guidelines or objectives were available for a COPC from CCME or Saskatchewan, provincial objectives from British Columbia (BC MOE 2004; BC MECCS 2019), Ontario (MOEE 1994), and the federal environmental quality guidelines (Government of Canada 2007, 2021) were considered. The thresholds for the COPC radionuclides for risk to aquatic life were calculated from a biota dose benchmark following the United States Department of Energy (USDOE 2019), as neither CCME nor provincial guidelines were available.

Chronic guidelines were chosen as they are more stringent than the acute (i.e., short-term) guidelines. Additionally, for the COPCs identified, guidelines for the protection of aquatic life over terrestrial life were chosen for the measurement indicator as these guidelines were also more stringent. The Project threshold for molybdenum used the 7.6 mg/L water quality objective for the protection of aquatic life from the British Columbia Ministry of Environment and Climate Change Strategy (BC MOE; BC MOE 2021), which is less stringent than the interim CCME chronic guideline for molybdenum (0.73 mg/L). The regulatory rationale for use of the BC MOE guideline over the Provincial Saskatchewan Water Security Agency (WSA) guideline (31 mg/L; WSA 2017) is because the BC MOE guideline is more conservative than the WSA guideline and is derived from more recent data following the CCME protocol for derivation of an objective and represent the best understanding of species sensitivity distribution (CCME 2007).

Table 10.2-5 provides a summary of the CCME guidelines, provincial water quality objectives, and the selected chronic (i.e., long-term) thresholds for the COPCs. The CCME water quality objectives for total ammonia for the protection of aquatic life used as the Project threshold are provided in Table 10.2-6. Table 10.2-5 is limited to presenting the selected chronic (i.e., long-term) Project thresholds for the COPCs that apply specifically to the protection of aquatic life. Thus, other surface water quality constituents such as pH, temperature, hardness, alkalinity, and specific conductivity have not been included in the table because they were not identified as COPCs. However, where the potential for toxicity by specific COPCs is modified based on these additional constituents defined as ETMFs (e.g., pH, temperature, hardness), assumptions regarding their influence on the selected Project threshold for those COPCs are presented as footnotes to Table 10.2-5 and linked to the relevant constituent to which they apply. These additional constituents have been included in baseline monitoring datasets and tables and would be included in monitoring programs during the life of the Project, including reporting under the MDMER.

As noted in Table 10.2-5, sulphate, cadmium, copper, lead, manganese, and nickel have guidelines and Project thresholds that incorporate hardness as a toxicity modifying factor. For these COPCs, aquatic health studies have shown that their toxicity potential is influenced by hardness; specifically, increasing hardness has been identified as the key modifying factor in the water that can reduce the potential for metal uptake and toxicity (Adams and Garman 2023). In addition to COPCs, effluent can contain base cations (e.g., calcium, magnesium) that contribute to a water's hardness. Increases in hardness reduces the toxicity potential for hardness-dependent COPCs to aquatic organisms, so long as the increasing COPC concentrations remain below their hardness-dependent Project threshold. Therefore, applying ambient hardness concentration in the calculation of the Project threshold for these COPCs in the receiving environment provides a standardization in the surface water quality and aquatic health assessment. This standardization accounts for the changes in hardness concentration in the receiving environment during the period of discharge of treated effluent from the Project.

Table 10.2-5: Canadian Council of Ministers of the Environment Guidelines, Saskatchewan Provincial Objectives, and Selected Water Quality Project Thresholds Based on Protection of Aquatic Life Chronic Guidelines

COPC	Unit	CCME: Long-Term (Chronic)[a]		Provincial Objectives (Chronic)[b]		Selected Project Threshold (Chronic)
General Parameters						
Total suspended solids	mg/L	Background + 5[c]		n/a		Background + 5
Major Ions						
Chloride	mg/L	120		n/a		120
Sulphate	mg/L	n/a		≤30 mg/L as $CaCO_3$ 31 - 75 mg/L as $CaCO_3$ 76 - 180 mg/L as $CaCO_3$ 181 - 250 mg/L as $CaCO_3$ >250 mg/L as $CaCO_3$	128 mg/L[d] 218 mg/L[d] 309 mg/L[d] 429 mg/L[d] Site-specific[d]	128[e]
Nutrients						
Ammonia (un-ionized) (as N)	µg/L	15.6				
Ammonia as N (total)	mg/L	Function of un-ionized ammonia, pH, and temperature[f]				
Nitrate (as N)	mg/L	3.0		n/a		3.0
Total Metals (unless otherwise noted, all metals are reported as total)						
Aluminum	mg/L	<6.5 pH ≥6.5 pH	0.005 mg/L 0.1 mg/L	<6.5 pH, <4 mg/L Ca, <2 mg/L DOC ≥6.5 pH, ≥4 mg/L Ca, ≥2 mg/L DOC	0.005 mg/L 0.1 mg/L	0.1[g]
Arsenic	mg/L	0.005		0.005		0.005
Cadmium	mg/L	<17 mg/L as $CaCO_3$ 17 - 280 mg/L as $CaCO_3$ >280 mg/L as $CaCO_3$	0.00004 mg/L $10^{0.83(\log(hardness))-2.46}$ 0.00037 mg/L	<17 mg/L as $CaCO_3$ 17 - 280 mg/L as $CaCO_3$ >280 mg/L as $CaCO_3$	0.00004 mg/L $10^{0.83(\log(hardness))-2.46}$ 0.00037 mg/L	0.00004[h]
Chromium	mg/L	Chromium, hexavalent: 0.001 mg/L Chromium, trivalent: 0.0089 mg/L		Chromium, hexavalent: 0.001 mg/L		0.001
Cobalt	mg/L	n/a		$\exp\{(0.414[\ln(hardness)] – 1.887\}$[i]		0.00078[i]
Copper	mg/L	<82 mg/L as $CaCO_3$ 82 - 180 mg/L as $CaCO_3$ >180 mg/L as $CaCO_3$	0.002 mg/L $0.2*e^{\{0.8545[\ln(hardness)]-1.465\}}$ 0.004 mg/L	<120 mg/L as $CaCO_3$ 120 - 180 mg/L as $CaCO_3$ >180 mg/L as $CaCO_3$	0.002 mg/L 0.003 mg/L 0.004 mg/L	0.002[h]
Iron	mg/L	0.3		0.3		0.3
Lead	mg/L	≤60 mg/L as $CaCO_3$ 60 - 180 mg/L as $CaCO_3$ >180 mg/L as $CaCO_3$	0.001 mg/L $0.2*e^{\{1.273[\ln(hardness)]-4.705\}}$ 0.007 mg/L	≤60 mg/L as $CaCO_3$ 60 - 120 mg/L as $CaCO_3$ 120 - 180 mg/L as $CaCO_3$ >180 mg/L as $CaCO_3$	0.001 mg/L 0.002 mg/L 0.004 mg/L 0.007 mg/L	0.001[h]
Manganese	mg/L	Calculated using the CCME calculator for manganese in Appendix B and is based on hardness and pH (CCME 2019)		n/a		0.26[h][j]

Table 10.2-5: Canadian Council of Ministers of the Environment Guidelines, Saskatchewan Provincial Objectives, and Selected Water Quality Project Thresholds Based on Protection of Aquatic Life Chronic Guidelines

COPC	Unit	CCME: Long-Term (Chronic)[a]		Provincial Objectives (Chronic)[b]		Selected Project Threshold (Chronic)
Mercury	mg/L	0.000026		0.000026		0.000026
Molybdenum	mg/L	0.073		7.6[d]		7.6[d]
Nickel	mg/L	≤60 mg/L as $CaCO_3$ 60 - 180 mg/L as $CaCO_3$ >180 mg/L as $CaCO_3$	0.025 mg/L $0.2*e^{\{0.76[\ln(hardness)]+1.06\}}$ 0.150 mg/L	≤60 mg/L as $CaCO_3$ 60 - 120 mg/L as $CaCO_3$ 120 - 180 mg/L as $CaCO_3$ >180 mg/L as $CaCO_3$	0.025 mg/L 0.065 mg/L 0.110 mg/L 0.150 mg/L	0.025[h]
Selenium	mg/L	0.001		0.001		0.001
Uranium	mg/L	0.015		0.015		0.015
Vanadium	mg/L	n/a		0.12[k]		0.12[k]
Zinc (dissolved)	mg/L	0.007		0.03		0.007
Radionuclides						
Lead-210	Bq/L	n/a		n/a		22[l]
Polonium-210	Bq/L	n/a		n/a		13.5[l]
Radium-226	Bq/L	n/a		n/a		0.11[l]
Thorium-230	Bq/L	n/a		n/a		95[l]

a) CCME 2023.

b) WSA 2015, unless otherwise indicated.

c) Long-term exposure or inputs lasting between 24 hours to 30 days.

d) BC MOE 2021.

e) 128 mg/L for all lakes excluding Patterson Lake based on hardness in the study areas that is consistently 21 mg/L as $CaCO_3$ or less. The Patterson Lake guideline would vary over time, based on the measured hardness in the lake.

f) Total ammonia based on un-ionized ammonia guideline that is adjusted for ambient pH and water temperature as provided in Table 10.2-6.

g) Based on the average pH range across all surface waterbodies (6.5-7.4 pH), except for Lake J with an average pH of 6.4.

h) Based on hardness in the study areas that is consistently 17 mg/L as $CaCO_3$ or less. During treated effluent discharge to the receiving environment, ambient hardness conditions are expected to increase due to the presence of supplemental calcium and magnesium in the treated effluent.

i) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).

j) Guideline is variable per lake. Listed threshold is based on a pH range of approximately 7.2 to 7.5 and a hardness range of 10 mg/L to 24 mg/L as $CaCO_3$.

k) Environment Canada 2016; Government of Canada 2021.

l) Thresholds for the COPC radionuclides were developed using United States Department of Energy (USDOE 2019) values, as neither CCME nor provincial guidelines were available.

Bq/L = becquerels per litre; $CaCO_3$ = calcium carbonate; CCME = Canadian Council of Ministers of the Environment; COPC = constituent of potential concern; DOC = dissolved organic carbon; n/a = not applicable; N = nitrogen; < = less than; > = greater than; ≤ = less than or equal to.

Table 10.2-6: Canadian Council of Ministers of the Environment Water Quality Guidelines for Total Ammonia for the Protection of Aquatic Life (in mg/L of Ammonia as Nitrogen)

Temperature (°C)	pH							
	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5
0	190	60.0	19.0	6.02	1.92	0.616	0.206	0.035
5	126	39.7	12.6	3.98	1.27	0.413	0.141	0.028
10	83.9	26.6	8.47	2.68	0.855	0.282	0.100	0.024
15	57.3	18.1	5.74	1.83	0.588	0.197	0.073	0.021
20	39.5	12.5	3.96	1.27	0.410	0.141	0.055	0.020
25	27.6	8.72	2.77	0.888	0.291	0.103	0.044	0.018
30	19.5	6.17	1.97	0.631	0.211	0.077	0.035	0.017

Note: The presented guideline values (expressed as mg/L as nitrogen) are based on the reported guideline values (CCME 2010) multiplied by a factor of 0.8224 to convert the reported guideline values from mg/L NH_3 to mg/L NH_3 as nitrogen.
mg/L NH_3 = milligrams per litre of ammonia.

10.2.8.3.2 Drinking Water Quality Thresholds

The thresholds for the drinking water quality constituent concentrations measurement indicator for the modelled COPCs in the assessment were developed based on Health Canada's guidelines for Canadian drinking water quality (Health Canada 2020). For parameters with no federal guidelines, the World Health Organization guidelines for drinking water quality were selected (WHO 2017). Table 10.2-7 provides a summary of the water quality guidelines as well as the selected threshold.

Table 10.2-7: Drinking Water Quality Guidelines and Water Quality Thresholds Selected for Constituents of Potential Concern

Parameter	Unit	Health Canada[a,b]	World Health Organization[c]	Selected Project Threshold
Major Ions				
Chloride	mg/L	250[d]	n/a	250
Sulphate	mg/L	500[d]	n/a	500
Nutrients				
Nitrate (as nitrogen)	mg/L	10	11	10
Total Metals (unless otherwise noted, all metals are reported as total)				
Aluminum	mg/L	0.1	n/a	0.1
Arsenic	mg/L	0.01	0.01	0.01
Cadmium	mg/L	0.007	0.003	0.007
Chromium[e]	mg/L	0.05	0.05	0.05
Copper	mg/L	2	2	2
Iron	mg/L	0.3[d]	n/a	0.3
Lead	mg/L	0.005	0.01	0.005
Manganese	mg/L	0.12	n/a	0.12
Mercury	mg/L	0.001	0.006	0.001
Nickel	mg/L	n/a	0.07	0.07
Selenium	mg/L	0.05	0.04	0.05
Strontium	mg/L	7	n/a	7
Uranium	mg/L	0.02	0.03	0.02
Zinc	mg/L	5	n/a	5

Table 10.2-7: Drinking Water Quality Guidelines and Water Quality Thresholds Selected for Constituents of Potential Concern

Parameter	Unit	Health Canada[a,b]	World Health Organization[c]	Selected Project Threshold
Radionuclides				
Lead-210	Bq/L	0.2	0.1	0.2
Polonium-210	Bq/L	n/a	0.1	0.1
Radium-226	Bq/L	0.5	0.1	0.5
Thorium-230	Bq/L	n/a	1	1

a) Health Canada 2020.
b) Maximum acceptable concentration provided unless otherwise indicated.
c) WHO 2017.
d) Guideline is an aesthetic objective.
e) Guidelines are for total chromium.
Bq/L = becquerels per litre; n/a = not applicable.

10.2.8.3.3 Productivity Status Thresholds

The threshold for the productivity status constituent concentrations measurement indicator was developed following a review of trophic status classification schemes for Canadian lakes and streams from the CCME (2004), Environment Canada (2004), and the Ontario provincial water quality objectives (MOEE 1994), which specifically use total phosphorus concentrations as the determinant of trophic state (more information regarding definition of trophic state is provided in Section 11.4.2, Secondary Pathways). While other water quality constituents (e.g., total nitrogen) or aquatic monitoring indicators can be used for determination of trophic status (e.g., chlorophyll *a*, Secchi disk depth) as well as total phosphorus (e.g., Carlson 1977; Vollenweider and Kerekes 1982; Carlson and Simpson 1996), the COPC threshold developed for the Project for the productivity status measurement indicator focused solely on total phosphorus. The rationale for solely using total phosphorus is because the baseline nutrient data for lakes in the LSA indicate that these lakes are phosphorus-limited; that is, the ratio of total nitrogen (derived from measured total Kjeldahl nitrogen + nitrate concentrations) to total phosphorus is greater than the nitrogen:phosphorus threshold references used to indicate potential nutrient deficiencies (e.g., molar mass nitrogen to phosphorus ratios exceeding approximately 16:1; Downing and McCauley 1992; Guildford and Hecky 2000; Wetzel 2001; Abelle et al 2010). Due to the phosphorus-limitation, any influx of phosphorus to the lakes would be expected to induce a productivity response, making it ideal as a Project constituent to use for the productivity status measurement indicator.

As shown in Table 10.2-8, the CCME (2004) guidelines present a series of trophic status classifications that range from ultra-oligotrophic (i.e., corresponding to the lowest potential algal productivity condition) to hyper-eutrophic (i.e., corresponding to the highest potential algal productivity), based on the concentration of phosphorus (Table 10.2-8); lower productivity has lower concentrations of phosphorus, and higher productivity has higher concentrations of phosphorus. The Ontario provincial water quality objective for total phosphorus is an interim objective, being an average total phosphorus concentration of 0.02 mg/L for the ice-free period to avoid nuisance concentrations of algae waterbodies (Table 10.2-8). The Ontario provincial objective was used as there are no Saskatchewan provincial objectives.

The waterbodies in the LSA are typically low in total phosphorus (less than 0.010 mg/L; Attachment 10A-1) and are classified as oligotrophic and mesotrophic (i.e., waters with low and intermediate productivity, respectively; Section 10.3.1, Water Quality). The COPC threshold for the productivity status measurement indicator was therefore based on the Ontario provincial interim objective, which aligns with the upper bound of the mesotrophic status (0.02 mg/L) as per the CCME (2004).

Table 10.2-8: Trophic Status Classifications Based on Total Phosphorus Selected Productivity Status Threshold

Parameter	Unit	CCME[(a)]	Provincial Objective	Selected Project Threshold
Phosphorus	mg/L	Ultra-oligotrophic <0.004 mg/L Oligotrophic: 0.004 - 0.01 mg/L Mesotrophic: 0.01 - 0.02 mg/L Meso-eutrophic: 0.02 - 0.035 mg/L Eutrophic: 0.035 - 0.1 mg/L Hyper-eutrophic: >0.1 mg/L	0.02[(b)]	0.02[(b)]

a) CCME (2004) and Environment Canada (2004).
b) MOEE 1994.
CCME = Canadian Council of Ministers of the Environment.

10.2.8.3.4 Sediment Quality Thresholds

Sediment quality thresholds for the Project were selected following a review of the available sediment quality guidelines and literature sources specific to the uranium industry (e.g., uranium mining). These sources included the Saskatchewan reference values for uranium operations (Burnett-Seidel and Liber 2013), which were prioritized as they are specific to Saskatchewan waterbodies, reference values for uranium mining and milling industry in Canada (Thompson et al. 2005), as these guidelines are specific to uranium mining and milling, and the CCME sediment quality guidelines (CCME 1999), which are generic guidelines that are applicable to all waterbodies in Canada.

Each guideline describes two-tiered concentrations, which are based on potential effects levels, as follows:

- Saskatchewan reference values for uranium operations (Burnett-Seidel and Liber 2013):
  - **Reference (REF) values:** derived solely on sediment metal and trace element concentrations from reference sites. Exceedances of REF values indicate elevated metal concentrations compared to typical natural background conditions.
  - **No-effect (NE2) values:** incorporate sites where benthic invertebrates were exposed to but unaffected by treated effluent.
- Uranium mining and milling industry in Canada (Thompson et al. 2005):
  - **Lowest effect level (LEL):** concentration below which harmful effects on benthic invertebrates are not expected to occur.
  - **Severe effect levels (SEL):** concentration above which harmful effects on benthic invertebrates are expected to occur.
- Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life (CCME 1999):
  - **Interim sediment quality guideline (ISQG):** concentration below which there is unlikely to be any adverse biological effects.
  - **Probable effect level (PEL):** concentration above which adverse effects are expected to frequently occur.

Sediment quality thresholds for the Project are presented in Table 10.2-9. The Project thresholds were selected for each COPC from each of the three referenced sources and are based preferentially on the Saskatchewan reference values (Burnett-Seidal and Liber 2013). If Saskatchewan reference values did not exist for a COPC, then the uranium mining and milling (Thompson et al. 2005) effects levels were used, and subsequently the CCME guidelines (CCME 1999). This approach to developing Project thresholds for sediment quality for COPCs is consistent with the ERA (TSD XXI; Ecometrix 2021).

Table 10.2-9: Sediment Quality Guidelines and Thresholds Associated with Uranium Milling and Mining Activities, and Selected Sediment Quality Project Thresholds

Parameter	Unit	Saskatchewan Reference Values for Uranium Operations[a]		Uranium Mining and Milling in Canada[b]		CCME Sediment Quality Guidelines[c]		Project Threshold
		REF	NE2	LEL	SEL	ISQG	PEL	
Metals								
Arsenic	mg/kg dw	20.8	522	9.8	346	5.9	17	**20.8**
Cadmium	mg/kg dw	n/a	n/a	n/a	n/a	0.6	3.5	**0.6**
Cobalt	mg/kg dw	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**
Copper	mg/kg dw	9.1	11.3	22.2	269	35.7	197	**9.1**
Lead	mg/kg dw	16.3	19.7	36.7	412	35	91.3	**16.3**
Molybdenum	mg/kg dw	22.6	245	13.8	1,239	n/a	n/a	**22.6**
Nickel	mg/kg dw	21.4	326	23.4	484	n/a	n/a	**21.4**
Selenium	mg/kg dw	3.6	29.7	1.9	16	n/a	n/a	**3.6**
Uranium	mg/kg dw	96.7	2,296	104.4	5,874	n/a	n/a	**96.7**
Vanadium	mg/kg dw	35.1	31.8	35	160	n/a	n/a	**35.1**
Zinc	mg/kg dw	n/a	n/a	n/a	n/a	123	315	**123**
Radionuclides								
Uranium-234	Bq/kg dw	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**
Uranium-238	Bq/kg dw	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**
Thorium-230	Bq/kg dw	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**
Radium-226	Bq/kg dw	n/a	n/a	600	14,400	n/a	n/a	**600**
Lead-210	Bq/kg dw	n/a	n/a	900	20,800	n/a	n/a	**900**
Polonium-210	Bq/kg dw	n/a	n/a	800	12,100	n/a	n/a	**800**

a) Burnett-Seidel and Liber 2013.
b) Thompson et al. 2005.
c) CCME 1999.
Bold values are selected thresholds.
ISQG = interim sediment quality guideline; PEL = probable effect level; LEL = lowest effect level; SEL = severe effect level; NE2 = no-effect; REF = reference; Bq/g = becquerels per gram; n/a = not applicable; CCME = Canadian Council of Ministers of the Environment; dw = dry weight; COPC = constituent of potential concern; ERA = environmental risk assessment.

10.2.9 Residual Effects Classification

The residual effects analysis used a reasoned narrative to describe anticipated changes to each measurement indicator caused by the proposed Project and other activities or projects and the associated effects on surface water quality. The residual effects analysis also considers effects from both the Project and RFDs. These narrative descriptions of anticipated effects represent the foundation for the residual effects classification. Residual effects are summarized or classified in tabular form using effects criteria, which is intended to provide structure and comparability across VCs and intermediate components assessed for the Project (Section 6.9.1, Residual Effects Classification).

The residual effects classification used direction, magnitude, geographic extent, duration, reversibility, frequency, and probability of occurrence as criteria. The approach to classify each residual effect criterion is provided in Table 10.2-10.

Table 10.2-10: Definitions Applied to Residual Effects Criteria Classifications for the Assessment of Surface Water Quality

Criterion	Rating	Definition
Direction	Positive	Change in measurement indicator results in net improvement or benefit to water quality
	Neutral	No changes in measurement indicator
	Negative	Change in measurement indicator results in net degradation or loss to water quality
Magnitude	Qualitative narrative or numeric quantification	Change in measurement indicator is described by effect size (e.g., comparison to Base Case or water quality thresholds)
Geographic extent	Local	Change in measurement indicator is within the LSA
	Regional	Change in measurement indicator extends beyond the LSA but is confined to the RSA
	Beyond regional	Change in measurement indicator extends beyond the RSA
Duration	Qualitative narrative or numeric quantification	Change in measurement indicator is described by effect duration (e.g., months, years, decades, permanent)
Reversibility	Reversible	Change in measurement indicator is reversible within a clearly defined time period
	Irreversible	Change in measurement indicator is predicted to influence the component indefinitely
Frequency	Occasional	Change in measurement indicator is expected to occur rarely (e.g., once or a few times)
	Periodic	Change in measurement indicator is expected to occur consistently at regular intervals or associated with temporal events (e.g., during dry summers)
	Continuous	Change in measurement indicator is expected to occur all the time
Probability of occurrence	Unlikely	Change in measurement indicator is not expected to occur, but not impossible
	Possible	Change in measurement indicator may occur, but is not likely
	Probable	Change in measurement indicator is likely to occur, but is uncertain
	Certain	Change in measurement indicator would occur

RSA = regional study area; LSA = local study area.

While most criteria could be assigned categorical ratings for surface water quality, predicted effects were provided in specific terms (i.e., narrative or numeric quantification) in the residual effects characterization (Table 10.2-10). Similarly, duration was described in specific terms (e.g., years). Applying a category rating to a criterion such as magnitude might lead to confusion or misinterpretation of the effects assessment or result in the criterion not being easily categorized in a meaningful way. For example, characterizing magnitude solely using an ordinal scale (i.e., low, moderate, or high) for surface water quality is often not appropriate as additional context is required to properly characterize the effects. Universal effect size boundaries, such as 20% change in a measurement indicator at the RSA or LSA scale used to define a high-magnitude effect (e.g., a 20% change in a water quality constituent concentration), work poorly because these size boundaries fail to consider context.

Depending on ecological context, and context from the cumulative effects from previous and existing developments and activities that also interact with surface water quality, a 20% change from existing conditions in one constituent in the LSA may be required to cause a high magnitude effect on the component, whereas for other constituents a 20% change may result in a low magnitude effect. Applying a timeline category rating to reversibility for surface water quality is challenging because the effects assessment has a far-future component that extends out to millennia (however, this has been managed through artificially truncating the far future surface water assessment to approximately 400 years). Therefore, for surface water quality, reversibility is determined if the water quality in the receiving environment, primarily in Patterson Lake and downstream lakes in the LSA, returns to conditions similar to baseline within the assessment time frame. This evaluation includes two distinct assessment periods that would be assessed: the Construction to the end of Decommissioning and Reclamation (i.e., Closure) period when there are direct discharges from the Project (and RFD) to Patterson Lake, and into the far future when surface runoff from the closed-out Project (and RFD) and Project-influenced groundwater flows into Patterson Lake.

10.2.10 Prediction Confidence and Uncertainty

The purpose of the assessment is to predict the future conditions specifically for surface water quality in the receiving environment (i.e., waterbodies in the LSA) with the addition of the Project and the Fission Patterson Lake South Property and climate change. As with all predictions of future conditions, the predictions made in this assessment embody some degree of uncertainty. The assessment applied a precautionary (i.e., conservative) approach to address uncertainty by identifying the greatest magnitude, duration, and geographic extent of potential adverse effects when a range of possible outcomes were possible. Consequently, uncertainty was addressed in a manner that increased the level of confidence that residual effects were conservatively estimated. The key uncertainties for surface water quality and the way they were addressed are presented as part of this assessment (Section 10.6, Prediction Confidence and Uncertainty).

The key uncertainties for the sediment quality assessment are not presented in this chapter; they are provided in the ERA (TSD XXI).

10.2.11 Monitoring, Follow-Up, and Adaptive Management

Monitoring programs are proposed to address the uncertainties associated with the effects predictions and to evaluate the performance of mitigation. In general, monitoring is used to verify the effects predictions. Monitoring is also used to identify any unanticipated effects and to support the implementation of adaptive management to limit these effects. Typically, monitoring includes one or both of the following categories that may be applied during the Project lifespan:

- **Regulatory compliance monitoring:** monitoring activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation and conditions of approval, and NexGen commitments (e.g., monitoring the quality of treated discharges from the Project).
- **Follow-up monitoring:** programs designed to test the accuracy of effects predictions, reduce or address uncertainties, determine the effectiveness of mitigation, or provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies and practices (e.g., implementation of adaptive management). Results from these programs can be used to increase the certainty of effect predictions in future EAs.

Where relevant, conceptual monitoring programs would also be proposed to address the uncertainties associated with the effect predictions and mitigation, and upon Project approval, would be included in NexGen's Integrated Management System.

The implementation of robust, long-term environmental testing and monitoring has also been requested by Indigenous Groups to verify protection of the environment, including community-led monitoring during Construction and Operations of the proposed Project (TSD IV: MN-S; TSD V.2: CRDN; TSD VI: YNLR). For example, Ya'thi Néné Lands and Resources have noted the importance of closely monitoring groundwater and treatment and testing of effluent from the Project prior to any release to the environment, as well as making all monitoring results available to communities within the Athabasca Basin for regular review (YNLRO 2019). The MN-S requested water testing and monitoring, and testing fish flesh for contaminants by community members (TSD IV: MN-S). The CRDN commented that "without independent on the-ground oversight by CRDN members and robust testing and monitoring programs developed and carried out by members and technical consultants working for the Nation, the ongoing safety of the community and the foods harvested within the Patterson Lake Area and the Clearwater River Watershed is definitely questioned" (TSD V.2: CRDN).

In alignment with this feedback and in addition to environmental monitoring programs typically implemented for projects (i.e., as noted above), NexGen is working with local Indigenous Groups to implement environmental monitoring. In combination with standard Project monitoring processes, independent Indigenous monitoring would be used to verify Project performance and to determine if mitigations and controls are effective in protecting the receiving environment.

Adaptive management measures may also be proposed to address the uncertainties associated with the effects predictions and mitigation. The process for determining when, how, and where to use adaptive management would be described within the Integrated Management System Manual.

10.3 Existing Conditions

This subsection provides a summary of existing surface water and sediment quality conditions for waterbodies and watercourses in the LSA and RSA. The existing conditions for water quality forms the Base Case against which Project effects and effects from the Project combined with RFDs were evaluated. Detailed discussions of the baseline water and sediment quality are provided in Appendix 10A, Attachment 10A-1, and Annex V.1, Aquatic Environment Baseline Report.

10.3.1 Water Quality

The existing surface water quality conditions for 18 surface waterbodies and watercourses in the LSA and RSA, including the Clearwater River, were determined from baseline studies conducted between 2015 and 2020 by PGL Environmental and Canada North Environmental Services (Section 10.2.6.1, Surface Water Quality). Four small lakes were also sampled to characterize the water quality of small lakes outside of the Clearwater River watershed and Project influence to determine potential air deposition effects.

Qualitatively, some CRDN, BNDN, and BRDN members have commented on the clear clean waters of the Clearwater River, up to and including Patterson Lake and other lakes in the area of the Project (TSD II: BNDN; TSD V.2: CRDN; BRDN-JWG 2019b):

> . . . here (tli kli na*/Where the Rivers Meet) it's all really clean clear good water . . . . Patterson, Forrest, all that, is really good water. (TSD V.2: CRDN)

> Well, if it's not as clear as it was back then, it's probably something's wrong. Because all these lakes here are just crystal-clear water . . . . If you start seeing algae and all that and just – something's not right because these are all rock and sand lakes – sand bottom, rock. (TSD II: BNDN)

> It's nice [around Patterson Lake], you know? . . . . It's a really nice area. Anywhere north is nice. It's kind of the same from Patterson, you know, west and east. A lot of sand and nice clear water. (TSD II: BNDN)

However, other Indigenous Group members from the CRDN, MN-S, and BNDN have noted a deterioration in water quality, fish health, and wildlife health in and around Patterson Lake (TSD II: BNDN; TSD IV: MN-S; TSDV.2: CRDN). The CRDN noted that the waters of Patterson Lake and Forrest Lake are no longer clear and clean since exploratory barge drilling began on Patterson Lake prior to 2013 and has resulted in some community members no longer fishing in the lake (TSD V.2: CRDN). The BNDN have reported that there have been diseased fish over the past few years in Patterson Lake which has resulted in some community members ceasing to fish and consume fish in the area (TSD II: BNDN).

A summary of the general conditions, the existing water quality, and the productivity of key waterbodies and Clearwater River in the LSA are provided in the following subsections. Surface water quality data in the Clearwater River below Beet Lake are also presented, as these data were used as the surface water quality inputs for Naomi Lake in the RSWQM (Appendix 10A, Section 10A6.3.1, Base Case Surface Water Quality). A detailed discussion of the baseline water quality of the studied waterbodies is provided in Appendix 10A, Attachment 10A-1.

10.3.1.1 General Description

The waterbodies and watercourses in the LSA, including the Clearwater River, typically exhibited high water clarity based on relatively low measurements of TSS and have a near neutral pH (Table 10.3-1). Table 10.3-1 presents annual ranges and does not consider winter and open-water conditions separately. Most waterbodies have an average TSS concentration between 1 mg/L and 2 mg/L, with a maximum average concentration of 6 mg/L. Smaller lakes have higher TSS, with the largest range measured in Lake H, with a maximum of 14 mg/L.

Most waterbodies are circumneutral (i.e., near neutral, pH value of 7), with the average pH ranging from 6.8 to 7.2. In all lakes, pH levels were measured lower than the CCME guideline of 6.5 for the protection of aquatic life (CCME 2021), particularly during the winter and early spring periods. It is common for lakes in this area to have low pH values that are below the CCME guideline in winter, during under-ice conditions.

Table 10.3-1: General Parameters Range (pH, and Total Suspended Solids) of Existing Conditions Water Quality for Waterbodies and Watercourses in the Local Study Area

Waterbodies and Watercourses	pH						TSS (mg/L)					
	# of Samples	Min.	25th Percentile	Average	95th Percentile	Max.	# of Samples	Min.	25th Percentile	Average[(a)]	95th Percentile	Max.
Broach Lake	19	6.2	6.6	6.9	7.7	7.9	18	1	1	1.0	2	2
Lake H	11	6.0	7.0	7.2	7.9	8.0	11	1	3	5.5	11	14
Lake G	11	6.4	6.6	7.1	7.8	8.2	11	1	2	3.3	6.5	7
Patterson Lake North Arm – East Basin	19	5.9	6.4	6.9	7.5	7.6	19	1	1	1.6	3.3	6
Patterson Lake North Arm – West Basin	19	6.2	6.6	7.0	7.7	7.7	19	1	1	1.1	2.4	6
Patterson Lake South Arm	19	6.1	6.4	6.9	7.4	7.5	19	1	1	1.0	2.4	6
Forrest Lake – North Basin	15	6.5	6.9	7.2	7.9	8.2	15	1	1	1.4	4.6	6
Forrest Lake – South Basin	18	5.8	7.0	7.2	7.7	7.9	18	1	1	1.0	2.6	6
Beet Lake	16	5.9	6.5	7.0	7.7	7.8	16	1	1	1.0	2	2
Naomi Lake	11	5.9	6.6	6.8	7.4	7.5	11	1	1	2.0	3.0	4
Clearwater River below Beet Lake	10	6.8	6.8	6.9	7.2	7.2	10	1	1	1.0	2	2
Reference Lakes	33	5.8	6.4	6.8	7.8	8.1	33	1	1	1.4	3.4	4

Note: For each parameter, the minimum, 25th percentile, average, 95th percentile, and maximum values are presented to two significant figures unless the value corresponds with laboratory reported values and fewer significant figures.
a) Calculated using half the detection limit.
TSS = total suspended solids.

The surface water temperatures of the waterbodies varied with seasons. The annual range of measured surface temperatures is presented in Table 10.3-2. During winter, water column temperatures ranged from near zero immediately below ice cover to 4°C, and during the summer, maximum surface temperatures between 18.8°C to 29.2°C were recorded. During the open water months, the increased surface temperatures compared to the cooler temperatures in the bottom of the lake caused a formation of water layers in deeper waterbodies due to water density difference (i.e., thermal stratification). During these conditions, a warmer surface water layer, which is less dense than the underlying cooler waters, created a discernible layer of water overlying a cooler bottom layer. Thermal stratification typically occurred between late spring and early fall. In winter, stratification was not generally evident; however, a reverse temperature gradient from what occurs in summer often existed. Water below the ice cover approached 0°C, but increased to around 4°C with depth, where 4°C represents the temperature where water is most dense. This temperature gradation was more pronounced in small lakes.

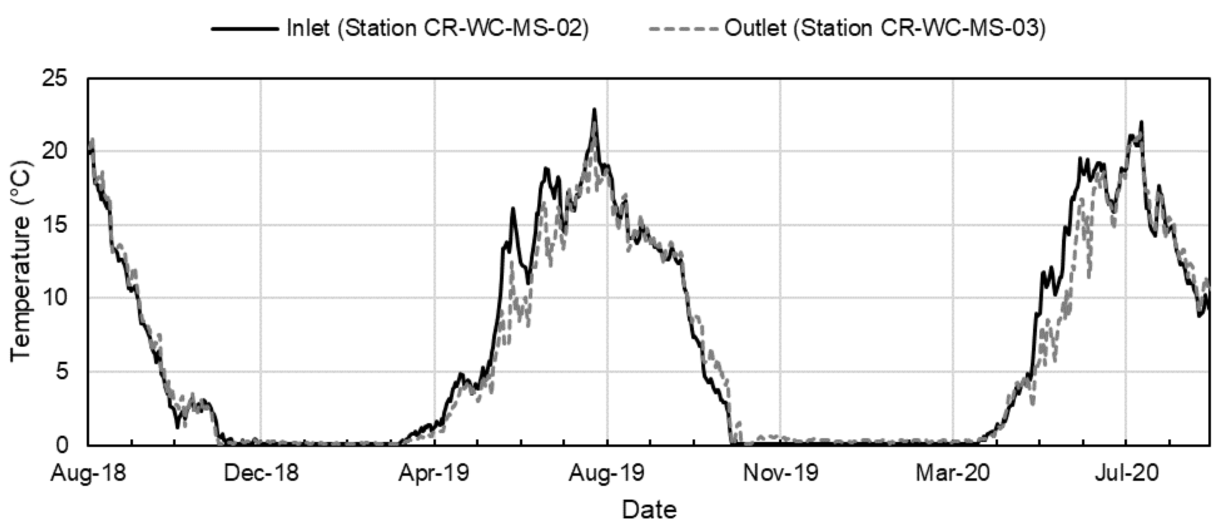
The waterbodies in the LSA that stratify often exhibited bi-annual lake turnover events in early spring and early winter when top and bottom water layers had the same temperature. As the surface water layer warms or cools to 4°C, its density is similar to that of the underlying water, and wind mixing results in the surface water layer migrating downwards and thereby mixing all or a large portion of the water column of the lake (i.e., a turnover event). No discernible chemical stratification, denoted by separation of water layers due to chemistry differences were observed in any of the waterbodies where seasonal stratification was observed.

Table 10.3-2: Annual Surface Temperature Statistics of Existing Conditions Waterbodies and the Clearwater River in the Local Study Area based on Quarterly Collected Data between November 2015 and October

Waterbodies and Watercourse	Temperature (°C)			
	# of Samples	Min.	Average	Max.
Broach Lake	19	0.77	7.1	18.8
Lake H	11	3.7	12.8	22.5
Lake G	11	1.1	12.8	22.7
Patterson Lake North Arm – East Basin	18	0.35	8.3	20.3
Patterson Lake North Arm – West Basin	18	0.35	6.9	18.8
Patterson Lake South Arm	19	0.13	7.5	19.8
Forrest Lake – North Basin	14	0.15	8.7	22.4
Forrest Lake – South Basin	18	0.18	6.8	17.0
Beet Lake	17	1.0	6.9	18.7
Naomi Lake	12	1.7	12.4	29.2
Clearwater River below Beet Lake	11	0.20	10.4	24.3
Reference Lakes	33	1.1	9.7	23.0

Supplemental in situ temperature monitoring performed at the inlet and outlet of Patterson Lake as part of a hydrometric monitoring program (Figure 10.3-1) showed that the surface temperature in Patterson Lake follows a unimodal distribution (i.e., maximum temperatures occur once per year), peaking between late July and early August. The average maximum surface water temperature recorded between 2018 and 2020 was 22.5°C. The minimum temperatures occurred between November and March, with the minimum monthly average temperature recorded between 2018 and 2019 being 0.16°C. Patterson Lake freezes over during the winter, with ice cover generally occurring between October and April.

Figure 10.3-1: Average Daily Surface Temperature Measured at Patterson Lake Station CR-WC-MS-02 and CR-WB-MS-03



10.3.1.2 Water Quality (Risk to Aquatic Life and Terrestrial Life) and Drinking Water Quality Constituent Concentrations

Surface waters in the LSA and RSA were low in dissolved solids (e.g., major ion concentrations), with the dominant major ions being calcium and bicarbonate (Attachment 10A-1 and Annex V.1). As expected, given the low ionic composition, the waters in the waterbodies and watercourses in the LSA and RSA were characterized as soft waters.

The summary of surface water quality of waterbodies in the LSA focuses on the COPCs as these are the key constituents assessed for the Project. Summary statistics for the measured COPCs of ions, metals, and radionuclides for key waterbodies and watercourses, including the reference lake concentrations, are presented in Table 10.3-3 through Table 10.3-6. Average COPC concentrations were computed using half of the detection limit for any value reported as less than the detection limit. This approach results in instances where average concentrations for some COPCs were reported lower than the minimum measured concentration because of changes in detection limits over time. Detailed tables of the existing water quality conditions (i.e., Base Case) are provided in Appendix 10A, Attachment 10A-1.

Table 10.3-3 through Table 10.3-6, Table 10.3-8, and Table 10.3-9, are limited to presenting the selected COPCs that apply specifically to protection of aquatic life, terrestrial life, and drinking water quality. Constituents that are ETMFs to specific COPCs, such as pH, temperature, and hardness, have not been included in the tables because they were not identified as COPCs. However, the derivation of the proportion of threshold exceedance for COPCs listed in these tables accounted for ETMFs. Sample results for each COPC, and any exceedance of their respective Project threshold, including those with ETMFs, are presented and highlighted for each waterbody and watercourse in Appendix 10A, Attachment 10A-1b.

Generally, concentrations of COPC ions and total metals were below the Project water quality thresholds for both aquatic and terrestrial life and drinking water within the LSA waterbodies and watercourses. Exceptions included:

- **Iron:** threshold exceedances in eight waterbodies and watercourses (i.e., Clearwater River below Broach Lake, Clearwater River above Patterson Lake, Patterson Lake, Lake H, Lake G, Beet Lake, Naomi Lake, and Clearwater River below Naomi Lake) and in the reference lakes;
- **Manganese:** threshold exceedances in Broach Lake, Lake H, Lake G, Beet Lake, and reference lakes;
- **Lead:** threshold exceedances in Forrest Lake and Beet Lake;
- **Nickel:** threshold exceedance in Patterson Lake; and
- **Arsenic:** threshold exceedance in Patterson Lake.

Exceedances over the threshold do not necessarily imply toxic effects but reflect naturally occurring high concentrations as these were measured during baseline conditions. Iron, lead, nickel, and arsenic concentrations were compared to the regional range from northern Saskatchewan sampled as part of the Athabasca Monitoring Program (CanNorth 2018). Manganese was not compared as it was not included in the Athabasca Monitoring Program. Iron, lead, nickel, and arsenic concentrations were generally within the regional range with the exemption of iron in Naomi Lake, which has an average concentration (830 µg/L) above the maximum value of the regional range of 790 µg/L.

Table 10.3-3: Existing Condition (Base Case) Surface Water Quality for Constituents of Potential Concern for Broach Lake, Lake H, and Lake G (2015 and 2020) for Water Quality (Risk to Aquatic Life and Terrestrial life) and Drinking Water Quality Measurement Indicators

Parameter	Units	Broach Lake								Lake H								Lake G							
		# of Samples	% Above Water Quality Threshold for Aquatic Life and Terrestrial Life	# Above Water Quality Threshold for Drinking Water Quality	Min.	25th Percentile	Average[(a)]	95th Percentile	Max.	# of Samples	% Above Water Quality Threshold for Aquatic Life and Terrestrial Life	# Above Water Quality Threshold for Drinking Water Quality	Min.	25th Percentile	Average[(a)]	95th Percentile	Max.	# of Samples	% Above Water Quality Threshold for Aquatic Life and Terrestrial Life	# Above Water Quality Threshold for Drinking Water Quality	Min.	25th Percentile	Average[(a)]	95th Percentile	Max.
Major Ions																									
Chloride	mg/L	18	0	0	0.4	0.4	0.41	0.42	0.5	11	0	0	0.1	0.2	0.2	0.25	0.3	11	0	0	0.1	0.1	0.095	0.2	0.3
Sulphate	mg/L	18	0	0	1.8	1.9	1.9	2.1	2.2	11	0	0	0.2	0.25	0.28	0.35	0.4	11	0	0	0.9	1.1	1.3	2.2	3.0
Total Metals (unless otherwise noted, all metals are reported as total)																									
Aluminum	mg/L	16	0	0	0.0005	0.00088	0.0018	0.0037	0.0058	11	0	0	0.0034	0.0079	0.015	0.032	0.043	1	0	0	0.0043	0.0047	0.0074	0.013	0.016
Arsenic	mg/L	19	0	0	0.0001	0.0001	0.00014	0.00023	0.0005	11	0	0	0.0001	0.0001	0.00016	0.0002	0.0002	11	0	0	0.0001	0.0001	0.000073	0.00015	0.0002
Cadmium	mg/L	19	0	0	0.000005	0.00001	0.0000049	0.00001	0.00001	11	0	0	0.00001	0.00001	0.0000055	0.00001	0.00001	11	0	0	0.00001	0.00001	0.0000073	0.00001	0.00001
Chromium	mg/L	19	0	0	0.0001	0.0005	0.00024	0.0005	0.0005	11	0	0	0.0005	0.0005	0.00025	0.0005	0.0005	11	0	0	0.0005	0.0005	0.00025	0.0005	0.0005
Cobalt	mg/L	19	0	n/a	0.0001	0.0001	0.00005	0.0001	0.0001	11	0	n/a	0.0001	0.0001	0.00005	0.0001	0.0001	11	0	n/a	0.0001	0.0001	0.000055	0.0001	0.0001
Copper	mg/L	19	0	0	0.0002	0.0002	0.00011	0.00023	0.0005	11	0	0	0.0002	0.0002	0.00010	0.0002	0.0002	11	0	0	0.0002	0.0002	0.00026	0.0011	0.0019
Iron	mg/L	19	0	0	0.0030	0.012	0.028	0.09	0.12	11	27%	27%	0.056	0.087	**0.43**	**1.7**	**2.1**	11	73%	73%	0.15	**0.31**	**0.69**	**2.1**	**2.4**
Lead	mg/L	19	0	0	0.00005	0.0001	0.000049	0.0001	0.0001	11	0	0	0.0001	0.0001	0.000068	0.00015	0.0002	11	0	0	0.0001	0.0001	0.00005	0.0001	0.0001
Manganese	mg/L	19	10%	10%	0.0018	0.0068	0.10	**0.42**	**1.4**	10	0	2	0.012	0.014	0.041	**0.14**	**0.14**	11	18%	18%	0.0073	0.013	0.067	**0.29**	**0.31**
Mercury	mg/L	18	0	0	0.000001	0.000001	0.0000016	0.0000043	0.000006	11	0	0	0.000001	0.000001	0.0000020	0.0000065	0.000008	11	0	0	0.000001	0.0000015	0.0000021	0.000004	0.000005
Molybdenum	mg/L	19	0	n/a	0.000052	0.0001	0.000074	0.00011	0.0002	11	0	n/a	0.0001	0.0001	0.000050	0.0001	0.0001	11	0	n/a	0.0001	0.0001	0.000055	0.0001	0.0001
Nickel	mg/L	19	0	0	0.0001	0.0001	0.000061	0.00014	0.0005	11	0	0	0.0001	0.0001	0.000050	0.0001	0.0001	11	0	0	0.0001	0.0001	0.000059	0.0001	0.0001
Selenium	mg/L	19	0	0	0.00005	0.0001	0.000049	0.0001	0.0001	11	0	0	0.0001	0.0001	0.000050	0.0001	0.0001	11	0	0	0.0001	0.0001	0.00005	0.0001	0.0001
Strontium	mg/L	19	0	0	0.032	0.036	0.037	0.04	0.041	11	0	0	0.01	0.012	0.014	0.020	0.021	11	0	0	0.019	0.020	0.025	0.043	0.050
Uranium	mg/L	19	0	0	0.00001	0.0001	0.000048	0.0001	0.0001	11	0	0	0.0001	0.0001	0.000050	0.0001	0.0001	11	0	0	0.0001	0.0001	0.00005	0.0001	0.0001
Vanadium	mg/L	19	0	n/a	0.0001	0.0001	0.000061	0.00014	0.0005	11	0	n/a	0.0001	0.0001	0.000050	0.0001	0.0001	11	0	n/a	0.0001	0.0001	0.00005	0.0001	0.0001
Zinc (dissolved)	mg/L	19	0	0	0.0005	0.0005	0.0008	0.0027	0.003	11	0	0	0.0005	0.00055	0.00095	0.0018	0.0019	11	0	0	0.0005	0.0006	0.0017	0.0045	0.0056
Radionuclides																									
Lead-210	Bq/L	19	0	0	0.02	0.02	0.010	0.022	0.037	11	0	0	0.02	0.02	0.012	0.03	0.03	11	0	0	0.02	0.02	0.013	0.025	0.03
Polonium-210	Bq/L	19	0	0	0.005	0.005	0.0029	0.0064	0.019	11	0	0	0.005	0.005	0.005	0.01	0.01	11	0	0	0.005	0.005	0.0051	0.0085	0.009
Radium-226	Bq/L	19	0	0	0.005	0.005	0.0034	0.0064	0.01	11	0	0	0.005	0.005	0.0031	0.007	0.009	11	0	0	0.005	0.005	0.0047	0.0095	0.01
Thorium-230	Bq/L	19	0	0	0.0074	0.01	0.0062	0.012	0.03	11	0	0	0.01	0.01	0.005	0.01	0.01	11	0	0	0.01	0.01	0.005	0.01	0.01

Notes: Shaded and **bold** indicates that the value is greater than the Project threshold for protection of aquatic life and terrestrial life or drinking water quality. Where a Project threshold has been identified for a COPC that is dependent on ETMFs (such as pH, temperature, and hardness), corresponding values of the ETMFs for that specific sample were used to establish the Project threshold for comparison to the measured COPC.

For each parameter, the minimum, 25th percentile, average, 95th percentile, and maximum values are presented to two significant figures unless the value corresponds with laboratory reported values and fewer significant figures.

a) Calculated using half the detection limit.

Bq/L = becquerels per litre; n/a = not applicable.

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Table 10.3-4: Existing Condition (Base Case) Surface Water Quality for Constituents of Potential Concern for Patterson Lake (2015 and 2020) for Water Quality (Risk to Aquatic Life and Terrestrial life) and Drinking Water Quality Measurement Indicators

Parameter	Units	Patterson Lake North Arm – East Basin								Patterson Lake North Arm – West Basin								Patterson Lake South Arm							
		# of Samples	% Above Water Quality Threshold for Aquatic Life and Terrestrial Life	# Above Water Quality Threshold for Drinking Water Quality	Min.	25th Percentile	Average[(a)]	95th Percentile	Max.	# of Samples	% Above Water Quality Threshold for Aquatic Life and Terrestrial Life	# Above Water Quality Threshold for Drinking Water Quality	Min.	25th Percentile	Average[(a)]	95th Percentile	Max.	# of Samples	% Above Water Quality Threshold for Aquatic Life and Terrestrial Life	# Above Water Quality Threshold for Drinking Water Quality	Min.	25th Percentile	Average[(a)]	95th Percentile	Max.
Major Ions																									
Chloride	mg/L	18	0	0	0.30	0.40	0.41	0.52	0.60	18	0	0	0.40	0.50	0.53	0.60	0.60	18	0	0	0.50	0.50	0.57	0.60	0.60
Sulphate	mg/L	18	0	0	1.1	1.2	1.2	1.3	1.6	18	0	0	1.3	1.4	1.5	1.6	1.7	18	0	0	1.4	1.5	1.6	1.9	2.1
Total Metals (unless otherwise noted, all metals are reported as total)																									
Aluminum	mg/L	16	0	0	0.0006	0.0032	0.0044	0.007	0.0098	16	0	0	0.0005	0.0008	0.003	0.012	0.016	16	0	0	0.0006	0.001	0.002	0.0049	0.0082
Arsenic	mg/L	19	3	0	0.0001	0.0001	0.000097	0.00011	0.0002	19	0	0	0.0001	0.0001	0.000087	0.0001	0.00011	19	5%	0	0.0001	0.0001	0.0013	0.0024	**0.023**
Cadmium	mg/L	19	0	0	0.00001	0.00001	0.0000066	0.00001	0.00001	19	0	0	0.000005	0.00001	0.0000061	0.00001	0.00001	19	0	0	0.00001	0.00001	0.0000053	0.00001	0.00001
Chromium	mg/L	19	0	0	0.0001	0.0005	0.00028	0.0005	0.0005	19	0	0	0.00022	0.0005	0.00025	0.0005	0.0005	19	0	0	0.0001	0.0005	0.00028	0.0005	0.0005
Cobalt	mg/L	19	0	n/a	0.0001	0.0001	0.000061	0.0001	0.0001	19	0	n/a	0.0001	0.0001	0.000066	0.00031	0.0004	19	0	n/a	0.0001	0.0001	0.000061	0.0001	0.0001
Copper	mg/L	19	0	0	0.0002	0.0002	0.00014	0.00023	0.0005	19	0	0	0.0002	0.0002	0.00012	0.00041	0.0005	19	0	0	0.0002	0.0002	0.00014	0.00023	0.0005
Iron	mg/L	19	10%	10%	0.0085	0.085	0.19	**0.59**	**0.79**	19	5%	5%	0.0068	0.012	0.051	0.19	**0.47**	19	0	0	0.0012	0.013	0.016	0.025	0.031
Lead	mg/L	19	0	0	0.00005	0.0001	0.000058	0.0001	0.0001	19	0	0	0.0001	0.0001	0.00005	0.0001	0.0001	19	0	0	0.00005	0.0001	0.000058	0.0001	0.0001
Manganese	mg/L	19	0	0	0.00090	0.016	0.033	0.13	0.16	18	0	0	0.00090	0.0062	0.015	0.029	0.035	19	0	0	0.00080	0.0066	0.021	0.047	0.091
Mercury	mg/L	18	0	0	0.000001	0.000001	0.0000018	0.0000045	0.000007	18	0	0	0.000001	0.000001	0.0000013	0.0000032	0.000004	18	0	0	0.000001	0.000001	0.0000013	0.0000033	0.000005
Molybdenum	mg/L	19	0	n/a	0.000064	0.0001	0.000051	0.0001	0.0001	19	0	n/a	0.000076	0.0001	0.000051	0.0001	0.0001	19	0	n/a	0.000085	0.0001	0.000052	0.0001	0.0001
Nickel	mg/L	19	5%	0	0.0001	0.0001	0.0026	0.014	**0.028**	19	0	0	0.0001	0.0001	0.000061	0.00014	0.0005	19	5%	0	0.0001	0.0001	0.0021	0.012	**0.026**
Selenium	mg/L	19	5%	0	0.0001	0.0001	0.000061	0.00014	0.0005	19	0	0	0.00005	0.0001	0.00005	0.0001	0.0001	19	5%	0	0.0001	0.0001	0.000061	0.00014	0.0005
Strontium	mg/L	19	n/a	0	0.026	0.027	0.028	0.031	0.032	19	0	0	0.029	0.030	0.030	0.032	0.032	19	0	0	0.029	0.030	0.031	0.034	0.034
Uranium	mg/L	19	0	0	0.0001	0.0001	0.00005	0.0001	0.0001	19	n/a	0	0.000031	0.0001	0.000057	0.00021	0.0003	19	0	0	0.000052	0.0001	0.000061	0.00011	0.0002
Vanadium	mg/L	19	0	n/a	0.0001	0.0001	0.000061	0.00014	0.0005	19	0	n/a	0.0001	0.0001	0.000061	0.00014	0.0005	19	0	n/a	0.0001	0.0001	0.000074	0.00014	0.0005
Zinc (dissolved)	mg/L	19	0	0	0.0005	0.0005	0.00088	0.0021	0.0052	19	0	0	0.0005	0.0005	0.00074	0.0028	0.003	19	0	0	0.0005	0.0005	0.0007	0.0021	0.003
Radionuclides																									
Lead-210	Bq/L	19	0	0	0.02	0.02	0.014	0.031	0.037	19	0	0	0.02	0.02	0.013	0.031	0.037	19	0	0	0.02	0.02	0.011	0.022	0.037
Polonium-210	Bq/L	19	0	0	0.005	0.005	0.0034	0.0064	0.019	19	0	0	0.005	0.005	0.0034	0.0064	0.019	19	0	0	0.005	0.005	0.0034	0.0073	0.019
Radium-226	Bq/L	19	0	0	0.005	0.005	0.0054	0.010	0.01	19	0	0	0.005	0.005	0.0041	0.0082	0.01	19	0	0	0.005	0.005	0.0041	0.01	0.01
Thorium-230	Bq/L	19	0	0	0.0074	0.01	0.0049	0.010	0.01	19	0	0	0.0074	0.01	0.0049	0.01	0.01	19	0	0	0.0074	0.01	0.0049	0.01	0.01

Notes: Shaded and **bold** indicates that the value is greater than the Project threshold for protection of aquatic life and terrestrial life or drinking water quality. Where a Project threshold has been identified for a COPC that is dependent on ETMFs (such as pH, temperature, and hardness), corresponding values of the ETMFs for that specific sample were used to establish the Project threshold for comparison to the measured COPC.

For each parameter, the minimum, 25th percentile, average, 95th percentile, and maximum values are presented to two significant figures unless the value corresponds with laboratory reported values and fewer significant figures.

a) Calculated using half the detection limit.

Bq/L = becquerels per litre; n/a = not applicable.

Table 10.3-5: Existing Condition (Base Case) Surface Water Quality for Constituents of Potential Concern for Forrest Lake and Beet Lake (2015 and 2020) for Water Quality (Risk to Aquatic Life and Terrestrial life) and Drinking Water Quality Measurement Indicators

Parameter	Units	Forrest Lake – North Basin								Forrest Lake – South Basin								Beet Lake							
		# of Samples	% Above Water Quality Threshold for Aquatic Life and Terrestrial Life	# Above Water Quality Threshold for Drinking Water Quality	Min.	25th Percentile	Average[(a)]	95th Percentile	Max.	# of Samples	% Above Water Quality Threshold for Aquatic Life and Terrestrial Life	# Above Water Quality Threshold for Drinking Water Quality	Min.	25th Percentile	Average[(a)]	95th Percentile	Max.	# of Samples	% Above Water Quality Threshold for Aquatic Life and Terrestrial Life	# Above Water Quality Threshold for Drinking Water Quality	Min.	25th Percentile	Average[(a)]	95th Percentile	Max.
Major Ions																									
Chloride	mg/L	14	0	0	0.50	0.60	0.63	0.70	0.70	17	0	0	0.60	0.70	0.78	0.90	0.90	17	0	0	0.60	0.60	0.60	0.70	0.70
Sulphate	mg/L	14	0	0	1.4	1.5	1.6	1.7	1.8	17	0	0	1.6	1.6	1.7	2.0	2.3	16	0	0	1.4	1.5	1.6	1.7	1.8
Total Metals (unless otherwise noted, all metals are reported as total)																									
Aluminum	mg/L	12	0	0	0.0025	0.0046	0.0065	0.011	0.012	15	0	0	0.0005	0.001	0.002	0.0042	0.0048	14	0	0	0.0009	0.0015	0.0021	0.004	0.0044
Arsenic	mg/L	15	0	0	0.0001	0.0001	0.00013	0.0002	0.0002	18	0	0	0.0001	0.00012	0.00017	0.0002	0.0002	17	0	0	0.0001	0.0001	0.0001	0.0002	0.0002
Cadmium	mg/L	15	0	0	0.000005	0.00001	0.0000073	0.00001	0.00001	18	0	0	0.000005	0.00001	0.0000064	0.00001	0.00001	17	0	0	0.00001	0.00001	0.00001	0.00001	0.00001
Chromium	mg/L	15	0	0	0.0001	0.0005	0.00024	0.0005	0.0005	17	0	0	0.0001	0.0005	0.00027	0.0005	0.0005	17	0	0	0.0001	0.0005	0.0002	0.0005	0.0005
Cobalt	mg/L	15	0	n/a	0.0001	0.0001	0.00005	0.0001	0.0001	18	0	n/a	0.0001	0.0001	0.000083	0.00016	0.0005	17	0	n/a	0.0001	0.0001	0.0001	0.0001	0.0001
Copper	mg/L	15	0	0	0.0002	0.0002	0.00028	0.0014	0.0014	18	0	0	0.0001	0.0002	0.00014	0.00025	0.0005	17	0	0	0.0002	0.0002	0.0002	0.0007	0.0014
Iron	mg/L	15	0	0	0.0016	0.029	0.043	0.089	0.11	18	0	0	0.00020	0.0059	0.024	0.062	0.26	17	6%	6%	0.004	0.020	0.11	**0.27**	**0.85**
Lead	mg/L	15	0	0	0.00005	0.0001	0.00006	0.0001	0.0001	18	6%	0	0.00005	0.0001	0.00028	0.00068	**0.004**	17	6%	0	0.0001	0.0001	0.0002	**0.0011**	**0.0013**
Manganese	mg/L	15	0	0	0.00080	0.0050	0.0094	0.024	0.030	18	0	0	0.00050	0.0013	0.0039	0.0094	0.013	17	6%	6%	0.0017	0.0063	0.083	**0.26**	**1.1**
Mercury	mg/L	14	0	0	0.000001	0.000001	0.00000089	0.000002	0.000002	17	0	0	0.000001	0.000001	0.0000011	0.0000032	0.000004	16	0	0	0.000001	0.000001	0.000001	0.000003	0.000003
Molybdenum	mg/L	15	0	n/a	0.000069	0.0001	0.000071	0.0001	0.0001	18	0	n/a	0.000068	0.0001	0.000051	0.0001	0.0001	17	0	n/a	0.00010	0.0001	0.00005	0.0001	0.0001
Nickel	mg/L	15	0	0	0.0001	0.0001	0.0001	0.00036	0.0005	18	0	0	0.0001	0.0001	0.000075	0.00033	0.0005	17	0	0	0.0001	0.0001	0.00014	0.0006	0.0012
Selenium	mg/L	15	0	0	0.00005	0.0001	0.00006	0.0001	0.0001	18	0	0	0.00005	0.0001	0.000058	0.0001	0.0001	17	0	0	0.0001	0.0001	0.00005	0.0001	0.0001
Strontium	mg/L	15	n/a	0	0.030	0.030	0.032	0.035	0.036	18	n/a	0	0.030	0.031	0.032	0.037	0.038	17	0	0	0.030	0.031	0.032	0.034	0.036
Uranium	mg/L	15	0	0	0.00010	0.0001	0.00006	0.0001	0.0001	18	0	0	0.00001	0.0001	0.000059	0.0001	0.0001	17	0	0	0.00010	0.0001	0.00005	0.0001	0.0001
Vanadium	mg/L	15	0	n/a	0.0001	0.0001	0.000063	0.00022	0.0005	17	0	n/a	0.0001	0.0001	0.000062	0.00018	0.0005	17	0	n/a	0.0001	0.0001	0.00006	0.0002	0.0001
Zinc (dissolved)	mg/L	15	0	0	0.0005	0.0005	0.00077	0.0022	0.003	18	0	0	0.0005	0.0005	0.00098	0.003	0.0032	17	0	0	0.0005	0.0005	0.0006	0.0014	0.0015
Radionuclides																									
Lead-210	Bq/L	15	0	0	0.02	0.02	0.014	0.025	0.037	18	0	0	0.02	0.02	0.014	0.023	0.037	17	0	0	0.02	0.02	0.01	0.02	0.04
Polonium-210	Bq/L	15	0	0	0.005	0.005	0.0043	0.0099	0.019	18	0	0	0.005	0.005	0.0038	0.0071	0.019	17	0	0	0.005	0.005	0.004	0.008	0.019
Radium-226	Bq/L	15	0	0	0.005	0.005	0.0042	0.0072	0.01	18	0	0	0.005	0.005	0.0041	0.0092	0.01	17	0	0	0.005	0.005	0.004	0.01	0.01
Thorium-230	Bq/L	15	0	0	0.007	0.01	0.0062	0.01	0.01	18	0	0	0.0074	0.01	0.006	0.01	0.01	16	0	0	0.01	0.01	0.01	0.01	0.01

Notes: Shaded and **bold** indicates that the value is greater than the Project threshold for protection of aquatic life and terrestrial life or drinking water quality. Where a Project threshold has been identified for a COPC that is dependent on ETMFs (such as pH, temperature, and hardness), corresponding values of the ETMFs for that specific sample were used to establish the Project threshold for comparison to the measured COPC.

For each parameter, the minimum, 25th percentile, average, 95th percentile, and maximum values are presented to two significant figures unless the value corresponds with laboratory reported values and fewer significant figures.

a) Calculated using half the detection limit.

Bq/L = becquerels per litre; n/a = not applicable.

Table 10.3-6: Existing Condition (Base Case) Surface Water Quality for Constituents of Potential Concern for Naomi Lake, Clearwater River below Beet Lake, and Reference Lake (2015 and 2020) for Water Quality (Risk to Aquatic Life and Terrestrial Life) and Drinking Water Quality Measurement Indicators

Parameters	Units	Naomi Lake								Clearwater River below Beet Lake								Reference Lake							
		# of Samples	% Above Water Quality Threshold for Aquatic Life and Terrestrial Life	# Above Water Quality Threshold for Drinking Water Quality	Min.	25th Percentile	Average[(a)]	95th Percentile	Max.	# of Samples	% Above Water Quality Threshold for Aquatic Life and Terrestrial Life	# Above Water Quality Threshold for Drinking Water Quality	Min.	25th Percentile	Average[(a)]	95th Percentile	Max.	# of Samples	% Above Water Quality Threshold for Aquatic Life and Terrestrial Life	# Above Water Quality Threshold for Drinking Water Quality	Min.	25th Percentile	Average[(a)]	95th Percentile	Max.
Major Ions																									
Chloride	mg/L	12	0	0	0.3	0.4	0.5	0.6	0.6	11	0	0	0.60	0.60	0.65	0.75	0.80	33	0	0	0.1	0.1	0.9	2.0	2.1
Sulphate	mg/L	12	0	0	0.5	0.6	0.6	0.8	0.8	11	0	0	1.4	1.5	1.6	1.8	1.8	33	0	0	0.6	0.1	0.9	2.0	2.1
Total Metals (unless otherwise noted, all metals are reported as total)																									
Aluminum	mg/L	12	0	0	0.0093	0.022	0.032	0.053	0.054	11	0	0	0.0022	0.0065	0.0074	0.011	0.011	29	0	0	0.0012	0.0032	0.0066	0.018	0.025
Arsenic	mg/L	12	0	0	0.0001	0.0002	0.0002	0.0002	0.0002	11	0	0	0.0001	0.0001	0.0001	0.0002	0.0002	33	0	0	0.0001	0.0001	0.00011	0.0002	0.0002
Cadmium	mg/L	12	0	0	0.00001	0.00001	0.00001	0.00001	0.00001	10	n/a	0	0.00001	0.00001	0.00001	0.00001	0.00001	33	0	0	0.00001	0.00001	0.0000061	0.00001	0.00001
Chromium	mg/L	12	0	0	0.0005	0.0005	0.0003	0.0005	0.0005	10	0	0	0.0005	0.0005	0.0003	0.0005	0.0005	32	0	0	0.0005	0.0005	0.00025	0.0005	0.0005
Cobalt	mg/L	12	0	n/a	0.0001	0.0001	0.0001	0.0001	0.0001	10	n/a	0	0.0001	0.0001	0.0001	0.0001	0.0001	33	0	0	0.0001	0.0001	0.000047	0.0001	0.0001
Copper	mg/L	12	0	0	0.0002	0.0002	0.0002	0.0005	0.0008	10	0	0	0.0002	0.0002	0.0001	0.0002	0.0002	33	0	0	0.0002	0.0002	0.00013	0.00028	0.0005
Iron	mg/L	12	100%	100%	**0.35**	**0.66**	**0.83**	**1.1**	**1.3**	11	0	0	0.022	0.052	0.09	0.18	0.19	33	3	3	0.0046	0.015	0.12	**0.63**	**1.6**
Lead	mg/L	12	0	0	0.0001	0.0001	0.0001	0.0002	0.0003	10	0	0	0.0001	0.0001	0.0001	0.0001	0.0001	33	0	0	0.0001	0.0001	0.000079	0.00022	0.0006
Manganese	mg/L	12	0	0	0.018	0.029	0.048	0.088	0.099	11	0	0	0.0020	0.0085	0.012	0.022	0.023	32	0	2	0.0012	0.0033	0.02	0.11	**0.2**
Mercury	mg/L	12	0	0	0.000001	0.000001	0.000002	0.000005	0.000006	11	0	0	0.000001	0.000001	0.000001	0.000002	0.000002	33	0	0	0.000001	0.000001	0.0000015	0.0000038	0.000007
Molybdenum	mg/L	12	0	n/a	0.00010	0.0001	0.0001	0.0001	0.0001	10	0	n/a	0.00010	0.0001	0.0001	0.0001	0.0001	33	0	n/a	0.0001	0.0001	0.000056	0.0001	0.0001
Nickel	mg/L	12	0	0	0.0001	0.0001	0.0001	0.0001	0.0002	10	0	0	0.0001	0.0001	0.0001	0.0003	0.0004	33	0	0	0.0001	0.0001	0.000082	0.0003	0.0004
Selenium	mg/L	12	0	0	0.0001	0.0001	0.0001	0.0001	0.0001	10	0	0	0.0001	0.0001	0.00005	0.0001	0.0001	33	0	0	0.0001	0.0001	0.000056	0.0001	0.0001
Strontium	mg/L	12	n/a	0	0.019	0.022	0.024	0.028	0.03	11	n/a	0	0.029	0.030	0.031	0.036	0.037	32	n/a	0	0.0036	0.013	0.032	0.063	0.064
Uranium	mg/L	12	0	0	0.00010	0.0001	0.00005	0.0001	0.0001	10	0	0	0.00010	0.0001	0.0001	0.0001	0.0001	33	0	0	0.0001	0.0001	0.000056	0.0001	0.0001
Vanadium	mg/L	12	0	n/a	0.0001	0.0001	0.0002	0.0003	0.0003	10	0	n/a	0.0001	0.0001	0.0001	0.0001	0.0001	32	0	n/a	0.0001	0.0001	0.000069	0.00015	0.0002
Zinc (dissolved)	mg/L	12	0	0	0.0005	0.0006	0.0009	0.0024	0.0037	11	0	0	0.0005	0.0005	0.0009	0.002	0.003	33	0	0	0.0005	0.0005	0.00095	0.0022	0.0028
Radionuclides																									
Lead-210	Bq/L	12	0	0	0.02	0.02	0.01	0.03	0.05	10	0	0	0.02	0.02	0.011	0.02	0.02	33	0	0	0.02	0.02	0.012	0.03	0.03
Polonium-210	Bq/L	12	0	0	0.005	0.005	0.003	0.006	0.007	10	0	0	0.005	0.005	0.0025	0.005	0.005	33	0	0	0.005	0.005	0.0043	0.01	0.01
Radium-226	Bq/L	12	0	0	0.005	0.005	0.004	0.008	0.008	10	0	0	0.005	0.005	0.0035	0.0082	0.01	33	0	0	0.005	0.005	0.0033	0.0068	0.01
Thorium-230	Bq/L	12	0	0	0.01	0.01	0.01	0.01	0.01	10	0	0	0.01	0.01	0.005	0.01	0.01	33	0	0	0.01	0.01	0.0052	0.01	0.01

Notes: Shaded and **bold** indicates that the value is greater than the Project threshold for protection of aquatic life and terrestrial life or drinking water quality. Where a Project threshold has been identified for a COPC that is dependent on ETMFs (such as pH, temperature, and hardness), corresponding values of the ETMFs for that specific sample were used to establish the Project threshold for comparison to the measured COPC.

For each parameter, the minimum, 25th percentile, average, 95th percentile, and maximum values are presented to two significant figures unless the value corresponds with laboratory reported values and fewer significant figures.

a) Calculated using half the detection limit.

Bq/L = becquerels per litre; n/a = not applicable.

10.3.1.3 Productivity Status Constituent Concentration

Similar to COPC ion and metal concentrations in the waterbodies and watercourses in the LSA, average concentrations of total phosphorus and nitrate were measured below or near their respective detection limits; however, ammonia concentrations were more variable.

Total phosphorus concentrations were measured at less than 0.01 mg/L, the detection limit, in over 90% of lake samples except for Lake G (Table 10.3-7). These consistently low levels lead to uncertainty in the precise existing condition of phosphorus in the waterbodies and watercourses in the LSA. Where the measurements were below detection, the average phosphorus concentration was computed using half of the detection limit. Due to the large portion of non-detectable values, the average concentration could be underestimated or overestimated.

Based on average existing condition total phosphorus concentrations, the waters in the LSA were classified as oligotrophic, except Lake G, which was classified as mesotrophic (Table 10.3-7). Despite the uncertainty noted above, it can confidently be concluded that waters are not at higher trophic classification levels, because the upper bound of mesotrophic conditions is the same as the detection limit for total phosphorus.

Table 10.3-7: Existing Condition (Base Case) Phosphorus Concentration (2015 and 2020) for Productivity Status Measurement Indicator

Waterbodies and Watercourses	# of Samples	Phosphorus (mg/L)					Trophic Classification[b]
		Min.	25th Percentile	Average[a]	95th Percentile	Max.	
Broach Lake	19	0.01	0.01	0.0053	0.01	0.01	Oligotrophic
Lake H	11	0.01	0.01	0.0064	0.015	0.02	Oligotrophic
Lake G	11	0.01	0.01	0.012	0.02	0.02	Mesotrophic
Patterson Lake North Arm — East Basin	18	0.01	0.01	0.0058	0.01	0.01	Oligotrophic
Patterson Lake North Arm — West Basin	18	0.01	0.01	0.005	0.01	0.01	Oligotrophic
Patterson Lake South Arm	18	0.01	0.01	0.005	0.01	0.01	Oligotrophic
Forrest Lake — North Basin	14	0.01	0.01	0.005	0.01	0.01	Oligotrophic
Forrest Lake — South Basin	17	0.01	0.01	0.005	0.01	0.01	Oligotrophic
Beet Lake	17	0.01	0.01	0.01	0.01	0.01	Oligotrophic
Naomi Lake	12	0.01	0.01	0.01	0.01	0.01	Oligotrophic
Clearwater River below Beet Lake	10	0.01	0.01	0.005	0.01	0.01	Oligotrophic
Reference Lake	33	0.01	0.01	0.0058	0.01	0.02	Oligotrophic

Note: The minimum, 25th percentile, average, 95th percentile, and maximum values are presented to two significant figures unless the value corresponds with laboratory reported values and fewer significant figures.
a) Calculated using half the detection limit, where applicable.
b) CCME (2004) and Environment Canada (2004).
mg/L = milligrams per litre.

Average total ammonia concentrations (Table 10.3-8) varied between 0.007 mg/L as nitrogen and 0.1 mg/L as nitrogen. Where measurements were below the analytical detection limit, the average concentration was calculated using half of the detection limit. Within the smaller waterbodies (e.g., Lake G, Lake H), total ammonia concentrations were generally close to the detection limit during the summer months with higher concentrations measured during the winter months. Within the larger, deeper waterbodies (e.g., Patterson Lake), the higher total ammonia concentrations were generally measured during the winter months or at depths where dissolved oxygen concentrations were low.

Average nitrate concentrations (Table 10.3-10) varied between 0.006 mg/L as nitrogen and 0.02 mg/L as nitrogen. The analytical detection limit for nitrate was not consistently at 0.01 mg/L and as such, some average concentrations may be overestimated due to an increased detection limit (e.g., Lake G). Similar to the total ammonia trends, higher nitrate concentrations were generally measured in the winter months.

Table 10.3-8: Existing Condition (Base Case) Total Ammonia Concentration (2015 and 2020)

Waterbodies and Watercourses	# of Samples	Total Ammonia (as Nitrogen)[(a)] (mg/L)				
		Minimum	25th Percentile	Average[(b)]	95th Percentile	Maximum
Broach Lake	18	0.01	0.01	0.022	0.1	0.18
Lake H	11	0.01	0.01	0.10	0.52	0.60
Lake G	11	0.01	0.025	0.15	0.58	0.65
Patterson Lake North Arm – East Basin	18	0.01	0.02	0.031	0.079	0.19
Patterson Lake North Arm – West Basin	18	0.01	0.01	0.018	0.06	0.12
Patterson Lake South Arm	18	0.01	0.01	0.011	0.026	0.06
Forrest Lake – North Basin	14	0.01	0.01	0.0086	0.024	0.03
Forrest Lake – South Basin	17	0.01	0.01	0.0074	0.02	0.02
Beet Lake	16	0.01	0.01	0.03	0.11	0.30
Naomi Lake	12	0.01	0.01	0.01	0.03	0.04
Clearwater River below Beet Lake	11	0.01	0.01	0.01	0.05	0.05
Reference Lake	33	0.01	0.01	0.077	0.47	0.84

Note: The minimum, 25th percentile, average, 95th percentile, and maximum values are presented to two significant figures unless the value corresponds with laboratory reported values and fewer significant figures.
As the Project threshold for ammonia is dependent on ETMFs (i.e., pH and temperature), corresponding values of the ETMFs for that specific sample were used to determine the Project threshold for comparison to the measured ammonia concentration.
a) Statistics calculated using half the detection limit, where necessary.
b) Calculated using half the detection limit, where necessary.
mg/L = milligrams per litre.

Table 10.3-9: Existing Condition (Base Case) Un-ionized Ammonia Concentration (2015 and 2020)

Waterbodies and Watercourses	# of Samples	Un-ionized Ammonia (as Nitrogen)[a,b] (mg/L)				
		Minimum	25th Percentile	Average	95th Percentile	Maximum
Broach Lake	18	0.000002	0.0000043	0.000054	0.00017	0.0006
Lake H	11	0.000009	0.000053	0.000091	0.0003	0.0003
Lake G	11	0.00002	0.000075	0.00017	0.00055	0.0006
Patterson Lake North Arm – East Basin	18	0.000003	0.00002	0.000057	0.00022	0.0003
Patterson Lake North Arm – West Basin	18	0.000003	0.000005	0.000035	0.00013	0.0003
Patterson Lake South Arm	18	0.000002	0.000004	0.000019	0.000092	0.0001
Forrest Lake – North Basin	14	0.000003	0.00001	0.00003	0.00016	0.0002
Forrest Lake – South Basin	17	0.0000025	0.000017	0.000057	0.00016	0.0002
Beet Lake	16	0.000003	0.00001	0.00003	0.0002	0.0002
Naomi Lake	12	0.000005	0.00001	0.00002	0.00008	0.0001
Clearwater River below Beet Lake	11	0.00001	0.00001	0.00003	0.0001	0.0002
Reference Lake	33	0.000002	0.0000073	0.00013	0.00052	0.0012

Notes:
The minimum, 25th percentile, average, 95th percentile, and maximum values are presented to two significant figures unless the value corresponds with laboratory reported values and fewer significant figures.
In cases where the un-ionized ammonia concentration was determined from the total ammonia concentration, the corresponding pH and temperature values for that specific sample were used for comparison to the derived un-ionized ammonia concentration.
a) Statistics calculated using half the detection limit for total ammonia concentrations, where necessary.
b) Un-ionized ammonia concentration calculated as a fraction of total ammonia, based on pH and temperature. Statistics were developed based on un-ionized ammonia concentrations calculated for each individual sample.
mg/L = milligram per litre.

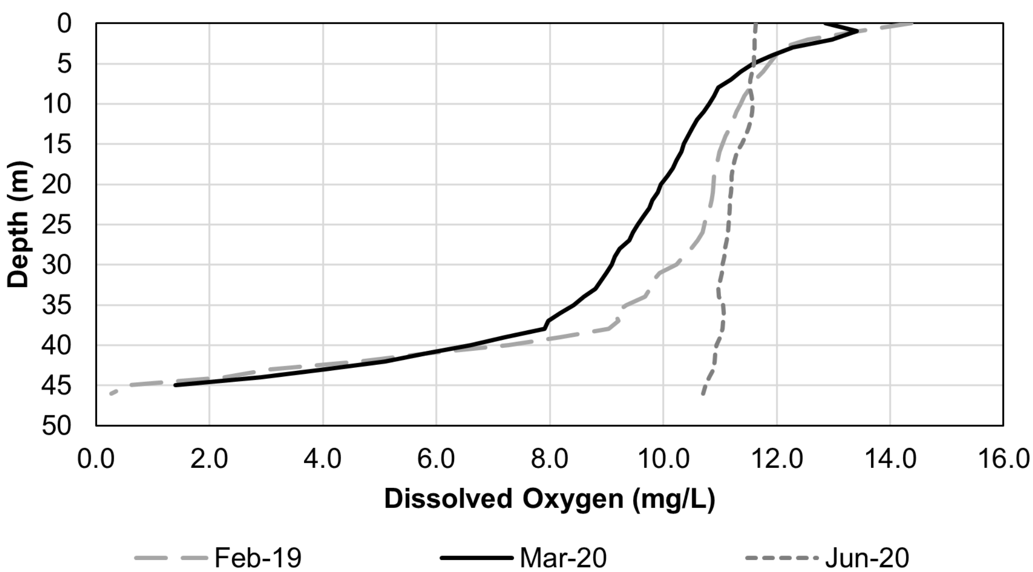
Table 10.3-10: Existing Condition (Base Case) Nitrate Concentration (2015 and 2020) for Water Quality (Risk to Aquatic Life and Terrestrial Life) and Drinking Water Quality Measurement Indicators

Waterbodies and Watercourses	# of Samples	% Above Water Quality Threshold for Aquatic Life and Terrestrial Life	# Above Water Quality Threshold for Drinking Water Quality	Nitrate (as Nitrogen) (mg/L)				
				Minimum	25th Percentile	Average[a]	95th Percentile	Maximum
Broach Lake	15	0	0	0.01	0.01	0.023	0.063	0.07
Lake H	11	0	0	0.01	0.01	0.0064	0.015	0.02
Lake G	11	0	0	0.01	0.01	0.043	0.21	0.23
Patterson Lake North Arm – East Basin	15	0	0	0.01	0.01	0.016	0.051	0.1
Patterson Lake North Arm – West Basin	15	0	0	0.01	0.01	0.0083	0.03	0.03
Patterson Lake South Arm	15	0	0	0.01	0.01	0.013	0.056	0.07
Forrest Lake – North Basin	11	0	0	0.01	0.01	0.0064	0.015	0.02
Forrest Lake – South Basin	14	0	0	0.01	0.01	0.0064	0.014	0.02
Beet Lake	14	0	0	0.01	0.01	0.01	0.03	0.03
Naomi Lake	12	0	0	0.01	0.01	0.02	0.10	0.11
Clearwater River below Beet Lake	10	0	0	0.01	0.01	0.02	0.13	0.22
Reference Lake	30	0	0	0.01	0.01	0.0088	0.026	0.04

Note: The minimum, 25th percentile, average, 95th percentile, and maximum values are presented to two significant figures unless the value corresponds with laboratory reported values and fewer significant figures.
a) Calculated using half the detection limit, where necessary.
mg/L = milligrams per litre.

Surface waters of waterbodies in the LSA had dissolved oxygen conditions above 6 mg/L. In some deeper lakes (e.g., Patterson Lake South Arm), particularly during winter conditions, dissolved oxygen varied through the water column, with anoxic (i.e., oxygen depleted) conditions observed in the deeper portions. With the onset of ice-off and freshet conditions and the resulting mixing processes, the water column of these lakes returned to oxygenated conditions. Representative water column profiles of dissolved oxygen through the ice-covered period (i.e., February and March) and open-water period (i.e., June) in a large, deep lake (e.g., Patterson Lake South Arm) are presented in Figure 10.3-2.

Figure 10.3-2: Late Winter to Spring Dissolved Oxygen Profiles in Patterson Lake South Arm



10.3.2 Sediment Quality

The existing sediment quality conditions for surface waterbodies in the LSA and RSA were determined from baseline studies conducted between 2019 and 2020 by Canada North Environmental Services (Section 10.2.6.2, Sediment Quality). The composition of the sediment showed that the top layer of sediment (i.e., 0 cm to 2 cm) consists of a mixture of coarse sand, fine sand, and silt, with some variance in the proportion of these fractions between waterbodies (Annex V.1); clay consistently represented a low percentage of the sediment composition. In Patterson Lake, there is variability in sediment composition within the waterbody, between basins and survey years. The lakebed sediment in the North Arm – East Basin is composed primarily of fine sand and silt. In the North Arm – West Basin, the lakebed sediment in the deeper areas is composed primarily of fine sand and silt, and coarse sand near the shoreline. In the South Arm, near the outlet of Patterson Lake, the lakebed sediment composition is primarily coarse sand.

Total organic carbon, a surrogate representing the organic composition of the lakebed sediment, showed a large variation between the waterbodies, ranging between 0.24% as dry weight[7] (Beet Lake) and 25.8% as dry weight (Naomi Lake). The average total organic carbon in Patterson Lake ranged between 0.5% as dry weight

[7] Fraction of µg/g on a dry weight basis unless otherwise specified.

(South Arm) and 13.8% as dry weight (North Arm – West Basin). The lower organic composition reflected coarser lakebed sediment composition.

Generally, sediment concentrations of COPC metals and radionuclides were low and below COPC thresholds in waterbodies in the LSA and RSA, with several COPCs measured at or near the detection limit. Patterson Lake South Arm and Beet Lake generally had the lowest sediment constituent concentrations, which is attributed to the coarser lakebed sand content of these waterbodies. Patterson Lake North Arm – West Basin had the highest concentrations of certain metals (i.e., arsenic, barium, iron, lead, manganese, and zinc) and high concentrations of radionuclides (i.e., lead-210, polonium-210, and radium-226). Elevated concentrations of radionuclides were also observed in the small lake, Lake H (i.e., lead-210 and polonium-210).

The following exceedances of CCME sediment quality guidelines and other reference thresholds recommended for the uranium mining and milling industry in Canada (Annex V.1) under baseline conditions are noted:

- Patterson Lake North Arm – West Basin:
  - arsenic mean concentration exceeded the ISQG, LEL, PEL guidelines, and REF values;
  - polonium-210 mean concentration exceeded the LEL;
- Naomi Lake:
  - arsenic mean concentration exceeded the ISQG and LEL; and
  - vanadium mean concentration exceeded the LEL.

Although there is much more discussion from local Indigenous Groups about recent changes in surface water quality, some feedback from the BNDN may point to existing sediment quality issues. The feedback indicated that whitefish (*Coregonus clupeaformis*), a bottom-feeding species in Patterson Lake, have shown evidence of disease and suggested a source of contamination at the bottom of Patterson Lake (TSD II: BNDN).

Additional details of the baseline sediment quality for the waterbodies in the LSA and RSA are found in the Aquatic Environment Baseline Report (Annex V.1).

10.4 Project Interactions and Mitigations

The pathway analysis identified potential adverse effects of the Project on surface water quality and sediment quality, identified practicable mitigation for these potential effects, and determined whether any of the potential effects can be sufficiently mitigated such that they are not expected to cause a residual adverse effect. As described in Section 10.2.7, Project Interactions and Mitigations, the pathway analysis assigned each potential effect as:

- no pathway (i.e., mitigation results in no effect on surface water quality or sediment quality);
- secondary pathway (i.e., mitigation results in a negligible effect on surface water quality or sediment quality); or
- primary pathway (i.e., effect that is greater than negligible and carried forward for further assessment).

The pathway analysis is summarized in Table 10.4-1. The subsections following the table provide the rationale used to assign potential effects to the no pathway and secondary pathway categories and list primary pathways. Each Project interaction identified as a primary pathway was carried forward for detailed assessment in Section 10.5. Effects pathways apply to all Project phases unless otherwise noted.

The environmental design features and mitigations in Table 10.4-1 represent the list of key actions used to inform the pathway analysis as part of preparing the EIS. In addition to this list of key actions, NexGen would implement the Environmental Protection Program, which would describe the processes required to monitor and characterize emissions from Project facilities and activities. This program would be used to periodically evaluate mitigation performance and identify additional mitigation, where required, and prompt potential adaptive management measures (Section 10.7, Monitoring, Follow-Up, and Adaptive Management). Where relevant, adaptive management measures may also be proposed to address uncertainties associated with effects predictions and mitigation. The process for determining when, how, and where to use adaptive management would be described within the Integrated Management System Manual.

Potential accidents and malfunctions that have the capability to influence biophysical or human environments are discussed in Section 21, Accidents and Malfunctions.

NexGen Energy Ltd.

Table 10.4-1: Potential Effects Pathways for Surface Water Quality and Sediment Quality

Pathway ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
SWQ-01	Project components/activities that contribute to emissions and deposition of fugitive dust during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ underground shaft/mine development ▪ process plant buildings and underground operations ▪ handling and storage of waste rock, special waste rock, and ore ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure ▪ site traffic ▪ transportation of personnel and materials to and from the site	**Deposition of fugitive dust emissions on waterbodies:** ▪ Deposition of fugitive dust emissions (e.g., particulate matter, metals, radionuclides) on local and regional waterbodies and watercourses may adversely affect surface water quality	▪ **Optimize haul routes** to reduce fuel consumption and emissions from equipment ▪ **Apply water and/or suppressants to site roads, access road, and airstrip**, as necessary. Use dust suppressants that minimize environmental risk and are government approved for use ▪ **Limit vehicle speed** on unpaved site roads to reduce fugitive dust during Construction and Operations ▪ **Establish and enforce speed limits** on site and access roads to reduce dust production ▪ Implement Project-specific monitoring programs (e.g., **Effluent and Emissions Plan, Environmental Monitoring Plan**) that includes ambient air monitoring, surface water quality monitoring and adaptive management, if necessary ▪ Implement a Project-specific **Environmental Protection Program**	Primary pathway
SWQ-02	Project components/activities that contribute to CAC emissions during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ underground shaft/mine development ▪ process plant buildings and underground operations ▪ additional infrastructure (e.g., camp, maintenance shop, offices) ▪ power generation ▪ handling and storage of waste rock, special waste rock, and ore ▪ non-hazardous waste incineration ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure ▪ site traffic ▪ transportation of personnel and materials to and from the site	**Deposition of CAC emissions on waterbodies:** ▪ Deposition of CAC emissions (e.g., particulate matter, sulphur, nitrogen oxides) on local and regional waterbodies and watercourses may adversely affect surface water quality	▪ Evaluate opportunities to **reduce fuel combustion requirements** of infrastructure and equipment, to the extent practical, during detailed design ▪ Primarily **use liquified natural gas** for power generation ▪ **Optimize haul routes** to reduce fuel consumption and emissions from equipment ▪ **Use and maintain emissions control devices** on combustion-based equipment ▪ **Limit idling of vehicles and equipment** to the extent practical ▪ Identify and implement **procurement criteria** to confirm stationary and mobile engines meet applicable performance standards ▪ **Maintain mobile mining equipment** and vehicles and operate the equipment within parameters for engine exhaust system design ▪ Implement Project-specific monitoring programs (e.g., **Effluent and Emissions Plan, Environmental Monitoring Plan)** that includes ambient air monitoring, surface water quality monitoring and adaptive management if necessary ▪ Implement a Project-specific **Environmental Protection Program**	Primary pathway
SWQ-03	Project components/activities that may change surface water and sediment quality through treated effluent discharges during **Construction, Operations, and Closure**: ▪ underground shaft/mine development ▪ dewatering the underground mine ▪ process plant buildings and underground operations ▪ handling and storage of waste rock, special waste rock, and ore ▪ effluent treatment	**Discharge of treated effluent:** ▪ Direct discharge of treated effluent during Construction, Operations, and Closure may affect surface water quality, including hardness, in Patterson Lake and in waterbodies and watercourses farther downstream	▪ **Recycle and reuse process water** to reduce freshwater intake and release to Patterson Lake, to the extent practical ▪ Design the treated effluent diffuser to **provide effective mixing and dilution of the effluent** to limit the area of the receiving environment affected by mine discharge ▪ Develop a **site-specific ETP** to treat COPCs to **appropriate release limits** in accordance with provincial standards and licence/permit conditions ▪ Design diffuser/outfall such that discharged **flow does not interact with sediment** ▪ Locate proposed treated effluent diffuser **away from sensitive or unique habitats**, to the extent practical ▪ Collect, store and routinely **monitor contact water** to confirm discharge water meets water quality criteria appropriate for release ▪ **Monitor treated effluent flow and quality** ▪ Implement an **Environmental Code of Practice** that defines actions levels and documents steps to be taken to mitigate elevated concentrations of chemical and radiological constituents in treated effluent discharge to acceptable levels ▪ Implement Project-specific monitoring programs (e.g., **Effluent and Emissions Plan, Environmental Monitoring Plan)** that includes monitoring treated effluent, surface water and sediment quality and applying adaptive management if necessary ▪ Implement a Project-specific **Mine Waste Management Plan** and site water management procedures. ▪ Implement a Project-specific **Environmental Protection Program** ▪ Develop and implement a **Detailed Decommissioning and Reclamation Plan** to decommission and transfer the site to the Province under the Institutional Control Program	Primary pathway

Table 10.4-1: Potential Effects Pathways for Surface Water Quality and Sediment Quality

Pathway ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
SWQ-04	Project components/activities that may change surface water and sediment quality through treated sewage discharges during **Construction, Operations, and Closure**: ▪ domestic waste water and sewage treatment	**Discharge of treated sewage:** ▪ Direct discharge of treated sewage during Construction, Operations, and Closure may affect surface water quality in Patterson Lake and in waterbodies and watercourses farther downstream	▪ Design the treated sewage outfall to **provide effective mixing and dilution of the effluent** to limit the area of the receiving environment affected by mine discharge ▪ Design discharge(s) such that discharged **flow does not interact with sediment** ▪ Treat sewage to **appropriate release limits** in accordance with provincial standards and licence/permit conditions ▪ **Monitor treated sewage flow and quality** ▪ Implement a Project-specific **Environmental Monitoring Plan** that includes monitoring surface water and sediment quality and applying adaptive management if necessary ▪ Implement a Project-specific **Environmental Protection Program** ▪ Develop and implement a **Detailed Decommissioning and Reclamation Plan** to decommission and transfer the site to the Province under the Institutional Control Program	Primary pathway
SWQ-05	Project components/activities that potentially change groundwater quality during **Construction and Operations**: ▪ handling and storage of waste rock, special waste rock, and ore	**Seepage from the WRSAs during Construction and Operations:** ▪ Seepage from the WRSAs during Construction and Operations may affect groundwater quality and affect surface water quality in Patterson Lake and in waterbodies and watercourses farther downstream	▪ **Segregate PAG material** from NPAG material and store separately ▪ **Contain and divert runoff and seepage from PAG** waste rock, special waste rock, and ore to the effluent treatment plant ▪ Implement a Project-specific **Environmental Monitoring Plan** that includes monitoring groundwater, surface water, and sediment quality and applying adaptive management, if necessary ▪ Implement a Project-specific **Mine Waste Management Plan** and site contact water management procedures ▪ Implement a Project-specific **Environmental Protection Program** ▪ Develop and implement a **Detailed Decommissioning and Reclamation Plan** to decommission and transfer the site to the Province under the Institutional Control Program	Primary pathway
SWQ-06	Project components/activities that potentially change groundwater quality **following Closure and in the far future**: ▪ handling and storage of waste rock in the WRSAs ▪ storage of tailings in the UGTMF and backfilled stopes	**Runoff and seepage from the WRSAs and UGTMF following Closure:** ▪ Runoff and seepage from the WRSAs and groundwater flow from the UGTMF may affect groundwater quality and affect surface water quality in Patterson Lake after Closure	▪ **Use engineered cemented paste backfill and tailings** to control source concentrations ▪ **Apply binder** to reduce permeability in backfill and tailings ▪ Install **engineered cover system** on PAG and NPAG material ▪ Develop and implement a **Detailed Decommissioning and Reclamation Plan** to decommission and transfer the site to the Province under the Institutional Control Program	Primary pathway
SWQ-07	Project components/activities that contribute to CAC emissions during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ underground shaft/mine development ▪ process plant buildings and underground operations ▪ additional infrastructure (e.g., camp, maintenance shop, offices) ▪ power generation ▪ handling and storage of waste rock, special waste rock, and ore ▪ non-hazardous waste incineration ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure ▪ site traffic ▪ transportation of personnel and materials to and from the site	**Deposition of CAC emissions on land:** ▪ Deposition of CAC emissions (e.g., particulate matter, sulphur, nitrogen oxides) on terrestrial components of local and regional watersheds may adversely affect surface water quality	▪ Evaluate opportunities to **reduce fuel combustion requirements** of infrastructure and equipment, to the extent practical, during detailed design ▪ Primarily **use liquified natural gas** for power generation ▪ **Optimize haul routes** to reduce fuel consumption and emissions from equipment ▪ **Use and maintain emissions control devices** on combustion-based equipment ▪ **Limit idling** of vehicles and equipment to the extent practical ▪ Identify and implement **procurement criteria** to confirm stationary and mobile engines meet applicable performance standards ▪ **Maintain and monitor mobile mining equipment and vehicles** to confirm emissions are within designed operating parameters for engine exhaust systems ▪ Implement a Project-specific **Effluent and Emissions Plan** ▪ Implement a Project-specific **Environmental Monitoring Plan** that includes ambient air monitoring, and surface water quality monitoring and adaptive management if necessary ▪ Implement a Project-specific **Environmental Protection Program**	Secondary pathway
SWQ-08	Project components/activities that may change surface water and sediment quality through direct site runoff during **Construction and Operations**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ infrastructure (e.g., roads, airstrip, camp, maintenance shop, offices) ▪ handling and storage of waste rock, special waste rock, and ore	**Site drainage and runoff during Construction and Operations:** ▪ Altered site drainage and runoff from the site during Construction and Operations may cause changes to water levels and flows, stream channel/bank stability, and sediment and constituent loading, affecting surface water quality in local waterbodies and watercourses	▪ **Limit the Project footprint** to the extent practical using practices such as: o optimizing use of existing cleared areas for Project activity o using existing road infrastructure, including existing access road and bridge crossing o storing tailings underground o designing an efficient infrastructure footprint (e.g., buildings clustered together) ▪ Provide **adequate contact water storage capacity** to manage runoff and seepage from Project infrastructure and disturbed areas ▪ **Minimize areas of vegetation clearing and soil disturbance**	Secondary pathway

Table 10.4-1: Potential Effects Pathways for Surface Water Quality and Sediment Quality

Pathway ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
SWQ-09	Project components/activities that may change surface water and sediment quality through direct site runoff during **Closure and in the far future**: ▪ storage of waste rock ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure	<u>**Site drainage and runoff during and following Closure:**</u> ▪ Altered site drainage and runoff from site during Closure and following may cause changes to water levels and flows, stream channel/bank stability, and sediment and constituent loading, affecting surface water quality in local waterbodies and watercourses	▪ **Limit steepness and length of slopes** of disturbed areas and stockpiled soils ▪ **Avoid placing soil stockpiles near waterbodies** (i.e., maintaining 150 m buffer from waterbodies and watercourses), and near natural drainage features, unless required for temporary storage ▪ **Use erosion control measures** as required ▪ To the extent practical, **work in sensitive areas** (i.e., erosive soils, wetland features, and fish habitats) would be scheduled **to avoid periods that may result in high flow volumes and/or increase erosion and sedimentation** (e.g., spring freshet) ▪ Implement **progressive reclamation and revegetation** of disturbed areas no longer required ▪ **Reclaim and revegetate** areas where non-permanent Project facilities have been decommissioned ▪ Perform routine inspection and maintenance of **water containment and conveyance structures** (i.e., roadside ditches and culverts) to limit the risk of road wash-out or sediment release to the environment ▪ Implement a Project-specific **Environmental Monitoring Plan** that includes monitoring surface water and sediment quality and applying adaptive management if necessary ▪ Implement a Project-specific **Mine Waste Management Plan** and site contact water management procedures under the **Environmental Protection Program** ▪ Implement a Project-specific Environmental Protection Program ▪ Develop and implement a Detailed **Decommissioning and Reclamation Plan** to decommission and transfer the site to the Province under the Institutional Control Program	Secondary pathway
SWQ-10	Project components/activities that contribute to TSS loadings through treated effluent discharge and treated sewage release during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ underground shaft/mine development ▪ process plant buildings and underground operations ▪ handling and storage of waste rock, special waste rock, and ore ▪ effluent treatment ▪ domestic waste water and sewage treatment ▪ additional infrastructure (e.g., roads, airport fuel pad, camp) ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure	<u>**TSS loadings:**</u> ▪ Direct discharge of treated effluent and treated sewage during Construction, Operations, and Closure can contribute to TSS loadings and may affect surface water quality in Patterson Lake and in waterbodies and watercourses farther downstream	▪ **Recycle and reuse process water** to reduce freshwater intake and release to Patterson Lake, to the extent practical ▪ Design the treated effluent diffuser and treated sewage outfall to **provide effective mixing and dilution of the effluent** to limit the area of the receiving environment affected by mine discharge ▪ Design discharge(s) such that discharged **flow does not interact with sediment** ▪ Locate proposed treated effluent diffuser **away from sensitive or unique habitats, to the extent practical** ▪ Collect, store, and routinely **monitor contact water** to confirm discharge water meets water quality criteria appropriate for release ▪ **Treat effluent and sewage** prior to release ▪ **Monitor treated effluent and treated sewage** flow and quality ▪ Implement a Project-specific **Environmental Monitoring Plan** that includes monitoring water and sediment quality and applying adaptive management if necessary ▪ Implement a Project-specific **Mine Waste Management Plan** and site contact water management procedures under the **Environmental Protection Program** ▪ Implement a Project-specific **Environmental Protection Program**	Secondary pathway
SWQ-11	Project components/activities that contribute to TSS loadings through treated effluent discharge and treated sewage release during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ underground shaft/mine development ▪ process plant buildings and underground operations ▪ handling and storage of waste rock, special waste rock, and ore ▪ effluent treatment ▪ domestic waste water and sewage treatment ▪ additional infrastructure (e.g., roads, airstrip, camp) ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure	<u>**Treated effluent and sewage affecting sediment quality:**</u> ▪ Direct discharge of treated effluent and treated sewage during Construction, Operations, and Closure can contribute to changes in sediment quality in Patterson Lake and in waterbodies and watercourses farther downstream		Secondary pathway
SWQ-12	Project components/activities that contribute to emissions and deposition of fugitive dust during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ underground shaft/mine development ▪ process plant buildings and underground operations ▪ handling and storage of waste rock, special waste rock, and ore ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure ▪ site traffic ▪ transportation of personnel and materials to and from the site	<u>**Deposition of fugitive dust emissions on land:**</u> ▪ Deposition of fugitive dust emissions (e.g., particulate matter, metals, radionuclides) on terrestrial components of local and regional watersheds may adversely affect surface water quality	▪ **Optimize haul routes** to reduce fuel consumption and emissions from equipment ▪ **Apply water and/or suppressants to site roads, access road, and airstrip**, as necessary. Use dust suppressants that minimize environmental risk and are government approved for use ▪ **Limit vehicle speed** on unpaved site roads to reduce fugitive dust during Construction and Operations ▪ **Establish and enforce speed limits** on site and access roads to reduce dust production ▪ Implement a Project-specific **Effluent and Emissions Plan** ▪ Implement Project-specific monitoring programs (i.e., **Environmental Monitoring Plan**) that include ambient air monitoring, surface water quality monitoring and adaptive management, if necessary ▪ Implement a Project-specific **Environmental Protection Program**	No pathway

Bolded text represents the key topic of the environmental design features and mitigation.

PAG = potentially acid generating; UGTMF = underground tailings management facility; WRSAs = waste rock storage areas; ETP = effluent treatment plant; COPC = constituents of potential concern; TSP = total suspended particulates; TSS = total suspended solids; CAC = criteria air contaminant.

10.4.1 No Pathways

The following Project interaction was predicted to result in no pathway to surface water quality and was not carried forward in the assessment.

SWQ-12: Deposition of fugitive dust emissions on land:

- Deposition of fugitive dust emissions (e.g., particulate matter, metals, radionuclides) on terrestrial components of local and regional watersheds may adversely affect surface water quality.

Activities such as land clearing, site preparation, construction of facilities, site traffic, and handling of waste rock during Construction and Operations, as well as activities associated with revegetation and removal of infrastructure during Closure, have the potential to generate fugitive dust. Accumulated fugitive dust deposition within terrestrial environments may enter local and regional waterbodies and watercourses via overland runoff, particularly if accumulated over the winter and mobilized in the spring freshet.

Generation of fugitive dust from the Project would be expected to occur primarily through the summer months, as minimal fugitive dust is anticipated to be generated under winter conditions. Snow- and ice-covered road surfaces and freezing temperatures provide a natural mitigation associated with, or afforded by, winter conditions. A study conducted at the De Beers Canada Inc. (De Beers) Snap Lake Mine (Golder 2012) showed that the natural mitigation of winter conditions suppressed approximately 96% of dust generation and dust fall. Because it is anticipated that there would be little generation and accumulation of fugitive dust through the winter months, the spring freshet would be unlikely to carry a high load of any dust fall to local and regional waterbodies and watercourses.

In the summer, the terrestrial components of the local and regional watersheds may accumulate fugitive dust from aerial dust plumes around Project activities. However, Project design and mitigation policies and procedures are anticipated to limit fugitive dust emissions from the Project during summer months. Mitigation to minimize dust generation during Project activities would include:

- establishing and enforcing speed limits on site roads and the access road to reduce dust production from vehicle wheel entrainment;
- applying water spray and chemical suppressant to control dust emissions on the airstrip, site roads, and access and haul roads during summer or non-frozen conditions; and
- incorporating the results of the ambient air quality monitoring program into the Project's protection plans.

With respect to the effectiveness of road watering, the De Beers study (Golder 2012) showed that road watering during summer months resulted in approximately 80% suppression of dust generation, which maintained its efficacy for periods between four and six hours after watering.

The Effluent and Emissions Plan includes air quality monitoring and adaptive management based on ambient air quality standards. Similarly, the Environmental Monitoring Plan would include monitoring soil and water quality during the Project lifespan and applying adaptive management, if necessary (i.e., if air quality monitoring data reach certain thresholds, then monitoring soils, vegetation, or water chemistry may be triggered).

Dust deposition to terrestrial areas from activities that have the potential to generate fugitive dust is expected to be limited in terms of loading and extent through the application of mitigation. As a result, it is expected that the majority of this deposition would be incorporated into the surface soil and vegetation and be effectively immobilized. Therefore, a measurable residual effect on surface water quality is not expected, and the pathway was not carried forward in the assessment.

10.4.2 Secondary Pathways

The following Project interactions were predicted to result in secondary pathways to surface water quality and/or sediment quality and were not carried forward in the assessment.

SWQ-07: Deposition of CAC emissions on land:

- Deposition of criteria air contaminant (CAC) emissions (e.g., particulate matter, sulphur, nitrogen oxides) on terrestrial components of local and regional watersheds may adversely affect surface water quality.

Deposition of CACs from emissions associated with Project activities are expected to occur from the combustion of fossil fuels in large equipment used in and around the Project, such as power generation, the operation of aircraft, trucks, and vehicles, and the burning of non-hazardous waste materials (e.g., food garbage) during Construction and Operations, as well as from activities associated with revegetation and removal of infrastructure during Closure. Criteria air contaminants include particulate matter less than 2.5 µm in diameter and less than 10 µm in diameter, sulphur dioxide, and nitrogen oxides. Deposited CAC emissions within terrestrial environments may enter local and regional waterbodies and watercourses via overland runoff, particularly if accumulated over the winter and mobilized in the spring freshet.

Unlike fugitive dust, where natural mitigation during the winter would limit the generation of dust from Project activities, CAC emissions would be generated year-round. This may result in a localized accumulation of CACs over the winter months within the snowpack around the Project site, as the deposited dust and associated CACs would not be mobilized by runoff during the winter. Following the accumulation over the winter months, the spring freshet may carry an increased load to local and regional waterbodies and watercourses. In the summer, a substantial proportion of any directly deposited CACs is more likely to be incorporated into the surface soil of the terrestrial landscape and be effectively immobilized.

Environmental protection and monitoring plans developed for the Project, which include adaptive management, are expected to limit the emissions of CACs and associated effects on surface water (e.g., Effluent Monitoring Plan, Environmental Monitoring Plan). Project design and mitigation include primary use of liquid natural gas for power generation, use of emission control devices on combustion-based equipment and vehicles, regular maintenance of equipment, and procurement criteria that specify stationary and mobile equipment must meet applicable performance standards.

Environmental design features, mitigation, and monitoring are anticipated to minimize generation and deposition of CAC emissions from the Project. Mobilization of any deposited CACs to the receiving environment would therefore be limited to the freshet period with snow melt, which could result in a potential minor localized change to surface water quality. However, it is anticipated that any CACs released from the terrestrial component of the respective watersheds, combined with the high volume of water released during freshet, would disperse quickly in the receiving environment, resulting in negligible residual effects on the surface water quality. Therefore, the pathway was not carried forward in the assessment.

SWQ-08: Site drainage and runoff during Construction and Operations:

- Altered site drainage and runoff from the site during Operations may cause changes to water levels and flows, stream channel/bank stability, and sediment and constituent loading, affecting surface water quality and sediment quality in local waterbodies and watercourses.

AND

SWQ-09: Site drainage and runoff during and following Closure:

- Altered site drainage and runoff from the site during and following Closure may cause changes to water levels and flows, stream channel/bank stability, and sediment and constituent loading, affecting surface water quality and sediment quality in local waterbodies and watercourses.

Project components and activities (e.g., land clearing, site preparation, construction of facilities and infrastructure, handling and storage of waste rock and ore) during Construction and Operations and activities associated with revegetation and removal and restoration of infrastructure and facilities during Closure can lead to altered drainage patterns and erosion of soil. This alteration can cause increased sediment loading in water that is not collected and managed on site (e.g., direct runoff from the catchment area of the Project to Patterson Lake). Altered drainage patterns and changes to water levels and flows may also affect stream channel and bank stability in the downstream environment, leading to increased sediment loading from the resulting erosion.

A regional hydrological model was used to characterize and predict changes from Project activities to water surface levels and watercourse flow rates for the LSA and RSA (Section 9.6, Residual Effects Analysis). Outputs from the regional hydrological model were used as inputs to stream channel relationships and a fluvial sediment transport model. The regional hydrological model predicted surface water flows and levels from the start of Construction to the end of Closure. The assessment indicates that the net discharge of water to Patterson Lake from Project activities during the Project lifespan is expected to result in small changes to annual water levels, such as an increase of the mean annual water surface elevation by in Patterson Lake of 1%. These water level changes are expected to increase mean monthly flows in the Clearwater River downstream of Patterson Lake by less than 2% and modify stream channel parameters (e.g., wetted area) by a maximum of 1.2%. These changes are not expected to result in a measurable change to the fluvial sediment transport regime and are not expected to affect water quality.

Surface water in the receiving environment downstream of the Project would be protected and managed through the Environmental Monitoring Plan. Site contact water would be intercepted and managed to reduce potential for effects on the surrounding environment in accordance with the Environmental Protection Program. More specifically, work required in areas of the Project that may be more prone to erosion from surface water runoff and changes in surface water levels, flows, and drainage areas would be scheduled to avoid the time of year when erosion has the greatest potential (i.e., spring freshet). The rate of discharge from the ETP would also be managed by having adequate surface water storage capacity to allow for controlled release rates, if required. A minimum 150 m buffer between soil stockpiles and waterbodies or drainages would be maintained (unless temporary soil storage is required), and all containment and conveyance structures (e.g., ditches and culverts) would be routinely inspected and maintained to limit risk of road wash-out or potential sediment release. Sediment and erosion control features would be implemented during Construction (e.g., temporary sediment ponds, silt curtains, sediment traps), and erosion control measures would be used as required during Construction, Operations, and Closure. Progressive reclamation and revegetation would also be implemented as disturbed areas are no longer required, and non-permanent features would be reclaimed and revegetated as they are decommissioned. The Environmental Monitoring Plan would include monitoring surface water levels and flows and applying adaptive management as required. During Construction and Operations, a Preliminary Decommissioning and Reclamation Plan would be developed and periodically updated to reflect changing site-specific conditions and surface water effects. Prior to transitioning to Closure, a Detailed Decommissioning and Reclamation Plan would be developed to reflect mitigations necessary to maintain protection of surface water and transfer the site to the Province under the Institutional Control Program.

Environmental design features, mitigation, and monitoring are anticipated to minimize changes in surface water levels and flows. Changes in surface water patterns from the Project could result in a measurable minor change to soil quality and distribution within the maximum disturbance area of the site study area (i.e., an area four times the size of the anticipated 228 ha Project footprint that was defined for the terrain and soils assessment [Section 12] and other terrestrial disciplines) relative to existing conditions. However, taking into account mitigation that would be implemented on the Project site and the changes in surface water patterns from the Project were predicted to have a negligible residual effect on surface water quality and sediment quality, the pathway was not carried forward in the assessment.

SWQ-10: TSS loadings:

- Direct discharge of treated effluent and treated sewage effluent during Construction, Operations, and Closure can contribute to TSS loadings and may affect surface water quality in Patterson Lake and in waterbodies and watercourses farther downstream.

Project components and activities (e.g., land clearing, site preparation, construction of facilities and infrastructure, handling and storage of waste rock and ore, removal of infrastructure and facilities) can lead to increased TSS loading in water that is collected and managed in the site contact water management infrastructure. Domestic water and treated sewage could also potentially contain suspended solids that could lead to increased TSS loading in the water management system. Discharges from the ETP and STP may change surface water quality in Patterson Lake due to higher levels of TSS in the discharged water compared to that in the receiving area of Patterson Lake.

The CRDN, MN-S, and BNDN have indicated concern in changes in water clarity. Additionally, the BNDN raised concerns related to effects of changes in sediment quality on bottom-feeding fish species such as whitefish (TSD II: BNDN).

The ETP and STP are expected to remove a large proportion of TSS as a consequence of their treatment processes, which would comply with the requirement that discharge of treated effluent and treated sewage from these plants meets regulated discharge thresholds for TSS, such as the maximum authorized monthly mean treated effluent concentration of 15 mg/L as per Schedule 4, Table 1 of the Metal and Diamond Mining Effluent Regulations. These limits are designed to be protective of the aquatic environment. The diffuser and outfall designs for the effluent treatment plant and the sewage treatment plant, respectively, would also provide effective mixing and dispersion of the treated discharges, which would result in reducing TSS in the receiving environment with distance from the diffuser. Regulated monitoring of treated discharges from the ETP and STP would be conducted to confirm water quality objectives are met for discharge, which includes TSS. More specifically for the ETP, the rate of discharge would also be managed by having adequate surface water storage capacity to allow for controlled release rates, as required; the storage ponds can also promote settlement of solids, which would reduce TSS concentrations in the treated effluent and treated sewage to be discharged.

Site contact water would be intercepted and managed to reduce potential for effects on the surrounding environment in accordance with the Environmental Protection Program. Also, surface water in the receiving environment downstream of the Project would be protected and managed through the Environmental Monitoring Plan. The detail in the Environmental Protection Program and the Environmental Monitoring Plan provides a basis for monitoring surface water quality on site and in the receiving environment, which includes monitoring for TSS concentrations, and applying adaptive management, if required. The ETP and STP are Project facilities that would fall under the oversight of these plans.

It is expected that the TSS present in discharges from the Project to Patterson Lake would be regulated to permitted limits at the points of discharge and would be dispersed rapidly within the RMZ, resulting in minor, localized changes to water and sediment quality in the immediate receiving environment of Patterson Lake. This discharge and deposition would not affect surface water quality or sediment quality on a scale beyond the proposed RMZ for the discharges. Changes are predicted to have a negligible residual effect on surface water and sediment quality; therefore, the pathway was not carried forward in the assessment.

SWQ-11: Treated effluent and treated sewage affecting sediment quality:

- Direct discharge of treated effluent and treated sewage during Construction, Operations, and Closure can contribute to changes in sediment quality in Patterson Lake and in waterbodies and watercourses farther downstream.

Project components and activities (e.g., land clearing, site preparation, construction of facilities and infrastructure, handling and storage of waste rock and ore, removal of infrastructure and facilities) can lead to increased COPC loading in water that is collected and managed in the site contact water management infrastructure and subsequently discharged to the receiving environment. Water quality of domestic water and treated sewage could also potentially lead to increased COPC loading in the water management system. Discharges from the ETP and STP may change sediment water quality in Patterson Lake due to higher levels of COPCs in the discharged water compared to those in the receiving area of Patterson Lake; sediment quality may also change due to deposition of TSS in this discharge water.

Predicted maximum concentrations of potential COPCs in sediment were derived from projected surface water quality in Patterson Lake in the ERA (TSD XXI). These maximum concentrations were compared against Project sediment quality thresholds (Section 10.2.8.3.4, Sediment Quality Thresholds), which were derived from sediment quality guidelines for the protection of aquatic life and other relevant screening values. Based on a comparison of maximum predicted sediment quality COPC concentrations in Patterson Lake North Arm – West Basin in the Application Case (Table 10.4-2) against the REF values from Burnett-Seidel and Liber (2013), only arsenic and molybdenum exceeded the REF value. However, they did not exceed the NE2 value, which suggests that negligible effects to biota would be expected. As cobalt was identified as a COPC in surface water, both cobalt and arsenic were carried forward for further quantitative assessment in the ERA to determine potential for risk to aquatic life. Predicted concentrations of all other potential COPCs, including molybdenum, selenium, and nickel, did not exceed Project thresholds. These sediment quality COPCs were not considered to pose a risk to aquatic health and were therefore not carried forward for further quantitative assessment in the ERA (TSD XXI).

The maximum predicted upper bound concentrations of lead-210 and polonium-210 in sediment in Patterson Lake North Arm – West Basin exceeded the screening-level LEL values from Thompson et al. (2005) (TSD XXI); however, they did not exceed the SEL values. While exceeding the LEL does not necessarily indicate that adverse effects would occur, all radionuclides in the uranium-238 decay series (i.e., uranium-238, uranium-234, thorium-230, radium-226, lead-210, and polonium-210), despite not all exceeding the LEL, were considered for further quantitative assessment in the ERA (TSD XXI). Including these maximum predicted upper bound concentrations of lead-210 and polonium-210 in sediment Patterson Lake North Arm – West Basin in the overall effects assessment for the ERA, the ERA concluded that the there would be no radiation dose benchmark constraints or exceedances for humans and terrestrial and riparian biota at or near the Project site (or in the LSA) for the Application Case (and upper bound sensitivity scenario) during the Project phases and far-future.

The ETP and STP are expected to remove a large proportion of TSS as a consequence of their treatment processes, which would comply with the requirement that discharge of treated effluent and treated sewage from these plants meets regulated discharge thresholds for TSS, such as the maximum authorized monthly mean treated effluent concentration of 15 mg/L as per Schedule 4, Table 1 of the Metal and Diamond Mining Effluent Regulations. These limits are designed to be protective of the aquatic environment. The diffuser and outfall designs for the treatment plants would also provide effective mixing and dispersion of the treated discharges, which would result in a less concentrated settling of TSS over a larger area (i.e., the RMZ), rather than a high degree (i.e., build-up) of TSS settlement in an area immediately surrounding the discharge point. Regulated monitoring of treated discharges from the ETP and STP would be conducted to confirm water quality objectives are met for discharge, which includes TSS. More specifically for the ETP, the rate of discharge would also be managed by having adequate surface water storage capacity to allow for controlled release rates, as required; the storage ponds can also promote settlement of solids, which would reduce TSS concentrations in the treated effluent and treated sewage to be discharged.

Regulated monitoring of treated discharges from the ETP and STP would be conducted to confirm water quality objectives are met for discharge. This monitoring would be in accordance with the control and management of site contact water to reduce potential for effects on the surrounding environment as described in the Environmental Protection Program. Also, surface water in the receiving environment downstream of the Project would be protected and managed through the Environmental Monitoring Plan.

As the discharges from the Project to Patterson Lake would be regulated to permitted limits and would be dispersed rapidly within the RMZ, minor, localized changes to sediment quality could occur in the immediate receiving environment of Patterson Lake (i.e., immediately around the diffuser) from changes to water quality. This discharge and deposition would not affect sediment quality on a scale beyond the RMZ for the discharges. Changes are predicted to have a minor, localized residual effect on sediment quality; therefore, the pathway was not carried forward in the surface water quality assessment. However, as described above, several COPC radionuclides (i.e., all radionuclides in the uranium-238 decay series) were considered for further quantitative assessment in the ERA (TSD XXI), which concluded that potential for effects to humans and aquatic and wildlife by the Project from non-radiological and radiological risk pathways was low.

Table 10.4-2: Sediment Quality Screening for the Rook I Project

Constituent	Units	Predicted Sediment Concentrations (Patterson Lake North Arm – West Basin) (a)			
		Maximum - Application Case	Maximum - Upper Bound	Maximum - Application Case (Far Future)	Maximum - Upper Bound (Far Future)
Non-radiological COPCs					
Arsenic	**µg/kg dw**	**30.50**	**31.00**	**10.60**	**10.93**
Cadmium	µg/kg dw	0.27	0.27	0.29	0.30
Cobalt	µg/kg dw	1.88	1.90	3.56	4.68
Copper	µg/kg dw	2.93	2.94	6.51	8.52
Lead	µg/kg dw	10.16	10.16	10.33	11.27
Molybdenum	**µg/kg dw**	**1.74**	**3.97**	**14.53**	**53.94**
Nickel	µg/kg dw	5.67	5.74	7.39	9.79
Selenium	µg/kg dw	0.56	0.57	0.95	1.37
Uranium	µg/kg dw	6.33	14.20	19.30	19.32
Zinc	µg/kg dw	11.57	11.63	15.71	18.03
Radiological COPCs					
Uranium-234	Bq/kg dw	62	47	39	67
Uranium-238	Bq/kg dw	62	47	39	66
Thorium-230	Bq/kg dw	116	76	76	22
Radium-226	Bq/kg dw	104	106	85	83
Lead-210	**Bq/kg dw**	**492**	**984**	**402**	**376**
Polonium-210	**Bq/kg dw**	**500**	**1,002**	**409**	**382**

Source: TSD XXI.
Note:
Shaded row indicates sediment concentration exceeds the REF or LEL value.
Bold indicates sediment guideline value selected for this assessment.
a) Sediment concentrations predicted based on release of aqueous source terms to Patterson Lake North Arm – West Basin and interaction with sediment. Modelling performed in IMPACT according to the equations outlined in the IMPACT Model Report (TSD XXI, Appendix A).
REF = reference; NE2 = no-effect; LEL = lowest effect level; SEL = severe effect level; CCME = Canadian Council of Ministers of the Environment; ISQG = interim Sediment Quality Guideline; PEL = probable effect level; n/d = no guideline or data available; dw = dry weight; Bq/kg = becquerels per kilogram.

10.4.3 Primary Pathways

The following Project interactions were predicted to be primary pathways to surface water quality and were advanced for further assessment of residual effects (Section 10.5):

SWQ-01: Deposition of fugitive dust emissions on waterbodies:

- Deposition of fugitive dust emissions (e.g., particulate matter, metals, radionuclides) on local and regional waterbodies and watercourses may adversely affect surface water quality.

SWQ-02: Deposition of CAC emissions on waterbodies:

- Deposition of CAC emissions (e.g., particulate matter, sulphur, nitrogen oxides) on local and regional waterbodies and watercourses may adversely affect surface water quality.

SWQ-03: Discharge of treated effluent:

- Direct discharge of treated effluent during Construction, Operations, and Closure may affect surface water quality, including hardness, in Patterson Lake and in waterbodies and watercourses farther downstream.

SWQ-04: Discharge of treated sewage:

- Direct discharge of treated sewage during Construction, Operations, and Closure may affect surface water quality in Patterson Lake and in waterbodies and watercourses farther downstream.

SWQ-05: Seepage from the WRSAs during Construction and Operations:

- Seepage from the WRSAs during Construction and Operations may affect groundwater quality and affect surface water quality in Patterson Lake and in waterbodies and watercourses farther downstream.

SWQ-06: Runoff and seepage from the WRSAs and UGTMF following Closure:

- Runoff and seepage from the WRSAs and groundwater flow from the UGTMF may affect groundwater quality and affect surface water quality in Patterson Lake after Closure.

The protection of water from Project effects is extremely important for Indigenous Groups and LPA communities (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; BNDN-JWG 2019; BRDN-JWG 2019a; MN-S-JWG 2019b; NexGen 2019). Indigenous Groups have expressed concerns regarding potential Project effects on water quality, and have indicated they are already experiencing the adverse effects from industrial developments, including mineral exploration activities and the Cluff Lake Mine, which they believe has impacted the health of the land and resources (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; BNDN-JWG 2019; BRDN-JWG 2020; BRDN-JWG 2021a; BRDN-JWG 2021b; CRDN-JWG 2020; CRDN-JWG 2021; MN-S-JWG 2019a; MN-S-JWG 2019b).

Patterson Lake is considered by Indigenous Groups to be an integral part of the Clearwater River system and Indigenous Groups expressed concerns that Project activities, including discharge could pollute Patterson Lake and other nearby lakes, and by extension, downstream the Clearwater River and the entire Clearwater River watershed (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN).

The CRDN, MN-S, BNDN, and BRDN raised concerns about Project-related contaminants entering the food chain within the Clearwater River watershed through effects to water quality in Patterson Lake, and adversely affecting the health of fish, plants and wildlife, and in turn human health (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; BRDN-JWG 2019b; BRDN-JWG 2020; BRDN-JWG 2021b; CRDN-JWG 2020; CRDN-JWG 2021). Trappers from the 2021 Fur Block N-19 trapper's workshop and LPA community members also commented on the potential Project effects on water quality, fish, and wildlife in the area of the Project (NexGen 2019).

> Most important thing because we drink that water and the fish lives on water. Creatures, they drink the water. You know, like moose, caribou, everything, you know. That's the most important thing . . . we drink a lot of water ourselves, you know. (TSD II: BNDN)

Indigenous Groups, trappers, and LPA community members also expressed concerns about potential effects to drinking water at Patterson Lake and the Clearwater River from Project related changes to water quality (TSD II: BNDN; TSD III: BRDN; TSD V.2: CRDN; BRDN-JWG 2020; MN-S-JWG 2019b; NexGen 2019).

Indigenous Groups expressed concerns about the potential effects of Project related air and dust emissions on water quality (TSD II: BNDN; TSD IV: MN-S). For example, MN-S members noted concerns about environmental heath risks from windblown dust dispersal and airborne contamination of water (TSD IV: MN-S). Specific concerns were expressed by Indigenous Groups related to the adverse effects of uranium dust, or radioactive materials in air emissions affecting water, vegetation, and wildlife (TSD II: BNDN; TSD IV: MN-S; TSD V.2: CRDN; MN-S-JWG 2019b).

The concerns raised by Indigenous Groups and LPA community members about surface water quality that are related to potential Project effects identified as primary pathways are assessed in Section 10.5, Residual Effects Analysis. Potential Project effects on the health of fish, vegetation, and wildlife from changes in surface water quality are assessed in the ecological risk assessment completed for the Project (TSD XXI). Potential Project effects on human health are assessed in the human health assessment (Section 15). Potential Project effects on underground water quality are assessed in the hydrogeology assessment (Section 8).

10.5 Residual Effects Analysis

This subsection assesses the predicted changes to receiving environment water quality from the primary pathways identified in Section 10.4.3, Primary Pathways. Since sediment quality was assessed to have no primary pathways, only surface water quality effects pathways are discussed.

The residual effects analysis was completed to evaluate incremental changes to water quality as a result of the Project (i.e., Application Case) and cumulative effects of the Project and Fission Patterson Lake South Property (i.e., RFD Case) in comparison to existing conditions (i.e., the Base Case) and Project thresholds. Sensitivity scenarios were also evaluated for each case. The residual effects analysis considered the spatial boundaries outlined in Section 10.2.3 and the temporal boundaries outlined in Section 10.2.4.

The effects of primary pathways on surface water quality were calculated numerically by integrating these pathways into surface water quality models developed for each phase (Section 10.2.8). The results presented are the net result of Project-related changes associated with the identified primary pathways. Project and cumulative effects were discussed in terms of changes to COPCs within the LSA, which is the predicted spatial limit or boundary of where direct and indirect effects on surface water quality are likely to be detectable. Farther downstream of the Clearwater River and Mirror River confluence, changes to surface water quality were considered not likely to be greater-than-negligible.

The residual effects analysis for the Application Case is structured using separate subsections for the NFWQM and the RSWQM following the methods described in Section 10.2.8; the residual effects analysis for the RFD Case is focused on the RSWQM as it was not considered for the NFWQM because there is no cumulative effect within the near-field zone. Predicted COPC trends are described for nutrients, major ions, trace metals, and radionuclides. These predicted trends are used to classify residual effects for the three measurement indicators for surface water quality at key waterbodies within the LSA (Section 10.5.3). Figures are provided in subsequent subsections showing trends over time for representative COPCs, with figures for all COPCs at the key waterbodies within the LSA available in Appendix 10A.

10.5.1 Application Case

Project activities, including direct and indirect discharges, would influence the water quality in Patterson Lake and downstream waterbodies. The Project discharge would include direct discharges of treated effluent and treated domestic sewage, as well as indirect discharges from the west bermed runoff collection area, and groundwater to Patterson Lake. An indirect Project discharge would also include the east non-contact water diversion runoff to Patterson Lake North Arm – East Basin. The surface water effects would propagate downstream but are expected to attenuate in relative magnitude with downstream extent through the LSA.

Detailed results and plots of predicted trends are presented in Appendix 10A.

10.5.1.1 Near-Field Water Quality Model

The NFWQM was used to simulate the change in COPC concentration within close proximity (i.e., 100 m and 200 m) of the discharge point and within the RMZ. The NFWQM was applied to Operations when there would be an active discharge to Patterson Lake from the ETP and STP. The modelled STP treated discharge remains constant in both discharge rate and COPC concentration during Operations. The modelled ETP treated discharge rate also remains constant, but its treated effluent concentration varies throughout Operations (TSD XVIII).

The concentrations of COPCs at the edge of the RMZs were calculated based on the estimated average dilution factor, treated effluent COPC concentrations predicted by the SWWBM, and lake-wide concentrations predicted by the RSWQM. The dilution factors at the edge of the RMZs for the ETP and STP discharges were calculated by averaging the predicted dilution factors at 100 m (i.e., the proposed boundary extent of the RMZ) for all the scenarios modelled for the Application Case. For the ETP diffuser, the predicted dilution factor at the edge of the RMZ ranged from 23:1 to 35:1, with an average of 30:1. For the STP outfall, the predicted dilution factor at the edge of the RMZ ranged from 210:1 to over 1,800:1, with an average of 518:1.

As the effluent from the ETP and STP would be discharged to Patterson Lake throughout Operations, COPC concentrations in Patterson Lake were predicted to increase throughout this phase due to the accumulation of COPC mass in the lake over this time. Concentrations at the edge of the RMZ were thus evaluated at two-time snapshots:

- beginning of Operations (i.e., in 2029 following a four-year construction period nominally commencing in 2025 for ease of reference, with Operations assumed to span the years 2029 to 2052 based on a 24-year mine life), representing the lowest annual average concentration during Operations; and
- near the end of the Operations (i.e., 2048), representing the highest annual average concentration during Operations.

These two snapshots present the lower and upper bound range of COPCs to be expected in the near field.

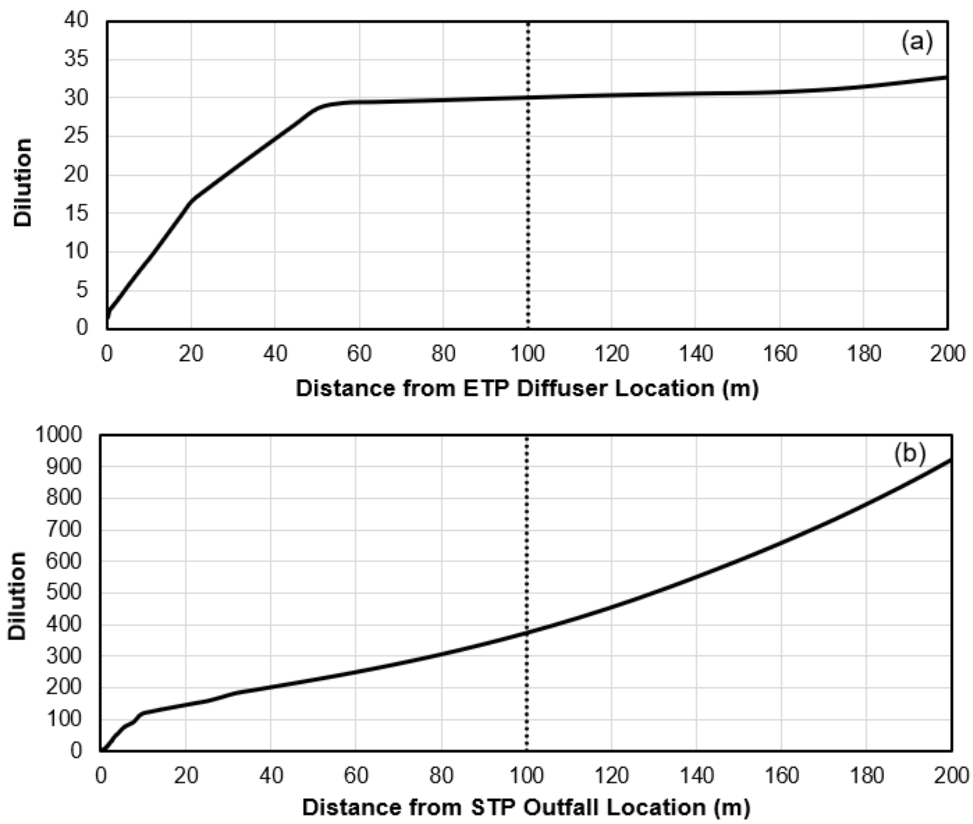
The near-field modelling showed that COPC concentrations remained below their respective thresholds at the edge of the RMZ for all COPCs. As the treated effluent continues to progress from the discharge point, its concentration decreases as it undergoes dispersion in the receiving environment waters (Figure 10.5-1). The ETP diffuser and STP outfall have different designs due to different effluent flow rates (Appendix 10A). The STP has a greater dilution potential near the discharge point due to its effluent flow rate being 100 times smaller than the ETP. The dilution from the ETP remains near constant between 50 m and 180 m distance from the diffuser

(Figure 10.5-1a). The STP dilution continuously increases up to and past 200 m distance from the outfall location (Figure 10.5-1b).

The ETP and STP discharges are also expected to have negligible effects on ambient TSS and water temperature at the edge of the RMZ. Total suspended solids concentrations at the edge of the mixing zones are projected to increase by less than 1 mg/L and water temperature at the edge of the mixing zones is projected to increase by less than 1°C.

Additional modelling details are provided in Appendix 10A.

Figure 10.5-1: Average Treated Effluent Dilution Factor in Terms of Distance from the Discharge Point



Note: Edge of RMZ is at 100 m distance from the outfall. The y-axis scales are different to illustrate trends more effectively.
a) From the diffuser for the effluent treatment plant.
b) From the outfall for the sewage treatment plant.
RMZ = regulated mixing zone.

The NFWQM sensitivity analysis included variations of effluent flow rates and TDS concentrations, which showed that the performance of the ETP diffuser and STP outfall was not expected to change under the reasonable upper bound sensitivity scenario in terms of provided dilutions. The COPC concentrations at the edge of the RMZs at the discharge locations for treated effluent and treated sewage were calculated based on the estimated average dilution factors.

10.5.1.1.1 Major Ions

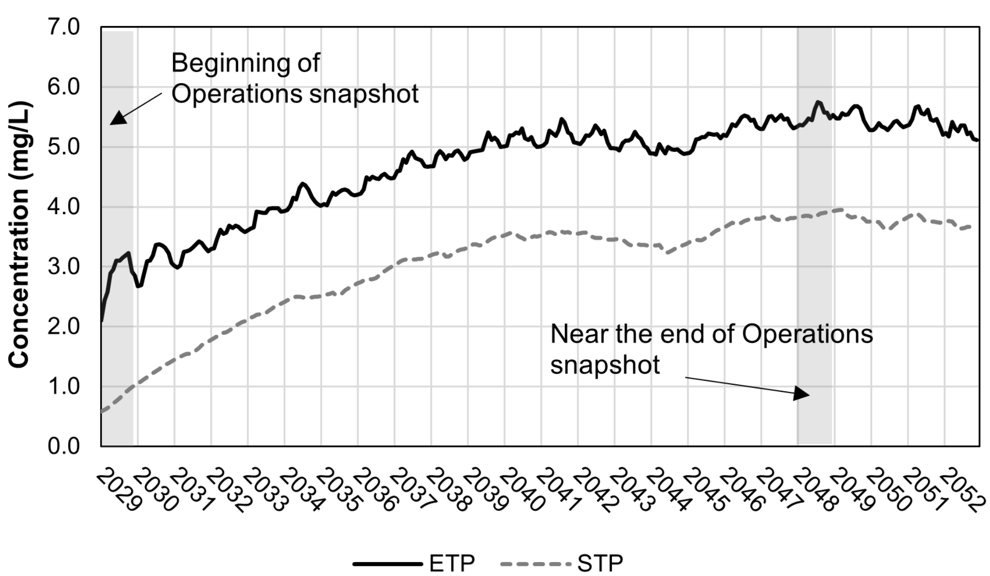
Concentrations of COPC major ions (i.e., chloride and sulphate) are predicted to remain below threshold values within the RMZ and at the edge of the RMZ of both the ETP and STP discharge locations for both time snapshots (Table 10.5-1). Major ion concentrations would increase within the RMZs through Operations as a result of ongoing operational discharge and increased concentrations in the ETP treated discharge during Operations. These concentrations would also result in accumulation of mass in Patterson Lake. The change in concentration of chloride, as a representative COPC major ion, throughout Operations (i.e., 2029 to 2052) is shown in Figure 10.5-2. Modelled concentrations for all COPC major ions at the edge of the proposed ETP and STP RMZs are summarized in Appendix 10A.

Table 10.5-1: Concentrations of Major Ions in Patterson Lake at the Edge of the Proposed Regulated Mixing Zone of the Effluent Treatment Plant and Sewage Treatment Plant

Parameter	Units	Water Quality Threshold for Aquatic and Terrestrial Life	Water Quality Threshold for Drinking Water	Concentration at the Edge of the ETP RMZ		Concentration at the Edge of the STP RMZ	
				Start(a)	End(b)	Start(a)	End(b)
Chloride	mg/L	120	250	2.9	5.5	0.8	3.9
Sulphate	mg/L	128 at start 309 near the end(c)	500	110	290	12	190

a) Start of Operations (2029 snapshot).
b) Near the end of Operations (2048 snapshot).
c) The Project water quality threshold for sulphate (for the protection of aquatic life is dependent on hardness; these threshold concentrations are adjusted based on the predicted hardness in Patterson Lake at the start and near the end of Operations.
RMZ = regulated mixing zone; ETP = effluent treatment plant; STP = sewage treatment plant.

Figure 10.5-2: Concentration of Chloride in Patterson Lake at the Edge of the Proposed Regulated Mixing Zones of the Effluent Treatment Plant and Sewage Treatment Plant during Operations



Note: The chloride threshold (120 mg/L) is not shown on the figure as it is well above the predicted concentration range.
ETP = effluent treatment plant; STP = sewage treatment plant.

10.5.1.1.2 Nutrients

Concentrations of COPC nutrients such as ammonia, phosphorus, and nitrate remained below their threshold values within the RMZ and at the edge of the RMZ of both ETP and STP discharge locations (Table 10.5-2). As noted for COPC major ions, COPC nutrient concentrations increased within the RMZs through Operations as a result of ongoing operational discharge and increased concentration in the ETP effluent during Operations. This would also result in accumulation of mass in Patterson Lake. The change in concentration of nitrate, as a representative COPC nutrient, throughout Operations (i.e., 2029 to 2052) is shown in Figure 10.5-3. Predicted concentrations for all COPC nutrients at the edge of the ETP and STP RMZs are summarized in Appendix 10A.

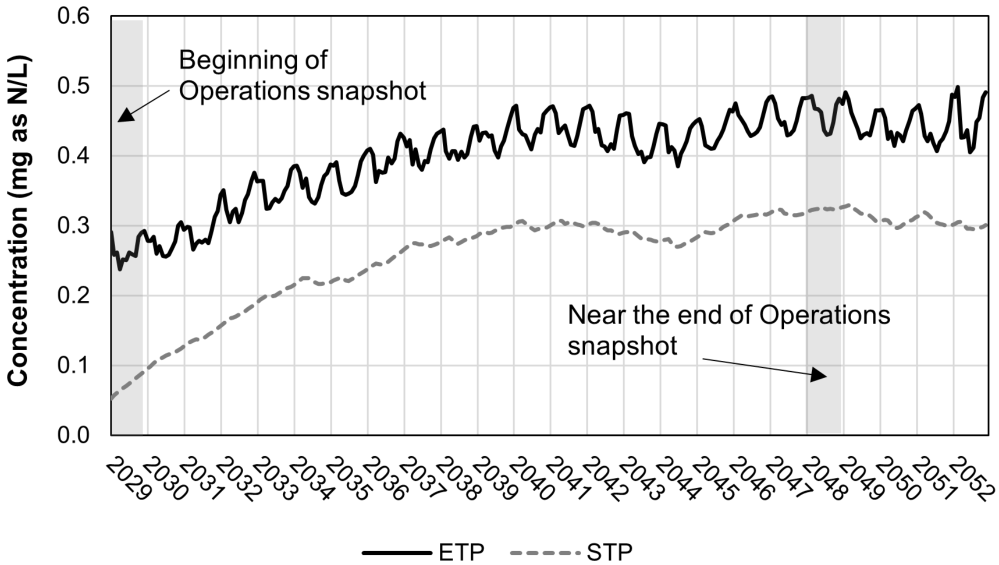
In addition to the potential changes to nutrient concentrations at the edge of the RMZs described above, the effects of treated discharge on dissolved oxygen concentrations at the edge of the RMZ mixing zones were also evaluated (see Section 10.2.8.1.2). The treated discharges are projected to have a negligible effect on ambient dissolved oxygen concentrations, with concentrations at the edge of the RMZs of both ETP and STP discharge locations expected to decrease by less than 0.1 mg/L.

Table 10.5-2: Concentrations of Nutrients in Patterson Lake at the Edge of the Regulated Mixing Zone of the Effluent Treatment Plant and Sewage Treatment Plant

Parameter	Units	Water Quality Threshold for Aquatic and Terrestrial Life	Water Quality Threshold for Drinking Water	Concentration at the Edge of the ETP RMZ		Concentration at the Edge of the STP RMZ	
				Start[(a)]	End[(b)]	Start[(a)]	End[(b)]
Total ammonia (as nitrogen)	mg/L	n/a[(c)]	n/a	0.26	0.47	0.18	0.43
Un-ionized ammonia[(d)] (as nitrogen)	mg/L	0.016	n/a	0.00022	0.00040	0.00016	0.00038
Nitrate (as nitrogen)	mg/L	3.0	10	0.27	0.46	0.070	0.32
Phosphorus	mg/L	0.02	n/a	0.0070	0.010	0.0080	0.011

a) Start of Operations (2029 snapshot).
b) Near the end of Operations (2048 snapshot).
c) Function of un-ionized ammonia, pH, and temperature. Threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia (Table 6, Appendix 10A, Attachment 10A-1).
d) Calculated as a fraction of total ammonia, as a function of pH and temperature. The average seasonal pH and average monthly temperature of individual samples were used to calculate the fraction factor.
n/a = not applicable; RMZ = regulated mixing zone; ETP = effluent treatment plant; STP = sewage treatment plant.

Figure 10.5-3: Concentration of Nitrate in Patterson Lake at the Edge of the Proposed Regulated Mixing Zones of the Effluent Treatment Plant and Sewage Treatment Plant during Operations



Note: The nitrate threshold (3 mg/L as N) is not shown on the figure as it is well above the predicted concentration range.
ETP = effluent treatment plant; STP = sewage treatment plant.

10.5.1.1.3 Trace Metals

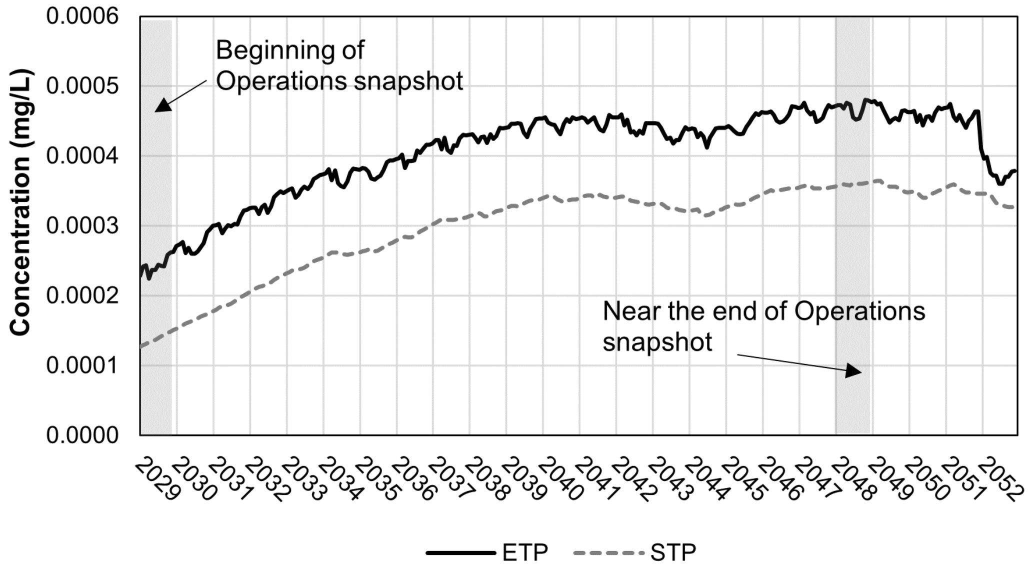
Concentrations of COPC trace metals remained below their thresholds within the RMZ and at the edge of the RMZ at both ETP and STP discharge locations (Table 10.5-3). As noted for COPC major ions and nutrients, COPC metal concentrations increased within the RMZs through Operations as a result of ongoing operational discharge and increased concentrations in the ETP discharge during Operations. These concentrations would also result in the accumulation of mass in Patterson Lake. The change in the concentration of copper, as a representative COPC metal, throughout Operations (i.e., 2029 to 2052) is shown in Figure 10.5-4. Predicted concentrations for COPC trace metals at the edge of the ETP and STP RMZs are summarized in Appendix 10A.

Table 10.5-3: Effluent Concentrations of Trace Metals at the Edge of the Proposed Regulated Mixing Zone of the Effluent Treatment Plant and Sewage Treatment Plant

Parameter	Units	Water Quality Threshold for Aquatic and Terrestrial Life	Water Quality Threshold for Drinking Water	Concentration at the Edge of the ETP RMZ		Concentration at the Edge of the STP RMZ	
				Start[a]	End[b]	Start[a]	End[b]
Aluminum	mg/L	0.1	0.1	0.0070	0.017	0.0040	0.014
Arsenic	mg/L	0.005	0.010	0.0014	0.0038	0.0002	0.0026
Cadmium	mg/L	0.00004	0.007	0.0000070	0.0000090	0.0000070	0.0000090
Chromium	mg/L	0.001	0.05	0.00026	0.00028	0.00026	0.00027
Cobalt	mg/L	0.00078[c]	n/a	0.00019	0.00042	0.00008	0.00031
Copper	mg/L	0.002[d]	2	0.00024	0.00047	0.00014	0.00036
Iron	mg/L	0.3	0.3	0.053	0.050	0.054	0.051
Lead	mg/L	0.001[d]	0.005	0.000059	0.000076	0.000059	0.000076
Manganese	mg/L	0.26[d,e]	0.12	0.018	0.023	0.019	0.024
Mercury	mg/L	0.000026	0.001	0.0000052	0.000013	0.0000031	0.000010
Molybdenum	mg/L	7.6	n/a	0.0003	0.0007	0.0001	0.0005
Nickel	mg/L	0.025[d]	0.07	0.00042	0.00104	0.00013	0.00074
Selenium	mg/L	0.001	0.05	0.000070	0.00010	0.000050	0.000090
Strontium	mg/L	n/a	7	0.042	0.056	0.031	0.048
Total Uranium	mg/L	0.015	0.02	0.00072	0.0018	0.00033	0.0015
Vanadium	mg/L	0.12	n/a	0.00013	0.00027	0.000070	0.00021
Zinc	mg/L	0.007	5	0.00080	0.00088	0.00078	0.00085

a) Start of Operations (2029 snapshot).
b) Near the end of Operations (2048 snapshot).
c) Threshold is based on the federal environmental water quality guideline (FEQG) for cobalt, and is variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).
d) Threshold is hardness-dependent and based on lowest measured ambient hardness condition (refer to Table 10.2-5).
e) Threshold is pH and hardness dependent (refer to Table 10.2-5). Listed threshold is based on a pH guideline range of approximately 7.2 to 7.5 and a hardness range of 10 mg/L to 24 mg/L as $CaCO_3$ (CCME 2023).
n/a = not applicable; RMZ = regulated mixing zone; ETP = effluent treatment plant; STP = sewage treatment plant.

Figure 10.5-4: Concentration of Copper in Patterson Lake at the Edge of the Proposed Regulated Mixing Zone for the the Effluent Treatment Plant and Sewage Treatment Plant during Operations



Note: The copper threshold (0.002 mg/L) is not shown on the figure as it is well above the predicted concentration range.
ETP = effluent treatment plant; STP = sewage treatment plant.

10.5.1.1.4 Radionuclides

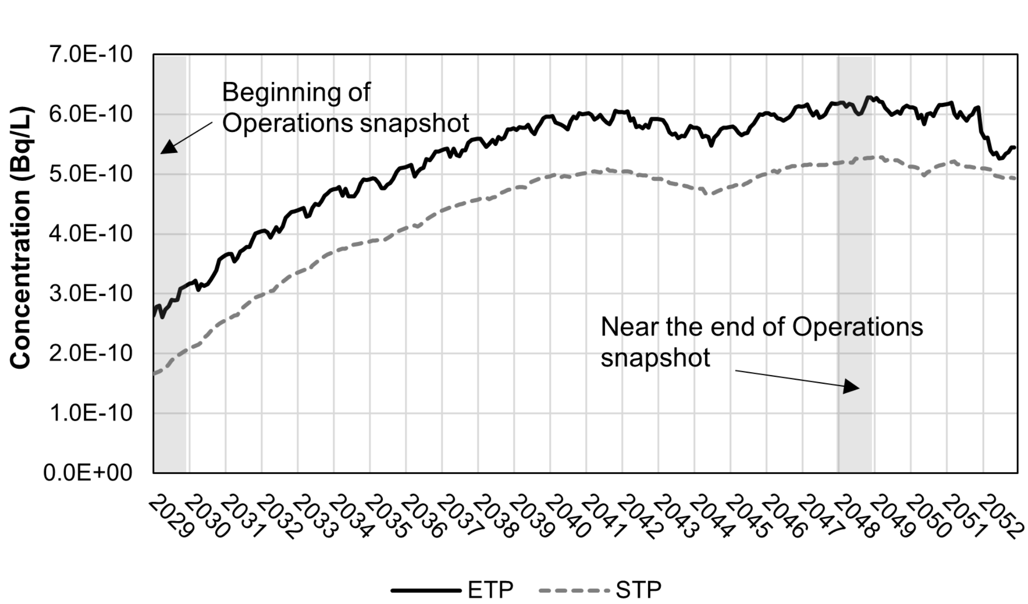
Concentrations of COPC radionuclides (i.e., lead-210, polonium-210, radium-226, and thorium-230) remained below thresholds within the RMZ and at the edge of the RMZ of both ETP and STP discharge locations (Table 10.5-4). As noted for the previous COPCs, COPC radionuclide concentrations increased within the RMZs through Operations as a result of ongoing operational discharge and increased concentrations in the ETP discharge during Operations. These concentrations would also result in the accumulation of mass in Patterson Lake. The change in concentration of radium-226, as a representative COPC radionuclide, throughout Operations (i.e., 2029 to 2052) is shown in Figure 10.5-5. Predicted concentrations for all COPC radionuclides at the edge of the ETP and STP RMZs are summarized in Appendix 10A.

Table 10.5-4: Effluent Concentrations of Radionuclides at the Edge of the Proposed Regulated Mixing Zone of the Effluent Treatment Plant and Sewage Treatment Plant

Parameter	Units	Water Quality Threshold for Aquatic and Terrestrial Life	Water Quality Threshold for Drinking Water	Concentration at the Edge of the ETP RMZ		Concentration at the Edge of the STP RMZ	
				Start[(a)]	End[(b)]	Start[(a)]	End[(b)]
Lead-210	Bq/L	22	n/a	1.8	2.6	1.1	2.1
Polonium-210	Bq/L	13.5	n/a	0.030	0.044	0.019	0.036
Radium-226	Bq/L	0.11	n/a	0.011	0.023	0.0068	0.019
Thorium-230	Bq/L	95	n/a	0.043	0.085	0.011	0.062

a) Start of Operations snapshot (2029).
b) Near the end of Operations snapshot (2048).
Bq/L = becquerels per litre; n/a = not applicable; RMZ = regulated mixing zone; ETP = effluent treatment plant; STP = sewage treatment plant.

Figure 10.5-5: Concentration of Radium-226 in Patterson Lake at the Edge of the Proposed Regulated Mixing Zones of the Effluent Treatment Plant and Sewage Treatment Plant during Operations



Note: The radium-226 threshold (0.11 Bq/L) is not shown on the figure as it is well above the predicted concentration range.
ETP = effluent treatment plant; STP = sewage treatment plant; Bq/L = becquerels per litre.

10.5.1.1.5 Sensitivity Analysis

A sensitivity analysis was completed for the NFWQM to assess the capability of the diffuser designs for the ETP and STP discharges in terms of the dispersion provided, which included reasonable upper bound COPC concentrations in the treated discharges. The same dilution factors were used to predict the concentration at the edge of the RMZs as the Application Case because the changes in treated effluent and treated sewage discharge flow rates and TDS concentration were not found to have an effect on the performance of the ETP diffuser and STP outfall (TSD XX). Therefore, variances in the predicted COPC concentrations at the edge of the RMZs between the Application Case and the reasonable upper bound sensitivity scenario were due to two main factors:

- changes in reasonable upper bound COPC concentrations in treated discharges from the ETP, mainly for chloride, phosphorus, mercury, molybdenum, strontium, uranium, lead-210, and polonium-210; and
- resulting incremental changes in the predicted water quality under the reasonable upper bound sensitivity scenario in Patterson Lake (Section 10.5.1.2.6, Sensitivity Analysis).

The modelled results for the COPC concentrations for the reasonable upper bound sensitivity scenario are provided in Table 10A7.3-3, Appendix 10A, and summarized below:

- Concentrations of COPC major ions (i.e., chloride, sulphate) remained below thresholds at the edge of the RMZs, except for chloride at the edge of the ETP RMZ. The chloride concentration is predicted to be above the threshold of aquatic and terrestrial life (i.e., 120 mg/L) for the last 14 years of Operations (i.e., maximum annual average of 134.9 mg/L) and for the Active Closure Stage (i.e., maximum annual average of 158.2 mg/L). This conservative upper bound scenario is thought to be unlikely but would be used to guide adaptive management of effluent treatment if concentrations trend in this direction over the course of Operations.

- Concentrations of COPC nutrients (i.e., ammonia, phosphorus, nitrate) remained below thresholds at the edge of the RMZs.
- Concentrations of COPC metals remained below thresholds at the edge of the RMZs. Results showed that the concentration of most parameters increased to the end of Operations.
- Concentrations of COPC radionuclides (i.e., lead-210, polonium-210, radium-226, thorium-230) remained below thresholds at the edge of the RMZs.

10.5.1.2 Regional Surface Water Quality Model

Regional surface water quality model results from the Application Case indicated that despite COPC concentrations increasing in the receiving environment due to the Project, concentrations remained below their respective thresholds throughout the lifespan of the Project. In addition, water hardness in the receiving environment is expected to increase during the lifespan of the Project, with a return to baseline conditions following Closure. Changes to hardness in the receiving environment are illustrated in the Hardness figures in Attachment 10-A2 of Appendix 10A. As shown in these figures, the hardness in Patterson Lake North Arm – West Basin is predicted to increase from less than 20 mg/L as $CaCO_3$ under existing conditions to approximately 100 mg/L as $CaCO_3$ during Operations. Increased hardness levels are also predicted in downstream waterbodies, but to a lesser extent with distance downstream. In downstream waterbodies, hardness levels are predicted to increase from less than 20 mg/L as $CaCO_3$ under existing conditions to maximum values of approximately 60 mg/L as $CaCO_3$ in Forrest Lake North Basin and 50 mg/L as $CaCO_3$ in Beet Lake and Naomi Lake. The increase in COPC concentrations and water hardness in the receiving environment is primarily the result of the active ETP and STP discharges to Patterson Lake during Operations.

In the far future, hardness is predicted to return to baseline levels, and most COPC concentrations remained below their respective thresholds, except cobalt and copper (Section 10.5.1.2.3, Trace Metals). Water quality projections for the far future (i.e., after Closure) indicated that COPC concentrations are influenced by climate where concentrations are generally higher during dry years and lower during wet years. Since trends in the far future are closely tied to climate, the trends in the model results are cyclical when the 43-year climate dataset repeats in the RSWQM.

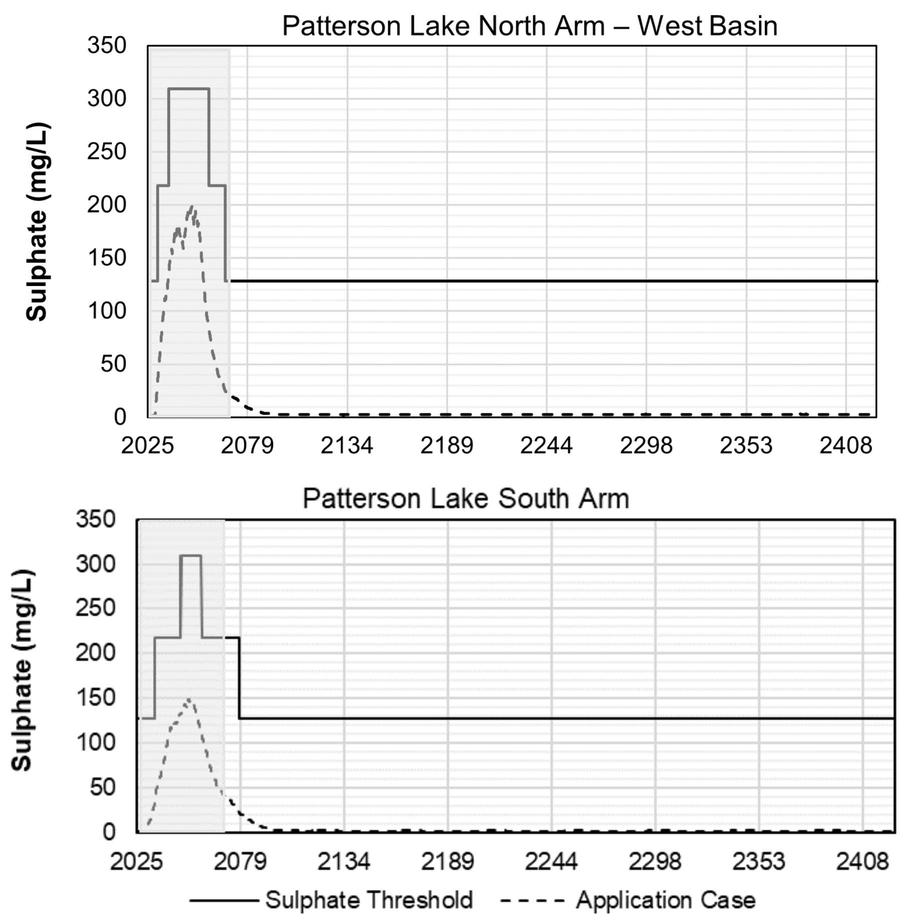
Predicted changes to COPC groups, and specific COPCs, in the regional environment for the Application Case and in the far future are summarized in the following subsections and all concentrations are reported as monthly averages. Time-series trends for all COPCs are plotted in Appendix 10A.

Concentrations of COPCs in Forrest Lake – North Basin tend to fluctuate more than they do in the other waterbodies. This is because Forrest Lake – North Basin contains a relatively small volume of water; therefore, this waterbody is more sensitive to dilutional effects from precipitation and concentration effects from evaporation.

10.5.1.2.1 Major Ions

Concentrations of COPC major ions (i.e., chloride and sulphate) are predicted to remain below thresholds in all waterbodies throughout the lifespan of the Project and in the far future. Concentrations of the COPC major ions would notably increase in Patterson Lake in 2029 at the beginning of Operations when the active discharge of treated effluent commences (e.g., sulphate; Figure 10.5-6). The magnitude of the increase was greatest for sulphate because of the large difference between the baseline sulphate concentration (i.e., 1.5 mg/L) and the average discharge concentration from the ETP (i.e., 2,900 mg/L). The sulphate concentrations entering the ETP are strongly influenced by processing activities (e.g., milling process water). An increase in major ion concentration was noted in all downstream lakes in the LSA, which diminishes with distance downstream. Peak concentrations for all major ions are projected in Patterson Lake North Arm – West Basin at the end of Operations, after slowly increasing throughout the time span when the ETP would be actively discharging. Concentrations would subsequently decrease with the cessation of active mine discharges (e.g., sulphate; Figure 10.5-6). Pseudo-steady-state conditions in the far future would be achieved by approximately 2100.

Figure 10.5-6: Application Case Sulphate Concentration in Patterson Lake North Arm – West Basin and Patterson Lake South Arm



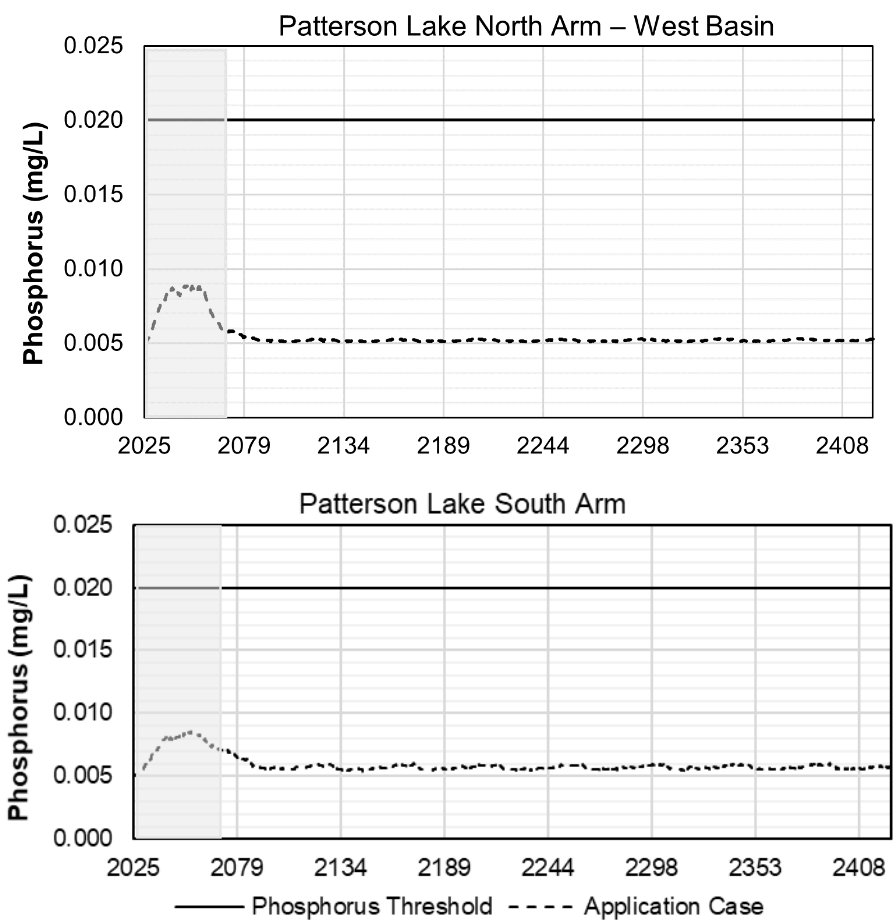
Notes: The sulphate threshold is calculated based on the projected hardness concentration in the waterbody, with threshold values ranging from 128 mg/L to 309 mg/L; see Section 10.2.8.3 for more detail.
The shaded area of the plot is representative of the lifespan of the Project, and the unshaded area is representative of the far-future projection.

10.5.1.2.2 Nutrients

Concentrations of COPC nutrients (i.e., ammonia, nitrate, phosphorus) are predicted to remain below thresholds in all waterbodies throughout the lifespan of the Project and in the far future. An increase in COPC nutrient concentration is noted in Patterson Lake at the beginning of Construction when the discharge of treated sewage effluent would commence in Patterson Lake North Arm – West Basin. Incremental increases in nutrient concentrations are noted in all downstream lakes in the LSA, with concentrations attenuating with distance downstream. Peak nutrient concentrations are observed in Patterson Lake North Arm – West Basin at the end of Operations (e.g., phosphorus; Figure 10.5-7) and concentrations subsequently decrease to Base Case concentrations following the cessation of Project discharges from the ETP and STP. Although concentrations of nutrients would be higher in the treated sewage discharge, the ETP would also provide a relatively high load of nutrients as a result of surface runoff from site sources. With the cessation of nutrient loading following the end of the Project, pseudo-steady-state conditions in the far future would be achieved by approximately 2100. Some residual loading of nutrients associated with site runoff and groundwater inputs to Patterson Lake would remain in the far-future projection.

Peak phosphorus concentrations approach 0.009 mg/L in Patterson Lake North Arm – West Basin at the end of Operations, which attenuates farther through the downstream basins in Patterson Lake, and farther downstream through the waterbodies in the LSA. Patterson Lake South Arm phosphorus concentrations peak near 0.006 mg/L in the far-future projection. Patterson Lake therefore remains oligotrophic with respect to phosphorus and does not change trophic status as a result of the Project.

Figure 10.5-7: Application Case Phosphorus Concentration in Patterson Lake North Arm – West Basin and Patterson Lake South Arm



Note: The shaded area of the plot is representative of the lifespan of the Project, and the unshaded area is representative of the far-future projection.

10.5.1.2.3 Trace Metals

Concentrations of COPC trace metals are predicted to remain below thresholds in all waterbodies throughout the lifespan of the Project. Except for cobalt and copper, all other COPC metals are predicted to remain below their thresholds in the far future.

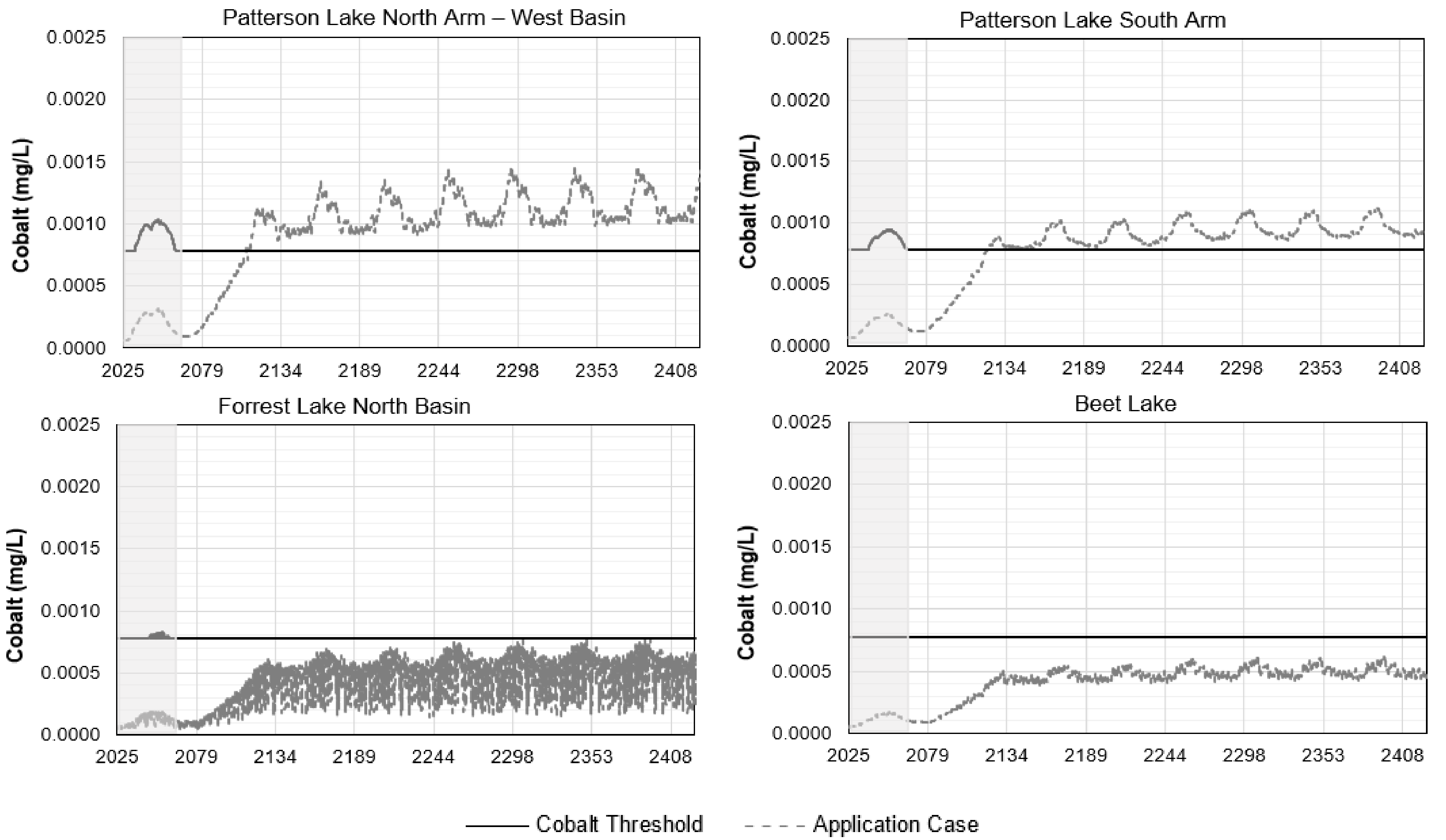
Concentrations of COPC metals would begin to increase in Patterson Lake in 2029 when active Project discharge commences at the start of Operations, which attenuates through the downstream waterbodies in the LSA. The primary source of metal loading to Patterson Lake would be the process plant via the treated effluent discharge from the ETP. As noted for COPC major ions and nutrients, COPC metal concentrations would peak in Patterson Lake North Arm – West Basin at the end of Operations.

In the far future, COPC metal concentrations would either increase or decrease compared to the Project phases before reaching a pseudo-steady-state concentration. For example, aluminum, cobalt, copper, iron, manganese, molybdenum, nickel, selenium, uranium, and zinc concentrations would be higher in the far future compared to their concentrations during the lifespan of the Project. The primary sources of mass loading of COPC metals in the far future would be the seepage load from the reflooded mine workings, primary backfill, secondary backfill, and UGTMF (i.e., underground workings) and PAG WRSA to groundwater inflows. Since the model input climate dataset cycles every 43 years (Section 10.2.8.1.3, Regional Surface Water Quality Model), the far-future metal trends in the model output also demonstrate cyclical trends that repeat throughout each climate cycle. Metal concentrations would generally be greatest during dry climate years and lowest during wet climate years when there would be higher natural runoff into the lake.

Although some metals are predicted to increase in concentration in the far future (i.e., after Closure), cobalt and copper are the only COPC metals that are anticipated to exceed thresholds. In the far future, the average monthly cobalt concentrations are predicted to consistently exceed the threshold value in Patterson Lake North Arm – West Basin and Patterson Lake South Arm (i.e., peaking at 0.0015 mg/L and 0.0011 mg/L, respectively: Figure 10.5-8). Cobalt concentrations would begin to increase in these basins following Closure when the ETP stops actively discharging and mass loadings from the groundwater increase. It would take approximately 50 years for the concentrations to exceed the threshold in Patterson Lake North Arm – West Basin and approximately 60 years to exceed the threshold in Patterson Lake South Arm. As noted in Section 10.2.4, the modelling timeframe for the far-future projection consists of a 157-year period that considers the hydrogeological processes from the site followed by 200 years where the hydrogeological mass load inputs are artificially increased in the RSWQM to incorporate maximum loadings in a timeframe that is more readily modelled.

In the far future, copper threshold exceedances are predicted periodically in Patterson Lake North Arm – West Basin (Figure 10.5-9). Similar to the trends noted for cobalt, the copper concentration in Patterson Lake would begin to increase after Closure due to influx of mass load inputs from groundwater that has been primarily affected by seepage inputs from the PAG WRSA. It would take approximately 90 years before an exceedance in copper is anticipated in Patterson Lake North Arm – West Basin (i.e., 2159) and the predicted concentrations fluctuate above and below the threshold for the remainder of the far-future projection as the climate dataset cycles through the model (peaking at 0.0024 mg/L; Figure 10.5-9). The duration of the exceedances increases in the 200-year interval after the maximum groundwater loadings are applied to the model. No copper exceedances are predicted in the waterbodies downstream of Patterson Lake North Arm – West Basin. As described further in Section 10.7, the predicted concentrations of cobalt and copper are thought to result from conservative assumptions and form the basis for an Adaptive Management Plan that would be applied throughout Operations to protect aquatic health in Patterson Lake and downstream lakes at Closure.

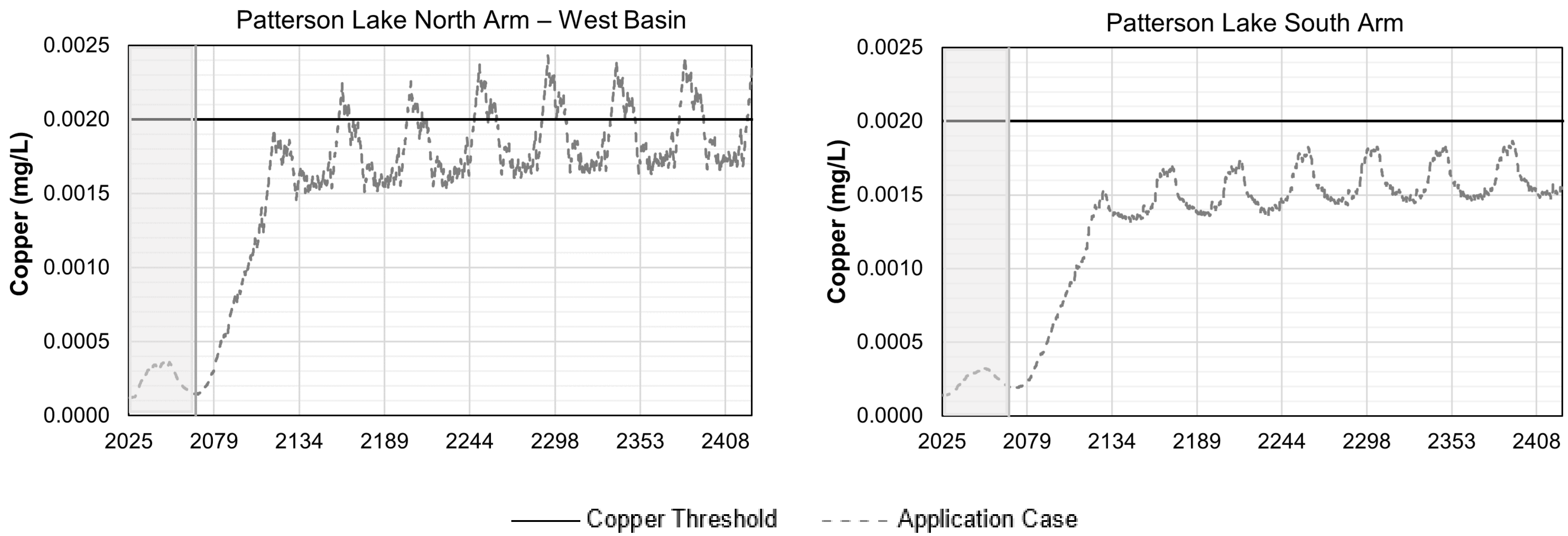
Figure 10.5-8: Application Case Cobalt Concentration in Patterson Lake North Arm – West Basin, Patterson Lake South Arm, Forrest Lake – North Basin, and Beet Lake



Note: The cobalt threshold is calculated based on the projected hardness concentration in each waterbody, with threshold values ranging from 0.00078 mg/L to 0.0010 mg/L; see Section 10.2.8.3 for more detail.

The shaded area of the plot is representative of the lifespan of the Project, and the unshaded area is representative of the far-future projection.

Figure 10.5-9: Application Case Copper Concentration in Patterson Lake North Arm – West Basin and Patterson Lake South Arm

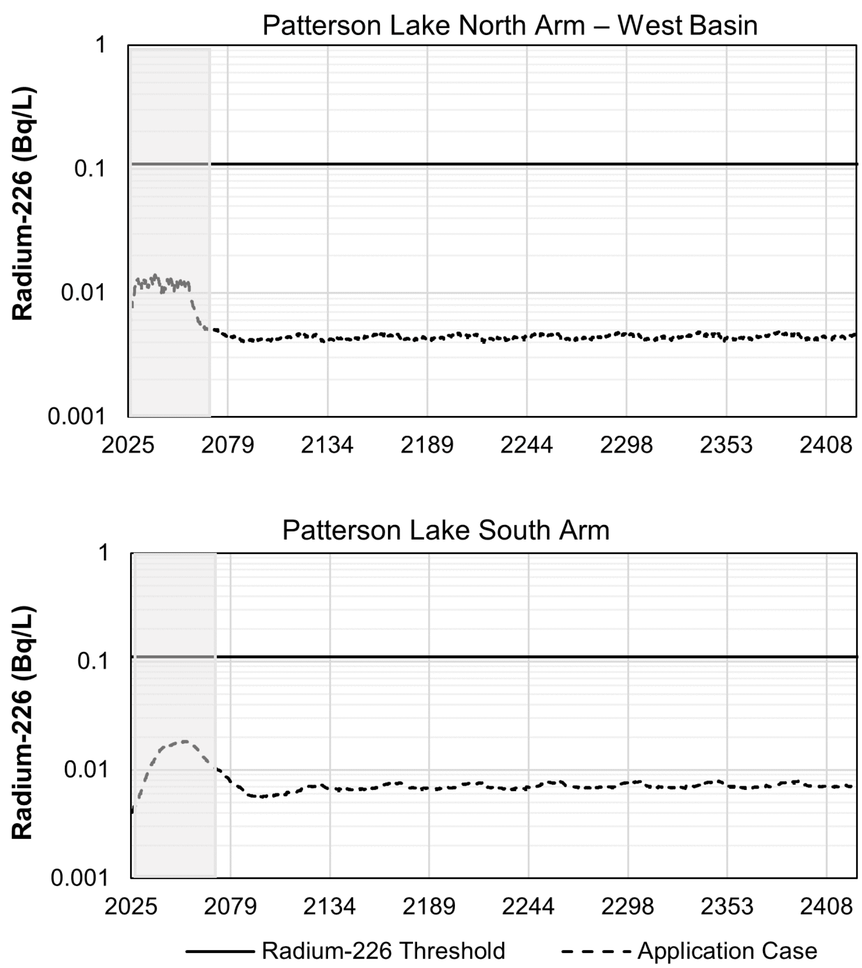


Note: The shaded area of the plot is representative of the lifespan of the Project, and the unshaded area is representative of the far-future projection.

10.5.1.2.4 Radionuclides

Concentrations of COPC radionuclides (i.e., lead-210, polonium-210, radium-226, thorium-230) are predicted to remain below Project thresholds in all waterbodies throughout the Project phases and in the far future. Radionuclide concentrations were predicted to increase in Patterson Lake in 2029 when active Project discharges commence at the beginning of Operations. The occurrence of peak concentrations at this time would propagate downstream through the waterbodies in the LSA (i.e., to Naomi Lake) but diminish in relative magnitude. The primary source of radionuclides to Patterson Lake would be the treated effluent discharge associated with groundwater pumped to surface from mining activities and collection of contact water from the PAG WRSA and ore storage stockpile at the surface. Peak COPC radionuclide concentrations are noted in Patterson Lake in 2052 in the final year of discharge, after which concentrations decrease in Patterson Lake and all downstream waterbodies reach a pseudo-steady-state concentration by approximately 2100 (e.g., radium-226; Figure 10.5-10).

Figure 10.5-10: Application Case Radium-226 Concentration in Patterson Lake North Arm – West Basin and Patterson Lake South Arm



Note: The shaded area of the plot is representative of the lifespan of the Project, and the unshaded area is representative of the far-future projection.

Bq/L = becquerels per litre.

10.5.1.2.5 Atmospheric Deposition

Results from the atmospheric deposition assessment (Appendix 7A) for the Application Case indicate that effects solely from air deposition would be localized and result in minor changes to COPC concentrations and TSP in Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2. These effects were limited to the lifespan of the Project and associated with Project air emissions during Operations.

The increase in COPC concentrations in Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2 from air deposition in the Application Case relative to the Base Case was minor and did not result in any COPC threshold exceedances (Table 10.5-5). The COPCs with the greatest predicted concentration increase relative to the Base Case were mercury, polonium-210, radium-226, thorium-230, and uranium (Table 10.5-5). The largest increases in COPC concentration based on maximum predicted monthly average concentrations were observed in Unnamed Lake 2, followed by Lake E, Lake C, and Unnamed Lake 1. The larger increases predicted in Unnamed Lake 2 were attributed to this waterbody being in the predominant downwind direction from the Project site. The mercury air deposition concentration calculated from the air quality dispersion model was below the detection limit for all lakes, so the source input to the deposition assessment for mercury was set at the detection limit, meaning there is some uncertainty with mercury concentration projections; however, these concentrations are likely to be lower than predicted (i.e., a conservative assumption).

Additional context regarding the air quality dispersion model is provided in Section 7.2, Air Quality. Detailed results of the atmospheric deposition assessment in the RSWQM are presented in Appendix 10A.

Table 10.5-5: Maximum Predicted Water Quality Concentrations as a Result of Atmospheric Deposition in Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2 for the Application Case

Constituent	Units	COPC Threshold	Base Case Concentration	Maximum Predicted Monthly Average Concentration during Lifespan of the Project			
				Lake C	Lake E	Unnamed Lake 1	Unnamed Lake 2
Mercury	mg/L	0.000026	0.0000015	0.0000031	0.0000035	0.0000034	0.0000053
Uranium	mg/L	0.015	0.000056	0.00015	0.00024	0.00014	0.00027
Lead-210	Bq/L	22	0.012	0.013	0.015	0.013	0.015
Polonium-210	Bq/L	13.5	0.0043	0.0078	0.012	0.0094	0.013
Radium-226	Bq/L	0.11	0.0033	0.0047	0.0062	0.0041	0.0062
Thorium-230	Bq/L	95	0.0052	0.0066	0.0081	0.0060	0.0081

COPC = constituent of potential concern; Bq/L = becquerels per litre.

The results of the desktop analysis undertaken to estimate the average annual incremental increase in TSS due to the aerial deposition (Section 10.2.8.1.3.1, Atmospheric Deposition) showed that the maximum predicted incremental increase in TSS concentration in Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2 during the lifespan of the Project is well under 0.1 mg/L and therefore not expected to be measurable. The estimated incremental TSS increase in the small lakes are as follows:

- Lake C – 0.01 mg/L
- Lake E – 0.031 mg/L
- Unnamed Lake 1 – 0.013 mg/L
- Unnamed Lake 2 – 0.033 mg/L

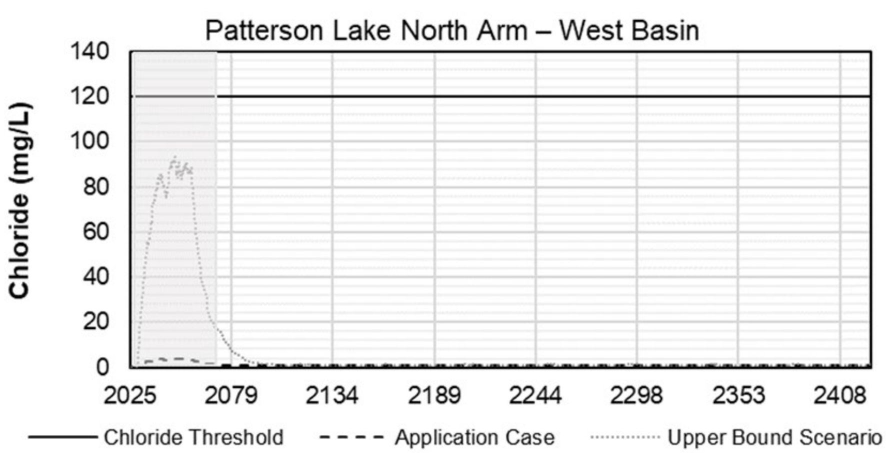
These results suggest that the deposition of TSP from the air emissions from the Project to small lakes in the LSA near the Project is expected to have negligible effects on ambient TSS concentrations.

10.5.1.2.6 Sensitivity Analysis

The reasonable upper bound sensitivity scenario used upper bound inputs from the integrated models supporting the RSWQM and was completed to provide a sensitivity assessment to model inputs for the Application Case. Results from the reasonable upper bound sensitivity scenario in the RSWQM indicated that all modelled COPCs remained below thresholds throughout the lifespan of the Project when the ETP and STP would be active. In the far-future projection, COPCs remained below their respective thresholds, except cobalt and copper. Cobalt exceedances are noted throughout the LSA (i.e., Patterson Lake North Arm – West Basin to Beet Lake). Copper exceedances are only noted in Patterson Lake North Arm – West Basin and Patterson Lake South Arm. Detailed results and time series plots of COPCs for the RSWQM are presented in Appendix 10A.

Concentrations of COPC major ions in the reasonable upper bound sensitivity scenario are predicted to be below thresholds throughout the Project lifespan and in the far-future projection. The modelled differences in sulphate concentrations and hardness (i.e., primarily calcium and magnesium) values between the modelled Application Case and the upper bound scenario are small because their primary source of loading is from the process plant and this input does not vary between the Application Case and reasonable upper bound sensitivity scenario. However, the modelled differences in chloride concentrations between the modelled Application Case and the upper bound scenario was large. Average monthly predicted chloride concentrations during Operations for the Patterson Lake North Arm – West Basin are 22 times higher in the reasonable upper bound sensitivity scenario compared to the Application Case (Figure 10.5-11). The primary loading source of chloride to the North Arm – West Basin would be from groundwater collected from the underground, transferred to the surface and treated, and subsequently discharged as treated effluent to Patterson Lake during Operations, and the chloride concentration input from this source varies between the Application Case and reasonable upper bound sensitivity scenario.

Figure 10.5-11: Chloride Concentration in Patterson Lake North Arm – West Basin for the Application Case and Reasonable Upper Bound Sensitivity Scenario

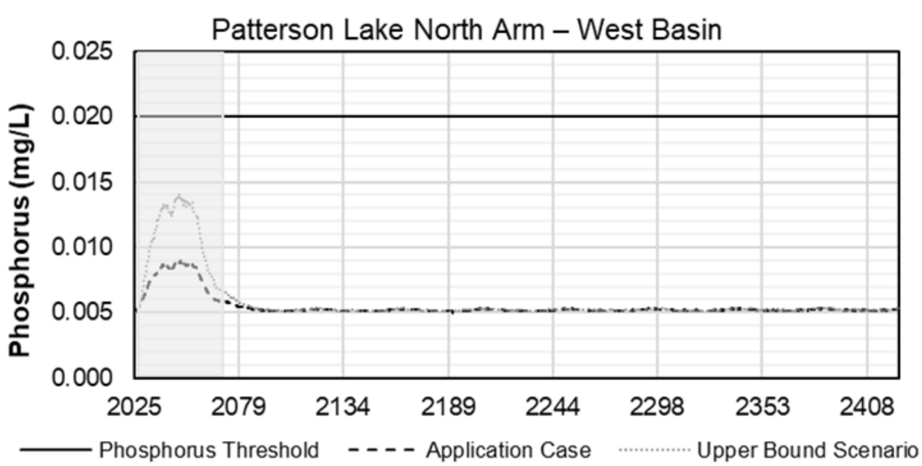


Note: The shaded area of the plot is representative of the lifespan of the Project, and the unshaded area is representative of the far-future projection.

In the reasonable upper bound sensitivity scenario, COPC nutrient concentrations are predicted to remain below thresholds in all waterbodies in the LSA throughout the Project lifespan and in the far future. Concentration trends over time for COPC nutrients are similar to the Application Case, where an increase in concentration is noted in Patterson Lake at the start of Construction (i.e., nominally 2025 for the purpose of modelling), which propagates to all downstream waterbodies in the LSA. Total ammonia and nitrate concentration trends are similar between the modelled Application Case and the reasonable upper bound sensitivity scenario. This similarity is because the primary sources of these COPCs (i.e., treated sewage and explosive blasting residuals) and their source term concentrations in the Application Case and the reasonable upper sensitivity scenario are similar. However, peak average monthly phosphorus concentrations in Patterson Lake during Operations in the reasonable upper bound sensitivity scenario are approximately 1.4 times higher than the Application Case (Figure 10.5-12) because of the increase in source term concentrations used for the WRSAs, ore stockpile, and special waste stockpile in the SWWBM.

For the reasonable upper bound sensitivity scenario, Patterson Lake North Arm – West Basin and Patterson Lake South Arm may temporarily shift trophic state from oligotrophic to mesotrophic during the lifespan of the Project. The maximum phosphorus concentration in the North Arm – West Basin and South Arm of Patterson Lake is predicted to be 0.014 mg/L and 0.012 mg/L, respectively. The downstream waterbodies would remain oligotrophic throughout all the Project phases (i.e., productivity status does not change). The North Arm – West Basin and South Arm of Patterson Lake are projected to be in a mesotrophic status for 27 years (2033 to 2060) and 25 years (2040 to 2065), respectively. The productivity status in all waterbodies would return to oligotrophic in the far future. Note, however, that the modelling considered conservative phosphorus inputs in the discharge from the Project and did not account for in-lake sinks and settlement of inorganic and organic forms of phosphorus; therefore, basin-wide concentrations are likely overestimated.

Figure 10.5-12: Phosphorus Concentration in Patterson Lake North Arm – West Basin for the Application Case and Reasonable Upper Bound Sensitivity Scenario

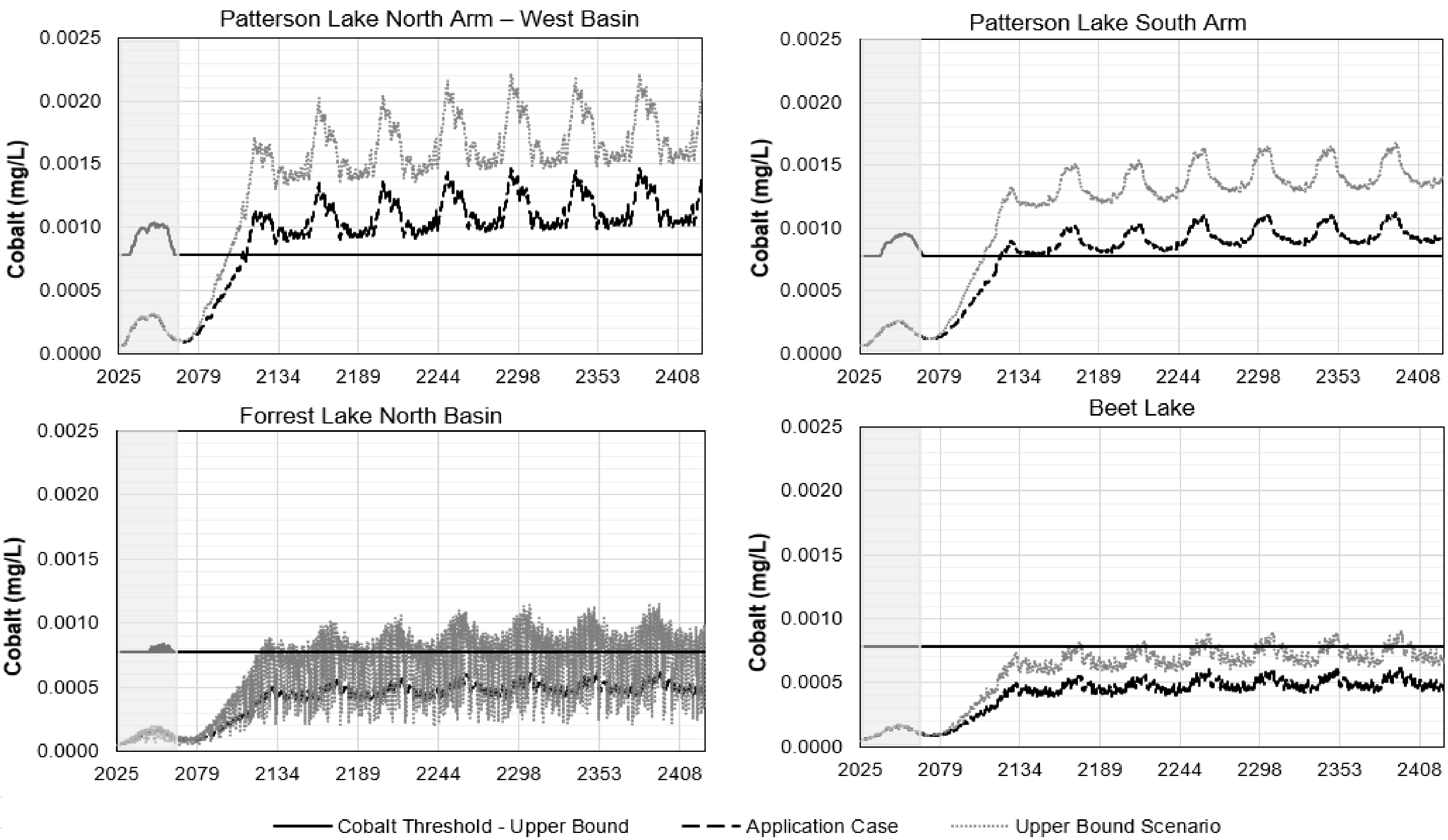


Note: The shaded area of the plot is representative of the lifespan of the Project, and the unshaded area is representative of the far-future projection.

Concentrations of COPC metals in the reasonable upper bound sensitivity scenario are predicted to remain below thresholds in all waterbodies in the LSA throughout the lifespan of the Project. Most COPC metals remained below thresholds in the far-future projection, except cobalt and copper. In general, COPC metal concentrations and trends during the lifespan of the Project under the reasonable upper bound sensitivity scenario were similar to those in the Application Case. This similarity is because the primary source of metals in ETP discharges to Patterson Lake would be from the process plant and metals concentrations are similar between the Application Case and reasonable upper bound scenario (TSD XVIII). One notable exception is uranium, where the average monthly uranium concentration in Patterson Lake North Arm – West Basin is approximately two times higher in the reasonable upper bound sensitivity scenario. This increase is primarily due to the difference in source term concentration for contact water from the ore storage stockpile between the Application Case and the reasonable upper bound sensitivity scenario.

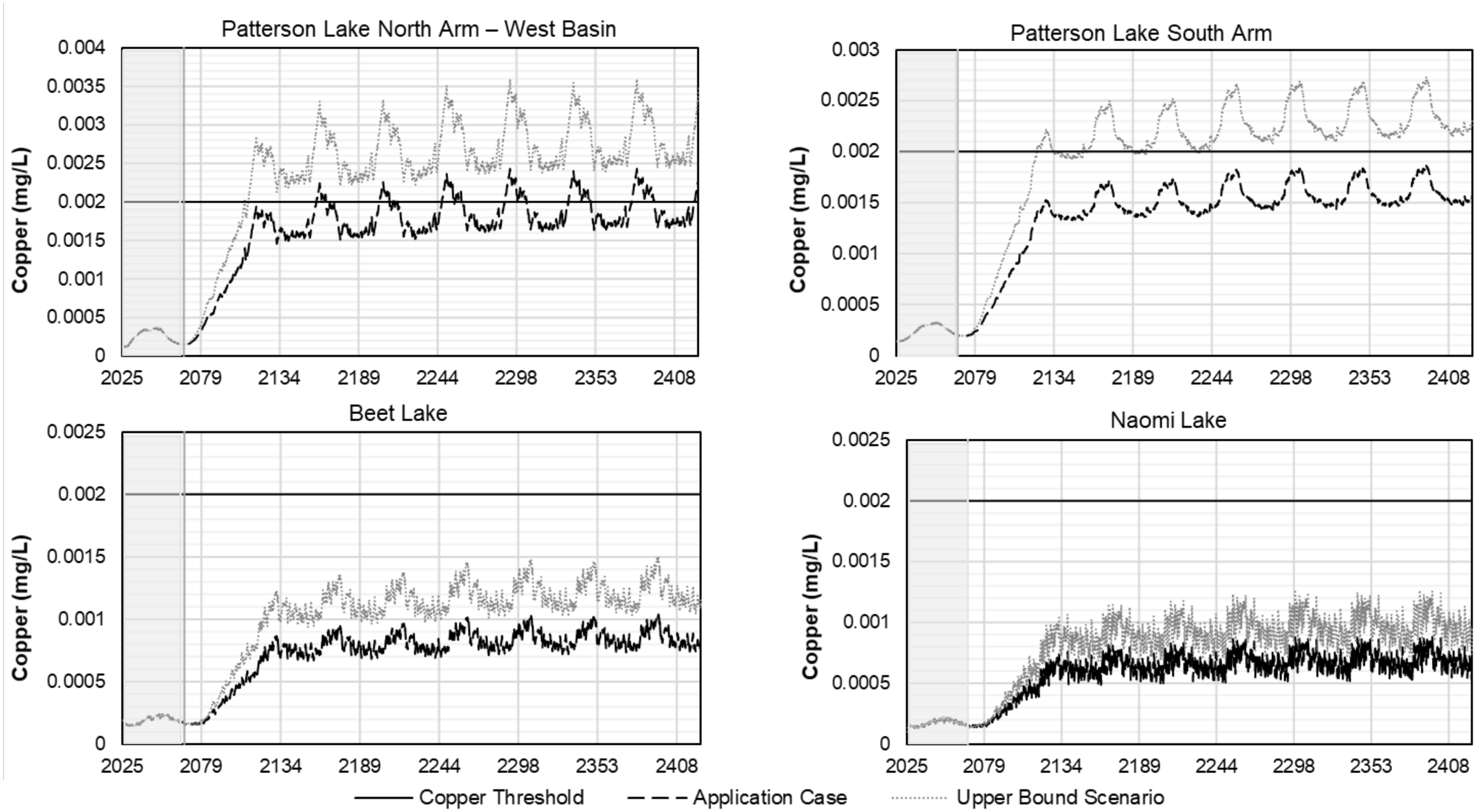
In the far-future projection, COPC metal concentrations in the reasonable upper bound sensitivity scenario were predicted to be up to 3.8 times higher, depending on the COPC metal, than the projected concentrations in the Application Case. The greatest differences were noted for lead and molybdenum. Similar to the Application Case, aluminum, cadmium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, uranium, and zinc concentrations would increase in the waterbodies downstream of the Project through the LSA in the far future before reaching a pseudo-steady-state. Although these COPC metal concentrations are predicted to be higher in the far future in the reasonable upper bound scenario, cobalt and copper remained the only COPCs that exceeded thresholds. The magnitude of the cobalt and copper exceedances in downstream waterbodies is greater in the reasonable upper bound sensitivity scenario compared to the Application Case (Figure 10.5-13 and Figure 10.5-14). Peak cobalt and copper concentrations in Patterson Lake and downstream waterbodies were 1.4 to 1.5 greater in the reasonable upper bound scenario compared to the Application Case.

Figure 10.5-13: Cobalt Concentration in Patterson Lake North Arm – West Basin, Patterson Lake South Arm, Forrest Lake – North Basin, and Beet Lake for the Application Case and Reasonable Upper Bound Sensitivity Scenario



Note: The cobalt threshold is calculated based on the projected hardness concentration in the waterbody, with threshold values ranging from 0.00078 mg/L to 0.0010 mg/L; see Section 10.2.8.3 for more detail.
The shaded area of the plot is representative of the Project lifespan, and the un-shaded area is representative of the far future.

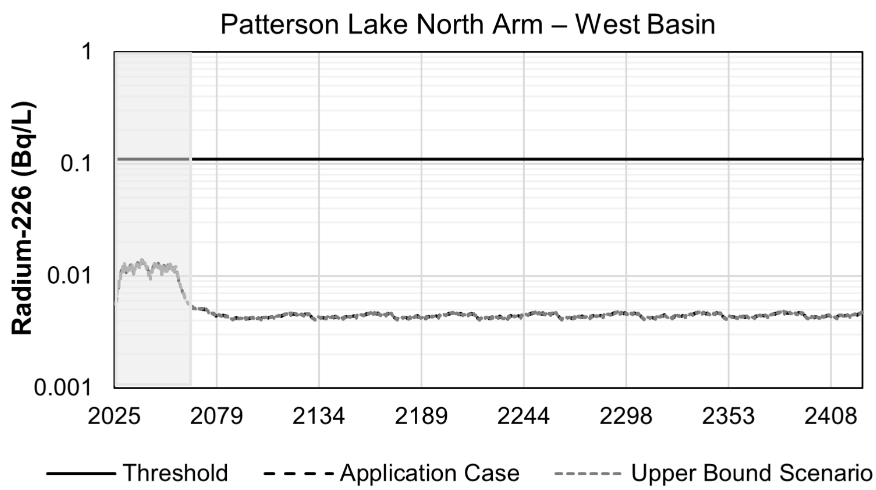
Figure 10.5-14: Copper Concentration in Patterson Lake North Arm – West Basin, Patterson Lake South Arm, Beet Lake, and Naomi Lake for the Application Case and Reasonable Upper Bound Sensitivity Scenario



Note: The shaded area of the plot is representative of the lifespan of the Project, and the unshaded area is representative of the far-future projection.

Concentrations of COPC radionuclides in the reasonable upper bound sensitivity scenario are predicted to remain below thresholds in all waterbodies throughout the lifespan of the Project and in the far-future projection. Concentration trends for radionuclides in the reasonable upper bound sensitivity scenario are similar to the Application Case, where concentrations increased steadily throughout Operations and peak concentrations occurred in Patterson Lake North Arm – West Basin in 2051 near the end of Operations (Figure 10.5-15). The changes to COPC concentrations are propagated downstream and attenuate through downstream waterbodies in the LSA (i.e., to Naomi Lake). Concentrations for all COPC radionuclides decreased in the far future and achieved pseudo-steady-state concentrations by approximately 2100.

Figure 10.5-15: Radium-226 Concentration in Patterson Lake North Arm – West Basin for the Application Case and Reasonable Upper Bound Sensitivity Scenario



Note: The shaded area of the plot is representative of the lifespan of the Project, and the unshaded area is representative of the far-future projection.
Bq/L = becquerels per litre.

10.5.2 Reasonably Foreseeable Development Case

The RFD Case includes the Application Case plus the planned Fission Patterson Lake South Property. This reasonably foreseeable mining development would be located on the west shore of Patterson Lake at the most westerly point where the North Arm and South Arm meet and would withdraw fresh water from Patterson Lake North Arm – West Basin and discharge treated effluent and treated sewage to Patterson Lake South Arm (Fission 2019, 2021). Surface runoff from a covered waste rock storage facility and an above-ground tailings management facility would be directed to the North Arm – West Basin and South Arm, respectively. The Fission Patterson Lake South Property is assumed to commence in 2025, with a three-year construction period followed by a six-year operations period and a five-year closure/decommissioning period (Section 10.2.5).

The RFD Case includes an assessment of effects on surface water quality from direct discharges to Patterson Lake from the ETP and STP from the Project and the Fission Patterson Lake South Property, and site surface runoff and deposition of aerial emissions from both developments. The effects of seepages from the UGTMF to groundwater associated with the Project during the lifespan of the Fission Patterson Lake South Property is also included in the assessment. Detailed results and time series plots for all COPCs for the RFD Case are presented in Appendix 10A.

10.5.2.1 Regional Surface Water Quality Model

Results from the RSWQM for the RFD Case indicate that there are no additional COPC threshold exceedances beyond cobalt and copper during the lifespan of the Project and in the far-future projection as a result of the cumulative effects from the Project and the Fission Patterson Lake South Property. Like the Application Case, all modelled COPCs remain below their respective thresholds throughout the Project phases, with cobalt and copper modelled above thresholds in the far future.

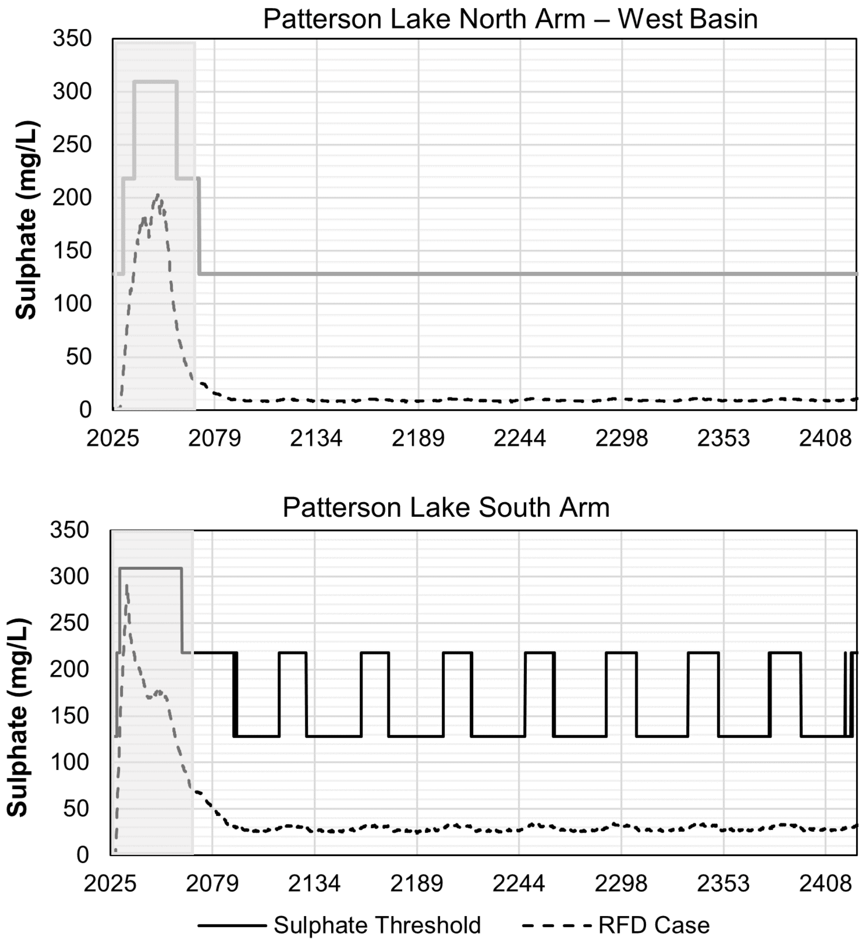
Predicted COPC concentrations in the regional environment are summarized in the following subsections, and all concentrations are presented as monthly averages.

10.5.2.1.1 Major Ions

In the RFD Case, concentrations of COPC major ions are predicted to remain below thresholds in all waterbodies throughout the lifespan of the Project and in the far-future projection. As in the Application Case, modelled concentrations of the COPC major ions would increase in Patterson Lake in 2029 at the beginning of Project Operations when the active discharge of treated effluent commences (e.g., sulphate; Figure 10.5-16). No substantial changes are predicted in Patterson Lake North Arm – East Basin and West Basin in the RFD Case compared to the Application Case. Peak concentrations for all major ions are predicted in Patterson Lake North Arm – West Basin at the end of Project Operations, after slowly increasing throughout the time span when the ETP would be actively discharging. Concentrations would subsequently decrease with the cessation of active mine discharges (e.g., sulphate; Figure 10.5-16). Pseudo-steady-state conditions in the far future would be achieved by approximately 2100. The concentrations of COPC major ions in Patterson Lake in the far future would be slightly higher in the RFD Case compared to the Application Case. This increase is due to the addition of major ion loadings to Patterson Lake South Arm from the Fission Patterson Lake South Property above-ground tailings management facility and covered waste rock storage facility site runoff, which would attenuate downstream in the LSA.

Concentrations of major ions in Patterson Lake South Arm, in terms of magnitude and timing, would differ from the Application Case because of effects from the Fission Patterson Lake South Property. Concentrations are predicted to be greatest in Patterson Lake South Arm during the Fission Patterson Lake South Property operational period, where treated effluent discharge and runoff from the above-ground tailings management facility would be directed. A distinct initial peak in COPC major ion concentrations is noted in 2033 in Patterson Lake South Arm at the end of the Fission Patterson Lake South Property operations when site discharges are expected to cease (e.g., sulphate, up to 290 mg/L; Figure 10.5-16). The initial peak is predicted to occur at this time because combined inputs from both projects accumulate loads and concentrations in the lake over time, which then begin to briefly decline as soon as the Fission Patterson Lake South Property operations ceases discharge. Compared to the Application Case, this peak is due to the additional influence on COPC major ion concentrations in Patterson Lake North Arm – West Basin as a result of surface runoff from the Fission Patterson Lake South Property covered waste rock storage facility. A smaller, secondary peak is noted in 2052 for all COPC major ions; the timing of this peak is consistent with the Application Case, coinciding with the end of Project Operations (Figure 10.5-16). The influence of the Fission Patterson Lake South Property on this peak with respect to sulphate is predicted to be an incremental increase of approximately 25 mg/L. The cumulative effects from the Project and the Fission Patterson Lake South Property would be propagated downstream and would be noted in all downstream lakes in the LSA (i.e., to Naomi Lake) but diminish in relative magnitude with both distance and time.

Figure 10.5-16: Reasonably Foreseeable Development Case Sulphate Concentration in Patterson Lake North Arm – West Basin and Patterson Lake South Arm



Note: The sulphate threshold is calculated based on the projected hardness concentration in the waterbody, with threshold values ranging from 128 mg/L to 309 mg/L; see Section 10.2.8.3 for more detail.
The shaded area of the plot is representative of the lifespan of the Project, and the unshaded area is representative of the far-future projection.
RFD = reasonably foreseeable development.

10.5.2.1.2 Nutrients

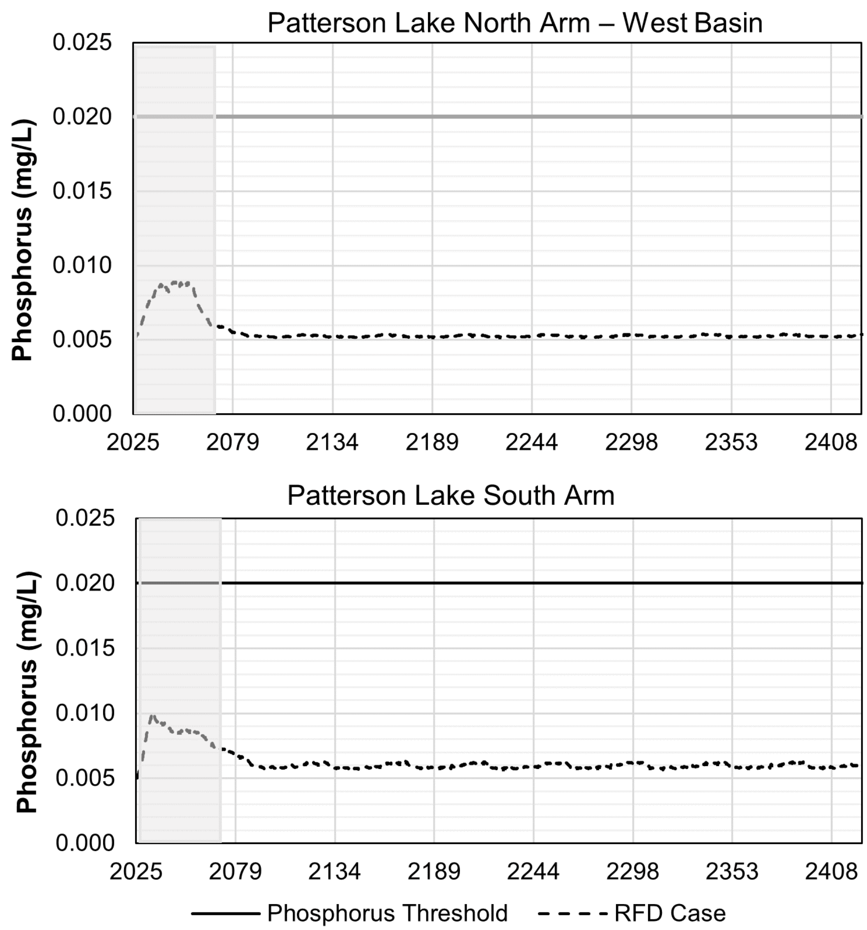
In the RFD Case, concentrations of COPC nutrients (i.e., ammonia, nitrate, phosphorus) are predicted to remain below thresholds in all waterbodies throughout the lifespan of the Project and the far-future projection. As in the Application Case, an increase in COPC nutrient concentration is noted in Patterson Lake at the beginning of Project Construction when the discharge of treated sewage effluent is anticipated to commence in Patterson Lake North Arm – West Basin. Peak nutrient concentrations are noted at the end of Project Operations (phosphorus; Figure 10.5-17) and concentrations are subsequently expected to decrease to Base Case concentrations following the cessation of Project discharges from the ETP and STP. Incremental increases in nutrient concentrations are predicted to be noted in all downstream lakes in the LSA, with concentrations attenuating with distance downstream. Like the Application Case, pseudo-steady-state conditions in the far-future projection would be achieved by approximately 2100.

In terms of magnitude and timing, concentrations of COPC nutrients in Patterson Lake South Arm differ from the Application Case because of effects from the treated effluent and treated domestic sewage discharges from Fission Patterson Lake South Property into this region of Patterson Lake. Concentrations are expected to be greatest in Patterson Lake South Arm during the Fission Patterson Lake South Property operational period. An initial peak in COPC nutrient concentrations is noted at the end of the Fission Patterson Lake South Property operations period at the point when the treated effluent and treated sewage discharges from the Fission Patterson Lake South Property is anticipated to cease (e.g., phosphorus; Figure 10.5-17). A smaller, secondary peak is noted in 2052 at the end of Project Operations, consistent with the predicted trends for the Application Case (Figure 10.5-17). The elevated COPC nutrient concentration effects would be propagated downstream through all downstream lakes in the LSA (i.e., to Naomi Lake), but attenuate in relative magnitude.

The peak phosphorus concentration in Patterson Lake South Arm at the end of the Fission Patterson Lake South Property operations period is anticipated to briefly reach the oligotrophic/mesotrophic trophic status boundary (i.e., 0.010 mg/L; Figure 10.5-17). Despite the peak concentration in Patterson Lake South Arm briefly reaching the phosphorus threshold, Patterson Lake and the downstream LSA waterbodies are projected to remain oligotrophic during the lifespan of the Project.

Similar to the COPC major ion trends, COPC nutrient concentrations in the far-future projection are predicted to be slightly higher in the RFD Case compared to the Application Case, but the increase is small. For example, pseudo-steady-state phosphorus concentrations are consistently less than 0.001 mg/L higher in Patterson Lake South Arm in the far future in the RFD Case compared to the Application Case, with concentrations peaking near 0.006 mg/L. The slight increase in COPC concentrations in the far future is because of the anticipated additional nutrient loadings to Patterson Lake from the Fission Patterson Lake South Property above-ground tailings management facility and covered waste rock storage facility site runoff after closure. Despite the small increase in phosphorus concentrations in the far future, the trophic state of Patterson Lake would remain oligotrophic.

Figure 10.5-17: Reasonably Foreseeable Development Case Phosphorus Concentration in Patterson Lake North Arm – West Basin and Patterson Lake South Arm



Note: The shaded area of the plot is representative of the lifespan of the Project, and the unshaded area is representative of the far-future projection.

RFD = reasonably foreseeable development.

10.5.2.1.3 Trace Metals

In the RFD Case, concentrations of COPC trace metals are predicted to remain below thresholds in all waterbodies throughout the lifespan of the Project. All COPC metals, except for cobalt and copper, are predicted to remain below their thresholds in the far-future projection. Similar to the Application Case, COPC metal concentrations are predicted to begin to increase in Patterson Lake North Arm – West Basin in 2029 when active Project discharge commences, and peak at the end of Operations.

The projected cobalt and copper concentrations and trends in the far future are very similar to the Application Case because the primary loading source of these constituents in the far future would be from the groundwater inflows to Patterson Lake from the Project.

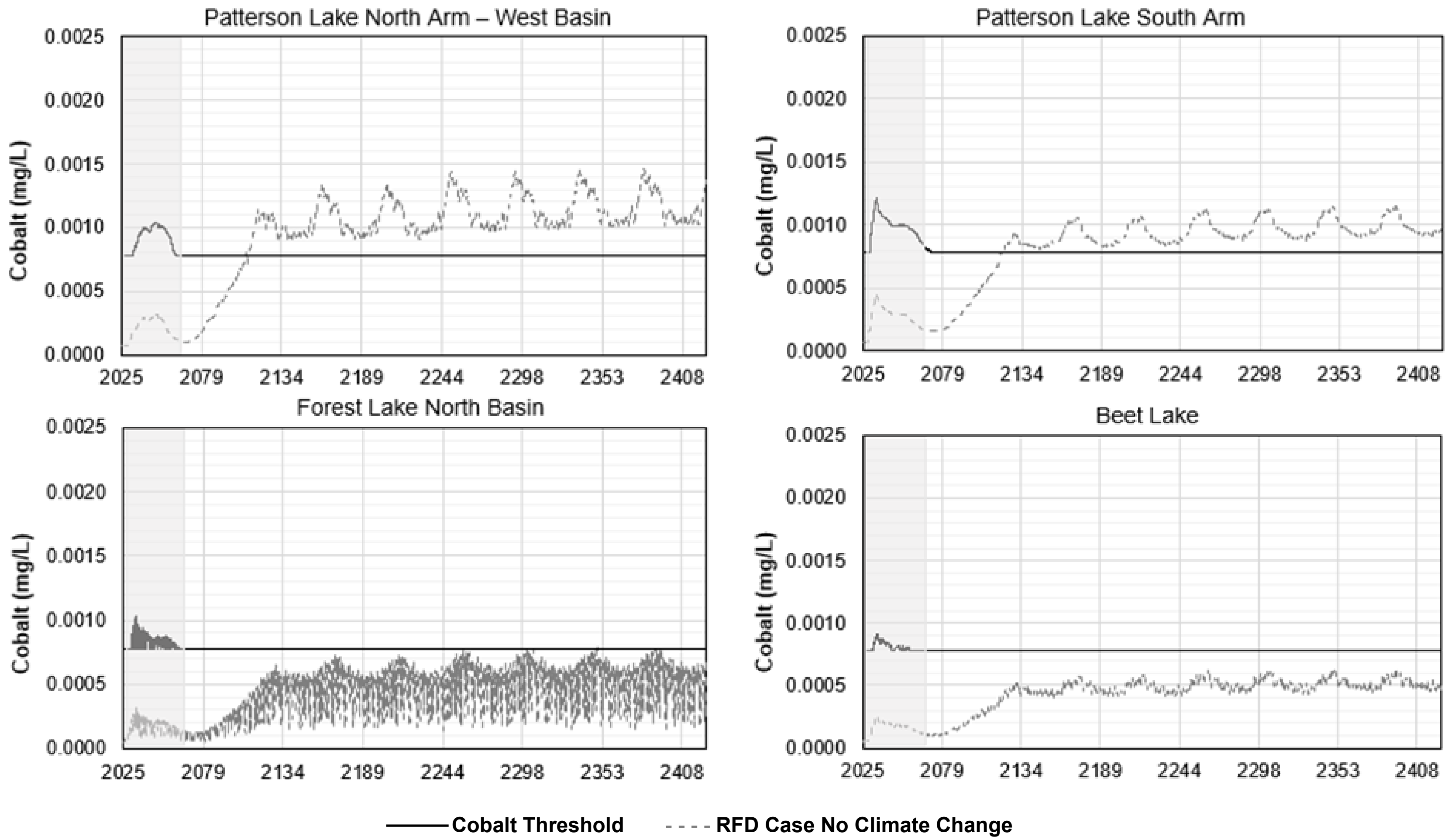
Similar to the COPC nutrient and major ion trends in the RFD Case during the life of the Project, a distinct increase in COPC metal concentrations in Patterson Lake South Arm is predicted to occur due to the treated effluent discharge from the Fission Patterson Lake South Property. Concentrations would steadily increase starting at the beginning of Project and Fission Patterson Lake South Property construction (i.e., nominally 2025 for the purposes of modelling) and reach a peak at the end of the operational period of the Fission Patterson Lake South Property (i.e., 2033). Concentrations in the South Arm would decrease slightly until reaching a smaller, secondary peak at the end of Project Operations.

As with the Application Case, the COPC metal concentrations in the far-future projection are predicted to either increase or decrease before reaching a pseudo-steady-state concentration, with aluminum, cobalt, copper, iron, manganese, molybdenum, nickel, selenium, uranium, and zinc concentrations being greater in the far future than during the lifespan of the Project. The primary loading source for metals in the far future would be from groundwater influenced by seepage from the underground workings and PAG WRSA. Despite the primary contribution of COPC metals from loading to groundwater from the Project, COPC metal concentrations are slightly elevated in the RFD Case compared to the Application Case (e.g., cobalt; Figure 10.5-18). This increase is because the Fission Patterson Lake South Property above-ground tailings management facility and covered waste rock storage facility site runoff is predicted to supply an additional mass load of metals to Patterson Lake. Since the model input climate dataset cycles every 43 years (Section 10.2.8.1.3, Regional Surface Water Quality Model), the far-future metal trends also demonstrate cyclical trends that repeat throughout each climate cycle. Metals concentrations are generally predicted to be highest during dry climate years and lowest during wet climate years when there would be higher natural runoff into the lake.

In the far future, the average monthly cobalt concentrations are predicted to consistently exceed the threshold value in Patterson Lake North Arm – West Basin and Patterson Lake South Arm, peaking at 0.0015 mg/L and 0.0011 mg/L, respectively (Figure 10.5-18). Similar to the COPC major ion and nutrient trends, cobalt concentrations in the far-future projection are predicted to be slightly higher in the RFD Case compared to the Application Case, but the increase is small. Cobalt concentrations would begin to increase in these basins following Project Closure when the ETP stops actively discharging and mass loadings from the groundwater increase. It takes approximately 50 years for the concentrations to exceed the threshold in the North Arm – West Basin and 60 years for the South Arm. As noted in Section 10.2.4, the modelling timeframe for the far-future projection consists of a 157-year period that considers the hydrogeological processes from the site followed by 200 years where the hydrogeological mass load inputs are artificially increased in the RSWQM to incorporate maximum loadings in an earlier than anticipated timeframe. Cobalt exceedances are limited to Patterson Lake with the maximum monthly cobalt concentrations in Forrest Lake – North Basin (i.e., 0.00077 mg/L) predicted to be just below the Project threshold. The cobalt concentrations in the far future would attenuate through the downstream waterbodies (Figure 10.5-18).

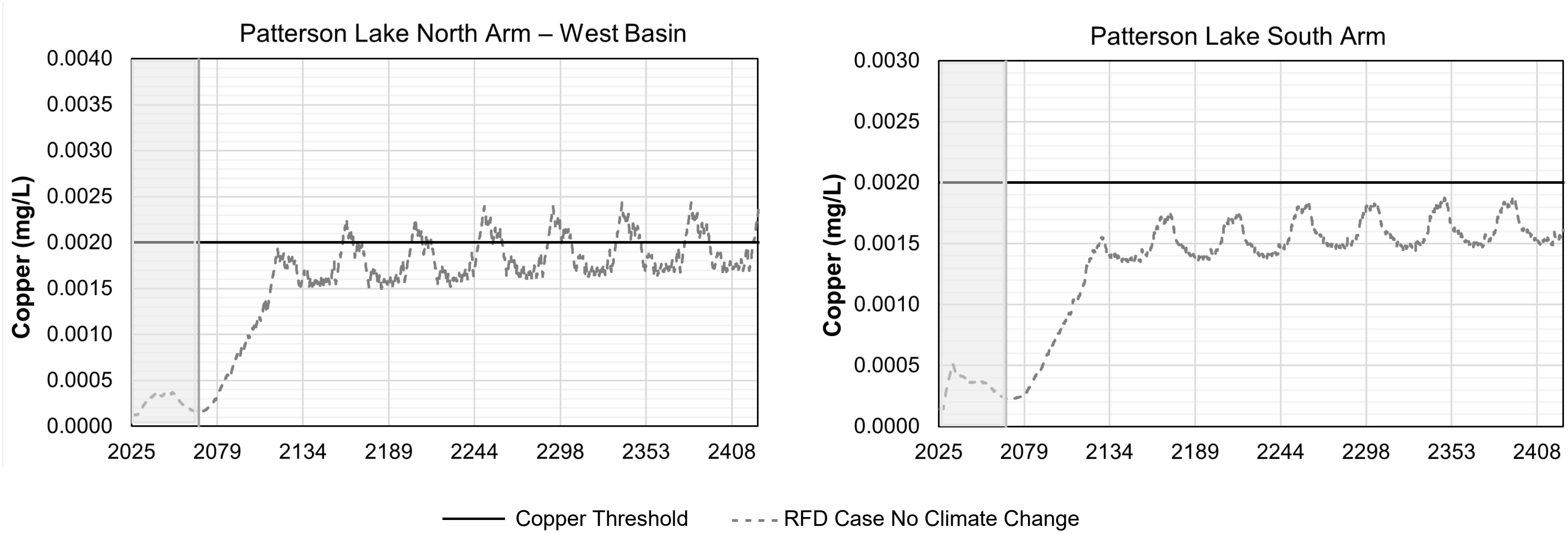
In the far future, copper threshold exceedances are predicted periodically in Patterson Lake North Arm – West Basin but remain below the threshold in Patterson Lake South Arm (Figure 10.5-19). As with cobalt in the RFD Case, copper concentrations in the far-future projection are predicted to be slightly higher compared to the Application Case, but the increase is small. Similar to the trends noted for cobalt, the copper concentration in Patterson Lake would begin to increase after Project Closure due to influx of mass load inputs from groundwater that has been affected by seepage from the PAG WRSA. It takes approximately 90 years before an exceedance in copper is predicted in Patterson Lake North Arm – West Basin (i.e., 2159), and the predicted concentrations fluctuate above and below the threshold for the remainder of the far-future projection as the climate dataset cycles through the model, peaking at 0.0024 mg/L (Figure 10.5-19). The duration of the exceedances increases in the 200-year interval after the maximum groundwater loadings are applied to the model. No copper exceedances are predicted in the waterbodies downstream of Patterson Lake North Arm – West Basin. As described further in Section 10.7, the predicted concentrations of cobalt and copper are thought to result from conservative assumptions; these results form the basis for an Adaptive Management Plan that would be applied throughout Operations to protect aquatic health in Patterson Lake and downstream lakes at Closure.

Figure 10.5-18: Reasonably Foreseeable Development Case Cobalt Concentration in Patterson Lake North Arm – West Basin, Patterson Lake South Arm, Forrest Lake – North Basin and Beet Lake



Note: The cobalt threshold is calculated based on the projected hardness concentration in each waterbody, with threshold values ranging from 0.00078 mg/L to 0.0010 mg/L; see Section 10.2.8.3 for more detail.
The shaded area of the plot is representative of the lifespan of the Project, and the unshaded area is representative of the far-future projection.
RFD = reasonably foreseeable development.

Figure 10.5-19: Reasonably Foreseeable Development Case Copper Concentration in Patterson Lake North Arm – West Basin and Patterson Lake South Arm



Note: The shaded area of the plot is representative of the lifespan of the Project, and the unshaded area is representative of the far-future projection.

RFD = reasonably foreseeable development.

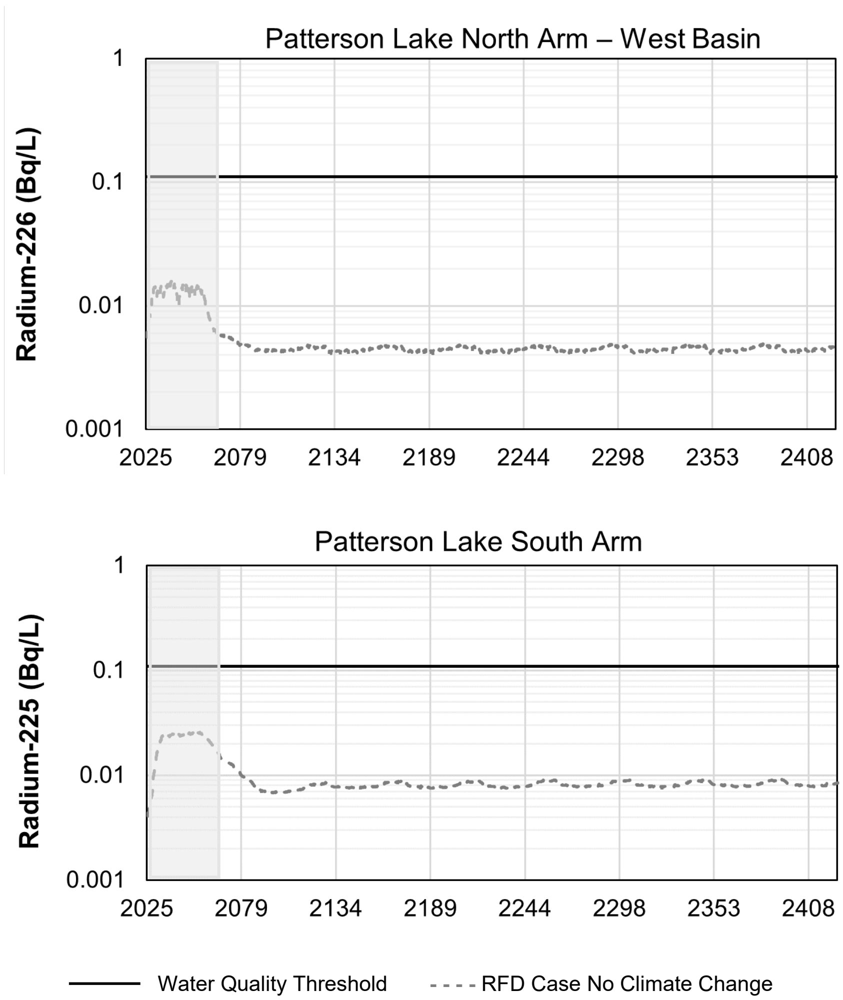
10.5.2.1.4 Radionuclides

In the RFD Case, concentrations of COPC radionuclides (i.e., lead-210, polonium-210, radium-226, thorium-230) are predicted to remain below Project thresholds in all waterbodies throughout the lifespan of the Project and the far-future projection. Similar to the Application Case, radionuclide concentrations were predicted to increase in Patterson Lake North Arm in 2029 when active Project discharges commences, which attenuates through the downstream waterbodies in the LSA.

Effects from the Fission Patterson Lake South Property would be observed in Patterson Lake South Arm downstream to Naomi Lake, and the magnitude of these effects would attenuate with distance downstream from Patterson Lake. The main source of radionuclide loads to Patterson Lake North Arm – West Basin would be the treated effluent discharge from the Project, and the main source to Patterson Lake South Arm would be the treated effluent discharge from the Fission Patterson Lake South Property.

During the period of overlap between the model predictions for Fission Patterson Lake South Property and the Project (i.e., 2025 through 2033), average monthly COPC radionuclide concentrations in the South Arm would be approximately 1.5 times higher than the predicted concentrations in the Application Case. The COPC radionuclide concentrations would increase earlier in the South Arm and the peaks would be more extended compared to the Application Case because of the timing and loading of inputs from the Fission Patterson Lake South Property (e.g., radium-226; Figure 10.5-20). Similar to the COPC major ions, nutrients, and metals, COPC radionuclide concentrations in the far-future projection in Patterson Lake South Arm are predicted to be slightly higher in the RFD Case compared to the Application Case, but the difference is small (i.e., 0.001 becquerels per litre [Bq/L] for radium-226). This increase would be due to the supplemental loading of these constituents to Patterson Lake from site runoff from the Fission Patterson Lake South Property waste rock storage facility and above-ground tailings management facility.

Figure 10.5-20: Reasonably Foreseeable Development Case Radium-226 Concentration in Patterson Lake North Arm – West Basin and Patterson Lake South Arm



Note: The shaded area of the plot is representative of the lifespan of the Project, and the unshaded area is representative of the far-future projection.
RFD = reasonably foreseeable development.

10.5.2.1.5 Atmospheric Deposition

Results from Annex I, Atmospheric Baseline Report for the RFD Case, like the Application Case, indicate that effects on surface water quality solely from air deposition would be localized and result in only minor changes to COPC concentrations in Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2. These effects would be limited to the lifespans of the Project and the Fission Patterson Lake South Property and are associated with air emissions from these projects during their respective overlap during construction and operations.

The increase of COPC concentrations in Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2 from air deposition in the RFD Case relative to the Base Case during the Fission Patterson Lake South Property overlap with the Project would also be minor and would not result in any COPC threshold exceedances. Larger concentration increases in the RFD Case compared to the Application Case were predicted for polonium-210, radium-226, thorium-230, and uranium (Table 10.5-6). Overall, results in the RFD Case are slightly higher than the Application Case, especially in Lakes C and E due to their proximity to the Fission Patterson Lake Property, resulting from the additional mass loadings from the deposition of total aerial emissions from the Fission Patterson Lake Property (e.g., maximum predicted uranium concentrations increase by 0.00016 Bq/L in Lake C, by 0.00013 Bq/L in Lake E, and by 0.00001 Bq/L in Unnamed Lake 1, with no increase in Unnamed Lake 2). The largest increases in COPC concentration based on maximum predicted monthly average concentrations were observed in Lake E, followed by Lake C, Unnamed Lake 2, and Unnamed Lake 1.

Detailed results of the atmospheric deposition assessment in the RSWQM are presented in Appendix 10A.

Table 10.5-6: Maximum Predicted Water Quality Concentrations as a Result of Atmospheric Deposition in Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2 for the Reasonably Foreseeable Development Case

Constituent	Units	COPC Threshold	Base Case Concentration	Maximum Predicted Monthly Average Concentration during the Lifespan of the RFD			
				Lake C	Lake E	Unnamed Lake 1	Unnamed Lake 2
Uranium	mg/L	0.015	0.000056	0.00031	0.00033	0.00015	0.00027
Polonium-210	Bq/L	13.5	0.0043	0.011	0.013	0.0096	0.013
Radium-226	Bq/L	0.11	0.0033	0.0076	0.0072	0.0044	0.0059
Thorium-230	Bq/L	95	0.0052	0.0095	0.0091	0.0063	0.0078

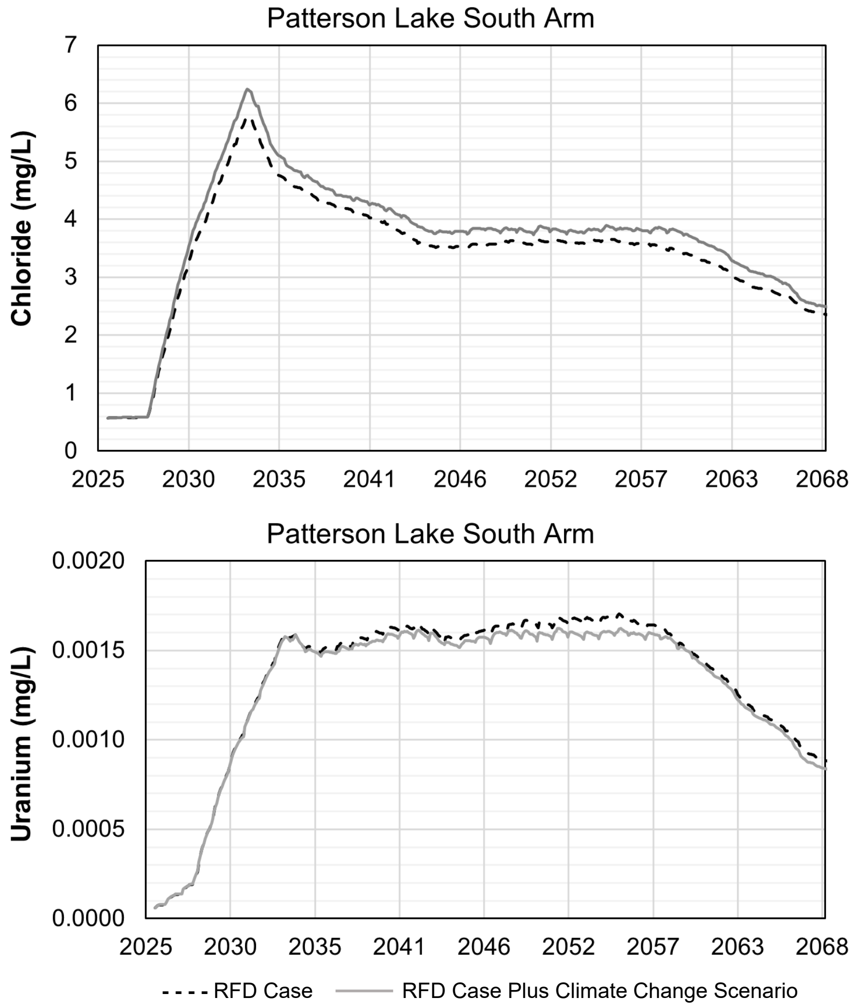
Bq/L = becquerels per litre; COPC = constituent of potential concern; RFD = reasonably foreseeable development.

10.5.2.1.6 Climate Change Sensitivity Scenario

The RFD plus climate change sensitivity scenario utilized the same source term inputs as the RFD Case, except that this sensitivity scenario incorporated a climate change scenario in the hydrological data inputs. Details of the RSWQM, as well as time series figures of COPCs, are presented in Appendix 10A.

Results from the RFD plus climate change sensitivity scenario indicated that climate change effects on surface water quality within the LSA based on hydrological projections would be negligible to minor relative to projections from the Project. During the lifespan of the Project, concentrations of COPC major ions, nutrients, metals, and radionuclides for the RFD plus climate change sensitivity scenario would be very similar to the RFD Case projections. Predicted COPC concentrations in the RFD plus climate change sensitivity scenario would not result in substantial differences in COPC concentration projections, and further, do not show a consistent greater or lesser concentration difference compared to the RFD Case predictions (e.g., chloride and uranium in Patterson Lake South Arm; Figure 10.5-21). These differences indicate that climate change would add mass loads by adding precipitation to Patterson Lake in the treated discharges from the Project and the Fission Patterson Lake South Property, and in direct watershed runoff from the Project and Fission Patterson Lake South Property. The quality of the treated discharges in the SWWBM sourced for the RFD plus climate change sensitivity scenario would differ slightly because of differences in meteorological inputs between the two modelling scenarios such as precipitation, evaporation, and site surface runoff rates.

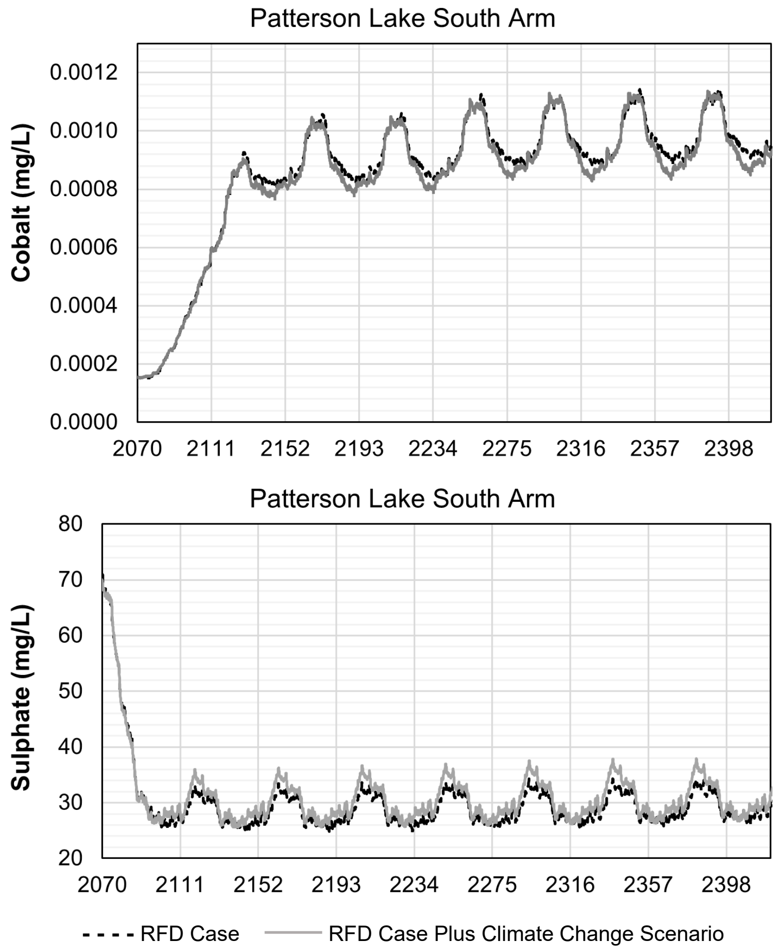
Figure 10.5-21: Chloride and Uranium Concentrations in Patterson Lake South Arm for the Reasonably Foreseeable Development Case and Reasonably Foreseeable Development Plus Climate Change Scenario



RFD = reasonably foreseeable development.

In the far-future projection, concentrations of COPC major ions, nutrients, metals, and radionuclides would also be similar between the RFD Case and the RFD plus climate change sensitivity scenario. As was observed for the lifespan of the Project, the far-future concentration trends would vary among the COPCs, and some constituents would have slightly higher concentrations in the RFD plus climate change sensitivity scenario (e.g., chloride, Figure 10.5-21; sulphate, Figure 10.5-22) while others would have slightly lower concentrations (e.g., uranium, Figure 10.5-21; cobalt, Figure 10.5-22). Under the RFD plus climate change sensitivity scenario in Patterson Lake South Arm, peak chloride concentrations would increase by 5% on average during the far-future projection, whereas peak uranium concentrations decrease by 5% on average. The minor variability between far-future projection COPC trends for the RFD Case and RFD plus climate change sensitivity scenario suggests that surface water quality in Patterson Lake is subject to the climate change effects on meteorological processes directly affecting the water surface (e.g., precipitation and evaporation), as well as changes to site surface runoff and associated mass loading. The overall effect of these combined changes is predicted to be relatively small.

Figure 10.5-22: Cobalt and Sulphate Concentrations in Patterson Lake South Arm for the Far-Future Reasonably Foreseeable Development Case and Reasonably Foreseeable Development Plus Climate Change Scenario



RFD = reasonably foreseeable development.

10.5.3 Residual Effects Classification

Residual effects were classified for two time periods: the lifespan of the Project, consisting of a 43-year period that encompasses Construction, Operations, and Closure; and the far-future projection that encompasses the long-term effects that may occur to surface water quality following Closure. Residual effects on surface water quality are summarized in Table 10.5-7 and Table 10.5-8 according to direction, magnitude, geographic extent, duration/reversibility, frequency, and probability of occurrence following the methods described in Section 10.2.8. Residual effects classification considered the implementation of mitigation outlined in Section 10.4, Project Interactions and Mitigations, to reduce the magnitude and duration of residual effects on surface water quality. Key mitigations for activities that have the influence to affect the water quality of the receiving environment are:

- maximization of the recycle and reuse of process water to reduce both freshwater intake and Project discharges to Patterson Lake;

- a site-specific ETP and STP to reduce COPCs in contact water and domestic sewage and greywater so that treated water can be discharged to Patterson Lake;
- design and construction of diffuser/outfall in the receiving environment for the ETP and STP discharges to provide effective mixing of the treated effluent and limit the area of the receiving water expected to have elevated concentrations of COPCs;
- robust site-wide water management procedures to identify contact water on site, its collection, and a process to determine whether treatment is required prior to release to the environment;
- treatment of any mine-affected discharge water to below the effluent release targets prior to being discharged to the receiving environment; and
- implementation of Project-specific management plans (e.g., Mine Waste Management Plan), monitoring programs (e.g., Effluent and Emissions Plan, Environmental Monitoring Plan), and a Preliminary Decommissioning and Reclamation Plan to reduce the potential for the receiving environment to be affected by Project activities during the lifespan of the Project and after Closure (e.g., aerial emissions and their deposition, surface runoff, direct discharge).

10.5.3.1 Lifespan of the Project

10.5.3.1.1 Application Case

Project effects during the lifespan of the Project (i.e., Construction, Operations, and Closure) for the Application Case are anticipated to be in a negative direction for two of the measurement indicators (i.e., water quality constituent concentrations and drinking water quality constituent concentrations), as COPC concentrations would increase from Base Case concentrations during the lifespan of the Project. The frequency of these effects is anticipated to be continuous as the Project discharges to the receiving environment would occur continuously over the Project lifespan. Although COPC concentrations would increase, the predicted concentrations do not exceed water quality or drinking water thresholds. Further, COPC thresholds would be met at the proposed 100 m RMZ boundaries associated with both the STP and ETP discharges, limiting the extent of potential risk to aquatic and terrestrial life, and drinking water quality, in the receiving environment. For the water quality constituent concentrations and drinking water quality constituent concentrations measurement indicators, the probability of residual effects is certain because COPC concentrations in the receiving environment would be affected through the lifespan of the Project. For the productivity status constituent concentrations measurement indicator, the direction is considered neutral; although there is a small increase in total phosphorus predicted, the productivity status of each waterbody in the LSA would remain oligotrophic, which is consistent with the Base Case trophic status classification. Because there is no net change to this measurement indicator from the Project, no additional effects criteria were characterized, other than probability of occurrence, which is also certain.

The incremental changes to COPC concentrations are predicted to extend beyond Patterson Lake; however, COPC concentrations would remain below thresholds in the downstream LSA waterbodies. Therefore, the geographical extent of the residual effects to the water quality and drinking water quality measurement indicators would be local. The maximum duration of Project-related changes to these measurement indicators in the Application Case would be 75 years, which includes the 43-year period of the Project (i.e., from Construction through to the end of Closure) where maximum COPC concentrations were projected, followed by a period of 32 years where COPC concentrations decrease to near Base Case concentrations. For this reason, the assessment results indicate that the Project-related changes to COPC concentrations in Patterson Lake and downstream waterbodies in the LSA are reversible because COPC concentrations would achieve near Base Case concentrations after the cessation of site discharges at the end of Operations. For the water quality constituent concentrations and drinking water quality constituent concentrations measurement indicators, residual effects from Operations would reach a pseudo-steady-state for applicable COPC concentrations in 2100; these residual effects are most obvious in Patterson Lake.

Air deposition effects on surface waters during the lifespan of the Project in the Application Case would also be localized, result in minor changes to COPC concentrations, and would not exceed any COPC thresholds. Changes in COPC concentrations in Patterson Lake and downstream waterbodies in the LSA driven by the deposition of COPCs from air emissions during the lifespan of the Project would be low relative to the changes driven by the STP and ETP discharges.

Conservatism associated with source term inputs in the integrated modelling conducted to support the near-field and regional surface water quality modelling provides confidence that the assessment does not underestimate potential surface water quality effects in the LSA.

The Project effects on the measurement indicators during the lifespan of the Project for the reasonable upper bound sensitivity scenario would be generally consistent with the effects described for the Application Case, albeit with higher projected COPC concentrations and a potential temporary trophic state shift from oligotrophic to mesotrophic in the Patterson Lake North Arm – West Basin and Patterson Lake South Arm. This general consistency provides further confidence that the assessment has not underestimated the potential effects of the Project during its lifespan with respect to the surface water quality projections.

10.5.3.1.2 Reasonably Foreseeable Development Case

The cumulative effects from the Project and the Fission Patterson Lake South Property on surface water quality in general would include an increase of COPC concentrations in the South Arm of Patterson Lake compared to the Application Case. The duration of effects from the RFD Case to the receiving environment (i.e., a maximum of 75 years) is consistent with that of the Application Case even though the proposed lifespan of the Fission Lake Patterson South Property is shorter than the Project (2025 to 2039). The Fission Patterson Lake South Property would overlap with the Project and would continue to affect Patterson Lake after its closure and decommissioning (i.e., through surface runoff from its above-ground tailings management facility to the South Arm and the flow through loading of runoff from the covered WRSA, which would drain to the North Arm – West Basin). Cumulative effects on water quality in the RFD Case are therefore anticipated to be in a negative direction for the measurement indicators of water quality constituent concentrations and drinking water quality constituent concentrations, as COPC concentrations would increase from Base Case concentrations. However, COPC concentrations associated with these measurement indicators would remain below Project thresholds. The probability of occurrence for cumulative effects for these measurement indicators is probable as the projected effects are likely but uncertain even though the Fission Patterson Lake South Property has recently entered the formal regulatory process.

Cumulative effects on the productivity status indicator are anticipated to be neutral, as changes in nutrient COPCs would not result in a trophic shift in Patterson Lake or any of the waterbodies farther downstream in the LSA. With respect to potential changes to productivity status in the RFD Case, phosphorus concentrations would very briefly reach the oligotrophic/mesotrophic boundary (i.e., 0.010 mg/L) at the end of the discharge period of the Fission Patterson Lake South Property. This brief change, however, is not considered substantial enough to reflect a projected trophic status change in Patterson Lake. Because there would be no net change to the productivity status constituent concentrations measurement indicator from the Project, no additional effects criteria were characterized, other than probability of occurrence, which is probable (i.e., effects are likely but uncertain even though the Fission Patterson Lake South Property has recently entered the formal regulatory process).

The incremental changes from the Fission Patterson Lake South Property to COPC concentrations for the water quality constituent concentrations and drinking water quality constituent concentrations measurement indicators are predicted to extend beyond Patterson Lake; however, these COPC concentrations would remain below thresholds in the downstream LSA waterbodies (i.e., resulting in a local geographical extent). Similar to the Application Case, the maximum duration of effects on changes to COPC concentrations in Patterson Lake as a result of the RFD Case is 75 years. This duration is due to the planned discharge for the Fission Patterson Lake South Property being in Patterson Lake South Arm, which would occur within the early lifespan of the Project (i.e., from 2025 through 2033); although this discharge ends during the initial period of Project Operations, surface runoff inputs from the Fission Patterson Lake South Property continue through and after the lifespan of the Project. The assessment results also indicate that changes to COPC concentrations in Patterson Lake and downstream waterbodies in the LSA are reversible as COPC concentrations would trend toward Base Case concentrations after the cessation of RFD and Project site discharges around 2100. The effects are anticipated to be continuous, as RFD discharges and surface runoff inputs to the receiving environment from Construction to the end of the Active Closure Stage would contribute to effects on COPC concentrations in the receiving environment because they would overlap with those from the Project through the lifespan of the Project.

Similar to the Application Case, air deposition effects in the RFD Case would be localized and result in minor changes to COPC concentrations and would not result in any COPC threshold exceedances. Changes to COPC concentrations driven by the deposition of Fission Patterson Lake South Property and Project air emissions in the LSA would be low relative to the incremental changes driven by the STP and ETP discharges.

The classification of Project effects during the lifespan of the Project for the RFD Case under the climate change scenario is consistent with the classification of the effects of the RFD Case. Results from the RFD plus climate change sensitivity scenario indicated that climate change effects on surface water quality within the LSA based on hydrological projections would be minor. During the lifespan of the Project, predicted concentrations of COPC major ions, nutrients, metals, and radionuclides for the RFD plus climate change sensitivity scenario are very similar to the RFD Case projections. This provides confidence that the assessment has not underestimated the potential effects of climate change throughout the lifespan of the Project with respect to the surface water quality projections.

Table 10.5-7: Classification of Residual Effects on Surface Water Quality Measurement Indicators for the Application Case and Reasonably Foreseeable Development Case during the Lifespan of the Rook I Project (Project Construction, Operations, and Closure)

Measurement Indicator	Criterion	Rating / Effect Size	
		Application Case	Reasonably Foreseeable Development Case
Water quality constituent concentrations	Direction	Negative	Negative
	Magnitude	Most COPCs increase in concentration, but projections remain below Project thresholds	Most COPCs increase in concentration, but projections remain below Project thresholds
	Geographic extent	Local; COPC changes are more pronounced in Patterson Lake, especially the North Arm – West Basin, and diminish downstream through the LSA	Local; COPC changes are more pronounced in Patterson Lake, especially the South Arm, and diminish downstream through the LSA
	Duration	A maximum of 75 years depending on COPC group, as Project-affected COPC concentrations persist in the receiving environment after discharge from the ETP and STP ceases at the end of Project Operations	A maximum of 75 years, as changes to COPC concentrations persist in the receiving environment after discharges cease from the Fission Patterson Lake South Property in 2035
	Reversibility	Reversible, as Project-affected COPC concentrations in the receiving environment rapidly decrease after Project Operations and approach Base Case conditions approximately 32 years after Closure	Reversible, as RFD and Project-affected COPC concentrations in the receiving environment decrease after Closure
	Frequency	Continuous, as Project effects on the receiving environment persist over the lifespan of the Project	Continuous, as RFD effects persist over the lifespan of the Project
	Probability of occurrence	Certain	Probable
Drinking water quality constituent concentrations	Direction	Negative	Negative
	Magnitude	Most COPCs increase in concentration, but projections remain below Project thresholds	Most COPCs increase in concentration, but projections remain below Project thresholds
	Geographic extent	Local	Local
	Duration	A maximum of 75 years depending on COPC group, as Project-affected COPC concentrations persist in the receiving environment over the lifespan of the Project even after discharge from the ETP and STP ceases at the end of Project Operations	A maximum of 75 years, as changes to COPC concentrations in the receiving environment from the RFD persist after discharges cease from the Fission Patterson Lake South Property in 2035
	Reversibility	Reversible	Reversible
	Frequency	Continuous	Continuous
	Probability of occurrence	Certain	Probable
Productivity status constituent concentrations	Direction	Neutral, as changes in nutrient COPCs do not result in a trophic shift in Patterson Lake or any of the farther downstream waterbodies in the LSA	Neutral, as changes in nutrient COPCs do not result in a trophic shift in Patterson Lake or any of the farther downstream waterbodies in the LSA
	Magnitude	No change; phosphorus concentrations increase in Patterson Lake, especially the North Arm West Basin, but Patterson Lake remains oligotrophic	No change; phosphorus concentrations increase in Patterson Lake, especially the North Arm West Basin, but Patterson Lake remains oligotrophic
	Geographic extent	n/a	n/a
	Duration	n/a	n/a
	Reversibility	n/a	n/a
	Frequency	n/a	n/a
	Probability of occurrence	Certain	Probable

n/a = If a net effect was identified as neutral because there is no change in the magnitude (i.e., no potential effect), no additional effects characteristics, other than probability of occurrence were characterized; COPC = constituent of potential concern; LSA = local study area; ETP = effluent treatment plant; STP = sewage treatment plant; RFD = reasonably foreseeable development.

10.5.3.2 Far-Future Projection

10.5.3.2.1 Application Case

Project effects in the far-future projection for the Application Case are anticipated to be negative for water quality constituent concentrations and drinking water quality constituent concentrations measurement indicators. Effects on COPC major ions, nutrients, and radionuclides associated with these measurement indicators are anticipated to be negative because even though source term inputs for these COPCs would diminish following the end of the Project, COPC concentrations are expected to remain above the Base Case, particularly some COPC metals, because of mass loading associated with ongoing surface runoff and groundwater inputs to Patterson Lake from the Project. Project effects are expected to be neutral for the productivity status constituent concentrations measurement indicator in the far-future projection because projected phosphorus concentrations would approach Base Case concentrations in Patterson Lake (i.e., within 0.0012 mg/L of the Base Case condition), thereby remaining oligotrophic.

The residual effects for water quality constituent concentrations and drinking water quality measurement indicators are determined to be permanent and irreversible as surface runoff and groundwater source terms for their COPCs persist in the receiving environment in the far future. In the far-future projection, infiltration, and seepages from the Project footprint to the groundwater regime invoke a long-term continuous period of extremely slow migration of COPC metals and radionuclides from the underground workings and WRSAs to the receiving environment. This would result in incremental mass loadings for a select group of COPC metals: aluminum, cobalt, copper, iron, manganese, molybdenum, nickel, selenium, uranium, and zinc. Concentrations of these COPC metals and radionuclides in the far future would be greater than the peak concentrations modelled during the lifespan of the Project. Although increases are noted for these COPCs, only cobalt and copper would exceed their surface water quality thresholds for the water quality measurement indicator.

The threshold exceedances for cobalt in the far future in the Application Case would occur consistently in Patterson Lake North Arm – West Basin and Patterson Lake South Arm. Copper exceedances in the far future in the Application Case would be limited to Patterson Lake North Arm – West Basin and would also be limited to dry climate years. The geographical extent of Project effects in the far future are therefore classified as local.

For the far-future projection, the probability of occurrence for the water quality constituent concentrations and drinking water quality constituent concentrations measurement indicators was classified as possible. This classification was selected because even though conservative assumptions are associated with the groundwater solute transfer inputs to the RSWQM in the far future and source control would be applied to the PAG WRSA, UGTMF, and backfilled mine workings to reduce and control infiltration and seepage to reduce the potential mass loading from these facilities to the groundwater, COPC concentrations in the receiving environment would still be expected to be above Base Case. The groundwater inputs would be the prime loading to Patterson Lake that result in incremental increases in COPC metals, such as cobalt and copper. Source control with respect to the PAG WRSA would include reducing oxygen ingress to the waste rock and constructing a cover system to minimize infiltration into the waste rock. Source control would therefore be expected to result in reductions in the mass loading to Patterson Lake via groundwater and produce long-term concentrations that are lower than predicted in Patterson Lake.

With respect to the productivity status constituent concentrations, no additional effects criteria other than probability of occurrence were characterized because there is no net change to this measurement indicator from the Project in the far future. The probability of occurrence was characterized as possible.

The Project effects during the far future for the reasonable upper bound sensitivity scenario would be consistent with the residual effects described for the Application Case; however, the magnitude and geographic extent of the changes within the LSA would be greater than those in the Application Case, particularly for cobalt and copper. The reasonable upper bound sensitivity scenario is also bound by a higher degree of uncertainty as the scenario assumes limited source control of mass loading to the groundwater system concurrent with the use of conservative inputs (Section 10.6).

10.5.3.2.2 Reasonably Foreseeable Development Case

Cumulative effects on water quality in the RFD Case in the far-future projection would be similar to those described for each measurement indicator in the far future of the Application Case. Peak COPC concentration trends in the far future would be similar between the Application Case and RFD Case, with concentrations of COPC major ions, nutrients, and radionuclides in the far-future projection slightly higher in the RFD Case compared to the Application Case. This difference is attributed to the incremental loading of these COPC groups from the Fission Patterson Lake South Property to Patterson Lake from site runoff from the above-ground tailings management facility to the South Arm and the flow through loading of runoff from the covered waste rock storage facility, which would drain to the North Arm – West Basin. For metals, only cobalt and copper would exceed the surface water quality thresholds for the water quality constituent concentrations measurement indicator. For the RFD Case, Patterson Lake would remain oligotrophic in the far future.

Cumulative effects on the productivity status constituent concentrations indicator are anticipated to be neutral in the far future, as COPC nutrients, especially phosphorus, would remain within the oligotrophic status in Patterson Lake, despite small increases in concentrations above Base Case, and in the farther downstream waterbodies in the LSA. Because there is no net change to this measurement indicator from the Project in the far future, no additional effects criteria were characterized, other than probability of occurrence, which is characterized as possible, despite the Fission Patterson Lake South Property recently entering into the regulatory process, because on site mitigations described above for the Project are expected to result in mass loading reductions to Patterson Lake via groundwater resulting in long-term COPC concentrations that are lower than predicted in Patterson Lake.

As a result, the classification of residual effects in the RFD Case in the far future is the same as determined for the far future in the Application Case. In the RFD Case, source terms for COPCs from surface runoff from the Project and the Fission Patterson Lake South Property and groundwater from the Project would persist in the receiving environment in the far future.

Cumulative effects during the far future for the RFD Case under the climate change scenario would be similar to the effects projected for the RFD Case. This indicates there is a reasonable level of confidence that the assessment has not underestimated the potential effects of climate change to the surface water quality projections. However, there is a high degree of inherent uncertainty projecting climate change based on hydrological processes so far into the future.

Table 10.5-8: Classification of Residual Effects on Surface Water Quality Measurement Indicators for the Application Case and Reasonably Foreseeable Development Case in the Far Future

Measurement Indicator	Criterion	Rating / Effect Size	
		Application Case	RFD Case
Water quality constituent concentrations	Direction	Negative	Negative
	Magnitude	Some COPCs increase in concentration above Base Case, but projections remain below Project thresholds, except cobalt and copper	Some COPCs increase in concentration above Base Case, but projections remain below Project thresholds, except cobalt and copper
	Geographic extent	Local; COPC changes are more pronounced in Patterson Lake (especially the North Arm – West Basin), which diminish downstream through the LSA	Local; COPC changes are more pronounced in Patterson Lake, which diminish downstream through the LSA
	Duration	Permanent, as Project-affected COPC concentrations persist in the receiving environment in the far future	Permanent, as RFD-affected COPC concentrations persist in the receiving environment in the far future
	Reversibility	Irreversible, as surface runoff and groundwater source terms for COPCs persist in the receiving environment in the far future	Irreversible, as for COPCs persist in the receiving environment in the far future
	Frequency	Continuous, as surface runoff and groundwater source terms for COPCs persist in the receiving environment in the far future	Continuous, as for COPCs persist in the receiving environment in the far future
	Probability of occurrence	Possible, as surface runoff and groundwater source terms for COPCs may be mitigated by future environmental design features and mitigations implemented during the lifespan of the Project	Possible; source terms for COPCs may be mitigated by future environmental design features and mitigations implemented during the lifespan of the Project
Drinking water quality constituent concentrations	Direction	Negative	Negative
	Magnitude	Some COPCs increase in concentration above Base Case, but projections remain below Project thresholds	Some COPCs increase in concentration above Base Case, but projections remain below Project thresholds
	Geographic extent	Local	Local
	Duration	Permanent	Permanent
	Reversibility	Irreversible	Irreversible
	Frequency	Continuous	Continuous
	Probability of occurrence	Possible	Possible
Productivity status constituent concentrations	Direction	Neutral	Neutral
	Magnitude	No change	No change
	Geographic extent	n/a	n/a
	Duration	n/a	n/a
	Reversibility	n/a	n/a
	Frequency	n/a	n/a
	Probability of occurrence	Possible	Possible

n/a = If a net effect was identified as neutral because there is no change in the magnitude (i.e., no potential effect), no additional effects characteristics, other than probability of occurrence were characterized; COPC = constituent of potential concern; LSA = local study area; RFD = reasonably foreseeable development.

10.6 Prediction Confidence and Uncertainty

As a consequence of the approach to complete the surface water quality assessment for this Project, which includes an understanding of the existing surface water quality and sediment quality conditions, the proposed mine plan at the time of the assessment, and the conservatism associated with the modelling tasks (and those of the other component assessments that provided inputs to the surface water quality models), NexGen is confident that the assessment has not underestimated the potential effects of the Project to the surface water quality. This conclusion includes the cumulative effects assessment incorporating RFDs. As the assessment includes both the expected water quality effects of the Project in the Application Case, as well as a reasonable upper bound scenario, the results of the assessment represent the range of water quality effects that can be expected from the Project.

Scientific inference is associated with uncertainty, and prediction confidence depends on the level of uncertainty and the way it is addressed. Primary factors affecting confidence in the predictions made in the surface water and sediment quality assessment include:

- availability and accuracy of baseline data;
- level of understanding of baseline conditions and range of natural and seasonal variation;
- accuracy and certainty in the source terms;
- accuracy and certainty of the models and modelling software;
- level of understanding of the strength of primary pathways (i.e., mechanisms) in terms of the effects they are likely to have on water and sediment quality;
- level of certainty associated with the effectiveness of proposed mitigations, where applicable; and
- level of understanding of the cumulative drivers of change in measurement indicators and associated effects on water and sediment quality.

Additionally, confidence in the assessment of predicted sulphate concentrations relied on the scientific understanding that increasing hardness is a modifying factor in the water that can reduce the potential for metal uptake and toxicity (Adams and Garman 2023, BC MECCS 2019).

Uncertainty was managed by:

- reviewing historical data and relevant studies completed in the LSA and RSA;
- completing quality assurance and quality control of baseline data;
- incorporating conservative estimates, inputs, and assumptions;
- using known constituent concentrations for similar site analogues when the information was unknown;
- calibrating the models to measured data; and
- conducting sensitivity analysis on key parameters.

The foundation of the surface water quality assessment for the Project is the use of modelling to project future conditions of surface water quality in the receiving environment (i.e., waterbodies in the LSA) under the Application Case, and in the RFD Case, which includes the addition of the Fission Patterson Lake South Property. As with all modelling approaches to project future water quality conditions, the predictions made in this assessment incorporate some degree of uncertainty. As a result, the assessment applied the precautionary approach to address uncertainty by identifying the greatest magnitude, duration, and geographic extent of potential adverse effects when a range of possible outcomes was possible. Consequently, uncertainty was addressed in a manner that increased the level of confidence that the assessed residual effects on surface water quality in the receiving environment did not underestimate potential effects from Project interactions. The components of the surface water quality assessment where key uncertainties are considered include:

- baseline water quality data;
- SWWBM;
- RSWQM; and
- NFWQM.

10.6.1.1 Existing Conditions Water Quality Data

Uncertainty related to the baseline water quality data used to develop the existing surface water conditions for COPCs in the Base Case included precision and variability of analytical data derived from sample analyses during the baseline studies as constituents approach a detection limit.

Analytical data that are reported as below detection or close to the detection limit have added uncertainty in the surface water quality assessment. Further, constituent concentrations reported as less than five times the detection limit may also be less precise than concentrations greater than five times the detection limit due to analytical method limitations. For developing the water quality existing conditions for each waterbody, where analytical constituent data were reported as below the detection limit, the detection limit value was used to calculate statistics, except for the average. To calculate the baseline average, half of the detection limit value was used for constituent data reported as below the detection limit. The average concentration was used as the Base Case input concentrations for COPCs in the water quality models. This consideration provides a measure of conservatism in the assessment so that modelling projections are unlikely to underestimate future conditions. Moreover, the constituents that are measured below detection tend not to be the drivers of predicted effects. Therefore, while the values reported below detection limits induce uncertainty to the assessment, these constituents seldom affect the residual effects classifications.

10.6.1.2 Site-wide Water Balance and Water Quality Model

The SWWBM utilized site-specific source term input data to predict the water chemistry of contact and non-contact water on the site. Uncertainty associated with input water quality data was addressed through the use of Application Case (i.e., average) and upper bound (i.e., 95th percentile) source terms. The Application Case for the surface water quality effects assessment utilized source terms representative of a best estimate and included a sensitivity case that used upper bound source terms to characterize potential effects, as well as address model uncertainty, under a reasonable upper bound sensitivity scenario. The individual source term development reports provide additional information on how uncertainty was incorporated into the development each of the source terms; these references are included in the Model Report for the SWWBM for the Project (TSD XVIII). These appendices show that multiple layers of conservatism were applied in the overall model development and application so that predictions are unlikely to be underestimated.

In addition, the SWWBM incorporated water quality predictions for nitrate and ammonia associated with the use of explosives on site. These predictions were developed using the current mine plan estimates for Construction and Operations; seasonal, annual, and total life of mine blasting activities may be modified from these preliminary projections. However, the treated effluent would be tested prior to release and would meet the proposed environmental release targets; as such, any exceedances driven by the variability of nitrogen species concentrations from those predicted would be mitigated. The calculated ammonia and nitrate source term inputs are considered reasonable because comparable nitrate and ammonia concentrations have been measured at operating uranium mines in northern Saskatchewan (i.e., Cameco Key Lake Operations and Cameco Rabbit Lake Operations).

10.6.1.3 Near-Field Water Quality Model

The NFWQM utilized input data to estimate mixing within a 200 m radius of the ETP diffuser and STP outfall and the dilution factors within 100 m from the ETP diffuser and STP outfall. The model included data representing ambient conditions associated with treated effluent and treated sewage discharges from the ETP and STP and Patterson Lake during Operations, and specifications associated with the engineering design assumptions for the ETP diffuser and STP outfall.

Several characteristics of the receiving waterbody (i.e., Patterson Lake) combine to affect the movement and spread of a plume and the performance of a diffuser. These characteristics include water depth, lake currents, water temperature, chemistry (i.e., TDS), and ice cover. To address the uncertainty of the receiving waterbody behaviour, a total of 35 scenarios for the ETP and 26 scenarios for the STP were considered in the model to assess the performance of the ETP diffuser and STP outfall designs in terms of dilution provided at the edge of the RMZ under a variety of ambient conditions. These scenarios were developed by considering historical and probable lake currents, water depth, ambient dissolved solids, and water temperature to confidently address different receiving waterbody behaviours in the calculations and results.

A sensitivity analysis was also completed to assess the robustness of the diffuser/outfall design in terms of the dilution provided. The sensitivity analysis included variations in effluent flow rates for the STP and ETP and TDS concentration in the ETP effluent. These scenarios, collectively, indicate that the prediction of COPCs remaining below thresholds beyond the RMZ for the duration of the Project’s active discharge are likely to be met under all reasonably foreseeable ambient and active discharge conditions.

10.6.1.4 Regional Surface Water Quality Model

The RSWQM utilized output data from three separate models developed by other environmental disciplines in the EIS: the air quality dispersion model (Section 7.2), the groundwater solute transport model (Section 8), and the SWWBM (TSD XVIII).

The inputs from the air quality dispersion model were considered conservative as the model itself addresses uncertainty by applying conservative assumptions (Section 7.2.8, Monitoring, Follow-Up, and Adaptive Management) such as the following:

- assuming the emissions inventory of the highest intensity year during Construction and Operations is used consistently throughout all Project phases;
- using conservative assumptions of operating loads for the power plant;
- assuming simultaneous occurrences of maximum active material storage areas, dust events, and climatic conditions conducive to transportation of dust;
- assuming maximum equipment use; and
- assuming all emissions underground exit through the mine vent.

The inputs from the groundwater solute transport model were considered to be conservative as the source terms used in the model were applied in a conservative manner. The assumptions in the groundwater solute transfer model include limited source control associated with the PAG WRSA, UGTMF, and backfilled mine workings, which means that all infiltration and seepages through and from these facilities generate mass via contact with waste rock and tailings and carry them to the groundwater. Despite this process being slow, the incremental mass is predicted to eventually reach Patterson Lake and propagate downstream through the waterbodies in the LSA and RSA. Further, the geochemical source terms associated with the waste rock and tailings that are assigned to the seepages and infiltration as they migrate to the groundwater in the far-future projection are conservative, assuming that all contact material is consistent with PAG material sources (i.e., assumed to be the prominent waste rock and tailings condition in the far future), and there is no source depletion over time. As part of the Project design, source control would be applied to the PAG WRSA, UGTMF, and backfilled mine workings to reduce and control infiltration and seepage to reduce the potential mass loading from these facilities to the groundwater, which would be expected to result in reductions in the mass loading that was carried into the far-future surface water quality assessment.

The groundwater solute transport model also included a number of sensitivity analyses to address uncertainty (Section 8.6, Prediction Confidence and Uncertainty). Results of these sensitivity analyses indicated that the solute transport model was primarily driven by the source terms for the surface waste rock, underground backfill, and the UGTMF tailings. Other parameters, such as the hydraulic conductivities of the groundwater flow pathways and backfill materials, and the cross-sectional area of the fracture zone area, contributed less than 5% difference in model sensitivity. As such, the results of the reasonable upper bound sensitivity scenario for the RSWQM, which uses the results of the groundwater solute transport model with upper bound source terms, addresses the prediction confidence and uncertainty of the solute transport model.

As discussed in Section 10.2.5, an RFD Case was conducted using the RSWQM. This assessment case required assumptions related to the expected treated effluent discharge quality, domestic treated sewage discharge quality, and site runoff quality from the Fission Patterson Lake South Property. Since this project has not yet been approved and these data are not yet publicly available, several assumptions were made in predicting the water quality of direct and indirect surface water inputs to Patterson Lake. For example, the treated effluent quality from the Fission Patterson Lake South Property was assumed to be equal to the median treated effluent quality from the Project. The estimated surface runoff quality from the Fission Patterson Lake South Property waste rock storage facility and above-ground tailings management facility was assumed to be equal to the median treated effluent quality from the Project. Given these assumptions, predictions generated by the RSWQM are considered to be reasonable in lieu of a lack of project-specific available data for the Fission Patterson Lake South Property.

10.7 Monitoring, Follow-Up, and Adaptive Management

This subsection presents a summary of the identified monitoring and follow-up proposed to monitor the Project interactions with potential adverse effects as well as validate the residual effects predictions, as described in Section 10.4 and Section 10.5, respectively. The monitoring program would be used to address the prediction uncertainties per Section 10.6.

Specifically, follow-up and monitoring programs would be used to:

- verify that the site contact water management infrastructure is operating as designed and evaluate the effectiveness of the surface water protection controls in place;

- monitor for changes in water quality, including hardness, in the receiving environment as a result of Project activities;
- verify the predictions of the EIS and confirm that the aquatic ecosystem in the receiving environment is protected;
- confirm the adequacy of the study areas (i.e., confirm that effects do not extend beyond boundaries);
- track the trajectories of constituents that were identified in sensitivity analyses, such as chloride, phosphorus, cobalt, and copper so that these constituents can be proactively and adaptively managed;
- evaluate the effectiveness of reclamation and other mitigation actions, and modify or enhance as necessary through monitoring and developing updated mitigation, if needed;
- identify unanticipated negative effects, including possible accidents and malfunctions; and
- contribute to the overall continual improvement of the Project.

Water quality monitoring for the Project may be divided into two parts:

- site contact water monitoring, which includes the Project processes as well as the area directly affected by the Project footprint, and monitoring of treated effluent to verify discharge criteria is met prior to batch discharge and release to Patterson Lake (i.e., upstream of the final point of control); and
- the surface water receiving environment monitoring (i.e., Patterson Lake and downstream).

Preliminary treated effluent release targets have been used for this assessment; through continued Project engineering and optimization, final treated effluent release targets would be proposed as part of the licence application submission to CNSC to meet REGDOC-2.9.2 requirements (CNSC 2021c). The follow-up work would also include an analysis of best available technology and techniques, economically achievable (BATEA). Additionally, an Environmental Code of Practice documenting action levels and corresponding management response measures for treated effluent would be in place based as per REGDOC-2.9.2. If the measurements in the Effluent and Emissions Plan or Environmental Monitoring Plan trend away from the EIS predictions and/or towards the COPC Project thresholds, response plans, and/or adaptive management actions would be triggered.

In addition, Environmental Committees (i.e., one per primary Indigenous Group) composed of two NexGen and two Indigenous Group representatives would be established to act in an oversight manner to monitor the environmental performance of the Project and verify the parties are implementing the regulatory and environmental commitments made in respect of the Project.

Indigenous Groups have made recommendations related to mitigating the effects of the Project on the environment, including community-led long-term environmental testing and monitoring during Construction and Operations of the proposed Project (TSD IV: MN-S; TSD V.2: CRDN; YNLRO 2019). NexGen has committed to provide funding for the lifespan of the Project for a full-time independent Indigenous Monitor chosen by each primary Indigenous Group; this Indigenous Monitor would have access to conduct environmental sampling for the Project, subject to the Indigenous Monitor complying with appropriate health and safety and other reasonable site-specific policies. The Indigenous Monitor would be able to report openly and without restriction to the Environmental Committee and Indigenous Group's community members on the performance of the Project. The Indigenous Monitor would also provide regular reports to the Environmental Committee.

10.7.1 Monitoring of Site Contact Water and Treated Effluent

Site contact water monitoring as a component of the control and management of site contact water would be used to verify that the Project is operating in accordance with the regulatory requirements, standards, best practices, principles and protocols, and guidelines for site contact water management. Site contact water monitoring would be described in documentation for the Environmental Protection Program, along with the controls and monitoring of the on-site infrastructure. The Effluent and Emissions Plan would include the analysis of treated effluent in ponds and confirmation that these waters meet release targets prior to release to the environment.

All site contact water management components would require routine inspections to verify system integrity, and where necessary, routine calibration of the equipment. Water quality monitoring would be required prior to release of non-mineralized contact water, treated contact water (i.e., treated effluent), and treated sewage to the environment. This monitoring would include the collection ponds on site, as well as the treated water ponds.

10.7.2 Surface Water Receiving Environment Monitoring

Surface water and sediment monitoring in the receiving environment (i.e., Patterson Lake, and other waterbodies and watercourses in the LSA) would be a component of the Project's Environment Monitoring Plan. The surface water quality monitoring program established for baseline data collection in Patterson Lake and the downstream waterbodies and watercourses in the LSA (Section 10.2.6, Existing Conditions; Appendix 10A, Attachment 10A-1) would form the basis for monitoring in the receiving environment throughout the Project lifespan. Annual data from these surveys would be compared to Project COPC thresholds, EIS predictions, and regulated objectives (i.e., criteria). It is expected that the program would evolve over time to account for any changes to the Project or in response to measured data. For example, it is expected that the Project would be required to meet Metal and Diamond Mining Effluent Regulations requirements, so the receiving environment monitoring would be adjusted as necessary to incorporate these requirements in the Environmental Monitoring Plan design.

The Environmental Monitoring Plan would include monitoring at the edge of the RMZ. One additional station per diffuser/outfall (i.e., the treated effluent and treated sewage discharge points) in Patterson Lake North Arm – West Basin is also proposed at the edge of the RMZ (i.e., 100 m from each diffuser/outfall). These stations would be used to confirm the diffuser/outfall is working as designed and that the concentrations at the edge of the RMZs are remaining within regulated RMZ objectives (i.e., criteria). Sediment quality monitoring would also be conducted at the RMZ station to confirm EIS predictions.

The proposed Environment Monitoring Plan would be developed based on the baseline water quality monitoring program. The majority of the stations would be located within the LSA (i.e., 14 of 16 proposed monitoring locations would be located within the LSA). Broach Lake would continue to be monitored as an upstream station. The three stations in Patterson Lake (i.e., one per basin) would continue to be sampled. Four new stations in Patterson Lake are proposed based on the Project interactions discussed in Section 10.4 as well as site processes. Downstream of the Project site and within the LSA, stations would be located on Forrest Lake, Beet Lake, Beet Creek, and Naomi Lake. A station in Clearwater River below Naomi Lake would also be monitored, which is located just outside of the LSA and within the RSA. Lloyd Lake, which is located downstream and outside of the RSA, would also be monitored. Two reference lakes would continue to be monitored: Hodge Lake, which is located outside of the RSA and LSA, and Lake D, which is located within the LSA.

Surface water quality monitoring would be included in Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2 to evaluate effects of the deposition of air emissions. As these are small lakes, one monitoring station in each of these lakes would be utilized, with monitoring limited to the open water season (e.g., following freshet and in fall).

Two additional stations proposed for Patterson Lake would be used to monitor for site-influenced groundwater daylighting in Patterson Lake. One of these stations would be located just north of the Project site in Patterson Lake North Arm – West Basin, and the other would be located south of the Project site in Patterson Lake South Arm.

Surface water monitoring, except for the small lakes (i.e., Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2), would take place seasonally (i.e., four times per year). Sediment quality monitoring would take place once a year, most likely in late summer or fall. A comprehensive list of water and sediment quality constituents would be measured in samples collected from the field and submitted for laboratory analyses, including general parameters, the identified COPCs, and constituents prescribed by the Metal and Diamond Mining Effluent Regulations for metal and mining environmental effects monitoring.

Monitoring, mitigation, and adaptive management that is focused on the far future would be primarily driven by mitigating the risk of the transportation of mass loads to Patterson Lake via groundwater. Monitoring of seepages and runoff water quality at the WRSAs and monitoring of the UGTMF during and after Operations would be conducted to determine the need for additional source control and adaptive management (Section 10.5.3, Residual Effects Classification).

In addition, Environmental Committees (i.e., one per Indigenous Group) composed of two NexGen and two Indigenous Group representatives would be established to act in an oversight manner to monitor the environmental performance of the Project and verify the parties are implementing the regulatory and environmental commitments made under the Benefit Agreements negotiated with each Indigenous Group.

Indigenous Groups have made recommendations related to mitigating the effects of the Project on the environment, including community-led long-term environmental testing and monitoring during Construction and Operations of the proposed Project (TSD IV: MN-S; TSD V.2: CRDN; TSD VI: YNLR). NexGen has committed to provide funding for the lifespan of the Project for a full-time independent Indigenous Monitor chosen by each primary Indigenous Group; this Indigenous Monitor would have access to conduct environmental sampling for the Project, subject to the Indigenous Monitor complying with appropriate health and safety and other reasonable site-specific policies. The Indigenous Monitor would be able to report openly and without restriction to the Environmental Committee and Indigenous Group's community members on the performance of the Project. The Indigenous Monitor would also provide regular reports to the Environmental Committee who, in turn, would report to the Implementation Committee and provide them with an annual report of activities undertaken and monitoring results.

The Indigenous Monitor would also provide regular reports to the Environmental Committee who, in turn, would report quarterly to the Implementation Committee and provide them with an annual report of activities undertaken and monitoring results.

10.8 Key Findings

The objectives of Section 10 were to provide a comprehensive assessment of all potential Project-specific effects and cumulative effects with RFDs on surface water quality and sediment quality. These objectives were met by predicting water quality COPC concentrations in the LSA during the Project lifespan and in a far-future projection using near-field and far-field models and comparing the concentrations to Project thresholds. Sediment quality changes in Patterson Lake were predicted by deriving sediment quality estimations based on the quality of the receiving environment in the vicinity of the discharges during Operations.

A summary of key findings for surface water quality and sediment quality is outlined below:

- Water quality COPC concentrations are predicted to be below Project thresholds for water quality in the receiving environment downstream of the Project for the lifespan of the Project in the Application Case and the RFD Case.
- Water quality COPC concentrations in the far-future projection indicate that cobalt and copper may exceed the thresholds for water quality in the receiving environment downstream of the Project, for both the Application Case and the RFD Case. This exceedance is due to seepage from the Project PAG WRSA and the underground workings (including the UGTMF) that would be transported to Patterson Lake via groundwater. The far-future projections for cobalt and copper show that the elevated concentrations are likely limited to Patterson Lake. In the RFD Case, there is a small incremental change to COPC concentrations in the far future, including cobalt and copper, which would be sourced from runoff from the Fission Patterson Lake South Property above-ground tailings management facility to the South Arm and the flow through loading of runoff from the Fission Patterson Lake South Property covered waste rock storage facility, which drains to the North Arm – West Basin. For all water quality COPCs, concentrations diminish downstream through the LSA as mass is attenuated. It is important to note that there is an inherent level of uncertainty in the far-future projection due to the timeframe being represented in the model (i.e., on the order of the tens of thousands of years), as well as the conservatism of the inputs to the sources of mass in the groundwater solute transport model. Such uncertainty would be adaptively managed throughout the lifespan of the Project.
- Copper concentrations are evaluated more fully in Appendix 11A, Aquatic Health Assessment of the Potential for Adverse Effects of Predicted Far-Future Copper Concentrations in Patterson Lake and form the basis of an Adaptive Management Plan to protect Patterson Lake, and they are further considered for potential effects to fish and other aquatic biota in Section 11.
- Water quality COPC concentrations are predicted to be below thresholds for drinking water quality in the receiving environment downstream of the Project for the lifespan of the Project in the Application Case and the RFD Case.
- Productivity status constituents are predicted to remain within the same trophic status classification in the receiving environment downstream of the Project for the lifespan of the Project and the far-future projections in the Application Case and the RFD Case.
- Cumulative effects for the RFD Case and RFD plus climate change sensitivity scenario are similar during the Project lifespan and the far future. Although there is inherent uncertainty associated with climate change predictions, the similarity indicates that climate change has a minor effect on surface water quality.
- Monitoring programs would be implemented to evaluate the effectiveness of the environmental protection measures and to confirm that the site contact water would comply with regulatory requirements, standards,

best practices, principles, protocols, and guidelines. Mitigation of the transportation of contaminants via groundwater in the far future would be completed through source control prior to Project Closure. Monitoring programs in the receiving environment would also be implemented throughout the Project lifespan and compared to Project thresholds.

- Key information from the surface water quality assessment was carried forward to other disciplines for consideration in the assessment of VCs. The water quality results, particularly for projected cobalt and copper concentrations in the far-future scenario, were carried forward in the ERA. The results of the ERA were subsequently considered in the fish and fish habitat VCs (Section 11), vegetation VCs (Section 13), wildlife VCs (Section 14), human health VC (Section 15), Indigenous land and resource use VC (Section 16) and other land and resource use VC (Section 17).

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Appendix 10A Surface Water Quality Modelling Report

Abbreviations and Units of Measure

Abbreviation	Definition
CCME	Canadian Council of Ministers of the Environment
COPC	constituent of potential concern
DO	dissolved oxygen
EA	Environmental Assessment
EIS	Environmental Impact Statement
ETP	effluent treatment plant
Golder	Golder Associates Ltd.
LSA	local study area
Project	Rook I Project
N	nitrogen
NexGen	NexGen Energy Ltd.
NFWQM	near-field water quality model
pH	potential of hydrogen
RFD	reasonably foreseeable development
RMZ	regulated mixing zone
RSWQM	regional surface water quality model
STP	sewage treatment plant
SWWBM	site-wide water balance and water quality model
TDS	total dissolved solids
TSS	total suspended solids
UGTMF	underground tailings management facility
WRSAs	waste rock storage areas
WSA	Water Security Agency
WSP	WSP Canada Inc.

Unit	Definition
%	percent
°C	degrees Celsius
>	greater than
<	less than
≤	less than or equal to
µg/L	micrograms per litre
Bq/L	becquerels per litre
h	hour
kg/ha/yr	kilograms per hectare per year
km	kilometre
km^2	square kilometre
m	metre
m/s	metres per second
m^3	cubic metre
m^3/s	cubic metres per second
m^3/yr	cubic metres per year
mg/L	milligrams per litre
mg/L as N	milligrams per litre as nitrogen
mm	millimetre

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10A1 INTRODUCTION

NexGen Energy Ltd. (NexGen) has retained WSP Canada Inc. (WSP, formerly Golder Associates Ltd. [Golder]) to assess the potential effects of the Rook I Project (Project) on surface water quality in downstream waterbodies. This modelling appendix supports the surface water quality assessment in the Environmental Impact Statement (EIS) for the Project.

Two models were developed to support the surface water quality effects assessment and include:

- the regional surface water quality model (RSWQM); and
- the near-field water quality model (NFWQM).

10A1.1 Regional Surface Water Quality Model

The RSWQM is a continuous daily surface water quality model that was developed to simulate concentrations of constituents of potential concern (COPCs) in waterbodies within the surface water quality local study area (LSA) under different conditions using the GoldSim modelling software. GoldSim is an object-oriented computer program for dynamically modelling complex systems (GoldSim 2018). The regional hydrology model (Section 9, Hydrology) formed the basis of the RSWQM, and water chemistry data were integrated with the flow rates simulated in the hydrological model (Section 9). The RSWQM provides continuous water quality predictions for 400 years, considering all Project activities throughout the Project lifespan and far-future projection:

- **Conditions at Project initiation (Base Case)**: the expected conditions that would exist prior to initiating the Project. The model was calibrated to the background water quality with no Project interactions.
- **Construction, Operations, Decommissioning and Reclamation (predictive)**: a predictive modelled period for the Construction, Operations, and Decommissioning and Reclamation (i.e., Closure) phases of the Project, also referred to as the Project lifespan. These phases are anticipated to proceed over an approximate 43-year time span, which includes a 4-year Construction Phase, 24-year Operations Phase, and a 15-year Closure Phase. Closure would include a 5-year Active Decommissioning Stage and a 10-year Transitional Monitoring Stage. During various phases of the Project lifespan, surface runoff, treated effluent, treated sewage effluent, and groundwater from the site would be discharged from the Project.
- **Far future (predictive)**: is a predictive modelled period for the far-future projection of 357 years. During the far future, surface runoff and groundwater from the decommissioned Project flows to the surrounding environment.

In addition to the Base Case, predictions were generated for two assessment cases:

1. **Application Case:** this assessment case evaluates the effects of the Project considering reasonable average inputs. Site discharges from the Project were developed based on the site-wide water balance and water quality model (SWWBM; technical support document [TSD] XVIII, Site-wide Water Balance Model and Water Quality Modelling Report), the groundwater solute transport model (TSD XIV, Groundwater Flow and Solute Transport Modelling Report), and the atmospheric deposition model (Appendix 7A, Air Dispersion Modelling Report).
2. **Reasonably Foreseeable Development (RFD) Case:** this assessment case evaluates the effects of the Project with the addition of known RFDs within the surface water quality LSA that have not yet been approved. The Fission Patterson Lake South Property, which is planned by Fission Uranium Corp. (Fission 2019, 2021) is the only RFD identified for the Environmental Assessment (EA).

Predictions were also generated for two sensitivity scenarios. A reasonable upper bound sensitivity scenario was modelled for the Application Case, and an RFD plus climate change sensitivity scenario was modelled for the RFD Case:

1. **Reasonable upper bound sensitivity scenario**: this scenario was conducted for the Application Case to evaluate Project effects using reasonable upper bound source terms inputs from the SWWBM. This scenario also included upper bound source terms for the mean and higher estimates of hydraulic conductivity associated with the underground workings (which include the underground tailings management facility [UGTMF]) and waste rock storage areas (WRSAs) for the groundwater solute transport model. The same inputs for atmospheric deposition as the Application Case were considered.
2. **RFD plus climate change sensitivity scenario**: this scenario was conducted for the RFD Case to evaluate Project effects with the addition of known RFDs and effects from climate change. This scenario considered how natural factors and climate change may interact with the Project and other developments to affect surface water quality.

10A1.2 Near-Field Water Quality Model

The NFWQM was developed to predict concentrations of COPCs in the immediate areas of the discharge locations of treated effluent from the effluent treatment plant (ETP) and sewage treatment plant (STP), as a result of the mixing and dilution of the effluent plumes. The NFWQM modelling was conducted using the CORMIX model system, a physically based mixing zone modelling platform (Doneker and Jirka 2007). The modelled scenarios considered a range of ambient conditions to reflect seasonal changes in the receiving environment temperature, ice cover, stratification, and current speeds and treated effluent cases (i.e., for the Application Case and reasonable upper bound sensitivity scenario). The ETP diffuser and STP outfall configurations were based on TSD XIX, Conceptual Diffuser Design Report, and the modelling extent focused on 200 m from the discharges, as this distance is double the expected regulated distance from the discharge locations that defines the mixing zone (i.e., the regulatory mixing zone [RMZ] of 100 m). More information is also provided in TSD XX, Downstream Use and Impact Study for Proposed Treated Sewage Discharge Report.

10A1.3 Report Structure

This report describes the surface water quality modelling completed in support of the EA for the surface water quality intermediate component (Section 10, Surface Water Quality and Sediment Quality). The structure of the report is as follows:

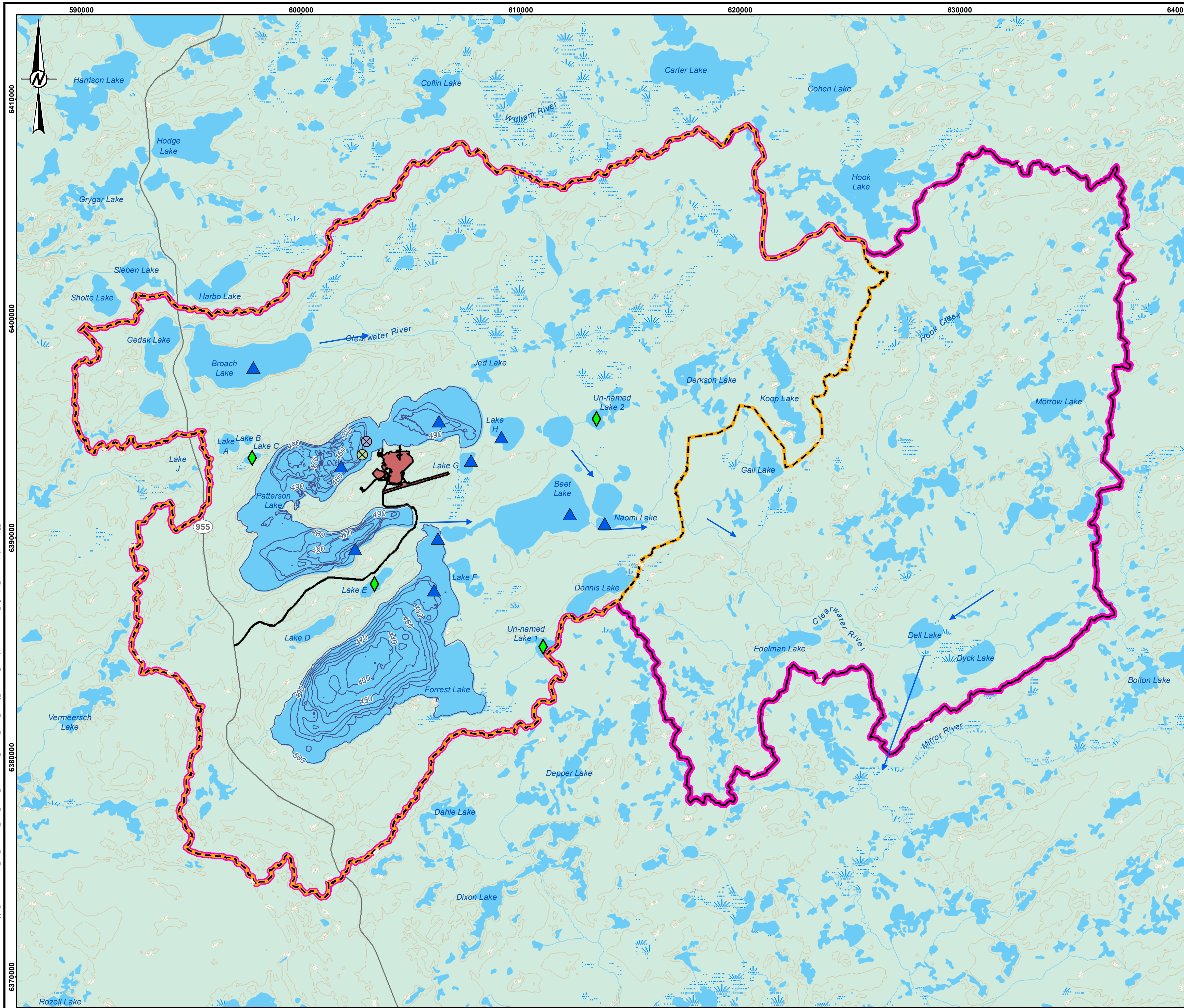
- Section 10A2 defines the objectives and scope that guided the modelling assessment and this report.
- Section 10A3 summarizes site descriptions and the background data, which form the basis for the model development.
- Section 10A4 summarizes the applicable water quality objectives and regulations that were used to develop the Project-specific water quality thresholds for comparison to the modelling results.
- Section 10A5 summarizes the modelling assumptions and limitations.
- Section 10A6 documents the model development and results of the RSWQM.
- Section 10A7 documents the model development and results of the NFWQM.
- Section 10A8 describes the modelling confidence and uncertainty.
- Section 10A9 provides a summary of the modelling results.

10A2 OBJECTIVES AND SCOPE

The objectives of this report are to describe the surface water quality modelling completed in support of the EA and present the modelling results for each of the assessment cases and sensitivity scenarios. To meet these objectives, the key goals of the surface water quality modelling were to:

- characterize the existing surface water quality conditions at the initiation of the Project and describe natural seasonal variation;
- develop predictive surface water quality models to assess the effects of Project activities on surface water quality at key downstream lakes in the upper Clearwater River watershed as delineated in Figure 10A-1;
- use modelling results to allow for predictions of the magnitude, extent, and duration of the effects of treated effluent and groundwater discharges from the Project and atmospheric deposition on surface water quality in the downstream lake(s);
- use modelling results to allow for predictions of the expected magnitude, extent, and duration of the effects of atmospheric deposition on the water quality in small lakes (Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2) within the LSA, which would not be influenced by effluent and groundwater discharges from the Project; and
- assess the mixing performance of the ETP diffuser and STP outfall for treated discharges within the RMZ under a range of ambient conditions and treated effluent scenarios.

The scope of the surface water quality modelling was to develop an existing conditions model and predictive models capable of supporting the surface water quality effects assessment for the Project EIS (Section 10.2.8, Residual Effects Analysis). The modelling extent for this Project was the LSA, as shown in Figure 10A-1.



LEGEND

- BATHYMETRY CONTOUR ELEVATION (10 m INTERVAL)
- ELEVATION CONTOUR (20 m INTERVAL)
- FLOW DIRECTION
- SECONDARY HIGHWAY
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED AREA
- PROPOSED PROJECT FOOTPRINT
- AIR DEPOSITION MONITORING LOCATION
- WATER QUALITY MODELLING NODE
- EFFLUENT TREATED PIPE DIFFUSER
- SEWAGE TREATED PIPE OUTFALL
- SURFACE WATER QUALITY LOCAL STUDY AREA
- SURFACE WATER QUALITY REGIONAL STUDY AREA

0 5 10
1:175,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
2. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
3. FORRESTT LAKE BATHYMETRY CONTOURS DERIVED FROM JUNE 2019 BATHYMETRY SURVEY DATA. PATTERSON LAKE BATHYMETRY CONTOURS DERIVED FROM DATA COLLECTED BY NEXGEN, 2016.

PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT
NexGen Energy Ltd.
ROOK I PROJECT

TITLE
ROOK I PROJECT WATER QUALITY MODELLING AND AIR DEPOSITION PREDICTIONS NODES

CONSULTANT
wsp

PROJECT		20144150	PHASE	3106 - 3
DESIGN	DL	2021-06-29	SCALE AS SHOWN	REV. 0
GIS	LMS	2023-02-07	**FIGURE 10A-1**	
CHECK	IC	2023-02-07		
REVIEW	GVA	2023-02-07		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

10A3 SITE DESCRIPTION

The proposed Project is located approximately 40 km east of the Saskatchewan-Alberta border, 130 km north of the Northern Village of La Loche, and 640 km northwest of the city of Saskatoon. The Project resides within Treaty 8 territory and the Métis Homeland and is situated within the southern Athabasca Basin adjacent to Patterson Lake, along the upper Clearwater River system.

The upper reach of the Clearwater River flows from Broach Lake through a series of lakes including Patterson, Forrest, Beet, and Naomi lakes in order from upstream to downstream (Figure 10A-1). From Naomi Lake, the Clearwater River flows another 20 km southeast before the Mirror River confluence. Below the Mirror River confluence, the river deepens with higher flow volumes from the Mirror River, and the channel form changes to meandering within a well-defined river valley. Farther downstream, the Clearwater River flows through Lloyd Lake, a large lake just upstream of the Clearwater River Provincial Park; the downstream end of the park is at the Saskatchewan-Alberta border.

10A3.1 Climate and Hydrological Setting

Continuous monitoring of water levels, discharge, and water temperature was performed by WSP between August 2018 and September 2020 within the LSA (Annex IV.2, Hydrometric Monitoring Characterization Report). Key monitoring locations in Patterson Lake and Forrest Lake are shown in Figure 10A-1. Bathymetric surveys were also conducted for Patterson Lake (Annex V.1, Aquatic Environment Baseline Report), Broach Lake, Lake G, Lake H, and Beet Lake (Annex V.1), and Naomi Lake (Annex V.3, Naomi Lake Bathymetry Report).

WSP completed several seasonal environmental baseline studies in 2018 characterizing the climate and hydrological conditions (Annex IV.2; Annex IV.3, Geomorphology Characterization Report; Annex IV.1, Regional Meteorological and Hydrological Characterization Report; Golder 2019). The climate conditions based on these surveys are as follows:

- The average air temperature varies between a low of -19.9°C in January to a high of 15.8°C in July, with an annual average of -1.24°C.
- The mean annual total precipitation is 531 mm (in water equivalent), with summer months experiencing the highest precipitation.
- Annual snowfall in the historical record ranges between 79 mm and 208 mm.
- Annual rainfall in the historical record ranges between 259 mm and 530 mm.
- The estimated mean annual lake evaporation is 510 mm.
- Even with ice cover, a baseflow is present during the winter months in many of the lakes in the Clearwater River system.
- The mean annual flows increase twelve-fold along the Clearwater River flow path in the LSA, ranging from 0.25 m^3/s at the Clearwater River below Broach Lake to 3.26 m^3/s at the Clearwater River below Naomi Lake.
- Annual flows through the LSA show a unimodal pattern, with peak flows occurring between May and June during spring freshet.

10A3.2 Regional Water Quality

Waterbodies (i.e., lakes) and watercourses (i.e., river and creeks) in the water quality LSA are characterized based on field surveys carried out between in 2015 and 2016 by PGL Environmental, and 2018 to 2020 by Canada North Environmental Services (CanNorth; Annex V.1). Typically, the lakes in the water quality LSA were found to have well-oxygenated surface waters, and possess low concentrations of ions, nutrients, total and dissolved metals, and radionuclides (Annex V.1). A description of the study waterbodies and watercourses including a summary of the existing water quality in the LSA, and the available water quality data, are provided in Attachment 10A-1, Background Surface Water Quality Characterization. The EIS hydrology section (Section 9) describes the watershed (Table 9.3-1, Regional Hydrological Model Sub-Watersheds), waterbody surface elevations (Section 9.3.4, Waterbody Water Surface Elevations), average flow rates through the watercourses (Section 9.3.5, Watercourse Flow Rates), and waterbody depth and morphometry (Appendix 9A, Hydrological Modelling Summary Report, Section 9A2.9.2, Lake Morphometry).

A broad characterization of the water quality of these waterbodies is provided below:

- Waters have high water clarity based on low levels of total suspended solids (TSS), turbidity, and colour.
- The deeper lakes, such as Patterson Lake, stratify during the late spring to early fall, and exhibit bi-annual turnover events in early spring and early winter. Despite the occurrences of thermal stratification, no discernible chemical stratification was observed.
- The dissolved oxygen (DO) in the surveyed lakes varies throughout the water column (i.e., 2 mg/L to 15 mg/L) and the surface waters are well oxygenated.
- The pH is, on average, near neutral levels with the recorded pH range of 5.83 to 8.20.
- Low dissolved solids with an average concentration between 23 mg/L and 60 mg/L.
- The dominant ions are calcium and bicarbonate (Attachment 10A-1 and Annex V.1).
- The water is soft with a hardness between 1.4 mg/L and 21.8 mg/L as calcium carbonate.
- The lakes are mostly characterized as oligotrophic based on low total phosphorus concentrations (i.e., less than 0.01 mg/L).
- Dissolved organic carbon ranges from 2.4 mg/L to 13 mg/L.
- The measured average concentrations of the COPCs are generally below the project water quality thresholds (Section 10A4.1, Water Quality Project Thresholds – Constituents of Potential Concern), except for iron, which exceeds in Clearwater River below Broach Lake, Clearwater River above Patterson Lake, Lake H, Lake G, Naomi Lake, and the Clearwater River downstream of Naomi Lake. Higher concentration of iron was generally associated with higher concentration of TSS. Many constituents (i.e., total phosphorus, beryllium, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, uranium, and vanadium) were frequently found at concentrations below the detection limit.
- Most measured radionuclides (i.e., lead-210, polonium-210, and thorium-230) were found at concentrations below the detection limit.

Average COPC concentrations for waters within the LSA were computed to characterize the background water quality conditions and to use as inputs into the water quality models for the receiving lakes (Table 10A-1).

Where baseline data were reported below the detection limit, half the detection limit was used to compute the average. Other notable information relevant to the calculation of average water quality data includes:

- The average concentrations for Patterson Lake and Forrest Lake were provided for each of their sub-basins.
- Baseline water quality for Naomi Lake was characterized by measured water quality data from the Clearwater River below Beet Lake (i.e., outlet of Naomi Lake) because the Naomi Lake monitoring station is in a basin that is not on the main flow path of the Clearwater River.

Table 10A-1: Base Case Water Quality (Based on Average Measured Baseline Concentrations)

Model Parameters	Units	Broach Lake	Lake G	Lake H	Clearwater River above Patterson Lake	Patterson Lake North Arm – East Basin	Patterson Lake North Arm – West Basin	Patterson Lake South Basin	Forrest Lake – North Basin	Forrest Lake – South Basin	Beet Lake	Clearwater River below Beet Lake	Naomi Lake[a]	Reference Lakes
Major Ions														
Bicarbonate	mg/L	22.9	31.1	32.0	14.4	30.2	36.5	39.8	26.0	30.3	28.2	28.3	25.7	16.0
Calcium	mg/L	3.8	4.0	3.7	2.6	3.1	3.6	3.9	4.1	4.5	4.2	2.5	4.2	3.5
Chloride	mg/L	0.41	0.10	0.20	0.30	0.41	0.53	0.57	0.63	0.78	0.63	0.50	0.65	0.59
Magnesium	mg/L	1.3	1.8	1.6	0.8	1.0	1.2	1.4	1.5	1.7	1.6	0.7	1.6	1.2
Sodium	mg/L	1.6	1.9	1.9	1.2	1.3	1.4	1.4	1.6	2.0	1.7	1.0	1.7	1.4
Sulphate	mg/L	1.9	1.3	0.3	1.2	1.2	1.5	1.6	1.6	1.7	1.6	0.6	1.6	1.2
Nutrients														
Ammonia as nitrogen	mg/L	0.02	0.1	0.1	0.01	0.03	0.02	0.01	0.01	0.01	0.03	0.01	0.01	0.02
Nitrate as nitrogen	mg/L	0.02	0.04	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01
Total phosphorus	mg/L	0.005	0.012	0.006	0.005	0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Total Metals														
Aluminum	µg/L	1.8	7.4	14.9	27.5	4.4	3.0	2.0	6.5	2.0	2.1	31.9	7.4	24.4
Arsenic	µg/L	0.14	0.07	0.16	0.14	0.10	0.09	1.31	0.13	0.17	0.11	0.19	0.11	0.13
Cadmium	µg/L	0.005	0.007	0.005	0.007	0.007	0.006	0.005	0.007	0.006	0.005	0.007	0.006	0.007
Cobalt	µg/L	0.05	0.05	0.05	0.05	0.06	0.07	0.06	0.05	0.08	0.05	0.05	0.05	0.06
Chromium	µg/L	0.24	0.25	0.25	0.25	0.28	0.25	0.28	0.24	0.27	0.24	0.25	0.25	0.29
Copper	µg/L	0.11	0.26	0.10	0.12	0.14	0.12	0.14	0.28	0.14	0.19	0.16	0.10	0.12
Iron	µg/L	28	**689**	**430**	**410**	195	51	16.1	43	24	107	**826**	93	**412**
Mercury	µg/L	0.0016	0.0021	0.0020	0.0013	0.0018	0.0013	0.0013	0.0009	0.0011	0.0012	0.0021	0.0010	0.0011
Manganese	µg/L	104.1	66.9	41.1	11.2	33.1	14.5	21.1	9.4	3.9	83.2	48.3	12.0	27.2
Molybdenum	µg/L	0.07	0.05	0.05	0.07	0.05	0.05	0.05	0.07	0.05	0.05	0.05	0.05	0.06
Nickel	µg/L	0.06	0.06	0.05	0.08	2.61	0.06	2.13	0.10	0.08	0.14	0.08	0.08	0.07
Lead	µg/L	0.05	0.05	0.07	0.05	0.06	0.05	0.06	0.06	0.28	0.19	0.07	0.05	0.07
Selenium	µg/L	0.05	0.05	0.05	0.05	0.06	0.05	0.06	0.06	0.06	0.05	0.05	0.05	0.06
Strontium	µg/L	37	25	14	26	28	30	31	32	32	32	24	31	29
Uranium	µg/L	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.06
Vanadium	µg/L	0.06	0.05	0.05	0.16	0.06	0.06	0.07	0.06	0.06	0.06	0.15	0.05	0.12
Zinc (dissolved)	µg/L	0.80	1.71	0.95	0.82	0.88	0.74	0.70	0.77	0.98	0.57	0.92	0.86	0.57
Radionuclides														
Lead-210	Bq/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Polonium-210	Bq/L	0.003	0.005	0.005	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.003	0.003	0.003
Radium-226	Bq/L	0.003	0.005	0.003	0.004	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Thorium-230	Bq/L	0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.005	0.005	0.005	0.006

Source: Attachment 10A-1, Background Surface Water Quality Characterization and Annex V.1, Aquatic Environment Baseline Report.

Note: **Bolded values** indicate that the average constituent concentration is greater than the Project threshold for that constituent. Where a Project threshold has been identified for a COPC that is dependent on ETMFs (such as pH, temperature, and hardness), corresponding values of the ETMFs for that specific sample were used to establish the Project threshold for comparison to the measured COPC.

a) Base Case water quality for Naomi Lake was characterized by measured water quality data from Clearwater River below Beet Lake, because the Naomi Lake monitoring station is in a basin that is not on the main flow path of the Clearwater River; Clearwater River below Beet Lake flows through Naomi Lake.

Bq/L = becquerels per litre.

10A3.3 Mine Hydraulic Infrastructure

There are four main components of the Project infrastructure that interact directly with the surface water receiving environment:

- freshwater intake pipe;
- ETP diffuser;
- STP outfall; and
- west bermed runoff collection area.

These infrastructure elements are illustrated in Figure 10A-2.

The freshwater intake pipe would be located upstream of the ETP and STP discharge locations in Patterson Lake North Arm – East Basin. Both the ETP and STP discharge locations would be located northeast of the mine terrace in Patterson Lake North Arm – West Basin.

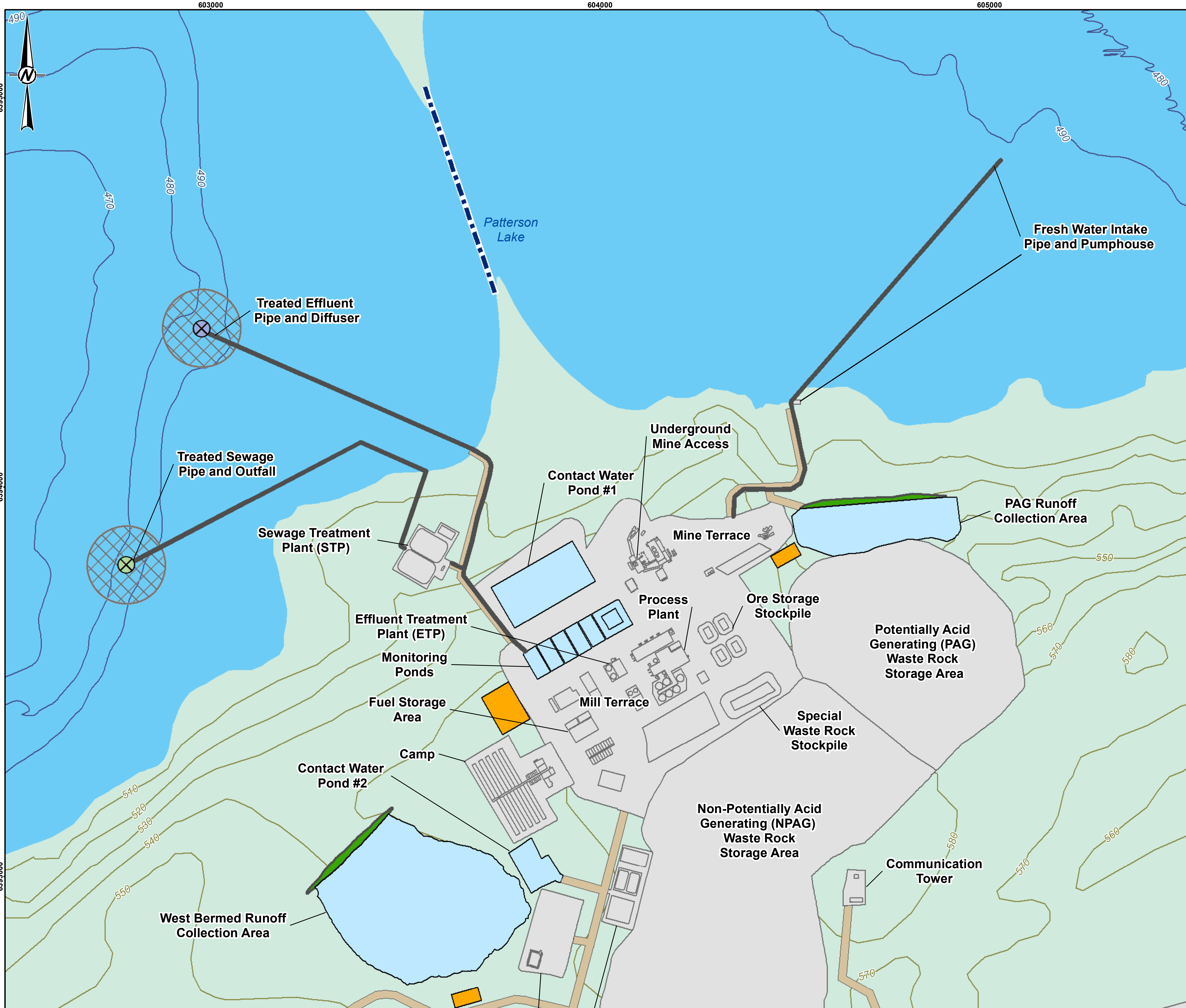
The ETP and STP would treat contact water and sewage, respectively, to produce a discharge that is suitable for release to the environment. The STP outfall would discharge independent of the ETP for contact water, including water from the process plant; the two discharge locations would be separated by approximately 600 m.

The ETP would treat process plant effluent, underground mine water, and site runoff from potentially contaminated areas. The ETP diffuser design and discharge location were determined through an options evaluation (TSD XIX). Six candidate locations were identified and evaluated to identify the optimum location of the ETP diffuser. The conceptual diffuser location, configuration, and design flow are the same as used in the TSD XIX, Conceptual Diffuser Design Report). Additional details of the ETP diffuser are provided in Section 10A7, Near-field Water Quality Model.

The STP would consist primarily of a sewage lagoon. Domestic sewage from the camp would be pumped to the sewage lagoon, while domestic sewage from the mine, process plant, and ancillary facilities would be hauled to the sewage lagoon (TSD XX, Downstream Use and Impact Study for Proposed Treated Sewage Discharge Report). The STP outfall would be located 600 m southwest from the ETP diffuser (Figure 10A-2) in the North Arm – West Basin of Patterson Lake. Additional details of the STP outfall are provided in Section 10A7.

It is expected that the ETP and STP would operate during Construction, Operations, and Closure of the Project, which is a maximum of 33 years. The ETP would stop operating during the decommissioning phase (part of Closure).

The west bermed runoff collection area would receive runoff from the local non-contact water catchment area, as well as water from contact water pond #2 (Figure 10A-2), that is suitable for release to the environment (i.e., release water). As the outlet of contact water pond #2 represents a final point of control, NexGen would apply to designate the outflow from contact water pond #2 as a final discharge point. This would mean that it would be a location where water would be monitored and analyzed to confirm all discharge criteria, including Metal and Diamond Mining Effluent Regulations limits excluding TSS, are met. As the water in the west bermed runoff collection area would be discharged to ground, it is expected that TSS would be naturally removed from the water before reaching fish habitat. If the remaining limits are not met within contact water pond #2, water from this pond would be pumped to the ETP rather than being discharged to the west bermed runoff collection area.



LEGEND

- BATHYMETRY CONTOUR ELEVATION (10 m INTERVAL)
- ELEVATION CONTOUR (10 m INTERVAL)
- WATERBODY
- WOODED AREA
- INTAKE OR DISCHARGE PIPE
- CONTACT WATER CONTAINMENT BERM
- PROJECT INFRASTRUCTURE
- SITE ROAD
- TOPSOIL STORAGE AREA
- WATER MANAGEMENT POND
- EFFLUENT TREATED PIPE DIFFUSER
- SEWAGE TREATED PIPE OUTFALL
- LAKE BASIN DIVISION
- PROPOSED REGULATED MIXING ZONE

0 0.3 0.6
1:10,000 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.
3. BATHYMETRY CONTOURS DERIVED FROM DATA COLLECTED BY NEXGEN, 2016.

PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

MINE HYDRAULIC INFRASTRUCTURE AND ASSOCIATED MIXING ZONE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	GVA	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-07	**FIGURE 10A-2**	
CHECK	IC	2023-02-07		
REVIEW	GVA	2023-02-07		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

10A4 APPLICABLE WATER QUALITY OBJECTIVES AND REGULATIONS

This subsection presents the applicable water quality objectives, defined as Project thresholds, and guidelines and regulations for mixing zones.

10A4.1 Water Quality Project Thresholds – Constituents of Potential Concern

As outlined in the surface water quality assessment methods (Section 10.2.8.3, Development of Thresholds), predicted water quality concentrations in the LSA were compared to project-specific water quality thresholds for all COPCs. The rationale for the development of the COPC list is provided in Section 10.2.8.2, Constituents of Potential Concern.

The water quality chronic (long-term) thresholds for the protection of aquatic life were generally based on the Canadian Environmental Quality Guidelines for the Protection of Aquatic Life (CCME 2019, 2023) and Saskatchewan's provincial objectives (WSA 2015). Where no guidelines or objectives were available from the Canadian Council for Ministers of the Environment (CCME) or Saskatchewan, provincial objectives from British Columbia (BC MWLAP 2004; BC MOE 2019), Ontario (MOEE 1994), and the Federal Environmental Quality Guidelines (Environment Canada 1999) were used. The thresholds for the radionuclides were provided by the environmental risk assessment for the Project (TSD XXI, Environmental Risk Assessment), as neither CCME nor provincial guidelines are available.

Table 10A-2 provides a summary of the CCME guidelines, provincial water quality objectives, and the selected chronic (i.e., long-term) thresholds for the COPCs. These thresholds were carried forward for use in the surface water quality assessment and were used to compare modelled data for each of the measurement indicators used in the surface water quality assessment: water quality, drinking water quality, and productivity status. Table 10A-3 provides a summary of the CCME objectives for total ammonia for the protection of aquatic life, which accounts for the toxicity modifying factors of pH and temperature.

The thresholds for the drinking water quality constituent concentrations measurement indicator for the modelled COPCs in the assessment were developed based on Health Canada's guidelines for Canadian drinking water quality (Health Canada 2019, 2020). For parameters with no federal guidelines, the World Health Organization guidelines for drinking water quality were selected (WHO 2017). Table 10A-4 provides a summary of the water quality guidelines as well as the selected threshold.

Table 10A-2: Canadian Council of Ministers of the Environment Guidelines, Saskatchewan Provincial Objectives, and Selected Water Quality Thresholds

Parameter	Unit	CCME: Long Term (Chronic)[(a)(c)]	Provincial Objectives (Chronic)[(b)(c)]	Selected Constituent Project Threshold
General Parameters				
pH	n/u	6.5 – 9.0	6.5 – 9.0	6.5 – 9.0
Temperature	°C	Thermal additions should not alter thermal stratification or turnover dates, exceed maximum weekly average temperatures, nor exceed maximum short-term temperatures		
TSS	mg/L	Background + 5	n/a	Background + 5
Major Ions				
Chloride	mg/L	120	n/a	120

Table 10A-2: Canadian Council of Ministers of the Environment Guidelines, Saskatchewan Provincial Objectives, and Selected Water Quality Thresholds

Parameter	Unit	CCME: Long Term (Chronic)[a][c]		Provincial Objectives (Chronic)[b][c]		Selected Constituent Project Threshold
Sulphate	mg/L	n/a		<30 mg/L $CaCO_3$ 31 – 75 mg/L $CaCO_3$ 76 – 180 mg/L $CaCO_3$ 181 – 250 mg/L $CaCO_3$ >250 mg/L $CaCO_3$	128 mg/L[d] 218 mg/L[d] 309 mg/L[d] 429 mg/L[d] site-specific[d]	128[e]
Nutrients						
Ammonia (un-ionized as N)	µg/L	15.6				
Ammonia as N (total)	mg/L	Function of un-ionized ammonia, pH, and temperature[f]				
Nitrate (NO_3 as N)	mg/L	3.0		n/a		3.0
Total phosphorus	mg/L	Ultra-oligotrophic <0.004 mg/L Oligotrophic: 0.004 – 0.01 mg/L Mesotrophic: 0.01 – 0.02 mg/L Meso-eutrophic: 0.02 – 0.035 mg/L Eutrophic: 0.035 – 0.1 mg/L Hyper-eutrophic: >0.1 mg/L		0.02[g]		0.02[g]
Total Metals (unless otherwise noted, all metals are reported as total)						
Aluminum	mg/L	<6.5 pH ≥6.5 pH	0.005 mg/L 0.1 mg/L	<6.5 pH, <4 mg/L calcium, <2 mg/L dissolved organic carbon ≥6.5 pH, ≥4 mg/L calcium, ≥2 mg/L dissolved organic carbon	0.005 mg/L 0.1 mg/L	0.1[h]
Arsenic	mg/L	0.005		0.005		0.005
Cadmium	mg/L	<17 mg/L $CaCO_3$ 17 – 280 mg/L $CaCO_3$ >280 mg/L $CaCO_3$	0.00004 mg/L $10^{\{0.83(\log(hardness))-2.46\}}$ 0.00037 mg/L	<17 mg/L $CaCO_3$ 17 – 280 mg/L $CaCO_3$ >280 mg/L $CaCO_3$	0.00004 mg/L $10^{\{0.83(\log(hardness))-2.46\}}$ 0.00037 mg/L	0.00004[i]
Chromium	mg/L	Chromium, hexavalent: 0.001 mg/L Chromium, trivalent: 0.0089 mg/L		Chromium, hexavalent: 0.001 mg/L		0.001
Cobalt	mg/L	n/a		exp{(0.414[ln(hardness)] – 1.887}[j]		0.00078[i]
Copper	mg/L	<82 mg/L $CaCO_3$ 82 – 180 mg/L $CaCO_3$ >180 mg/L $CaCO_3$	0.002 mg/L $0.2*e^{\{0.8545[\ln(hardness)]-1.465\}}$ 0.004 mg/L	<120 mg/L $CaCO_3$ 120 – 180 mg/L $CaCO_3$ >180 mg/L $CaCO_3$	0.002 mg/L 0.003 mg/L 0.004 mg/L	0.002[i]
Iron	mg/L	0.3		0.3		0.3

Table 10A-2: Canadian Council of Ministers of the Environment Guidelines, Saskatchewan Provincial Objectives, and Selected Water Quality Thresholds

Parameter	Unit	CCME: Long Term (Chronic)[a][c]		Provincial Objectives (Chronic)[b][c]		Selected Constituent Project Threshold
Lead	mg/L	≤60 mg/L $CaCO_3$ 60 – 180 mg/L $CaCO_3$ >180 mg/L $CaCO_3$	0.001 mg/L $0.2*e^{\{1.273[\ln(hardness)]-4.705\}}$ 0.007 mg/L	≤60 mg/L $CaCO_3$ 60 – 120 mg/L $CaCO_3$ 120 – 180 mg/L $CaCO_3$ >180 mg/L $CaCO_3$	0.001 mg/L 0.002 mg/L 0.004 mg/L 0.007 mg/L	0.001[i]
Manganese	mg/L	Calculated using the CCME calculator for manganese in Appendix B and is based on hardness and pH (CCME 2019)		n/a		0.26[i][k]
Mercury	mg/L	0.000026		0.000026		0.000026
Molybdenum	mg/L	0.073		7.6[d]		7.6[d]
Nickel	mg/L	≤60 mg/L $CaCO_3$ 60 – 180 mg/L $CaCO_3$ >180 mg/L $CaCO_3$	0.025 mg/L $0.2*e^{\{0.76[\ln(hardness)]+1.06\}}$ 0.150 mg/L	≤60 mg/L $CaCO_3$ 60 – 120 mg/L $CaCO_3$ 120 – 180 mg/L $CaCO_3$ >180 mg/L $CaCO_3$	0.025 mg/L 0.065 mg/L 0.110 mg/L 0.150 mg/L	0.025[i]
Selenium	mg/L	0.001		0.001		0.001
Strontium	mg/L	n/a		7[l]		7[l]
Uranium	mg/L	0.015		0.015		0.015
Vanadium	mg/L	n/a		0.12[m]		0.12[m]
Zinc	mg/L	0.007		0.03		0.007
Radionuclides						
Lead-210	Bq/L	n/a		n/a		22[n]
Polonium-210	Bq/L	n/a		n/a		13.5[n]
Radium-226	Bq/L	n/a		n/a		0.11[n]
Thorium-230	Bq/L	n/a		n/a		95[n]

a) CCME 2023.
b) WSA 2015.
c) Long-term exposure or inputs lasting between 24 hours to 30 days.
d) BC MOE 2021.
e) 128 mg/L for all lakes excluding Patterson Lake based on hardness in the study areas that is consistently 21 mg/L as $CaCO_3$ or less. Patterson Lake's guideline would vary over time, based on the measured hardness in the lake.
f) Total ammonia based on un-ionized ammonia guideline that is adjusted for ambient pH and water temperature as provided in Table 10A-3.
g) MOEE 1994.
h) Based on the average pH range across all surface waterbodies (6.5 to 7.4 pH), except for Lake J with an average pH of 6.4.
i) Based on hardness in the study areas that is consistently 21 mg/L as $CaCO_3$ or less, except for cobalt. For cobalt, the water quality guideline shown is based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).
j) Environment Canada 2017; Government of Canada 2021.
k) Guideline is variable per lake. Example based on the pH guideline range of approximately 6.3 to 6.9 for Patterson Lake.
l) Health Canada 2019.
m) Environment Canada 2016; Government of Canada 2021.
n) TSD XXI, Environmental Risk Assessment.
< = less than; > = greater than; ≤ = less than or equal to; ≥ = greater than or equal to; COPC = constituent of potential concern; $CaCO_3$ = calcium carbonate; Bq/L = becquerels per litre; CCME = Canadian Council of Ministers of the Environment; N = nitrogen; TSS = total suspended solids; WSA = Water Security Agency; n/u = no unit; n/a = no guideline.

Table 10A-3: Canadian Council for Ministers of the Environment Water Quality Objectives for Total Ammonia for the Protection of Aquatic Life (in mg/L as Nitrogen)

Temperature (°C)	pH							
	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5
0	231	73.0	23.1	7.32	2.33	0.749	0.250	0.042
5	153	48.3	15.3	4.84	1.54	0.502	0.172	0.034
10	102	32.4	10.3	3.26	1.04	0.343	0.121	0.029
15	69.7	22.0	6.98	2.22	0.715	0.239	0.089	0.026
20	48.0	15.2	4.82	1.54	0.499	0.171	0.067	0.024
25	33.5	10.6	3.37	1.08	0.354	0.125	0.053	0.022
30	23.7	7.50	2.39	0.767	0.256	0.094	0.043	0.021

mg/L as N = milligrams per litre as nitrogen.

Table 10A-4: Drinking Water Quality Guidelines and Water Quality Thresholds Selected for Constituents of Potential Concern

Parameter	Unit	Health Canada[a,b]	World Health Organization[c]	Selected Project Threshold
Major Ions				
Chloride	mg/L	250[d]	n/a	250
Sulphate	mg/L	500[d]	n/a	500
Nutrients				
Nitrate (as nitrogen)	mg/L	10	11	10
Total Metals (unless otherwise noted, all metals are reported as total)				
Aluminum	mg/L	0.1	n/a	0.1
Arsenic	mg/L	0.01	0.01	0.01
Cadmium	mg/L	0.007	0.003	0.007
Chromium[e]	mg/L	0.05	0.05	0.05
Copper	mg/L	2	2	2
Iron	mg/L	0.3[d]	n/a	0.3
Lead	mg/L	0.005	0.01	0.005
Manganese	mg/L	0.12	n/a	0.12
Mercury	mg/L	0.001	0.006	0.001
Nickel	mg/L	n/a	0.07	0.07
Selenium	mg/L	0.05	0.04	0.05
Strontium	mg/L	7	n/a	7
Uranium	mg/L	0.02	0.03	0.02
Zinc	mg/L	5	n/a	5

Table 10A-4: Drinking Water Quality Guidelines and Water Quality Thresholds Selected for Constituents of Potential Concern

Parameter	Unit	Health Canada[a,b]	World Health Organization[c]	Selected Project Threshold
Radionuclides				
Lead-210	Bq/L	0.2	0.1	0.2
Polonium-210	Bq/L	n/a	0.1	0.1
Radium-226	Bq/L	0.5	0.1	0.5
Thorium-230	Bq/L	n/a	1	1

a) Health Canada 2020.
b) Maximum acceptable concentration provided unless otherwise indicated.
c) WHO 2017.
d) Guideline is an aesthetic objective.
e) Guidelines are for total chromium.
Bq/L = becquerels per litre; n/a = not applicable.

As noted in Table 10A-2, sulphate, cadmium, cobalt, copper, lead, manganese, and nickel have guidelines and Project thresholds that incorporate hardness as a toxicity modifying factor. For these COPCs, aquatic health studies have shown that their toxicity potential is influenced by hardness; specifically, increasing hardness has been identified as the key modifying factor in the water that can reduce the potential for metal uptake and toxicity (Adams and Garman 2023). In addition to COPCs, effluent can contain base cations (e.g., calcium, magnesium) that contribute to a water's hardness. Increases in hardness reduces the toxicity potential for hardness-dependent COPCs to aquatic organisms, so long as the increasing COPC concentrations remain below their hardness-dependent Project threshold. Therefore, applying ambient hardness concentration in the calculation of the Project threshold for these COPCs in the receiving environment provides a standardization in the surface water quality and aquatic health assessment. This standardization accounts for the changes in hardness concentration in the receiving environment during the period of discharge of treated effluent from the Project.

During this period, the hardness in Patterson Lake North Arm – West Basin is predicted to increase from less than 20 mg/L as $CaCO_3$ under existing conditions to approximately 100 mg/L as $CaCO_3$ during Operations. Increased hardness levels are also predicted in downstream waterbodies, but to a lesser extent with distance downstream. In downstream waterbodies, hardness levels are predicted to increase from less than 20 mg/L as $CaCO_3$ under existing conditions to maximum values of approximately 60 mg/L as $CaCO_3$ in Forrest Lake North Basin and 50 mg/L as $CaCO_3$ in Beet Lake and Naomi Lake. These changes to hardness in the receiving environment are illustrated in the Hardness figures in Attachment 10-A2.

As also illustrated in Attachment 10-A2, maximum predicted concentrations of cadmium, copper, lead, manganese, and nickel remain below thresholds that are derived using baseline hardness concentrations. Consequently, adjustment for ambient hardness was not required to assess potential effects related to these metals. In contrast, the sulphate threshold is calculated based on the projected hardness concentration and varies over time, with threshold values ranging from 128 mg/L to 309 mg/L. The cobalt threshold also varies with ambient hardness over time, with threshold values ranging from 0.00078 mg/L to 0.0010 mg/L. These variable thresholds are illustrated in Attachment 10-A2, which also shows how the predicted concentrations of sulphate and cobalt compare to these thresholds.

10A4.2 Regulatory Mixing Zones

A mixing zone is a transitional area within a waterbody in which a treated discharge is gradually mixed with the ambient water. The size of the mixing zone is influenced by the difference in water quality and density between the treated effluent and the receiving waterbody, and the receiving waterbody size and volume. The RMZ is an area defined by regulators to accommodate mixing and dispersion of the treated effluent after being discharged, where water quality objectives need to be met accounting for various discharge and receiving environment conditions. In this respect, Project water quality thresholds should not be exceeded outside of the outer edge of the mixing zone. Regulated mixing zones are applicable to both the ETP and STP discharge locations.

The regulatory framework applicable to the Project RMZ is from the Saskatchewan Water Security Agency (WSA). The WSA has published a set of effluent mixing zone guidelines to prescribe the general characteristics that a mixing zone should have in larger surface waterbodies, such as Patterson Lake (WSA 2015). The WSA (2015) general objectives of the RMZ are presented in Table 10A-5.

Table 10A-5: Applicable General Objectives for Effluent Discharges

ID	Description
1	Effluent should be free from substances in concentrations or combinations, which are acutely toxic or may be harmful to human, animal, or aquatic life.
2	Effluent should be free from substances that will settle to form putrescent or otherwise objectionable sludge deposits, or that will adversely affect aquatic life or waterfowl.
3	Effluent should be free from debris, oil, grease, scum, or other materials in amounts sufficient to be noticeable in the receiving water.
4	Effluent should be free from colour, turbidity, or odour-producing materials that would adversely affect aquatic life or waterfowl, significantly alter the natural colour of the receiving water, or directly or through interaction among themselves or with chemicals used in water treatment, result in undesirable taste or odour in treated water.
5	Effluent should be free from nutrients in concentrations that create nuisance growths of aquatic weeds or algae or that results in an unacceptable degree of eutrophication of the receiving water.
6	Effluent discharged to surface waters should not utilize more than 30% of the assimilation capacity of the receiving waterbody when discharged via means of a diffused outfall, or more than 10% when discharged via a point source outfall. These design objectives should be utilized during the planning stages of projects involving effluent discharges. For purposes of determining available assimilation capacity of a receiving waterbody, a flow rate equal to or less than the average seven-day low flow, which occurs once in ten years (7Q10), at the outfall area, generally should be used.

Source: WSA 2015.

In addition to the general objectives, WSA (2015) provides applicable guidelines for effluent mixing zones, presented in Table 10A-6. These guidelines state that at the outer edge of the mixing zone, the water quality should not be appreciably different from the water quality prior to the discharge of the effluent.

Table 10A-6: Applicable Guidelines for Effluent Mixing Zones

Guideline	Description
1	The mixing zone should be as small as practicable and should not be of such size or shape as to cause or contribute to the impairment of existing or likely water uses.
2	In lakes and other surface impoundments, surface water quality objectives applicable to that waterbody must be achieved at all points beyond a radius of 100 m from the effluent outfall. The volume of limited use zones in lakes should not exceed 10% of that part of the receiving waters available for mixing.
3	The mixing zone should be designed to allow an adequate zone of passage for the movement or drift of all stages of aquatic life; specific portions of a cross-section of flow or volume may be arbitrarily allocated for this purpose.
4	The mixing zones should not interfere with fish spawning and nursery areas.
5	The mixing zones should not cause an irreversible organism response or attract fish or other organisms and thereby increase their exposure period within the zone.
6	The 96 hour LC_{50} toxicity criteria, for indigenous fish species and other important aquatic species should not be exceeded at any point in the mixing zones.
7	The mixing zones should not result in contamination of natural sediments so as to cause or contribute to excursions of the water quality objectives outside the mixing zone.
8	The mixing zone will not be in close proximity or overlap with other mixing zones or effluent plumes.
9	The mixing zone will not intersect domestic water supply intakes, bathing areas, or other sensitive designated use areas.

Source: WSA 2015.
LC_{50} = lethal concentration resulting in the mortality of 50% of test organisms.

Based on the WSA (2015) guidelines, the RMZ was chosen as a 100 m radius from the centre of each of the ETP and STP discharge locations; these are illustrated in Figure 10A-2. The 600 m distance between the ETP and STP discharges considers the RMZ for both discharges, such that the closest distance between the RMZs for the two discharges locations is 400 m. This distance is sufficient to meet the requirement that mixing zones would not be in close proximity to each other (Guideline 8 in Table 10A-6). Additionally, as the freshwater intake pipe is located in the North Arm – East Basin, Guideline 9 (Table 10A-6) is met.

10A5 MODELLING ASSUMPTIONS AND LIMITATIONS

10A5.1 Regional Surface Water Quality Model

Key assumptions and limitations for the RSWQM were as follows:

- The model was configured to predict hardness based on calcium and magnesium concentrations, which are used to modify specific hardness-based water quality thresholds (i.e., sulphate and cobalt).
- The water quality threshold for ammonia was considered as un-ionized ammonia. Ammonia concentrations were reported as un-ionized ammonia for Patterson Lake and total ammonia for the other waterbodies in the LSA. If predicted un-ionized ammonia concentrations exceeded the threshold in Patterson Lake, then un-ionized ammonia would be calculated for downstream waterbodies until the predicted concentration was below the threshold.
- Un-ionized ammonia concentrations were estimated in Patterson Lake from the predicted total ammonia concentrations, ambient water temperature, and ambient pH using the approach described by CCME (CCME 2023):
  - The monthly water temperature of Patterson Lake was represented by the monthly average water temperature data collected at Station CR-WB-MS-002 (i.e., water level gauge installed by WSP).
  - The pH in Patterson Lake was represented by the seasonal average values from collected field data.

- COPC mass inputs from rainfall and snowmelt and mass loss from evaporation were considered to be negligible.
- Construction for the Fission Patterson Lake South Property was conservatively assumed to start at the same time as the Project.
- Except for the assessment of atmospheric deposition on small lakes (i.e., Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2), all lake volumes and flow rates in the RSWQM were linked to the regional hydrology model (Section 9), and as such, varied over time according to the regional hydrological conditions.
- For the assessment of atmospheric deposition on the water quality in small lakes (i.e., Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2), all lakes were assumed to have the same baseline water quality and it was assumed that inflow to these lakes was equal to outflow. Hydrological assumptions made for these lakes in the RSWQM and the proximity of these lakes to the Project are tabulated in Table 10A-7.

Table 10A-7: Volume, Surface Area, and Flow Rate for Lakes Assessed for Atmospheric Deposition Effects

Lake	Volume (m^3)	Surface Area (km^2)	Flow Rate (m^3/yr)	Proximity to Project	Proximity to Fission Patterson Lake South Property
Lake C	309,182	0.22	1,622,853	6 km west	3.5 km north
Lake E	1,743,214	0.79	2,626,625	5 km south	5 km southeast
Unnamed Lake 1	1,683,776	0.77	2,763,683	11 km southeast	11 km southeast
Unnamed Lake 2	1,394,915	0.67	993,743	10 km east	15 km east

10A5.2 Near-Field Water Quality Model

Key assumptions and limitations for the NFWQM are summarized below.

10A5.2.1 Ambient Conditions

- Ambient water temperatures of 5°C, 10°C, 15°C, and 20°C were assumed to represent the range of ambient conditions expected in Patterson Lake for the near-field modelling.
- For the ETP, thermal stratification depths of 4 m, 5 m, and 6 m were modelled in the NFWQM based in the lake profiles and the maximum stratification depth allowed by CORMIX (i.e., 60% of the depth at the discharge).
- As the water depth at the location of the proposed STP outfall is the same as the minimum recorded thermal stratification depth (i.e., 4 m), stratified conditions were not modelled for the STP outfall.
- Three ambient current speeds were used in the NFWQM:
  - The current speed of 0.001 m/s used at the STP to represent calm and under-ice conditions as it is the lowest value that can be entered in CORMIX. Calm and under-ice conditions at the ETP were assumed to be 0.009 m/s as it was the smallest current speed that resulted in stable predictions in CORMIX.
  - The typical current speed was assumed to be 0.042 m/s based on the average current speed measured at mid-depth (i.e., 5 m). A complete analysis of the current speeds and directions can be found in Annex IV.4 (Patterson Lake Currents Assessment Report).

  - The maximum current speed was assumed to be 0.079 m/s based on the 95th percentile value of the measured at mid-depth (i.e., 5 m).
- Specific conductivity measurements (in microsiemens per centimetre [µS/cm]) were converted to total dissolved solids (TDS; in mg/L) using a calculated TDS/specific conductivity coefficient of 0.64 as recommended for natural waters by Maidment (1994), which lies within the range of the TDS/specific conductivity coefficients between 0.55 and 0.7 recommended by American Public Health Association (APHA 2012).
- The density of the water in Patterson Lake and the effluent was estimated based on the temperature and TDS concentration using the formula from Wells (2019).

10A5.2.2 Effluent Treatment Plant Diffuser

- The ETP diffuser design is consistent with the one presented in the Conceptual Diffuser Design Report (TSD XIX) and assumed to have the following key features:
  - design flow of 0.231 m^3/s;
  - a single port oriented vertically with a diameter of 0.194 m;
  - port height of 1 m above the bottom;
  - total water depth at diffuser of 10 m; and
  - a design exit velocity of 7.8 m/s.
- The TDS concentration of the treated effluent from the ETP was assumed to be equal to the sum of calcium, chloride, magnesium, sodium, and sulphate concentrations predicted by the SWWBM. The NFWQM used the average predicted TDS concentration of 4,332 mg/L over the operational period of the ETP for the Application Case.
- The following three effluent temperatures were assumed to represent the expected range of effluent temperatures:
  - 4°C, representing a lower bound for effluent water temperature as this would be the temperature at which water density is the highest;
  - 8.5°C, representing an average effluent temperature, which is consistent with the water temperature used in the Conceptual Diffuser Design Report (TSD XIX) and the same as the estimated effluent temperature (NexGen 2019); and
  - 20°C, representing the highest effluent temperature based on measured temperatures in nearby small lakes:
    - Recorded water temperatures during July and August in small lakes near the Project (Lakes D, G, H, and J) that ranged from 19°C to 23°C, with an average of 21°C.
    - Reported effluent water temperatures at the Rabbit Lake Mine in 2015 and 2018 (Cameco 2016, 2019) that ranged from 10°C to 18°C, with an average of 16°C. Reported effluent water temperatures at the Rabbit Lake Mine in 2015 and 2018 (Cameco 2016, 2019) that ranged from 10°C to 18°C, with an average of 16°C.

10A5.2.3 Sewage Treatment Plant Outfall

- The conceptual design of the STP outfall was assumed to have the following key features:
  - design flow of 0.002 m^3/s;
  - a single port-oriented 45° above horizontal with a diameter of 0.029 m;
  - port height of 0.5 m above the bottom;
  - total water depth at outfall of 4 m; and
  - a design exit velocity of 3 m/s.
- The TDS of the treated sewage effluent from the STP was assumed to be equal to the sum of the calcium, chloride, magnesium, sodium, and sulphate concentrations predicted by the SWWBM. The NFWQM used the average predicted TDS concentration of 8.2 mg/L over the operational period of the STP for the Application Case.
- The same discharge temperatures as the ETP diffuser were considered for the STP outfall.
- The treated effluent concentrations for the STP were based on the following assumptions to reflect the expected effluent quality:
  - Total phosphorus concentration was assumed to be equal to 1.2 mg/L (Stantec 2021), which is consistent with typical literature values for treated STP discharges (USEPA 2011).
  - Total ammonia concentration was assumed to be equal to the total Kjeldahl nitrogen concentration of 45 mg/L (Stantec 2021), which is consistent with the upper bound of values reported in literature for treated STP discharges (USEPA 2011).
  - While nitrate concentration in the effluent is expected to be low (Stantec 2021), a concentration of 2 mg/L was assumed, which is approximately double the reported nitrate concentration in aerated lagoons located in cooler climates (USEPA 2011).
  - The remaining COPCs were assumed to be equal to background concentrations as they are not expected to be affected by the STP.

10A6 REGIONAL SURFACE WATER QUALITY MODEL

The RSWQM was developed to predict the effects of the Project on surface water quality in the LSA for the near future period and the far-future projection. The following subsections describe the model configuration, development, inputs, and application as well as the modelling results.

10A6.1 Model Description

The RSWQM was developed using GoldSim version 12.1 (GoldSim 2018). GoldSim is a graphical, object-oriented mathematical model where input constituents and functions are defined by the user and then linked together by mathematical expressions. The modelling approach includes a mass-balance mixing cell model consisting of natural components (e.g., natural flows) and Project components (e.g., operational discharge) that are linked together to form a series of sequential, fully mixed basins. Basins can either represent a single lake or a discrete basin or region of a larger lake. Each basin has two or more sources that are combined to determine a mixed water quality.

Specific objectives of the RSWQM were:

- to assess seasonal variations in water quality;
- to assess the expected magnitude, extent, and duration of effect of effluent discharge on lake water quality; and
- to assess water quality effects in small lakes associated with atmospheric deposition and the subsequent cumulative downstream effects.

The regional hydrology model (Section 9) forms the basis of the RSWQM; water chemistry data were integrated with the flow rates simulated in the hydrological model. The spatial boundaries of the RSWQM extend from Broach Lake to the outlet of Naomi Lake in the Clearwater River Upper Reach watershed. Patterson Lake was partitioned into three modelling basins (i.e., discrete and unique parts of a lake that are specifically represented in the model): the North Arm – East Basin, North Arm – West Basin, and South Arm. Forrest Lake was partitioned into two basins separated by a sand bar: the North Basin and South Basin. The model assumes that flows between waterbodies occur in a downstream direction only and mixing between basins for Patterson Lake and Forrest Lake are based on surface water elevations.

The model was run on a daily timestep, considered radioactive decay, and assumed that all available mass would remain reactive for the time frame modelled. All waterbodies are vertically well mixed, and the model does not consider the effects of seasonal stratification. The RSWQM conservatively tracks concentrations of the following constituents:

- ionic and nutrient chemistry: chloride, nitrate (as nitrogen [N]), sulphate, total ammonia (as N), and total phosphorus;
- total metals: aluminum, arsenic, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, selenium, sodium, strontium, uranium, vanadium, and zinc; and
- radionuclides: lead-210, polonium-210, radium-226, and thorium-230.

10A6.2 Assessment Cases and Model Scenarios

Water quality in the LSA was simulated for 400 years. The modelled period consisted of the Project lifespan (4-year Construction Phase, 24-year Operations Phase, 5-year Active Closure Stage, 10-year Transitional Monitoring Stage), and an extended far-future projection. The far-future projection consisted of a 357-year modelled timeline, where peak groundwater mass loads were applied during the last 200 years.

As discussed in Section 10A1.1, Regional Surface Water Quality Model, two assessment cases were considered in the RSWQM: the Application Case and the RFD Case. The Application Case evaluated Project effects on regional water quality considering reasonable average (i.e., expected case) inputs from the SWWBM and groundwater solute transport models. A reasonable upper bound sensitivity scenario was also modelled for the Application Case, which evaluated Project effects on regional water quality, considering reasonable upper bound inputs from the SWWBM and groundwater solute transport models.

The RFD Case included the Application Case and known RFDs in the LSA that have not yet been approved. The Fission Patterson Lake South Property was identified as an RFD. The RFD Case considered treated effluent discharge quality and treated sewage effluent discharge quality, and in the far future, uncontrolled site discharges related to the Fission Patterson Lake South Property. The RFD Case did not account for groundwater seepage from the Fission Patterson Lake South Property, as it is unknown whether this would occur as a result of this planned project. An RFD plus climate change sensitivity scenario was also modelled for the RFD Case, which considered how natural factors and climate change may interact with the Project and other developments to affect surface water quality.

10A6.3 Model Input Data

10A6.3.1 Base Case Surface Water Quality

The Base Case surface water quality in the LSA was developed using the regional water quality data described in Section 10A3.2. The Base Case condition in a given waterbody was represented by the average baseline water quality constituent concentration measured in that waterbody.

The sampling location for Naomi Lake is located at the north of the lake near the outlet of Naomi Creek and the sampling taken at this location is not a good representation of the overall lake quality as it is so close to the outlet. Because of this, the sampling location chosen to best represent the baseline concentrations in this waterbody is the station located at the outlet of Clearwater River below Beet Lake.

In the absence of water quality monitoring data for natural runoff and natural groundwater quality reporting to a waterbody, runoff water quality and natural groundwater quality were assigned the average baseline concentration measured in the respective waterbody (Attachment 10A-1) and was assumed to remain constant over time.

10A6.3.1.1 Data Preparation for Model Calibration

The existing regional water quality dataset used to define the average existing conditions for COPC concentrations was modified during the model calibration process to remove outliers and high detection limits. The modifications made to the dataset, along with rationale, are described in Table 10A-8. The existing conditions were modelled, and calibration factors were applied in instances where the modelled existing conditions varied distinctly from the average existing conditions data.

Table 10A-8: Modifications Made to Surface Water Quality Dataset for Model Calibration

Lake/Basin	Modification	Rationale
Broach Lake	May 2019 manganese concentration (1.4 mg/L) removed from dataset	Concentration greater than the 99th percentile of the dataset
Patterson Lake North Arm – East Basin	November 2015 and March 2016 nickel concentrations (<0.010 mg/L and <0.026 mg/L, respectively) removed from dataset	Increased detection limit compared to other samples from the basin artificially increases the average nickel concentration
Patterson Lake North Arm – West Basin	Calibration factor of 0.35 applied for iron as water passes from East Basin to West Basin	Total iron concentrations in the North Arm – West Basin are expected to be lower compared to the North Arm – East Basin due to settling and/or secondary mineral precipitation
Patterson Lake South Arm	Calibration factor of 0.40 applied for iron as water passes from West Basin to South Arm	Total iron concentrations in the South Arm are expected to be lower compared to the North Arm – East Basin due to settling and/or secondary mineral precipitation
	November 2015 arsenic concentration (0.023 mg/L) removed from dataset	Concentration greater than the 99th percentile of the dataset
	November 2015 and March 2016 nickel concentrations (<0.010 mg/L and <0.026 mg/L, respectively) removed from dataset	Increased detection limit compared to other samples from the basin artificially increases the average nickel concentration
Beet Lake	March 2020 iron concentration (0.85 mg/L) removed from dataset	Concentration greater than the 99th percentile of the dataset
	March 2020 lead concentration (0.0013 mg/L) removed from dataset)	Concentration greater than the 99th percentile of the dataset
	March 2020 manganese concentration (1.1 mg/L) removed from dataset	Concentration greater than the 99th percentile of the dataset
Naomi Lake	February 2019 nitrate concentration (0.22 mg/L as N) removed from dataset	Concentration greater than the 99th percentile of the dataset

< = less than.

10A6.3.2 Surface Water Intakes and Discharges

10A6.3.2.1 Rook I Project

The RSWQM considered the following Project activities:

- fresh water supply intake;
- treated effluent discharge;
- treated sewage discharge;
- untreated non-contact water surface runoff (i.e., west surface runoff discharge and east non-contact water diversion); and
- atmospheric deposition.

The Project fresh water supply intake would be located in Patterson Lake North Arm – East Basin and the intake rate would be equal to the rate used in the SWWBM (TSD XVIII, Site-Wide Water Balance and Water Quality Modelling Report). Discharge from the ETP and STP and west surface runoff would report to Patterson Lake North Arm – West Basin, while runoff from the east non-contact water diversion would discharge to Patterson Lake North Arm – East Basin. The treated effluent and site runoff chemistry was input to the RSWQM on a daily timestep as mass loadings (i.e., mass per unit time), while the treated sewage effluent quality was input as a concentration and flow (i.e., mass per unit volume).

10A6.3.2.2 Reasonably Foreseeable Developments

The RFD Case considered the Project activities under the Application Case and the following activities related to the Fission Patterson Lake South Property:

- fresh water supply intake;
- treated effluent discharge;
- treated sewage discharge;
- site surface runoff from a covered waste rock storage facility and above-ground tailings management facility; and
- atmospheric deposition.

Based on the Pre-Feasibility Study (Fission 2019), fresh water for the Fission Patterson Lake South Property would be sourced from Patterson Lake North Arm – West Basin, and runoff from the covered waste rock storage facility would be released to the same basin. The treated effluent discharge, treated sewage discharge, and site runoff from a covered above-ground tailings management facility would be released to Patterson Lake South Arm.

Flows associated with freshwater intake and discharges accounting for the Project and the Fission Patterson Lake South Property were based on the regional hydrology model for the RFD Case and were pro-rated based on the ore processing rate and expected workforce.

As the Fission Patterson Lake South Property has not been approved and expected quality of the discharges is not within the public domain, the treated sewage quality was set equal to the treated sewage discharge quality from the Project. Additionally, the treated mine effluent discharge quality during the assumed three-year construction period and six-year operating period of the Fission Patterson Lake South Property was assumed to be equal to the median treated effluent quality predicted for the Project during the corresponding mine life phases. The quality assigned to site surface runoff from the Fission Patterson Lake South Property above-ground tailings management facility and covered waste rock storage facility in the far future was set to equal to the median treated effluent quality predicted for the Project during Operations.

10A6.3.3 Groundwater

Results from the Project groundwater solute transport model were used to represent groundwater discharges to Patterson Lake North Arm – West Basin. The groundwater model incorporates mass loading of COPC metals to the chemistry of groundwater flows from the following Project infrastructure: the PAG WRSAs and underground workings, which include the seepage load from the reflooded mine workings, primary backfill, secondary backfill, and UGTMF.

Results used in the Application Case and RFD Case are representative of the Application Case outputs from the solute transport model. Results used as inputs to the reasonable upper bound sensitivity scenario were developed using upper bound source term inputs from underground and waste rock sources plus higher estimates of hydraulic conductivity.

The groundwater solute transport model results were input into the RSWQM as mass loadings (mass per unit time). The groundwater solute transport model included predictions for 400,000 years into the future to capture maximum loadings for each COPC. The RSWQM included a 400-year model timeframe, and as such, the solute transport model results were used according to a phased approach:

- During the initial 200 years of the model, the results were input as received from the groundwater solute transport model. This time period included Operations and Closure of the Project, and the onset of the far future.
- Following the first 200 years, the maximum load for each parameter predicted by the groundwater solute transport model was applied for the remaining 200 years of the model simulation at a constant rate to examine the maximum potential effects from groundwater inflows over multiple climate cycles and steady state conditions.

10A6.3.4 Atmospheric Deposition

Results from the air quality modelling were used as inputs to the RSWQM to assess effects of atmospheric deposition on the chemistry of the receiving waterbodies. Aluminum, ammonia, calcium, chloride, nitrate, total phosphorus, sulphate, strontium, and titanium were not included in the list of modelled constituents for the air quality model and as such are not included in the results presented in Section 10A6.4, Local Study Area Surface Water Quality Predictions. The reason for the omission for these constituents is that emissions source terms for the air dispersion modelling for these COPCs were not available at the time of the air dispersion and deposition assessment. As more information becomes available regarding air emission source terms, the modelling may be updated to include these constituents. Further, although source terms are available for sulphur dioxide and nitrogen dioxide, the air dispersion modelling default for Saskatchewan projects (i.e., AERMOD) does not include chemical transformation in the air dispersion to generate sulphate and nitrate projections (as the CALPUFF modelling system does). However, this requirement is deemed unnecessary for this assessment because as per Government of Saskatchewan (2012) guidance, sulphur dioxide and nitrogen dioxide emissions during the lifespan of the Project were determined to not be high enough to trigger a potential acid input assessment.

The Application Case and reasonable upper bound sensitivity scenario utilized the same atmospheric deposition predictions (i.e., based on the Project emissions), while the RFD Case utilized atmospheric deposition predictions that included predicted cumulative effects from emissions from the Fission Patterson Lake South Property. Constituent deposition values were provided for each modelled waterbody and input to the RSWQM as loads (i.e., mass per unit surface area per unit time). Constituent deposition values that were reported as below the air quality model precision limits were assumed to be 50% of the precision limit. Atmospheric loadings to snow and ice that were deposited over waterbodies were accumulated over the winter (i.e., October to May; six months) and released over a 30-day period during spring melt.

10A6.4 Local Study Area Surface Water Quality Predictions

Predicted water quality COPC concentrations in the LSA are summarized in the following subsections; concentrations are presented as monthly averages or summary statistics calculated from the monthly averages. Results were compared to the Project water quality thresholds described in Section 10A4.1. Time series plots of all results are provided in Attachment 10A-2, Regional Surface Water Quality Model Results.

The following subsections provide a summary of the model results by location for each assessment case and sensitivity scenario. The discussion focuses on the following selected parameters: total ammonia, nitrate, total phosphorus, chloride, hardness, sulphate, cobalt, copper, uranium, and radium-226. These constituents encompass the COPCs that are predicted to be most notably affected by the Project or are expected to be of concern by regulators or Indigenous Groups. Cadmium and iron are also discussed for Broach Lake, Lake G, and Lake H.

Unless otherwise noted, predicted concentrations of COPCs remained below their respective water quality thresholds. Modelled occurrences of constituents above the water quality thresholds are denoted by bold values in the summary tables in the following subsections.

Cadmium concentrations are most affected by atmospheric deposition in the waterbodies that have small volumes. Iron concentrations are also discussed for Lake G and Lake H because the Base Case concentrations are greater than the threshold value.

10A6.4.1 Application Case

10A6.4.1.1 Broach Lake, Lake G, and Lake H

In the Application Case, the only predicted contribution of mass loads to Broach Lake, Lake G, and Lake H from the Project is atmospheric deposition of metals and radionuclides. Concentrations of nutrients and major ions in these waterbodies do not notably change from the existing conditions throughout the modelled periods. In general, concentrations are lowest from April to June during freshet and highest from August to March. There is no anticipated measurable atmospheric deposition of ammonia, nitrate, sulphate, and chloride to these lakes, so any variation in their concentration is due to natural seasonal variability.

Predicted concentrations of selected COPCs are summarized for the Project lifespan and far future in Table 10A-9 and Table 10A-10, respectively, and are illustrated in Attachment 10A-2. Water quality in Broach Lake, Lake H, and Lake G demonstrate slightly increased metal and radionuclide concentrations from atmospheric deposition compared to existing (i.e., baseline) conditions throughout the Construction, Operations, and Closure of the Project.

The increased concentrations are more prominent in the waterbodies with smaller volumes (i.e., Lake G and Lake H) or smaller catchment areas with less natural runoff. Except for iron, all modelled constituents remained below the Project thresholds in all waterbodies throughout the modelled period. The increase in cadmium relative to existing conditions results in a peak monthly average value of 0.000015 mg/L for Lake G and 0.000016 mg/L for Lake H, which is similar to the water quality threshold for cadmium (0.000017 mg/L). The atmospheric deposition load for cadmium in these waterbodies was below the detection limit (0.0001 kg/ha/yr), suggesting some uncertainty in the projections (i.e., these projections are anticipated to be less than modelled).

The existing conditions for iron in Lake G and Lake H are above the threshold value (i.e., 0.30 mg/L), and as such, modelled iron concentrations in these waterbodies remain above the threshold level throughout the Project lifespan. The water quality in Broach Lake, Lake H, and Lake G is predicted to return to baseline concentrations within five years after the end of the Closure of the Project.

In the far future, all modelled constituents in Broach Lake, Lake G, and Lake H are predicted to return to conditions similar to existing conditions (Table 10A-10).

Table 10A-9: Application Case Summary Statistics for Selected Constituents in the Rook I Project Lifespan for Broach Lake, Lake G, and Lake H

Constituent	Unit	Project Threshold	Minimum			Average			Maximum		
			Broach Lake	Lake G	Lake H	Broach Lake	Lake G	Lake H	Broach Lake	Lake G	Lake H
Total ammonia (as nitrogen)	mg/L	n/a[(a)]	0.021	0.13	0.084	0.021	0.14	0.095	0.022	0.16	0.11
Un-ionized ammonia (as nitrogen)[(b,c)]	mg/L	0.016	0.000011	0.000069	0.000045	0.000069	0.00045	0.0003	0.000282	0.0019	0.0013
Nitrate (as nitrogen)	mg/L	2.9	0.022	0.038	0.0054	0.022	0.042	0.0061	0.023	0.048	0.0072
Phosphorus (total)	mg/L	0.020	0.0050	0.010	0.0054	0.0052	0.012	0.0061	0.0053	0.013	0.0072
Chloride	mg/L	120	0.39	0.083	0.17	0.40	0.093	0.19	0.41	0.11	0.22
Hardness	mg/L	n/a	14	15	13	14	17	15	15	19	18
Sulphate	mg/L	128	1.8	1.1	0.23	1.9	1.3	0.27	1.9	1.4	0.31
Cobalt	mg/L	0.00078[(d)]	0.000050	0.000050	0.000044	0.000051	0.000061	0.000053	0.000052	0.000076	0.000066
Copper	mg/L	0.0020	0.00011	0.00024	0.000089	0.00011	0.00028	0.00012	0.00011	0.00035	0.00015
Uranium	mg/L	0.015	0.000048	0.000048	0.000050	0.00013	0.0013	0.00093	0.00018	0.0029	0.0017
Radium-226	Bq/L	0.11	0.0034	0.0044	0.0029	0.0043	0.017	0.014	0.0047	0.031	0.024

a) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.
b) Calculated as a fraction of total ammonia, as a function of pH and temperature.
c) The average seasonal pH and average monthly temperature of individual samples were used to calculate the fraction factor. Individual temperature and pH samples for Broach Lake, Lake G, and Lake H were combined to calculate the monthly fraction factor. Data gaps in monthly temperature data were infilled by averaging data from the closest months with available data.
d) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).
n/a = not applicable; Bq/L = becquerels per litre.

Table 10A-10: Application Case Summary Statistics for Selected Constituents in the Far Future for Broach Lake, Lake G, and Lake H

Constituent	Unit	Project Threshold	Minimum			Average			Maximum		
			Broach Lake	Lake G	Lake H	Broach Lake	Lake G	Lake H	Broach Lake	Lake G	Lake H
Total ammonia (as nitrogen)	mg/L	n/a[(a)]	0.021	0.13	0.084	0.021	0.14	0.096	0.021	0.16	0.11
Un-ionized ammonia (as nitrogen)[(b,c)]	mg/L	0.016	0.000011	0.000069	0.000045	0.000068	0.00046	0.00031	0.00027	0.0020	0.0014
Nitrate (as nitrogen)	mg/L	2.9	0.022	0.038	0.0054	0.022	0.042	0.0062	0.022	0.048	0.0074
Phosphorus (total)	mg/L	0.020	0.0050	0.011	0.0054	0.0051	0.012	0.0062	0.0051	0.014	0.0074
Chloride	mg/L	120	0.39	0.083	0.17	0.39	0.094	0.19	0.40	0.11	0.23
Hardness	mg/L	n/a	14	15	13	14	17	15	14	20	18
Sulphate	mg/L	128	1.8	1.1	0.23	1.8	1.3	0.27	1.8	1.5	0.32
Cobalt	mg/L	0.00078[(d)]	0.000047	0.000048	0.000042	0.000048	0.000054	0.000048	0.000050	0.000062	0.000057
Copper	mg/L	0.0020	0.00010	0.00023	0.000084	0.00011	0.00026	0.000096	0.00011	0.00029	0.00011
Uranium	mg/L	0.015	0.000045	0.000044	0.000042	0.000053	0.000049	0.000048	0.00013	0.000056	0.000059
Radium-226	Bq/L	0.11	0.0032	0.0042	0.0026	0.0033	0.0047	0.0030	0.0042	0.0054	0.0036

a) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.
b) Calculated as a fraction of total ammonia, as a function of pH and temperature.
c) The average seasonal pH and average monthly temperature of samples were used to calculate the fraction factor. Individual temperature and pH samples for Broach Lake, Lake G, and Lake H were combined to calculate the monthly fraction factor. Data gaps in monthly temperature data were infilled by averaging data from the closest months with available data.
d) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).
n/a = not applicable; Bq/L = becquerels per litre.

10A6.4.1.2 Patterson Lake

In the Application Case, the three Patterson Lake basins are predicted to be affected by surface discharges and, to a lesser extent, atmospheric deposition from the Project; however, modelled COPCs in Patterson Lake remain below their respective thresholds throughout the Project lifespan. Modelled COPCs remain below their respective thresholds throughout the far future, except for cobalt and copper (Table 10A-11 and Table 10A-12). The model predicts cobalt and copper concentrations in Patterson Lake above their thresholds due to groundwater mass loading in the far future.

During the Project lifespan, the North Arm – East Basin is affected by the surface runoff (i.e., non-contact and contact with borrow material) from the Project. The North Arm – West Basin receives the ETP and STP discharges, west surface runoff discharge, and groundwater seepage from the Project. The South Arm does not receive any direct discharges from the Project. Water in the North Arm – West Basin occasionally flows into the North Arm – East Basin and South Arm, as dictated by water surface elevation in the basin.

Predicted concentrations of selected constituents are summarized for the Project lifespan and far future in Table 10A-11 and Table 10A-12, respectively, and are illustrated in Attachment 10A-2. An increase from existing conditions for all modelled constituents as well as hardness is predicted in the three basins during Operations (i.e., 2029 to 2052). In general, COPC concentrations and hardness gradually increase throughout the Project lifespan in the three basins with the highest concentrations of COPCs observed in the North Arm – West Basin, which receives the Project discharges, followed by the South Arm and the North Arm – East Basin. Peak COPC concentrations during the Project lifespan are noted in the final years of Operations (i.e., 2051 in the North Arm – East Basin and North Arm – West Basin, and in 2052 in the South Arm), after which they steadily decline as the COPC mass loads are dispersed downstream after Operations discharges cease. Hardness is also expected to return to baseline conditions following Closure. The modelled projections do not show a discernible seasonal effect in the basins, likely due to their large volumes. The primary source of the increases in major ions and nutrients in the Patterson Lake basins during the Project lifespan is the treated effluent discharge and treated sewage discharge. Following the cessation of these discharges, modelled concentrations of major ions and nutrients start to decline. All modelled major ions and nutrients remain below thresholds during the Project lifespan and in the far future in the three basins. Concentrations of metals and radionuclides also increase in the three basins during the Project lifespan, which is due to the treated effluent discharge. Following the cessation of these discharges, modelled concentrations of metals and radionuclides start to decline. All metal and radionuclide concentrations remain below threshold values during the Project lifespan.

In the far future, the primary load contribution to the North Arm – West Basin is from groundwater inflows that are influenced by surface water infiltration and constituent mobilization from Project infrastructure (i.e., WRSAs and underground workings). The COPCs that are influenced by this input and are modelled to increase in concentration are primarily metals and radionuclides. While the majority of COPCs remain below thresholds, cobalt and copper are the only COPCs projected to be higher than their respective thresholds in the far future. Cobalt concentrations consistently exceed the threshold value (i.e., 0.00078 mg/L) in the North Arm – West Basin and the South Arm, and copper concentrations periodically exceed the threshold value (0.0020 mg/L) in the North Arm – West Basin (Attachment 10A-2). During the far future, the highest concentrations correspond to years with low natural inflows to the lake and the lowest concentrations correspond to years with high natural inflows to the lake. Additional context regarding the modelled threshold exceedances of cobalt and copper is provided in the environmental risk assessment (TSD XXI, Environmental Risk Assessment).

Elevated COPC concentrations as a result of groundwater discharges during the far future are predicted to remain elevated indefinitely, because the groundwater modelling assumed that the PAG WRSAs and underground workings (including the UGTMF) are inexhaustible loading sources. The groundwater solute transport model predicts maximum cobalt and copper loads to occur 23,300 years and 36,600 years into the modelled period, respectively.

Table 10A-11: Application Case Summary Statistics for Selected Constituents in the Rook I Project Lifespan for Patterson Lake

Constituent	Unit	Project Threshold	Minimum			Average			Maximum		
			North Arm – East Basin	North Arm – West Basin	South Arm	North Arm – East Basin	North Arm – West Basin	South Arm	North Arm – East Basin	North Arm – West Basin	South Arm
Total ammonia (as nitrogen)	mg/L	n/a[a]	0.030	0.018	0.011	0.057	0.23	0.18	0.085	0.36	0.27
Un-ionized ammonia (as nitrogen)[b,c]	mg/L	0.016	0.0000081	0.0000059	0.0000030	0.000050	0.00020	0.00015	0.00014	0.00062	0.00048
Nitrate (as nitrogen)	mg/L	2.9	0.016	0.0083	0.013	0.046	0.20	0.16	0.073	0.33	0.25
Phosphorus (total)	mg/L	0.020	0.0054	0.0050	0.0050	0.0057	0.0076	0.0074	0.0061	0.0089	0.0086
Chloride	mg/L	120	0.40	0.51	0.57	0.71	2.7	2.2	0.98	4.0	3.3
Hardness	mg/L	n/a	12	14	15	21	66	56	28	103	82
Sulphate	mg/L	128-309	1.2	1.5	1.6	17	107	83	35	198	149
Cobalt	mg/L	0.00078-0.0010[d]	0.000059	0.000066	0.000061	0.000078	0.00019	0.00017	0.00010	0.00031	0.00026
Copper	mg/L	0.0020	0.00012	0.00012	0.00014	0.00015	0.00025	0.00024	0.00017	0.00037	0.00032
Uranium	mg/L	0.015	0.000050	0.000057	0.000061	0.00065	0.0010	0.00094	0.00099	0.0015	0.0014
Radium-226	Bq/L	0.11	0.0041	0.0051	0.0041	0.014	0.010	0.014	0.020	0.014	0.018

a) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.
b) Function of total ammonia, pH, and temperature.
c) The average seasonal pH and average monthly temperature of samples were used to calculate the fraction factor.
d) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).
Bq/L = becquerels per litre.

Table 10A-12: Application Case Summary Statistics for Selected Constituents in the Far Future for Patterson Lake

Constituent	Unit	Project Threshold	Minimum			Average			Maximum		
			North Arm – East Basin	North Arm – West Basin	South Arm	North Arm East – Basin	North Arm – West Basin	South Arm	North Arm – East Basin	North Arm – West Basin	South Arm
Total ammonia (as nitrogen)	mg/L	n/a[a]	0.026	0.028	0.026	0.029	0.031	0.031	0.042	0.082	0.13
Un-ionized ammonia (as nitrogen)[b,c]	mg/L	0.016	0.0000073	0.0000077	0.0000072	0.000025	0.000027	0.000027	0.000072	0.00014	0.00023
Nitrate (as nitrogen)	mg/L	2.9	0.018	0.016	0.017	0.019	0.018	0.021	0.031	0.064	0.11
Phosphorus (total)	mg/L	0.020	0.0051	0.0051	0.0054	0.0053	0.0052	0.0058	0.0057	0.0059	0.0072
Chloride	mg/L	120	0.39	0.72	0.77	0.44	0.83	0.86	0.60	1.3	2.0
Hardness	mg/L	n/a	12	13	15	13	14	16	17	28	45
Sulphate	mg/L	128-218	1.5	2.3	2.4	1.8	3.1	4.0	6.9	23	48
Cobalt	mg/L	0.00078[d]	0.000065	0.000091	0.00012	0.00020	**0.0010**	**0.00083**	0.00032	**0.0015**	**0.0011**
Copper	mg/L	0.0020	0.00012	0.00015	0.00019	0.00035	0.0017	0.0014	0.00054	**0.0024**	0.0019
Uranium	mg/L	0.015	0.00014	0.00041	0.00052	0.00040	0.0024	0.0020	0.00067	0.0034	0.0026
Radium-226	Bq/L	0.11	0.0051	0.0040	0.0055	0.0070	0.0044	0.0071	0.0085	0.0052	0.011

a) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.
b) Function of total ammonia, pH, and temperature.
c) The average seasonal pH and average monthly temperature of samples were used to calculate the fraction factor.
d) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).
Bold values represent concentrations that exceed the Project threshold.
Bq/L = becquerels per litre.

10A6.4.1.3 Forrest Lake, Beet Lake, and Naomi Lake

In the Application Case, COPC concentrations in Forrest Lake, Beet Lake, and Naomi Lake are predicted to increase as a result of atmospheric deposition inputs and Project discharges to Patterson Lake, located upstream. The primary COPCs from these sources are metals and radionuclides, which attenuate with distance downstream from Patterson Lake.

Forrest Lake is modelled as two distinct basins (i.e., North Basin and South Basin), separated by a sandbar, with the inlet and outlet of Forrest Lake located in the North Basin. Natural runoff into the South Basin of Forrest Lake flows to the North Basin. The outflow from the North Basin is to Beet Lake and then to Naomi Lake. As such, Project effects are projected in Forrest Lake – North Basin, Beet Lake, and Naomi Lake.

Predicted concentrations of selected constituents in these lakes are summarized for the Project lifespan and the far future in Table 10A-13 and Table 10A-14, respectively, and are illustrated in Attachment 10A-2. Although modelled concentrations of COPCs increase during the Project lifespan, all COPCs remain below threshold values.

In general, peak concentrations occur in Forrest Lake – North Basin in 2053 and in Beet Lake and Naomi Lake in 2055, due to a lag effect through the series of waterbodies. Seasonal effects on modelled water quality are observed mostly in Forrest Lake – North Basin due to its small volume. This includes lower COPC concentrations in December to March when there is a lower flow from Patterson Lake, and increased concentrations in April through November when flow from Patterson Lake increases.

Concentrations of major ions and nutrients increase in Forrest Lake – North Basin, Beet Lake, and Naomi Lake during the Project lifespan due to mass load inputs from Patterson Lake. These concentrations subsequently decrease in the far future as the corresponding concentrations in Patterson Lake decrease. All modelled major ions and nutrients remain below thresholds in the Project lifespan and far future in these waterbodies.

Concentrations of metals and radionuclides also increase in the three waterbodies in the Project lifespan, but all concentrations remain below threshold values. In the far future, metal and radionuclide concentrations remain below threshold values, including cobalt. The maximum cobalt concentration in Forrest Lake – North Basin (0.00077 mg/L), as a result of the loading from Patterson Lake (Attachment 10A-2), peaks at just below the Project threshold.

Table 10A-13: Application Case Summary Statistics for Selected Constituents in the Rook I Project Lifespan for Forrest Lake – North Basin, Beet Lake, and Naomi Lake

Constituent	Unit	Project Threshold	Minimum			Average			Maximum		
			Forrest North	Beet Lake	Naomi Lake	Forrest North	Beet Lake	Naomi Lake	Forrest North	Beet Lake	Naomi Lake
Total ammonia (as nitrogen)	mg/L	n/a[(a)]	0.0057	0.015	0.013	0.095	0.092	0.076	0.19	0.15	0.13
Un-ionized ammonia (as nitrogen)[(b,c)]	mg/L	0.016	0.0000020	0.0000070	0.0000070	0.00034	0.00019	0.00015	0.0017	0.0011	0.00092
Nitrate (as nitrogen)	mg/L	2.9	0.0053	0.0088	0.0050	0.085	0.081	0.066	0.17	0.14	0.12
Phosphorus (total)	mg/L	0.020	0.0030	0.0047	0.0046	0.0057	0.0058	0.0056	0.0073	0.0067	0.0065
Chloride	mg/L	120	0.46	0.60	0.59	1.4	1.4	1.2	2.4	2.1	1.8
Hardness	mg/L	n/a	11	15	15	36	35	31	60	52	47
Sulphate	mg/L	128-218	1.1	1.5	1.5	44	42	34	98	80	70
Cobalt	mg/L	0.00078-0.00083[(d)]	0.000049	0.000050	0.000050	0.00012	0.00012	0.00010	0.00019	0.00017	0.00016
Copper	mg/L	0.0020	0.000085	0.00015	0.00010	0.00019	0.00019	0.00017	0.00028	0.00024	0.00023
Uranium	mg/L	0.015	0.000051	0.000048	0.000050	0.00057	0.00059	0.00048	0.0011	0.00092	0.00080
Radium-226	Bq/L	0.11	0.0028	0.0044	0.0035	0.0092	0.0095	0.0084	0.015	0.013	0.012

a) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.

b) Calculated as a fraction of total ammonia, as a function of pH and temperature.

c) The average seasonal pH and average monthly temperature of samples were used to calculate the fraction factor. Individual temperature and pH samples for Beet Lake and Naomi Lake were combined to calculate the monthly fraction factor. Individual temperature and pH samples for Patterson Lake and Forrest North, respectively, were used to calculate the monthly fraction factor for Forrest North. Data gaps in monthly temperature data were infilled by averaging data from the closest months with available data.

d) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).

n/a = not applicable; Bq/L = becquerels per litre.

Table 10A-14: Application Case Summary Statistics for Selected Constituents in the Far Future for Forrest Lake – North Basin, Beet Lake, and Naomi Lake

Constituent	Unit	Project Threshold	Minimum			Average			Maximum		
			Forrest North	Beet Lake	Naomi Lake	Forrest North	Beet Lake	Naomi Lake	Forrest North	Beet Lake	Naomi Lake
Total ammonia (as nitrogen)	mg/L	n/a[(a)]	0.0064	0.016	0.015	0.019	0.020	0.019	0.090	0.074	0.066
Un-ionized ammonia (as nitrogen)[(b,c)]	mg/L	0.016	0.0000020	0.0000070	0.0000070	0.000066	0.000041	0.000038	0.00084	0.00055	0.00047
Nitrate (as nitrogen)	mg/L	2.9	0.0047	0.010	0.0086	0.013	0.013	0.012	0.076	0.063	0.055
Phosphorus (total)	mg/L	0.020	0.0025	0.0044	0.0044	0.0048	0.0049	0.0049	0.0065	0.0058	0.0057
Chloride	mg/L	120	0.38	0.64	0.63	0.72	0.73	0.71	1.5	1.3	1.2
Hardness	mg/L	n/a	8.1	14	14	15	15	16	36	31	29
Sulphate	mg/L	128-218	0.98	1.7	1.7	2.6	2.7	2.5	31	27	23
Cobalt	mg/L	0.00078[(d)]	0.000052	0.000086	0.000073	0.00046	0.00044	0.00036	0.00077	0.00062	0.00052
Copper	mg/L	0.0020	0.000092	0.00015	0.00014	0.00077	0.00075	0.00062	0.0013	0.0010	0.00089
Uranium	mg/L	0.015	0.00013	0.00028	0.00020	0.0010	0.00099	0.00080	0.0018	0.0014	0.0012
Radium-226	Bq/L	0.11	0.0025	0.0045	0.0042	0.0052	0.0052	0.0049	0.0090	0.0078	0.0072

a) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.
b) Calculated as a fraction of total ammonia, as a function of pH and temperature.
c) The average seasonal pH and average monthly temperature of samples were used to calculate the fraction factor. Individual temperature and pH samples for Beet Lake and Naomi Lake were combined to calculate the monthly fraction factor. Individual temperature and pH samples for Patterson Lake and Forrest North, respectively, were used to calculate the monthly fraction factor for Forrest North. Data gaps in monthly temperature data were infilled by averaging data from the closest months with available data.
d) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).
n/a = not applicable; Bq/L = becquerels per litre.

10A6.4.1.4 Atmospheric Deposition Effects in Small Lakes

Although atmospheric deposition effects were included in the overall Application Case assessment of all modelled waterbodies in the LSA, potential Project effects derived solely from atmospheric deposition were assessed in four small waterbodies in the LSA. These waterbodies included Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2. Atmospheric deposition effects were assessed in these small waterbodies because atmospheric deposition effects are anticipated to be more pronounced in waterbodies with a small surface area or volume, and these waterbodies are located in the LSA and not influenced by Project surface or groundwater discharges. Results from the air quality model that were used in this assessment are conservative predictions; additional context regarding the air quality model results is provided in the air quality assessment (Appendix 7A).

Since no water quality samples were collected from the four small waterbodies, baseline water quality was assumed to be equal to the average of four reference lakes: Harbo Lake, Hodge Lake, Lake D, and Lake J. These waterbodies were chosen as a reference following a detailed review of the baseline water quality dataset. Based on that review, it is anticipated that the baseline quality in Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2 would be similar to the average quality of the reference waterbodies.

In these waterbodies, predicted changes to water quality can be attributed solely to atmospheric deposition as there are no other Project-related mass inputs inflows or contributions. The predicted maximum monthly concentrations of a subset of COPCs in each waterbody are tabulated in Table 10A-15, with all maximum modelled projections remaining below water quality thresholds.

The atmospheric deposition modelling as presented in Table 10A-15 showed that:

- Maximum predicted increases in most COPCs remained within 5% of existing conditions.
- Modelled increases to existing concentrations for mercury, uranium, and the radionuclides (i.e., lead-210, polonium-210, radium-226, and thorium-230) ranged from 10% to three-fold differences (Table 10A-15). While relatively large increases (i.e., one- to three-fold increases) are noted for some parameters (e.g., mercury, uranium, polonium-210), these increases are associated with very low initial concentrations in the reference lakes relative to the loading input.
- The largest COPC concentration increases are predicted to occur in Unnamed Lake 2, which is attributed to its predominant downwind location relative to the Project site.

Overall, the effects of atmospheric deposition in these waterbodies are determined to be minor. This indicates that for most COPCs, the relative change in concentration in small waterbodies surrounding the Project over the Project lifespan is expected to remain within 5% of existing conditions and be limited to those waterbodies within close proximity to the Project. For COPCs that are projected to have larger relative increases over existing conditions, the peak concentrations do not approach their respective Project thresholds. Further, the influence of atmospheric deposition to water quality in the small waterbodies is limited to the Project lifespan; once Project activities cease, the influence of deposition from Project air emissions also ceases.

Table 10A-15: Maximum Predicted Constituent Concentrations as a Result of Atmospheric Deposition in Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2 for the Application Case

Constituent	Units	Project Threshold[(a)]	Representative Base Case Lake Quality[(b)]	Maximum Predicted Monthly Average Concentration			
				Lake C	Lake E	Unnamed Lake 1	Unnamed Lake 2
Arsenic	mg/L	0.0050	0.00011	0.00011	0.00011	0.00011	0.00011
Cadmium	mg/L	0.00004	0.0000061	0.0000077	0.0000081	0.0000080	0.0000099
Chromium	mg/L	0.0010	0.00022	0.00022	0.00023	0.00022	0.00023
Cobalt	mg/L	0.00078	0.000047	0.000049	0.000049	0.000049	0.000051
Copper	mg/L	0.0020	0.00013	0.00013	0.00013	0.00013	0.00014
Iron	mg/L	0.3	0.12	0.12	0.12	0.12	0.12
Lead	mg/L	0.0010	0.000079	0.000082	0.000083	0.000083	0.000087
Magnesium	mg/L	n/a	0.70	0.70	0.70	0.70	0.70
Manganese	mg/L	0.26	0.020	0.020	0.020	0.020	0.020
Mercury	mg/L	0.000026	0.0000015	0.0000031	0.0000035	0.0000034	0.0000053
Molybdenum	mg/L	7.6	0.000056	0.000058	0.000060	0.000058	0.000060
Nickel	mg/L	0.025	0.000082	0.000084	0.000086	0.000084	0.000086
Selenium	mg/L	0.001	0.000056	0.000058	0.000058	0.000058	0.000060
Sodium	mg/L	n/a	1.0	1.0	1.0	1.0	1.0
Uranium	mg/L	0.015	0.000056	0.00015	0.00024	0.00014	0.00027
Vanadium	mg/L	0.12	0.000069	0.000072	0.000073	0.000071	0.000077
Zinc	mg/L	0.0070	0.00095	0.00095	0.00095	0.00095	0.00095
Lead-210	Bq/L	22	0.012	0.013	0.015	0.013	0.015
Polonium-210	Bq/L	13.5	0.0043	0.0078	0.012	0.0094	0.013
Radium-226	Bq/L	0.11	0.0033	0.0047	0.0062	0.0041	0.0062
Thorium-230	Bq/L	95	0.0052	0.0066	0.0081	0.0060	0.0081

a) Water quality thresholds selected for this report are provided in Section 10A4.1.
b) Base Case COPC concentrations are assumed to be the average measured values in Broach Lake and Hodge Lake.
n/a = not available; Bq/L = becquerels per litre; COPC = constituent of potential concern.

10A6.4.1.4.1 Total Suspended Particulate Matter in Small Lakes

As TSS was not included in the RSWQM, a supplementary desktop analysis was performed to estimate the average annual increase in TSS concentration in small lakes due to the aerial deposition of total suspended particulates emitted from the Project during the Project lifespan. The atmospheric modelling results for Construction and Operations during the Project lifespan were used to estimate the total annual atmospheric deposition of total suspended particulates, as grams per year, to each lake based on surface area. The average annual concentration increase was estimated by dividing the annual mass deposited by the average annual outflow rate over 80 years from the regional hydrological model for each lake.

The results are summarized in Table 10A-16 and show that the predicted increases in TSS concentration in Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2 are less than 0.1 mg/L and are not expected to be measurable.

Table 10A-16: Atmospheric Deposition Effects on Total Suspended Solids Concentration in Small Lakes during the Rook I Project Lifespan

Lake	Estimated TSS Increase during Construction and Operations (mg/L)
Lake C	0.010
Lake E	0.031
Unnamed Lake 1	0.013
Unnamed Lake 2	0.033

TSS = total suspended solids.

10A6.4.1.5 Reasonable Upper Bound Sensitivity Scenario

10A6.4.1.5.1 Broach Lake, Lake G, and Lake H

Since Broach Lake, Lake G and Lake H lie upstream of the Project, surface water quality model inputs to these waterbodies in the reasonable upper bound sensitivity scenario remain the same as the inputs in the Application Case. These include natural watershed flow and atmospheric deposition from the Project; the modelled atmospheric deposition inputs represent a conservative loading, and are therefore the same for the Application Case and the reasonable upper bound sensitivity scenario.

As such, water quality projections for the COPCs in Broach Lake, Lake G, and Lake H in the reasonable upper bound sensitivity scenario are similar to those described for the Application Case (Section 10A6.4.1).

10A6.4.1.5.2 Patterson Lake

In the reasonable upper bound sensitivity scenario, concentrations of COPCs in Patterson Lake are predicted to increase during the Project lifespan as a consequence of atmospheric deposition effects and Project discharges. These increases are more pronounced than in the Application Case due to more conservative inputs associated with operational discharges and groundwater seepage. During the Project lifespan, all three Patterson Lake basins are affected by atmospheric deposition from the Project. With respect to site runoff, Project discharges, and groundwater inflows, the North Arm – East Basin is affected by surface runoff (i.e., non-contact and contact with borrow material) from the site and the North Arm – West Basin receives the ETP and STP discharges, west surface runoff, and groundwater inflows from the Project. The South Arm does not receive any direct discharges from the Project but is downstream of the North Arm basins.

Similar to the Application Case, an increase from existing conditions is predicted for all COPCs in the three basins during Operations (i.e., 2029 to 2052). Predicted concentrations of selected constituents are summarized for the Project lifespan and far future in Table 10A-17 and Table 10A-18, respectively, and are illustrated in Attachment 10A-2. Constituents are predicted to remain below their respective thresholds, except for cobalt and copper in the far future, as discussed below.

Modelled concentrations in the three Patterson Lake basins during the Project lifespan demonstrate similar trends and concentrations compared to the Application Case, except for chloride, mercury, total phosphorus, and uranium. The main source of mass loads of these constituents to the basins in the Project lifespan is the treated effluent discharge. The greatest differences between the Application Case and the reasonable upper bound sensitivity scenario were for COPCs where inputs increased and no treatment efficiency was defined for the constituent (i.e., chloride, mercury, and total phosphorus). Additionally, differences were noted where the input increased by more than an order of magnitude between Application Case and the reasonable upper bound sensitivity scenario (i.e., uranium). In the far future, an increase is predicted for most constituents between the Application Case and the reasonable upper bound sensitivity scenario (Attachment 10A-2).

Concentrations of major ions and nutrients increase in the Patterson Lake basins in the Project lifespan due to the treated ETP and STP discharges, and subsequently decrease in the far future. All major ions and nutrients remain below threshold values in the three basins in the Project lifespan and the far future.

Concentrations of metals and radionuclides also increase in the three basins during the Project lifespan, primarily due to mass load inputs from the treated effluent discharge, and all predicted concentrations remain below thresholds. In the far future, the primary load contribution to the North Arm – West Basin is from groundwater and some concentrations of metals increase in this period. Cobalt and copper concentrations in the North Arm – West Basin and South Arm consistently exceed the threshold values in the far future (Attachment 10A-2). Similar to the Application Case, the highest concentrations correspond to years with low natural flows into the waterbodies and the lowest concentrations correspond to years with high natural inflows.

Table 10A-17: Reasonable Upper Bound Scenario Summary Statistics for Selected Constituents in the Rook I Project Lifespan for Patterson Lake

Constituent	Unit	Project Threshold	Minimum			Average			Maximum		
			North Arm – East Basin	North Arm – West Basin	South Arm	North Arm – East Basin	North Arm – West Basin	South Arm	North Arm – East Basin	North Arm – West Basin	South Arm
Total ammonia (as nitrogen)	mg/L	n/a[(a)]	0.029	0.018	0.011	0.058	0.23	0.18	0.086	0.36	0.28
Un-ionized ammonia (as nitrogen)[(b,c)]	mg/L	0.016	0.0000081	0.0000059	0.0000031	0.000050	0.00020	0.00016	0.00014	0.00062	0.00048
Nitrate (as nitrogen)	mg/L	2.9	0.016	0.0083	0.013	0.048	0.22	0.17	0.077	0.35	0.27
Phosphorus (total)	mg/L	0.020	0.0056	0.0050	0.0050	0.0062	0.011	0.0098	0.0069	0.014	0.012
Chloride	mg/L	120	0.40	0.52	0.57	9.1	60	45	16	93	72
Hardness	mg/L	n/a	12	14	15	21	70	58	28	104	85
Sulphate	mg/L	128-309	1.2	1.5	1.6	17	108	84	35	200	151
Cobalt	mg/L	0.00078-0.0010[(d)]	0.000059	0.000066	0.000061	0.000079	0.00020	0.00017	0.00010	0.00032	0.00026
Copper	mg/L	0.0020	0.00012	0.00012	0.00014	0.00015	0.00025	0.00024	0.00017	0.00037	0.00033
Uranium	mg/L	0.015	0.000050	0.000057	0.000061	0.00077	0.0018	0.0015	0.0012	0.0028	0.0024
Radium-226	Bq/L	0.11	0.0041	0.0051	0.0041	0.014	0.010	0.014	0.020	0.014	0.019

a) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.
b) Function of total ammonia, pH, and temperature.
c) The average seasonal pH and average monthly temperature of samples were used to calculate the fraction factor.
d) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).
Bq/L = becquerels per litre.

Table 10A-18: Reasonable Upper Bound Scenario Summary Statistics for Selected Constituents in the Far Future for Patterson Lake

Constituent	Unit	Project Threshold	Minimum			Average			Maximum		
			North Arm – East Basin	North Arm – West Basin	South Arm	North Arm – West Basin	North Arm – West Basin	South Arm	North Arm – East Basin	North Arm – West Basin	South Arm
Total ammonia (as nitrogen)	mg/L	n/a[a]	0.026	0.030	0.028	0.029	0.033	0.033	0.042	0.083	0.14
Un-ionized ammonia (as nitrogen)[b,c]	mg/L	0.016	0.0000073	0.0000082	0.0000080	0.000025	0.000028	0.000028	0.000072	0.00014	0.00024
Nitrate (as nitrogen)	mg/L	2.9	0.018	0.016	0.017	0.019	0.018	0.021	0.032	0.068	0.12
Phosphorus (total)	mg/L	0.020	0.0051	0.0051	0.0054	0.0054	0.0053	0.0058	0.0059	0.0068	0.0089
Chloride	mg/L	120	0.41	0.92	0.93	0.60	1.6	2.3	5.6	21	38
Hardness	mg/L	n/a	12	13	15	13	14	17	18	32	51
Sulphate	mg/L	128-218	1.6	2.8	2.8	1.9	3.7	4.5	7.0	23	49
Cobalt	mg/L	0.00078[d]	0.000066	0.000094	0.00012	0.00028	**0.0015**	**0.0012**	0.00045	**0.0022**	**0.0017**
Copper	mg/L	0.0020	0.00013	0.00015	0.00019	0.00047	**0.0025**	0.0020	0.00075	**0.0036**	**0.0027**
Uranium	mg/L	0.015	0.00015	0.00055	0.00066	0.00041	0.0024	0.0020	0.00067	0.0034	0.0026
Radium-226	Bq/L	0.11	0.0051	0.0040	0.0055	0.0071	0.0044	0.0071	0.0085	0.0052	0.011

a) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.

b) Function of total ammonia, pH, and temperature.

c) The average seasonal pH and average monthly temperature of samples were used to calculate the fraction factor.

d) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).

Bold values represent concentrations that exceed the Project threshold.

Bq/L = becquerels per litre.

10A6.4.1.5.3 Forrest Lake, Beet Lake, and Naomi Lake

As discussed for the Application Case (Section 10A6.4.1), Forrest Lake – North Basin, Beet Lake, and Naomi Lake are predicted to receive mass loads of metals and radionuclides via atmospheric deposition from the Project, as well as flows from upstream waterbodies. Predicted concentrations of selected constituents in these waterbodies are summarized for the Project lifespan and far future in Table 10A-19 and Table 10A-20, respectively, and are illustrated in Attachment 10A-2. Modelled constituents remain below their respective thresholds, except for cobalt in the far future.

Similar to the Application Case, concentrations of modelled constituents in the reasonable upper bound sensitivity scenario increase in the Project lifespan due to inflows from Patterson Lake; however, modelled COPC concentrations remain below thresholds. The highest COPC concentrations are projected for Forrest Lake – North Basin, which attenuate as flow progresses through Beet Lake and Naomi Lake. As noted for the Application Case, some seasonal trends are evident each year for all three waterbodies, with lower COPC concentrations in December to March when there is a lower flow from upstream waterbodies and higher concentrations in April through November when flow from upstream waterbodies increases.

Concentrations of major ions and nutrients increase in Forrest Lake – North Basin, Beet Lake, and Naomi Lake in the Project lifespan due to mass load inputs from Patterson Lake, peaking shortly after the cessation of the Project, and subsequently decrease in the far future as the concentrations in Patterson Lake decrease. All modelled major ions and nutrients remain below thresholds in these waterbodies in the Project lifespan and the far future.

Concentrations of metals and radionuclides also increase in the three waterbodies in the Project lifespan, also peaking shortly after the end of the Project, and all metal and radionuclide concentrations remain below threshold values. In the far future, maximum modelled cobalt concentrations exceed the threshold value in Forrest Lake – North Basin and Beet Lake, with peak concentrations attenuating through the waterbodies (Attachment 10A-2).

Table 10A-19: Reasonable Upper Bound Scenario Summary Statistics for Selected Constituents in Rook I Project Lifespan for Forrest Lake, North Lake, Beet Lake, and Naomi Lake

Constituent	Unit	Project Threshold	Minimum			Average			Maximum		
			Forrest North	Beet Lake	Naomi Lake	Forrest North	Beet Lake	Naomi Lake	Forrest North	Beet Lake	Naomi Lake
Total ammonia (as nitrogen)	mg/L	n/a[(a)]	0.0057	0.015	0.013	0.096	0.093	0.077	0.19	0.16	0.13
Un-ionized ammonia (as nitrogen)[(b,c)]	mg/L	0.016	0.0000020	0.0000070	0.0000070	0.00034	0.00019	0.00016	0.0017	0.0011	0.00094
Nitrate (as nitrogen)	mg/L	2.9	0.0053	0.0088	0.0050	0.091	0.086	0.070	0.18	0.15	0.13
Phosphorus (total)	mg/L	0.020	0.0032	0.0047	0.0046	0.0069	0.0069	0.0065	0.0098	0.0088	0.0083
Chloride	mg/L	120	0.46	0.60	0.59	24	22	18	49	39	33
Hardness	mg/L	n/a	11	15	15	37	36	32	63	53	48
Sulphate	mg/L	128-218	1.1	1.5	1.5	44	42	34	99	80	71
Cobalt	mg/L	0.00078-0.00084[(d)]	0.000049	0.000050	0.000050	0.00012	0.00012	0.00010	0.00020	0.00017	0.00016
Copper	mg/L	0.0020	0.000086	0.00015	0.00010	0.00019	0.00019	0.00017	0.00028	0.00024	0.00023
Uranium	mg/L	0.015	0.000051	0.000048	0.000050	0.00087	0.00088	0.00071	0.0017	0.0014	0.0012
Radium-226	Bq/L	0.11	0.0028	0.0044	0.0035	0.0093	0.0096	0.0084	0.015	0.013	0.012

a) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.

b) Function of total ammonia, pH, and temperature.

c) The average seasonal pH and average monthly temperature of samples were used to calculate the fraction factor. Individual temperature and pH samples for Beet Lake and Naomi Lake were combined to calculate the monthly fraction factor. Individual temperature and pH samples for Patterson Lake and Forrest North, respectively, were used to calculate the monthly fraction factor for Forrest North. Data gaps in monthly temperature data were infilled by averaging data from the closest months with available data.

d) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).

n/a = not applicable; Bq/L = becquerels per litre.

Table 10A-20: Reasonable Upper Bound Scenario Summary Statistics for Selected Constituents in the Far Future for Forrest Lake, North Lake, Beet Lake, and Naomi Lake

Constituent	Unit	Project Threshold	Minimum			Average			Maximum		
			Forrest North	Beet Lake	Naomi Lake	Forrest North	Beet Lake	Naomi Lake	Forrest North	Beet Lake	Naomi Lake
Total ammonia (as nitrogen)	mg/L	n/a[(a)]	0.0066	0.017	0.015	0.019	0.021	0.019	0.091	0.075	0.067
Un-ionized ammonia (as nitrogen)[(b,c)]	mg/L	0.016	0.0000020	0.0000080	0.0000070	0.000069	0.000043	0.000039	0.00085	0.00055	0.00047
Nitrate (as nitrogen)	mg/L	2.9	0.0047	0.010	0.0086	0.013	0.013	0.012	0.081	0.067	0.059
Phosphorus (total)	mg/L	0.020	0.0025	0.0044	0.0044	0.0048	0.0049	0.0049	0.0076	0.0066	0.0064
Chloride	mg/L	120	0.41	0.72	0.68	1.4	1.5	1.3	25	21	18
Hardness	mg/L	n/a	8.2	14	14	15	16	16	39	34	31
Sulphate	mg/L	128-218	1.1	2.0	1.8	2.9	3.0	2.7	32	27	24
Cobalt	mg/L	0.00078[(d)]	0.000055	0.000088	0.000074	0.00066	0.00064	0.00052	**0.0011**	**0.00091**	0.00077
Copper	mg/L	0.0020	0.000097	0.00015	0.00014	0.0011	0.0011	0.00087	0.0019	0.0015	0.0013
Uranium	mg/L	0.015	0.00015	0.00035	0.00025	0.0010	0.0010	0.00081	0.0018	0.0014	0.0012
Radium-226	Bq/L	0.11	0.0025	0.0045	0.0042	0.0052	0.0052	0.0049	0.0091	0.0079	0.0073

a) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.

b) Function of total ammonia, pH, and temperature.

c) The average seasonal pH and average monthly temperature of samples were used to calculate the fraction factor. Individual temperature and pH samples for Beet Lake and Naomi Lake were combined to calculate the monthly fraction factor. Individual temperature and pH samples for Patterson Lake and Forrest North, respectively, were used to calculate the monthly fraction factor for Forrest North. Data gaps in monthly temperature data were infilled by averaging data from the closest months with available data.

d) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).

Bold values represent concentrations that exceed the Project threshold.

n/a = not applicable; Bq/L = becquerels per litre.

10A6.4.2 Reasonably Foreseeable Development Case

10A6.4.2.1 Broach Lake, Lake G, and Lake H

In the RFD Case, potential atmospheric deposition effects from the Project and the Fission Patterson Lake South Property are considered for Broach Lake, Lake G, and Lake H.

Similar to the Application Case, concentrations of nutrients and major ions in these waterbodies are consistent with the existing conditions throughout the modelled period, and no exceedances of Project thresholds are predicted to occur. In general, concentrations are lowest from April to June during freshet and highest from August to March.

Water quality in Broach Lake, Lake H, and Lake G demonstrate slightly increased metal and radionuclide concentrations, compared to existing conditions throughout the Project lifespan, from atmospheric deposition of these constituents. Predicted concentrations of selected constituents are summarized for the Project lifespan and far future in Table 10A-21 and Table 10A-22, respectively, and are illustrated in Attachment 10A-2. Overall, concentrations in the RFD Case are similar in magnitude and concentration to the Application Case.

Table 10A-21: Reasonably Foreseeable Development Case Summary Statistics for Selected Constituents in the Rook I Project Lifespan for Broach Lake, Lake G, and Lake H

Constituent	Unit	Project Threshold	Minimum			Average			Maximum		
			Broach Lake	Lake G	Lake H	Broach Lake	Lake G	Lake H	Broach Lake	Lake G	Lake H
Total ammonia (as nitrogen)	mg/L	n/a[(a)]	0.021	0.13	0.084	0.021	0.14	0.095	0.022	0.16	0.11
Un-ionized ammonia (as nitrogen)[(b,c)]	mg/L	0.016	0.000011	0.000069	0.000045	0.000069	0.00045	0.00030	0.00028	0.0019	0.0013
Nitrate (as nitrogen)	mg/L	2.9	0.022	0.038	0.0054	0.022	0.042	0.0061	0.023	0.048	0.0072
Phosphorus (total)	mg/L	0.020	0.0050	0.010	0.0054	0.0052	0.012	0.0061	0.0053	0.013	0.0072
Chloride	mg/L	120	0.39	0.083	0.17	0.40	0.093	0.19	0.41	0.11	0.22
Hardness	mg/L	n/a	14	15	13	14	17	15	15	19	18
Sulphate	mg/L	128	1.8	1.1	0.23	1.9	1.3	0.27	1.9	1.4	0.31
Cobalt	mg/L	0.00078[(d)]	0.000050	0.000050	0.000044	0.000051	0.000057	0.000053	0.000052	0.000068	0.000066
Copper	mg/L	0.0020	0.00011	0.00024	0.000089	0.00011	0.00028	0.00012	0.00011	0.00035	0.00015
Uranium	mg/L	0.015	0.000048	0.000048	0.000050	0.00019	0.0014	0.00097	0.00026	0.0030	0.0018
Radium-226	Bq/L	0.11	0.0034	0.0044	0.0029	0.0053	0.021	0.014	0.0063	0.040	0.024

a) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.
b) Function of total ammonia, pH, and temperature.
c) The average seasonal pH and average monthly temperature of samples were used to calculate the fraction factor. Individual temperature and pH samples for Broach Lake, Lake G, and Lake H were combined to calculate the monthly fraction factor. Data gaps in monthly temperature data were infilled by averaging data from the closest months with available data.
d) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).
n/a = not applicable; Bq/L = becquerels per litre.

Table 10A-22: Reasonably Foreseeable Development Case Summary Statistics for Selected Constituents in the Far Future for Broach Lake, Lake G, and Lake H

Constituent	Unit	Project Threshold	Minimum			Average			Maximum		
			Broach Lake	Lake G	Lake H	Broach Lake	Lake G	Lake H	Broach Lake	Lake G	Lake H
Total ammonia (as nitrogen)	mg/L	n/a[(a)]	0.021	0.13	0.084	0.021	0.14	0.096	0.021	0.16	0.11
Un-ionized ammonia (as nitrogen)[(b,c)]	mg/L	0.016	0.000011	0.000069	0.000045	0.000068	0.00046	0.00031	0.00027	0.0020	0.0014
Nitrate (as nitrogen)	mg/L	2.9	0.022	0.038	0.0054	0.022	0.042	0.0062	0.022	0.048	0.0074
Phosphorus (total)	mg/L	0.020	0.0050	0.011	0.0054	0.0051	0.012	0.0062	0.0051	0.014	0.0074
Chloride	mg/L	120	0.39	0.083	0.17	0.39	0.094	0.19	0.40	0.11	0.23
Hardness	mg/L	n/a	14	15	13	14	17	15	14	20	18
Sulphate	mg/L	128	1.8	1.1	0.23	1.8	1.3	0.27	1.8	1.5	0.32
Cobalt	mg/L	0.00078[(d)]	0.000047	0.000048	0.000042	0.000048	0.000054	0.000048	0.000050	0.000062	0.000057
Copper	mg/L	0.0020	0.00010	0.00023	0.000084	0.00011	0.00026	0.000096	0.00011	0.00029	0.00011
Uranium	mg/L	0.015	0.000045	0.000044	0.000042	0.000057	0.000049	0.000048	0.00018	0.000056	0.000059
Radium-226	Bq/L	0.11	0.0032	0.0042	0.0026	0.0034	0.0047	0.0030	0.0053	0.0054	0.0036

a) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.
b) Function of total ammonia, pH, and temperature.
c) The average seasonal pH and average monthly temperature of samples were used to calculate the fraction factor. Individual temperature and pH samples for Broach Lake, Lake G, and Lake H were combined to calculate the monthly fraction factor. Data gaps in monthly temperature data were infilled by averaging data from the closest months with available data.
d) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).
n/a = not applicable; Bq/L = becquerels per litre.

10A6.4.2.2 Patterson Lake

In the RFD Case, the three Patterson Lake basins are affected by atmospheric deposition and discharges from the Project and the Fission Patterson Lake South Property. The North Arm – East Basin is affected by surface runoff (i.e., non-contact and contact with borrow material) from the Project. The North Arm – West Basin receives the treated ETP and STP discharges, west surface runoff discharge, and groundwater seepage from the Project. The North Arm – West Basin is also affected by runoff from the covered waste rock storage facility of the Fission Patterson Lake South Property. Patterson Lake South Arm receives treated effluent discharge, treated sewage discharge, and runoff from the covered above-ground tailings management facility from the Fission Patterson Lake South Property.

No exceedances of thresholds are predicted during the Project lifespan in the RFD Case; however, similar to the Application Case, cobalt and copper are predicted to exceed their respective thresholds in the far future. Predicted concentrations of selected constituents are summarized for the Project lifespan and the far future in Table 10A-23 and Table 10A-24, respectively, and are illustrated in Attachment 10A-2.

All major ion and nutrient concentrations remain below threshold values throughout the Project lifespan and in the far future. Modelled concentrations of major ions and nutrients for the North Arm – East Basin and North Arm – West Basin are similar to predicted concentrations for these basins in the Application Case. Project effects on water quality are greater in magnitude in the South Arm compared to the Application Case due to the treated effluent and treated sewage discharges from the Fission Patterson Lake South Property. As such, concentrations of major ions and nutrients in the South Arm steadily increase during the Fission Patterson Lake South Property operational period (i.e., 2028 to 2033) and reach their maximum concentrations towards the end of operations. Concentrations slightly decrease in the South Arm until a second peak is reached at the end of Project Operations. This second peak is consistent with the time when maximum mass loads from the North Arm – West Basin flow to the South Arm.

All metal and radionuclide concentrations remain below threshold values except for cobalt and copper in the far future. Concentrations of metals and radionuclides in the three basins demonstrate similar trends as major ions and nutrients. Effects from the Fission Patterson Lake South Property in the South Arm reach a peak at the end of the Fission Patterson Lake South Property operational period, and a secondary peak representative of the Project effects occurs at the end of Project Operations. Metal and radionuclide concentrations remain below threshold values in all basins during the Project lifespan. In the far future, cobalt concentrations in the North Arm – West Basin and South Arm and copper concentrations in the North Arm – West Basin exceed threshold values (Attachment 10A-2). These exceedances are a result of groundwater inflows from the Project influenced by the effects of loading inputs from infiltration through the WRSAs and underground workings (including the UGTMF) and are not due to effects from the Fission Patterson Lake South Property. The maximum concentrations and concentration trends noted in the far future are very similar to the concentrations in the Application Case.

Additional context regarding the modelled threshold exceedances of cobalt and copper is provided in TSD XXI.

Table 10A-23: Reasonably Foreseeable Development Case Summary Statistics for Selected Constituents in the Rook I Project Lifespan for Patterson Lake

Constituent	Unit	Project Threshold	Minimum			Average			Maximum		
			North Arm – East Basin	North Arm – West Basin	South Arm	North Arm – East Basin	North Arm – West Basin	South Arm	North Arm – East Basin	North Arm – West Basin	South Arm
Total ammonia (as nitrogen)	mg/L	n/a[a]	0.029	0.018	0.011	0.057	0.23	0.29	0.083	0.36	0.49
Un-ionized ammonia (as nitrogen)[b,c]	mg/L	0.016	0.0000081	0.0000059	0.0000060	0.000049	0.00020	0.00025	0.00014	0.00063	0.00084
Nitrate (as nitrogen)	mg/L	2.9	0.016	0.0083	0.013	0.046	0.21	0.27	0.071	0.33	0.50
Phosphorus (total)	mg/L	0.020	0.0054	0.0050	0.0050	0.0057	0.0076	0.0084	0.0060	0.0090	0.010
Chloride	mg/L	120	0.40	0.51	0.57	0.71	2.7	3.4	0.98	4.0	5.8
Hardness	mg/L	n/a	12	14	15	21	68	88	27	105	149
Sulphate	mg/L	128-309	1.2	1.5	1.6	17	110	150	33	200	290
Cobalt	mg/L	0.00078-0.0012[d]	0.000059	0.000066	0.000061	0.000076	0.00020	0.00026	0.000097	0.00032	0.00045
Copper	mg/L	0.0020	0.00013	0.00012	0.00014	0.00015	0.00026	0.00034	0.00018	0.00038	0.00051
Uranium	mg/L	0.015	0.000050	0.000057	0.000061	0.00069	0.0011	0.0013	0.0010	0.0017	0.0017
Radium-226	Bq/L	0.11	0.0041	0.0055	0.0041	0.017	0.012	0.021	0.023	0.016	0.026

a) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.
b) Function of total ammonia, pH, and temperature.
c) The average seasonal pH and average monthly temperature of samples were used to calculate the fraction factor.
d) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).
Bq/L = becquerels per litre.

Table 10A-24: Reasonably Foreseeable Development Case Summary Statistics for Selected Constituents in the Far Future for Patterson Lake

Constituent	Unit	Project Threshold	Minimum			Average			Maximum		
			North Arm – East Basin	North Arm – West Basin	South Arm	North Arm – East Basin	North Arm – West Basin	South Arm	North Arm – East Basin	North Arm – West Basin	South Arm
Total ammonia (as nitrogen)	mg/L	n/a[(a)]	0.027	0.036	0.057	0.030	0.040	0.066	0.044	0.090	0.16
Un-ionized ammonia (as nitrogen)[(b,c)]	mg/L	0.016	0.0000075	0.0000099	0.000016	0.000026	0.000035	0.000057	0.000075	0.00016	0.00029
Nitrate (as nitrogen)	mg/L	2.9	0.019	0.026	0.053	0.021	0.029	0.062	0.033	0.073	0.15
Phosphorus (total)	mg/L	0.020	0.0051	0.0051	0.0057	0.0054	0.0053	0.0060	0.0057	0.0060	0.0074
Chloride	mg/L	120	0.40	0.84	1.2	0.46	0.94	1.3	0.62	1.4	2.4
Hardness	mg/L	n/a	13	16	25	13	17	28	17	31	56
Sulphate	mg/L	128-218	2.1	8.2	25	2.8	9.8	30	8.1	28	72
Cobalt	mg/L	0.00078-0.0008[(d)]	0.000067	0.000098	0.00015	0.00020	**0.0010**	**0.00086**	0.00031	**0.0015**	**0.0011**
Copper	mg/L	0.0020	0.00013	0.00016	0.00022	0.00035	0.0017	0.0014	0.00053	**0.0024**	0.0019
Uranium	mg/L	0.015	0.00015	0.00047	0.00065	0.00041	0.0024	0.0021	0.00066	0.0035	0.0027
Radium-226	Bq/L	0.11	0.0057	0.0041	0.0068	0.0074	0.0045	0.0082	0.0089	0.0058	0.014

a) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.

b) Function of total ammonia, pH, and temperature.

c) The average seasonal pH and average monthly temperature of samples were used to calculate the fraction factor.

d) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).

Bold values represent concentrations that exceed the Project threshold.

Bq/L = becquerels per litre.

10A6.4.2.3 Forrest Lake, Beet Lake, and Naomi Lake

In the RFD Case, COPC concentrations in Forrest Lake – North Basin, Beet Lake, and Naomi Lake increase as a result of atmospheric deposition inputs and Project and Fission Patterson Lake Property discharges to Patterson Lake, located upstream. The primary COPCs from these sources are metals and radionuclides, which attenuate with distance downstream from Patterson Lake.

Predicted concentrations of selected constituents in these waterbodies are summarized for the Project lifespan and the far future in Table 10A-25 and Table 10A-26, respectively, and are illustrated in Attachment 10A-2. Although modelled concentrations of COPCs increase during the Project lifespan, all COPCs remain below threshold values. Similar to the Application Case, cobalt exceedances are noted in Forrest Lake – North Basin in the far future.

Effects from the Fission Patterson Lake Property are noted in Forrest Lake – North Basin, Beet Lake, and Naomi Lake. A concentration peak occurs in the three waterbodies at the end of the Fission Patterson Lake South Property operational period, consistent with when peak mass loads from Patterson Lake South Arm flow to the downstream waterbodies. A secondary peak is noted in the waterbodies shortly after the end of Project Operations, consistent with the time when peak mass loads from Patterson Lake North Arm – West Basin flow to the downstream waterbodies. Seasonal effects are observed most notably in Forrest Lake – North Basin due to its small volume. Lower concentrations are noted in December to March when there is a lower flow from Patterson Lake, and concentrations increase slightly in April through November when flow from Patterson Lake increases.

Concentrations of major ions and nutrients remain below thresholds in the Project lifespan and the far future. Metal and radionuclide concentrations also remain below thresholds in the three waterbodies during the Project lifespan and the far future, except for cobalt. Maximum cobalt concentrations are periodically marginally greater than the threshold value in Forrest Lake – North Basin in the far future due to groundwater mass load inputs from the Project. Concentrations in the waterbodies in the far future are very similar to the Application Case predictions (Attachment 10A-2). Additional context regarding the modelled threshold exceedances of cobalt is provided in the TSD XXI.

Table 10A-25: Reasonably Foreseeable Development Case Summary Statistics for Selected Constituents in the Rook I Project Lifespan for Forrest Lake North, Beet Lake, and Naomi Lake

Constituent	Unit	Project Threshold	Minimum			Average			Maximum		
			Forrest North	Beet Lake	Naomi Lake	Forrest North	Beet Lake	Naomi Lake	Forrest North	Beet Lake	Naomi Lake
Total ammonia (as nitrogen)	mg/L	n/a[a]	0.0086	0.022	0.013	0.15	0.15	0.12	0.32	0.24	0.21
Un-ionized ammonia (as nitrogen)[b,c]	mg/L	0.016	0.0000030	0.000010	0.000010	0.00050	0.00030	0.00020	0.0030	0.0020	0.0014
Nitrate (as nitrogen)	mg/L	2.9	0.0064	0.0088	0.0050	0.15	0.14	0.11	0.33	0.24	0.20
Phosphorus (total)	mg/L	0.020	0.0031	0.0048	0.0047	0.0062	0.0063	0.0060	0.0084	0.0072	0.0070
Chloride	mg/L	120	0.44	0.61	0.59	2.1	2.0	1.7	4.0	3.0	2.7
Hardness	mg/L	n/a	11	16	15	53	51	44	102	77	69
Sulphate	mg/L	128-309	1.0	1.5	1.5	81	76	61	187	135	117
Cobalt	mg/L	0.00078-0.0010[d]	0.000047	0.000050	0.000050	0.00017	0.00016	0.00014	0.00032	0.00024	0.00022
Copper	mg/L	0.0020	0.000088	0.00016	0.00010	0.00024	0.00024	0.00021	0.00039	0.00032	0.00029
Uranium	mg/L	0.015	0.000057	0.000048	0.000050	0.00082	0.00083	0.00068	0.0014	0.0011	0.0010
Radium-226	Bq/L	0.11	0.0029	0.0044	0.0035	0.014	0.014	0.012	0.021	0.018	0.017

a) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.

b) Function of total ammonia, pH, and temperature.

c) The average seasonal pH and average monthly temperature of samples are used to calculate the fraction factor. Individual temperature and pH samples for Beet Lake and Naomi Lake were combined to calculate the monthly fraction factor. Individual temperature and pH samples for Patterson Lake and Forrest North, respectively, were used to calculate the monthly fraction factor for Forrest North. Data gaps in monthly temperature data were infilled by averaging data from the closest months with available data.

d) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).

Bq/L = becquerels per litre.

Table 10A-26: Reasonably Foreseeable Development Case Summary Statistics for Selected Constituents in the Far Future for Forrest Lake North, Beet Lake, and Naomi Lake

Constituent	Unit	Project Threshold	Minimum			Average			Maximum		
			Forrest North	Beet Lake	Naomi Lake	Forrest North	Beet Lake	Naomi Lake	Forrest North	Beet Lake	Naomi Lake
Total ammonia (as nitrogen)	mg/L	n/a[a]	0.010	0.031	0.025	0.037	0.037	0.032	0.11	0.090	0.079
Un-ionized ammonia (as nitrogen)[b,c]	mg/L	0.016	0.000003	0.000014	0.000012	0.00013	0.000080	0.000070	0.0010	0.00065	0.00050
Nitrate (as nitrogen)	mg/L	2.9	0.0093	0.027	0.020	0.034	0.034	0.028	0.10	0.081	0.070
Phosphorus (total)	mg/L	0.020	0.0026	0.0045	0.0045	0.0049	0.0050	0.0050	0.0066	0.0059	0.0058
Chloride	mg/L	120	0.45	0.83	0.77	0.95	0.95	0.89	1.8	1.5	1.4
Hardness	mg/L	n/a	10	18	18	21	21	20	43	36	33
Sulphate	mg/L	128-218	3.9	12	8.9	16	15	13	49	38	33
Cobalt	mg/L	0.00078[d]	0.000057	0.00010	0.000082	0.00047	0.00045	0.00037	**0.00079**	0.00063	0.00054
Copper	mg/L	0.0020	0.000099	0.00017	0.00015	0.00079	0.00077	0.00063	0.0013	0.0010	0.00090
Uranium	mg/L	0.015	0.00020	0.00038	0.00027	0.0011	0.0010	0.00084	0.0018	0.0014	0.0012
Radium-226	Bq/L	0.11	0.0026	0.0051	0.0046	0.0059	0.0059	0.0055	0.012	0.010	0.0094

a) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.
b) Function of total ammonia, pH, and temperature.
c) The average seasonal pH and average monthly temperature of samples were used to calculate the fraction factor. Individual temperature and pH samples for Beet Lake and Naomi Lake were combined to calculate the monthly fraction factor. Individual temperature and pH samples for Patterson Lake and Forrest North, respectively, were used to calculate the monthly fraction factor for Forrest North. Data gaps in monthly temperature data were infilled by averaging data from the closest months with data.
d) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).
Bold values represent concentrations that exceed the Project threshold.
n/a = not applicable; Bq/L = becquerels per litre.

10A6.4.2.4 Atmospheric Deposition Effects in Small Lakes

Although atmospheric deposition effects were included in the overall RFD Case assessment of all modelled lakes in the LSA, potential cumulative effects from the Project and the Fission Patterson Lake South Property derived solely from atmospheric deposition were assessed in four small waterbodies in the LSA: Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2. Results from the air quality model used in this assessment are conservative predictions; additional context regarding the air quality model results is provided in the air quality assessment (Section 7).

The atmospheric deposition assessment for the four small waterbodies in the RFD Case was conducted in the same manner as for the Application Case (Section 10A6.4.1.4). The predicted maximum monthly concentrations of a subset of COPCs in each waterbody are tabulated in Table 10A-27, with all maximum modelled projections remaining below Project thresholds. As per Section 10A6.3.4, Atmospheric Deposition, aluminum, ammonia, calcium, chloride, nitrate, total phosphorus, sulphate, strontium, and titanium were not included in the list of modelled constituents for the air quality model because at the time of the air dispersion modelling, Project emissions source terms for these constituents were not available.

Based on the results presented in Table 10A-27, the following conclusions are drawn:

- Approximately 25% of the predicted increases are less than 20% relative to Base Case water quality for all the locations except Lake C. Given the proximity of Lake C to the planned Fission Patterson Lake South Property, the predicted increases in constituent concentrations are higher than in the other waterbodies and the Application Case.
- Larger relative increases (more than 20% above Base Case) are limited to a subset of constituents (i.e., cadmium, mercury, lead, uranium, polonium-210, radium-226); these specific constituents make up all of the predicted constituent increases that are more than 20% above the Base Case. In all these cases, the maximum projected changes remain well below their Project thresholds.
- Overall, the effects of atmospheric deposition in these waterbodies are minor.

Table 10A-27: Maximum Predicted Water Quality Constituent Concentrations as a Result of Atmospheric Deposition in Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2 for the Reasonably Foreseeable Development Case

Constituent	Units	Project Threshold [(a)]	Representative Base Case Lake Quality [(b)]	Maximum Predicted Concentration							
				Lake C		Lake E		Unnamed Lake 1		Unnamed Lake 2	
				Application Case	RFD Case	Application Case	RFD Case	Application Case	RFD Case	Application Case	RFD Case
Arsenic	mg/L	0.005	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011
Cadmium	mg/L	0.00004	0.0000061	0.0000077	0.0000077	0.0000081	0.0000080	0.0000080	0.0000079	0.0000099	0.0000098
Chromium	mg/L	0.001	0.00022	0.00022	0.00024	0.00023	0.00023	0.00022	0.00022	0.00022	0.00023
Cobalt	mg/L	0.00078[(c)]	0.000047	0.000049	0.000049	0.000049	0.000049	0.000049	0.000049	0.000051	0.000051
Copper	mg/L	0.002	0.00013	0.00013	0.00014	0.00013	0.00014	0.00013	0.00013	0.00014	0.00013
Iron	mg/L	0.3	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Lead	mg/L	0.001	0.000079	0.000082	0.000092	0.000083	0.000090	0.000083	0.000081	0.000087	0.000083
Magnesium	mg/L	n/a	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Manganese	mg/L	0.26	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Mercury	mg/L	0.000026	0.0000015	0.0000031	0.0000031	0.0000035	0.0000034	0.0000034	0.0000033	0.0000053	0.0000052
Molybdenum	mg/L	7.6	0.000056	0.000058	0.000062	0.000060	0.000062	0.000058	0.000058	0.000060	0.000060
Nickel	mg/L	0.025	0.000082	0.000084	0.000089	0.000086	0.000087	0.000084	0.000084	0.000086	0.000086
Selenium	mg/L	0.001	0.000056	0.000058	0.000058	0.000058	0.000058	0.000058	0.000058	0.000060	0.000060
Sodium	mg/L	n/a	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Uranium	mg/L	0.015	0.000056	0.00015	0.00031	0.00024	0.00033	0.00014	0.00015	0.00027	0.00027
Vanadium	mg/L	0.12	0.000069	0.000072	0.000082	0.000073	0.000079	0.000071	0.000071	0.000077	0.000073
Zinc	mg/L	0.007	0.00095	0.00095	0.00095	0.00095	0.00095	0.00095	0.00095	0.00095	0.00095
Lead-210	Bq/L	22	0.012	0.013	0.016	0.015	0.016	0.013	0.013	0.015	0.014
Polonium-210	Bq/L	13.5	0.0043	0.0078	0.011	0.012	0.013	0.0094	0.0097	0.013	0.013
Radium-226	Bq/L	0.11	0.0033	0.0047	0.0076	0.0062	0.0072	0.0041	0.0044	0.0062	0.0059

a) Water quality thresholds selected for this report are outlined in Section 10A4.1.
b) Representative Base Case Lake Quality concentrations assumed to be the average measured values in Broach Lake and Hodge Lake.
c) Federal environmental water quality guideline (FEQG), variable based on hardness concentration in the surface waterbody; guideline value shown based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).
RFD = reasonably foreseeable development; Bq/L = becquerels per litre; n/a = not available.

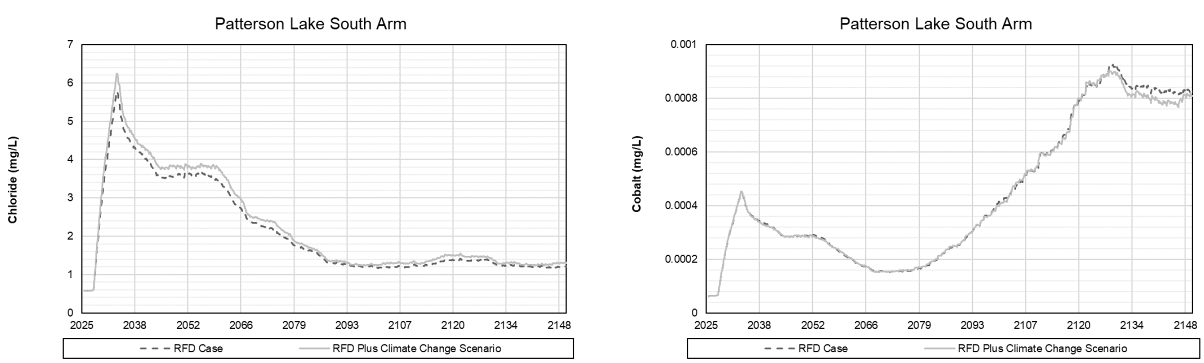
10A6.4.2.5 Reasonably Foreseeable Development Plus Climate Change Sensitivity Scenario

Results from the RFD plus climate change sensitivity scenario indicate that climate change has a minor overall effect on regional water quality. The minor overall effects are most noticeable in the Project lifespan for Patterson Lake North Arm – West Basin and South Arm, which receive the treated effluent discharge from the Project and the Fission Patterson Lake South Property, respectively. As noted in Section 10A6.3, Model Input Data, the treated effluent quality from the Fission Patterson Lake South Property was assumed to be equal to the median treated effluent quality from the Project. Since the treated effluent quality differed slightly between the Application Case and climate change scenarios in the SWWBM (TSD XVIII), those differences are carried through to the RSWQM.

The climate change effects on water quality are more distinct for major ions than for trace metals and radionuclides. This distinction is because the primary source of trace metals and radionuclides to the treated effluent are from the process plant, which is overall unaffected by climate change. The main source of major ions to the treated effluent are from sources that are affected by hydrological processes such as precipitation, evaporation, and runoff from the Project. A comparison of major ion (e.g., chloride) and trace metal (e.g., cobalt) concentrations in the RFD Case and RFD plus climate change scenario is illustrated in Figure 10A-3. Concentrations of major ions are slightly higher in the RFD plus climate change scenario, whereas trace metal concentrations are very similar between the two assessments.

The projected water quality projections in the RFD Case and RFD plus climate change scenario in the far future are also very similar. This is because the primary loading source to Patterson Lake in the far future is groundwater, which is overall unaffected by climate change. This indicates that changes to Project or Fission Patterson Lake South Property site runoff water quality from modelled climate change has an overall minor effect on regional water quality in the far future.

Figure 10A-3: Comparison of Reasonably Foreseeable Development Case and Reasonably Foreseeable Development Plus Climate Change Scenario Results for Patterson Lake South Arm



RFD = reasonably foreseeable development.

10A7 NEAR-FIELD WATER QUALITY MODEL

The NFWQM was developed to assess the potential water quality effects of the Project in the immediate areas of the ETP diffuser and STP outfall during Construction, Operations, and Closure. As the ETP and STP do not operate beyond Closure, near-field modelling is not required for the far-future projection. The extents of the near-field modelling were limited to the immediate area of the ETP diffuser and STP outfall (i.e., within 200 m of either outfall or diffuser).

Although the modelling extent of the NFWQM was 200 m from the STP outfall and ETP diffuser, the model was also used to predict water quality at a 100 m proposed RMZ for outfall/diffuser as a result of mixing and dilution of the effluent plume as it moves away from the outfall/diffuser. The NFWQM is based on the predicted effluent quality from the SWWBM, outfall configurations, and ambient conditions. As the two RMZs do not overlap, the NFWQM was applied independently for outfall and diffuser.

The NFWQM was specifically used to:

- predict the concentration of each COPC at the edge of the proposed 100 m RMZ;
- predict the distance from the outfall/diffuser the plume must travel before a COPC threshold is met where a COPC concentration predicted by the SWWBM exceeds its respective threshold; and
- assess the performance of outfall/diffuser design in terms of dilution provided at the edge of the RMZ under a variety of ambient conditions (e.g., current speeds, ice cover).

The results of the NFWQM are also used in the fish and fish habitat assessment (Section 11, Fish and Fish Habitat) and the Environmental Risk Assessment (TSD XXI).

10A7.1 Model Description

Detailed mixing and dilution modelling was conducted using the CORMIX model system (Doneker and Jirka 2007) to assess the dilution performance of the STP outfall and ETP diffuser under a range of treated effluent temperature and ambient conditions. The CORMIX model was developed at Cornell University and has been endorsed by the United States Environmental Protection Agency. The CORMIX model system uses a physically based, reliable, and empirical approach by assembling all available data and resulting formulas for analyzing and modelling jets and plumes.

10A7.2 Model Scenarios and Input Data

10A7.2.1 Ambient Conditions

The purpose of defining the ambient conditions for simulation is to simplify representation of the variable lake ambient current and water temperature conditions in Patterson Lake, and to provide the model inputs for steady-state simulation of the resulting jets or plumes from the ETP diffuser and STP outfall discharges.

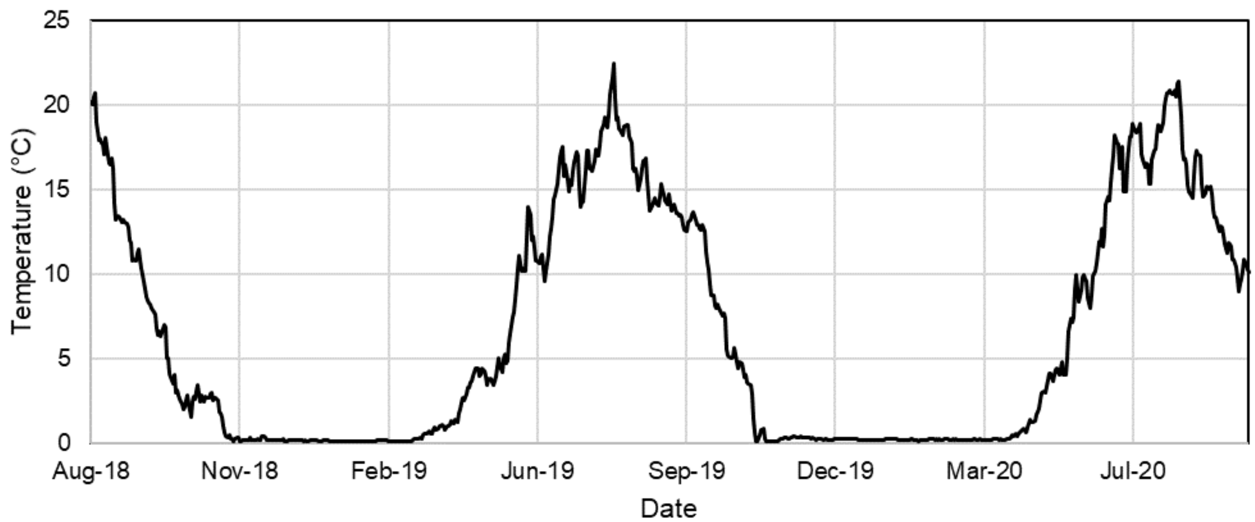
Several characteristics of the receiving waterbody (i.e., Patterson Lake) combine to affect the movement and spread of a plume and the performance of a diffuser. These characteristics include water depth, lake currents that affect mixing of the plume with ambient water, and water temperature and chemistry (i.e., TDS concentration) that affect the ambient water density. The following subsections describe the characteristics of Patterson Lake that were considered for developing the near-field model.

10A7.2.1.1 Water Temperature

Surface water temperature in Patterson Lake varies throughout the year. Available temperature data include continuous daily temperature measurements between August 2018 to September 2020 (Annex IV.2) and from seasonal baseline field studies (Annex V.1). Average daily temperatures of Patterson Lake (2018 to 2020) are shown in Figure 10A-4. During winter months, the lake has ice cover, and the water temperature is just above freezing (i.e., approximately 0.1°C). Peak temperatures typically occur in July. The baseline water temperature in Patterson Lake is further described in Attachment 10A-1.

The monthly mean temperatures in Patterson Lake during the ice-free season vary from 2.3°C in April to 18°C in July (Attachment 10A-1). Maximum water temperatures above 20°C were measured during all summers between 2018 and 2020. To capture the range of ambient conditions in Patterson Lake in the near-field modelling, ambient water temperatures of 5°C, 10°C, 15°C, and 20°C were modelled.

Figure 10A-4: Patterson Lake Averaged Measured Surface Water Temperature, August 2018 to August 2020



10A7.2.1.2 Lake Stratification

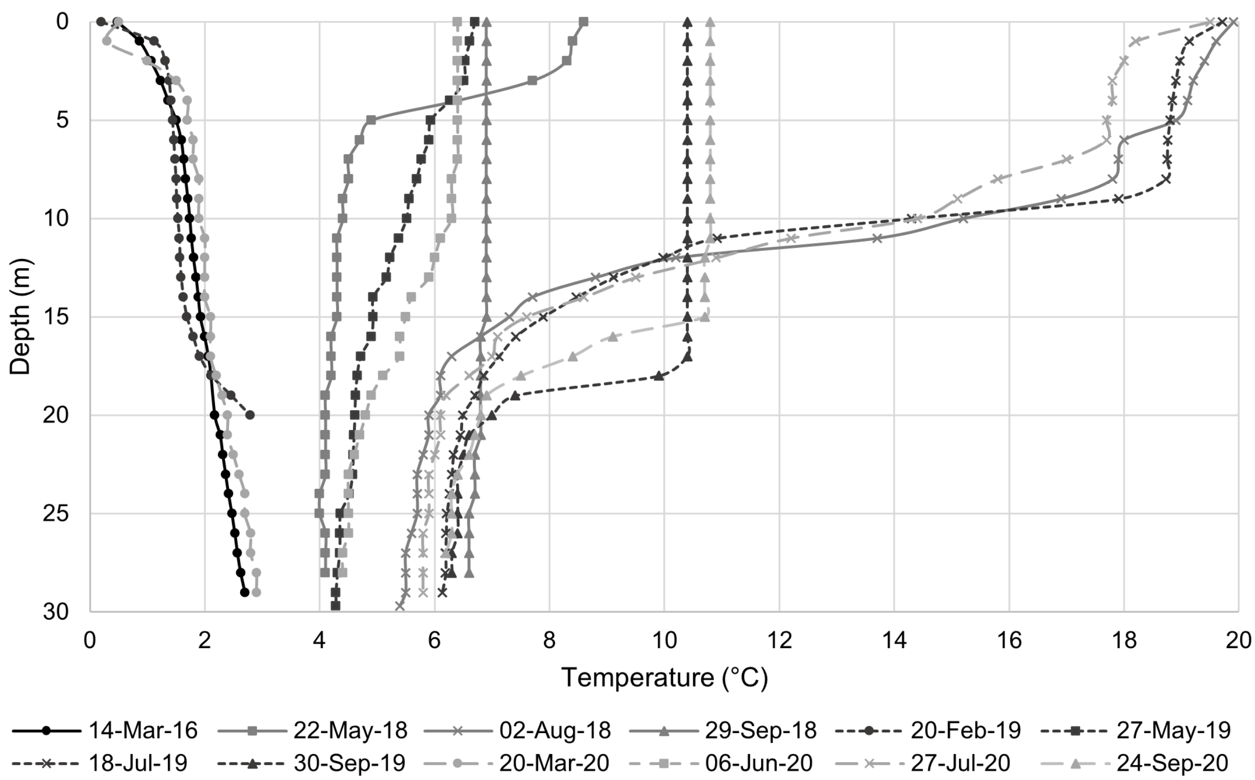
Water column profiles in Patterson Lake of DO, pH, specific conductivity, and temperature were measured during baseline field studies (Attachment 10A-1). The temperature profile measurements in Patterson North Arm – West Basin are shown in Figure 10A-5. Measured lake profiles for DO, pH, and specific conductivity in Patterson Lake are provided in Attachment 10A-1c, Lake Physio-chemical Water Column Profile Plots.

Thermal stratification occurs in the lake between late spring and early fall, with the lake exhibiting bi-annual (i.e., spring and fall) turnover events. Depending on the time of year, the thermocline depth varies between 4 m and 18 m. Temperature at the bottom of the lake (i.e., between 20 m and 30 m in depth) is on average 5°C. The surface temperature varies between 0°C and 20°C, aligning with the surface temperatures measured from the continuous measurement discussed in Section 10A7.2.1.1, Water Temperature. The largest difference in temperature between the epilimnion (i.e., lake surface) and hypolimnion (i.e., lake bottom) occurs in the summer (i.e., August 2018, July 2019, and July 2020 profiles). The thermocline (i.e., the transition layer between the epilimnion and hypolimnion) is the deepest in the fall, which can be seen from the September measurement in 2019 and 2020. During the winter, the surface temperature is lowest due to the ice cover, as can be seen from the March 2016, February 2019, and March 2020 profiles. Consistent temperatures through the entire lake depth are observed in spring and fall, following lake turnover events, as can be seen from the September 2018, May 2019, and June 2020 profiles.

The ETP diffuser would be located at a depth of 10 m, which is typically above the thermocline. However, as seen in Figure 10A-5, on 22 May 2018, a thermocline was observed at a depth of approximately 4 m. As such, for the ETP diffuser, the three stratification depths modelled were 4 m, 5 m, and 6 m based in the lake profiles and the maximum stratification depth allowed by CORMIX (i.e., 60% of the depth at the discharge).

As the water depth at the location of the proposed STP outfall is 4 m, stratified conditions were not modelled for the STP outfall.

Figure 10A-5: Temperature Profile Measured at Patterson Lake North Area – West Basin, March 2016 to September 2020



10A7.2.1.3 Lake Currents

Information on lake currents in Patterson Lake is required to predict the mixing of the effluent in the RMZ. Current speed and direction were measured near the proposed ETP diffuser location from July to September 2020 using an acoustic doppler current profiler (Annex IV.4). While the acoustic doppler current profiler provided current data at 1 m intervals, the data collected at mid-depth (i.e., 5 m) were used as the typical current speed at the outfall/diffuser location. A complete analysis of the current speeds and directions can be found in Annex IV.4.

The three current speed scenarios used in the NFWQM are provided in Table 10A-28. The current speed of 0.001 m/s used at the STP is the lowest value that can be entered in CORMIX, while the ambient current speed of 0.009 m/s is the smallest current speed that resulted in stable solutions at the ETP diffuser.

Table 10A-28: Assumed Current Speeds and Direction Near the Effluent Treatment Plant Diffuser and Sewage Treatment Plant Outfall

Current Speed Scenario	Speed (m/s)	Direction(s)	Lake Condition
High current speeds	95th percentile mid-depth = 0.079	Alongshore and onshore	Open water
Typical current speeds	Average mid-depth = 0.042	Alongshore and onshore	Open water
Calm condition (STP)	0.001	All	Open water and ice covered
Calm condition (ETP)	0.009	All	Open water and ice covered

ETP = effluent treatment plant; STP = sewage treatment plant.

10A7.2.1.4 Total Dissolved Solids

Total dissolved solids concentration is generally well correlated with specific conductivity. The water column profile measurements of specific conductivity in Patterson Lake North Arm – West Basin show little variation with depth despite the presence of thermal stratification (Attachment 10A-1c, Lake Physico-chemical Water Column Profile Plots, Figure 6). Specific conductivity measurements (in µS/cm) were converted to TDS (in mg/L) using a calculated TDS/specific conductivity coefficient of 0.64 as recommended for natural waters by Maidment (1994), which lies within the range of the TDS/specific conductivity coefficients between 0.55 and 0.7 recommended by American Public Health Association (APHA 2012). Using the available average specific conductivity measurements, TDS at Patterson Lake North Arm – West Basin was estimated to be approximately 24 mg/L. This estimated value aligns with the measured TDS (i.e., average of 38 mg/L).

10A7.2.1.5 Water Density

The density of the water in Patterson Lake was estimated for each modelling scenario based on the temperature and TDS concentration using the following formula (Wells 2019):

$$\rho_W = \rho_T + \Delta\rho_{TDS}$$

$$\rho_T = 999.842594 + 6.793952 \times 10^{-2} T_W - 9.095290 \times 10^{-3} {T_W}^2 + 1.001685 \times 10^{-4} {T_W}^3 - 1.120083 \times 10^{-6} {T_W}^4 + 6.536332 \times 10^{-9} {T_W}^5$$

$$\Delta\rho_{TDS} = (8.221 \times 10^{-4} - 3.87 \times 10^{-6} T_W - 4.99 \times 10^{-8} T_W^2) C_{TDS}$$

Where: ρ_W = density of water (kg/m³);

ρ_T = water density as a function of temperature (kg/m³);

$\Delta\rho_{TDS}$ = density increment due to dissolved solids (kg/m³);

T_W = water temperature (°C); and

C_{TDS} = TDS concentration (g/m³ or mg/L).

This formula was also used to estimate the density of the treated effluents from the ETP and STP.

10A7.2.1.6 Selected Ambient Conditions

The ambient conditions in Patterson Lake used in the NFWQM were as follows:

- Ice cover conditions: during ice covered periods, the total water depth at the outfall/diffuser was reduced by 1 m, and a current speed of 0.009 m/s was used as it represents the lowest current speed that resulted in stable results in CORMIX.
- Open water with no stratification: three ambient current speeds (i.e., 0.009[1] m/s, 0.042 m/s, and 0.079 m/s) and four different lake water temperatures (i.e., 5°C, 10°C, 15°C, and 20°C) were modelled.
- Open water with vertical stratification: A total of nine scenarios composed of three ambient current speeds (i.e., 0.0091 m/s, 0.042 m/s, and 0.079 m/s) and three stratification interface depths from the lake water surface (i.e., 4 m, 5 m, and 6 m) were modelled. Lake surface water temperature and lake bottom water temperature were 20°C (density of 998.26 kg/m^3) and 6°C (density of 999.99 kg/m^3), respectively. Three stratification depths were simulated to test the sensitivity of diffuser performance to the depth of stratification.

10A7.2.2 Effluent Treatment Plant Diffuser

Treated effluent temperature and TDS concentrations were used to estimate the effluent density for the scenarios summarized in Table 10A-29.

Table 10A-29: Summary of CORMIX Model Simulations for the Effluent Treatment Plant Diffuser for the Application Case

Conditions	Scenario	Effluent		Ambient			
		Temperature (°C)	Density (kg/m^3)	Current Speed (m/s)	Temperature (°C)	Density (kg/m^3)	Thermocline Depth (m)
Ice covered	ETP-1	8.5	1,003.270	0.009[(a)]	0	999.901	none
	ETP-2	4.0	1,003.480				
Open water, no stratification	ETP-3	20	1,001.501	0.009	5	1,000.022	none
	ETP-4				10	999.760	none
	ETP-5				15	999.160	none
	ETP-6				20	998.260	none
	ETP-7			0.042	5	1,000.022	none
	ETP-8				10	999.760	none
	ETP-9				15	999.160	none
	ETP-10				20	998.260	none
	ETP-11			0.079	5	1,000.022	none
	ETP-12				10	999.760	none
	ETP-13				15	999.160	none
	ETP-14				20	998.260	none

[1] At the ETP diffuser, 0.009 m/s was the lowest ambient current speed that resulted in stable results in CORMIX. At the STP outfall, the ambient current speed of 0.001 m/s was considered the lowest ambient speed resulting in stable results.

Table 10A-29: Summary of CORMIX Model Simulations for the Effluent Treatment Plant Diffuser for the Application Case

Conditions	Scenario	Effluent		Ambient			
		Temperature (°C)	Density (kg/m³)	Current Speed (m/s)	Temperature (°C)	Density (kg/m³)	Thermocline Depth (m)
Open water, no stratification	ETP-15	8.5	1,003.301	0.009	5	1,000.022	none
	ETP-16				10	999.760	none
	ETP-17				15	999.160	none
	ETP-18				20	998.260	none
	ETP-19			0.042	5	1,000.022	none
	ETP-20				10	999.760	none
	ETP-21				15	999.160	none
	ETP-22				20	998.260	none
	ETP-23			0.079	5	1,000.022	none
	ETP-24				10	999.760	none
	ETP-25				15	999.160	none
	ETP-26				20	998.260	none
Open water, with stratification	ETP-27	8.5	1,003.301	0.009	20 at surface 6 at bottom	998.260 at surface 999.990 at bottom	4
	ETP-28						5
	ETP-29						6
	ETP-30			0.042			4
	ETP-31						5
	ETP-32						6
	ETP-33			0.079			4
	ETP-34						5
	ETP-35						6

a) The ambient current speed of 0.009 m/s is the smallest speed that resulted in stable solutions.
ETP = effluent treatment plant.

10A7.2.3 Sewage Treatment Plant Outfall

Effluent temperature and TDS concentrations were used to estimate the effluent density for the scenarios summarized in Table 10A-30. As the water depth at the STP outfall is assumed to be 4 m, stratified conditions are not expected for the STP outfall.

Table 10A-30: Summary of CORMIX Model Simulations for the Sewage Treatment Plant Outfall for the Application Case

Conditions	Scenario	Effluent		Ambient			
		Temperature (°C)	Density (kg/m³)	Current Speed (m/s)	Temperature (°C)	Density (kg/m³)	Thermocline Depth (m)
Ice covered	STP-1	8.5	999.851	0.001	0	999.901	none
	STP-2	4.0	1000.007				
Open water, no stratification	STP-3	20	998.240	0.001	5	1,000.022	none
	STP-4				10	999.760	none
	STP-5				15	999.160	none
	STP-6				20	998.260	none
	STP-7			0.042	5	1000.022	none
	STP-8				10	999.760	none
	STP-9				15	999.160	none
	STP-10				20	998.260	none
	STP-11			0.079	5	1,000.022	none
	STP-12				10	999.760	none
	STP-13				15	999.160	none
	STP-14				20	998.260	none
	STP-15	8.5	999.851	0.001	5	1,000.022	none
	STP-16				10	999.760	none
	STP-17				15	999.160	none
	STP-18				20	998.260	none
	STP-19			0.042	5	1,000.022	none
	STP-20				10	999.760	none
	STP-21				15	999.160	none
	STP-22				20	998.260	none
	STP-23			0.079	5	1,000.022	none
	STP-24				10	999.760	none
	STP-25				15	999.160	none
	STP-26				20	998.260	none

STP = sewage treatment plant.

10A7.3 Near-Field Dilution Predictions

10A7.3.1 Effluent Treatment Plant Diffuser

The predicted dilution factors at 50 m and 100 m from the ETP diffuser are summarized in Table 10A-31, and the minimum and maximum dilution factors with distance are shown in Figure 10A-6. Based on the results, the following conclusions are drawn:

- In most cases, the predicted dilution factor at 100 m was the same or only slightly higher than at 50 m, which suggests that most of the mixing of the effluent plume occurs less than 50 m from the diffuser.
- The predicted dilution factor at the edge of the proposed RMZ (i.e., 100 m distance) ranged from 23:1 to 35:1, with an average of 29.9:1.
- The lowest predicted dilution factor at the edge of the RMZ occurs when the density difference between the effluent and lake water is the greatest.

- At the edge of the proposed RMZ, the dilution factor was not predicted to change with variations in current speed. However, at 50 m, the predicted dilution factor decreased slightly with an increase in current speed.
- Both presence and depth of the thermocline are predicted to have minimal effects on predicted dilution factor at the edge of the proposed RMZ.
- The predicted dilution factor at the edge of the proposed RMZ is expected to be approximately 18% lower during ice covered periods compared to open-water periods.

Table 10A-31: Summary of Predicted Dilution Factors for the Effluent Treatment Plant Diffuser

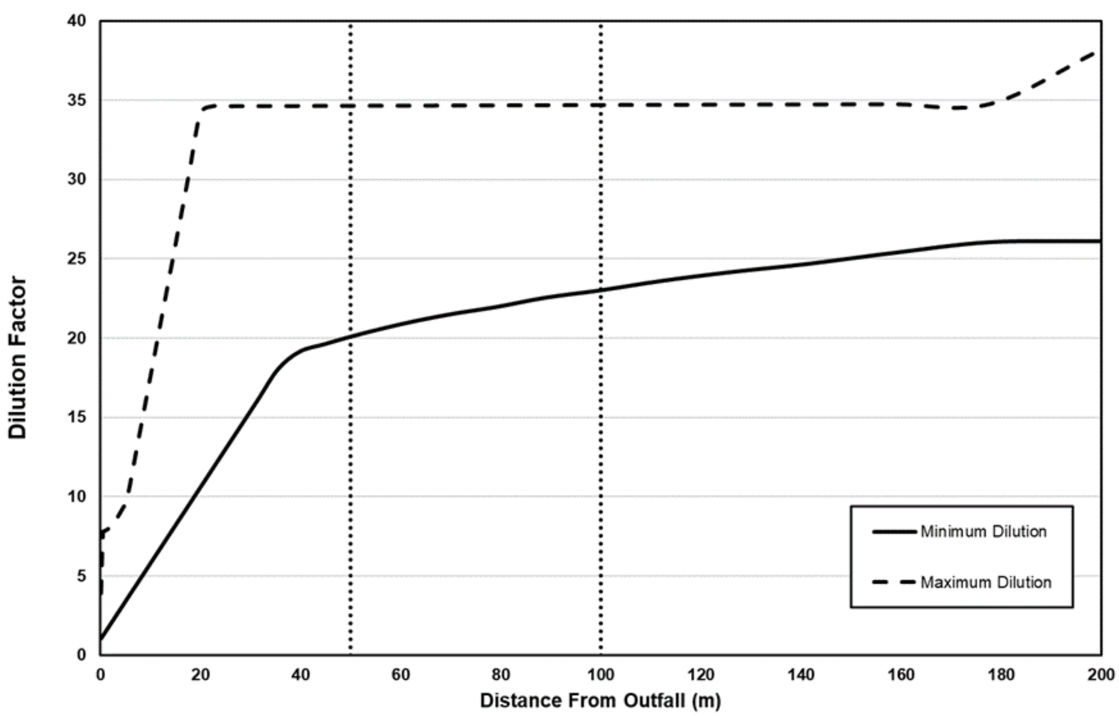
Conditions	Scenario	Effluent Temperature (°C)	Current Speed (m/s)	Lake Temperature (°C)	Thermocline Depth (m)	Estimated Dilution	
						50 m	Edge of RMZ (100 m)
Ice covered	ETP-1	8.5	0.009[(a)]	0	none	26	26
	ETP-2	4.0				25	25
Open water, no stratification	ETP-3	20	0.009	5	none	23	23
	ETP-4			10	none	24	24
	ETP-5			15	none	27	27
	ETP-6			20	none	30	30
	ETP-7		0.042	5	none	23	23
	ETP-8			10	none	24	25
	ETP-9			15	none	27	27
	ETP-10			20	none	30	30
	ETP-11		0.079	5	none	20	23
	ETP-12			10	none	20	23
	ETP-13			15	none	27	28
	ETP-14			20	none	29	31
	ETP-15	8.5	0.009	5	none	30	30
	ETP-16			10	none	31	31
	ETP-17			15	none	32	32
	ETP-18			20	none	35	35
	ETP-19		0.042	5	none	30	30
	ETP-20			10	none	31	31
	ETP-21			15	none	32	33
	ETP-22			20	none	35	35
	ETP-23		0.079	5	none	29	31
	ETP-24			10	none	31	32
	ETP-25			15	none	32	33
	ETP-26			20	none	35	35

Table 10A-31: Summary of Predicted Dilution Factors for the Effluent Treatment Plant Diffuser

Conditions	Scenario	Effluent Temperature (°C)	Current Speed (m/s)	Lake Temperature (°C)	Thermocline Depth (m)	Estimated Dilution	
						50 m	Edge of RMZ (100 m)
Open water, with stratification	ETP-27	8.5	0.009	20 at surface 6 at bottom	4	33	33
	ETP-28				5	32	32
	ETP-29				6	32	32
	ETP-30		0.042		4	33	33
	ETP-31				5	32	33
	ETP-32				6	32	32
	ETP-33		0.079		4	32	34
	ETP-34				5	32	33
	ETP-35				6	32	33

a) At the proposed ETP diffuser discharge location, 0.009 m/s was the lowest ambient current speed that achieved stable results in CORMIX. At the proposed STP outfall discharge location, the ambient current speed of 0.001 m/s was applied as it is the lowest current speed allowed as an input into CORMIX.
RMZ = regulatory mixing zone; ETP = effluent treatment plant.

Figure 10A-6: Minimum and Maximum Dilution Factors with Distance from the Effluent Treatment Plant Diffuser



10A7.3.2 Sewage Treatment Plant Outfall

The predicted dilution factors at 50 m and 100 m from STP outfall are summarized in Table 10A-32, and the minimum and maximum dilution factors with distance are shown in Figure 10A-7. Based on the results, the following conclusions are drawn:

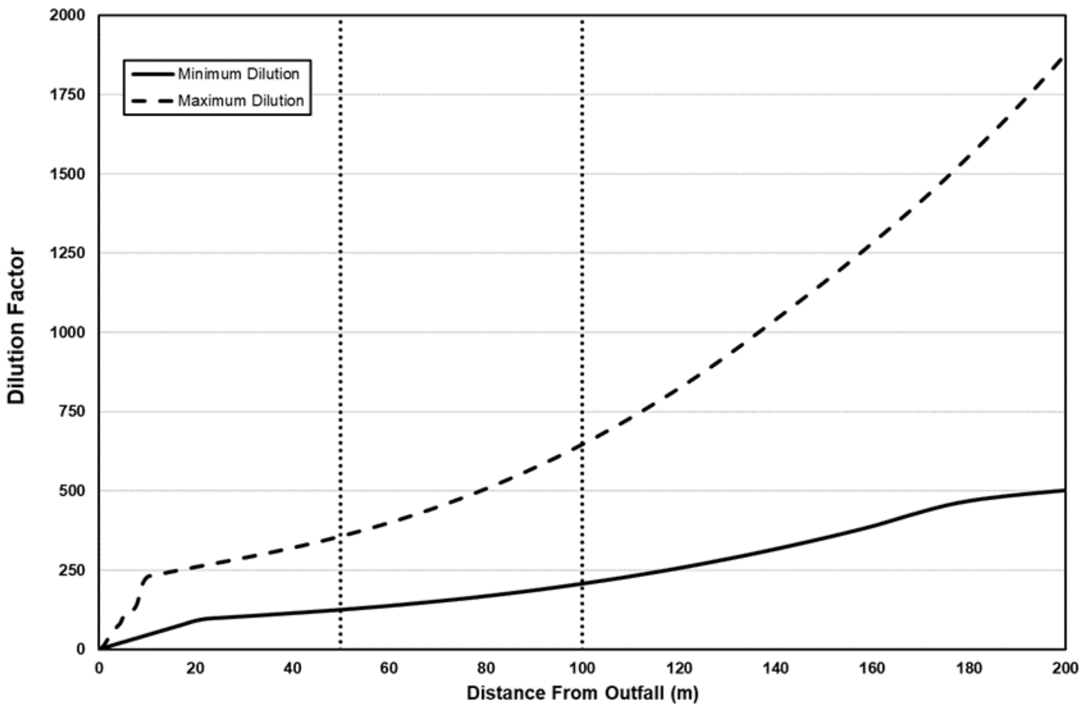
- While most of the mixing of the effluent plume occurs at less than 40 m from the outfall, the predicted dilution factor continues to increase with distance from the outfall.
- The predicted dilution factor at the edge of the proposed RMZ (i.e., 100 m distance) ranged from 210:1 to over 1,800:1, with an average of 518:1.
- The lowest predicted dilution factor at the edge of the proposed RMZ occurs when the density difference between the effluent and lake water is the greatest.
- At the edge of the proposed RMZ, the dilution factor is predicted to increase with an increase in current speed.
- During ice-covered periods, the predicted dilution factor at the edge of the proposed RMZ is similar to open-water periods.

Table 10A-32: Summary of Predicted Dilution Factors for the Sewage Treatment Plant Outfall

Conditions	Scenario	Effluent Temperature (°C)	Current Speed (m/s)	Lake Temperature (°C)	Thermocline Depth (m)	Estimated Dilution	
						50 m	Edge of RMZ (100 m)
Ice covered	STP-1	8.5	0.001	0	none	230	350
	STP-2	4.0				240	350
Open water, no stratification	STP-3	20	0.001	5	none	290	410
	STP-4			10	none	280	400
	STP-5			15	none	250	360
	STP-6			20	none	270	400
	STP-7		0.042	5	none	120	210
	STP-8			10	none	120	220
	STP-9			15	none	120	220
	STP-10			20	none	390	590
	STP-11		0.079	5	none	360	650
	STP-12			10	none	360	670
	STP-13			15	none	380	740
	STP-14			20	none	810	1,800
	STP-15	8.5	0.001	5	none	200	280
	STP-16			10	none	270	400
	STP-17			15	none	270	400
	STP-18			20	none	250	370
	STP-19		0.042	5	none	140	340
	STP-20			10	none	250	700
	STP-21			15	none	200	300
	STP-22			20	none	220	300
	STP-23		0.079	5	none	650	1,500
	STP-24			10	none	740	1,600
	STP-25			15	none	600	1,200
	STP-26			20	none	580	870

RMZ = regulated mixing zone; STP = sewage treatment plant.

Figure 10A-7: Minimum and Maximum Dilution Factors with Distance from the Sewage Treatment Plant Outfall



10A7.3.3 Sensitivity Analysis

A sensitivity analysis was completed to assess the robustness of the outfall/diffuser designs in terms of the dilution factor. The sensitivity analysis included variations in effluent flow rates and TDS concentration. Previous studies found that the performance of the ETP diffuser and STP outfall was not sensitive to the discharge rate (TSD XXI).

The sensitivity analysis was completed for a subset of the scenarios listed in Table 10A-29 and Table 10A-30 that represent a range of conditions that included the following scenarios:

- with predicted dilution factors near the upper and lower bounds of the predicted range, as well as approximately the same as the average dilution factor;
- with and without thermal stratification (ETP only);
- with and without ice cover;
- high and low current speeds;
- large and small differences between effluent temperature and lake water temperature (i.e., range of density differences); and
- deep and shallow thermocline depths (ETP only).

For the ETP, the sensitivity analysis was based on Scenarios ETP-1, ETP-11, ETP-18, ETP-23, ETP-27, and ETP-35. For the STP, the sensitivity analysis was based on Scenarios STP-1, STP-7, STP-11, and STP-21.

In Section 10A7.3.1, Effluent Treatment Plant Diffuser, dilution factors for the ETP diffuser were predicted using the TDS concentration of 4,332 mg/L estimated for the Application Case scenario by the SWWBM. A sensitivity analysis was completed considering a TDS concentration of 5,696 mg/L, as estimated for the reasonable upper bound scenario.

A sensitivity analysis was also completed by considering variations to the ETP and STP effluent flow rates. Dilution factors were estimated for the ETP by increasing effluent flow rate by 25% (i.e., from 0.231 m^3/s to 0.289 m^3/s) and reducing effluent flow rate by 25% (i.e., from 0.231 m^3/s to 0.173 m^3/s). Similarly, the dilution factors for the STP by increasing effluent flow rate by 25% (i.e., from 0.002 m^3/s to 0.0025 m^3/s) and reducing effluent flow rate by 25% (i.e., from 0.002 m^3/s to 0.0015 m^3/s).

Sensitivity to water depth was assessed by increasing and decreasing the water depth at outfall/diffuser by 0.2 m based on the natural variation of the measured water levels in Patterson Lake (Annex IV.2).

Sensitivity to ice thickness was assessed by considering an ice thickness of 0.5 m and open water for one winter scenario for each of the ETP diffuser and STP outfall (i.e., Scenarios ETP-01 and STP-02, respectively).

Based on the results of the sensitivity analysis summarized in Table 10A-33, the following conclusions are drawn:

- Changes in the ETP effluent TDS concentration between the Application Case and the reasonable upper bound sensitivity scenario did not measurably change the dilution factor at the edge of the RMZ for the ETP diffuser.
- For the ETP diffuser and STP outfall, increases in the effluent flow rates generally reduced the dilution factors at the edge of the RMZ, and decreases in effluent flow rate generally increased the dilution factors.
- For the ETP diffuser and STP outfall, increases in water depth increased the dilution factors at the edge of the RMZ, and decreases in water depth decreased the dilution factors at the edge of the RMZ.
- For the ETP diffuser and STP outfall, both lower ice thickness and ice-free conditions increased the dilution factors at the edge of the RMZ.
- The largest variations in the dilution factors occurred from varying the effluent flow rates. As the effluent flow rates can be managed to operate within a specified range (e.g., within 25% of the design flows), variations in effluent flow rates are therefore not expected to affect the performance of either the ETP diffuser or the STP outfall.
- The predicted dilution factors for the sensitivity analysis for water depth and ice thickness fell within the predicted range of the dilution factors presented in Table 10A-31 and Table 10A-32, suggesting that natural variations in Patterson Lake are not expected to affect the performance of either the ETP diffuser or the STP outfall.

Table 10A-33: Predicted Dilution Factors at Edge of the Proposed 100 m Regulated Mixing Zone for the Effluent Treatment Plant Diffuser and Sewage Treatment Plant Outfall

Scenario	Dilution Factor							
	Application Case	Reasonable Upper Bound Scenario	25% Increase in Effluent Flow Rate	25% Decrease in Effluent Flow Rate	0.2 m Increase in Water Level	0.2 m Decrease in Water Level	0.5 m Ice Thickness (Winter Only)	No Ice (Winter Only)
ETP Diffuser[(a)]								
ETP-01	26	26	23	31	27	25	28	31
ETP-11	23	23	22	25	25	21	n/a	n/a
ETP-18	35	35	30	42	44	29	n/a	n/a
ETP-23	31	31	26	38	40	25	n/a	n/a
ETP-27	33	33	28	40	41	27	n/a	n/a
ETP-35	33	33	28	40	42	27	n/a	n/a
STP Outfall[(a)]								
STP-01	350	n/d	350	350	361	340	376	400
STP-07	210	n/d	170	360	175	340	n/a	n/a
STP-11	650	n/d	500	870	529	845	n/a	n/a
STP-21	300	n/d	220	820	236	425	n/a	n/a

a) RMZ assumed to extend 100 m from diffuser/outfall.

ETP = effluent treatment plant; STP = sewage treatment plant; RMZ = regulated mixing zone; n/a = not available; n/d = no developed reasonable upper bound scenario for the STP discharge.

10A7.4 Estimated Concentrations at the Edge of the Regulated Mixing Zones

The concentrations of water quality constituents at the edge of the RMZs were calculated based on the dilution factors predicted by the NFWQM. The following formula was used to estimate the water quality concentrations at various distances from the outfall/diffuser including the edge of the mixing zone.

$$C_x = \frac{C_{eff}}{D_x} + (1 - \frac{1}{D_x}) \times C_{lake}$$

Where: C_x = concentration at a distance from the outfall/diffuser (mg/L);

x = distance from outfall/diffuser (m);

C_{eff} = effluent concentration predicted by SWWBM (mg/L);

C_{lake} = lake-wide concentration predicted by RSWQM (mg/L); and

D_x = dilution factor at distance x.

The dilution factors at the edge of the RMZs for the ETP diffuser and STP outfall were calculated by averaging the predicted dilution factors at 100 m for all scenarios modelled for the Application Case. As the sensitivity analysis showed that the ETP diffuser performance was not predicted to change under the reasonable upper bound sensitivity scenario, a dilution factor of 29.9:1 was also used for the ETP diffuser for the reasonable upper bound sensitivity scenario.

The following subsection provides the predictions of concentrations at the edge of the RMZs for the COPCs represented in the RSWQM. Additional water quality parameters not represented in the RSWQM, specifically, water temperature, DO, and TSS, are discussed in Section 10A7.4.2, Additional Water Quality Constituents in the Near-Field Area.

10A7.4.1 Regional Surface Water Quality Model Modelled Constituents

Predicted COPC concentrations at the edge of the mixing zone are summarized in Table 10A-34, based on average treated effluent concentrations discharged from the STP and ETP over Project Operations, as predicted by the SWWBM and the lake-wide concentrations predicted by the RSWQM. As the Project is expected to alter the water quality in Patterson Lake, results are provided for predicted conditions at the beginning of Operations (i.e., 2029) and near the end of Operations where the concentrations are highest at the edge of the mixing zone (i.e., 2048).

Table 10A-34 is limited to presenting the selected COPCs that apply specifically to protection of aquatic life, drinking water quality, and primary productivity. Constituents that are ETMFs to specific COPCs, such as pH, temperature, and hardness, have not been included because they were not identified as COPCs. However, the determination of a threshold exceedance for COPCs based on their projection takes into account the associated projection of any ETMF as applicable to a COPC. Where the potential for toxicity by specific COPCs is modified based on additional constituents defined as ETMFs (e.g., pH, temperature), assumptions regarding their influence on the selected Project threshold for those COPCs are provided as footnotes to Table 10A-34.

The near-field modelling results for the STP and ETP discharges show that concentrations of COPCs remain below water quality thresholds at the edge of the mixing zones, except for chloride from the ETP for the reasonable upper bound sensitivity scenario, at near the end of Operations.

Table 10A-34: Predicted Constituent of Potential Concern Concentrations at the Edge of the Regulated Mixing Zones

Constituent	Units	Effluent Concentration							
		ETP Application Case		ETP Reasonable Upper Bound Sensitivity Scenario		STP Application Case		STP Reasonable Upper Bound Sensitivity Scenario	
		Start[a]	End[b]	Start[a]	End[b]	Start[a]	End[b]	Start[a]	End[b]
Major Ions									
Calcium	mg/L	20	48	20	48	5.1	33	5.1	34
Chloride	mg/L	2.9	5.5	67	**130**	0.8	3.9	6.7	91
Sulphate	mg/L	108	290	110	290	12	190	12	200
Nutrients									
Total ammonia (as nitrogen)[c]	mg/L	0.26	0.47	0.26	0.47	0.18	0.43	0.18	0.44
Un-ionized ammonia (as nitrogen)[d,e]	mg/L	0.00022	0.00040	0.0002	0.00040	0.00016	0.00038	0.00016	0.00038
Nitrate (as nitrogen)	mg/L	0.27	0.46	0.28	0.49	0.070	0.32	0.080	0.34
Total phosphorus	mg/L	0.0070	0.010	0.010	0.017	0.0080	0.011	0.0090	0.016
Total Metals (unless otherwise noted, all metals are reported as total)									
Aluminum	mg/L	0.007	0.017	0.0070	0.017	0.004	0.014	0.004	0.014
Arsenic	mg/L	0.0014	0.0038	0.0014	0.0039	0.0002	0.0026	0.0002	0.0027
Cadmium	mg/L	0.000007	0.000009	0.000007	0.000009	0.000007	0.000009	0.000007	0.000009
Chromium	mg/L	0.00026	0.00028	0.00026	0.00028	0.00026	0.00027	0.00026	0.00027
Cobalt	mg/L	0.00019	0.00042	0.00020	0.00044	0.00008	0.00031	0.00008	0.00032
Copper	mg/L	0.00024	0.00047	0.00025	0.00047	0.00014	0.00036	0.00014	0.00036
Iron	mg/L	0.053	0.050	0.053	0.050	0.054	0.051	0.054	0.051
Lead	mg/L	0.000059	0.000076	0.000059	0.000076	0.000059	0.000076	0.000059	0.000076
Manganese	mg/L	0.018	0.023	0.018	0.023	0.019	0.024	0.019	0.024
Mercury	mg/L	0.0000052	0.0000125	0.0000067	0.0000159	0.0000031	0.0000103	0.0000035	0.0000127
Molybdenum	mg/L	0.0003	0.0007	0.0010	0.0020	0.0001	0.0005	0.0004	0.0014
Nickel	mg/L	0.00042	0.00104	0.00042	0.00106	0.00013	0.00074	0.00013	0.00075
Selenium	mg/L	0.00007	0.00010	0.00007	0.00011	0.00005	0.00009	0.00005	0.00009
Strontium	mg/L	0.042	0.056	0.537	1.057	0.031	0.048	0.077	0.723
Uranium	mg/L	0.00072	0.00183	0.00164	0.00348	0.00033	0.00152	0.00074	0.00271
Vanadium	mg/L	0.00013	0.00027	0.00013	0.00027	0.00007	0.00021	0.00007	0.00021
Zinc	mg/L	0.00080	0.00088	0.00081	0.00090	0.00078	0.00085	0.00078	0.00086

Table 10A-34: Predicted Constituent of Potential Concern Concentrations at the Edge of the Regulated Mixing Zones

Constituent	Units	Effluent Concentration							
		ETP Application Case		ETP Reasonable Upper Bound Sensitivity Scenario		STP Application Case		STP Reasonable Upper Bound Sensitivity Scenario	
		Start[a]	End[b]	Start[a]	End[b]	Start[a]	End[b]	Start[a]	End[b]
Radionuclides									
Lead-210	Bq/L	1.8	2.6	5.3	8.2	1.1	2.1	2.6	5.9
Polonium-210	Bq/L	0.03	0.044	0.092	0.14	0.019	0.036	0.045	0.10
Radium-226	Bq/L	0.011	0.023	0.011	0.023	0.0068	0.019	0.0069	0.02
Thorium-230	Bq/L	0.043	0.085	0.043	0.086	0.011	0.062	0.011	0.063

a) Start of Project Operations (2029).
b) Near end of Project Operations (2048).
c) Project threshold for ammonia considers the proportion of total ammonia that is un-ionized ammonia.
d) Function of total ammonia, pH, and temperature.
e) The average seasonal pH and average monthly temperature of samples were used to calculate the fraction factor.
Bold values indicate exceedances of selected water quality COPC thresholds.
Bq/L = becquerels per litre; COPC = constituent of potential concern; ETP = effluent treatment plant; STP = sewage treatment plant.

10A7.4.2 Additional Water Quality Constituents in the Near-Field Area

Total suspended solids, water temperature, and DO were not directly modelled in the RSWQM or the SWWBM. As such, the near-field effect of the Project on these water quality constituents was assessed separately.

The treated effluent discharge and lake-wide concentrations summarized in Table 10A-35 were estimated using available resources as follows:

- The lake-wide TSS concentration was based in the average reported baseline TSS concentration of 1 mg/L.
- The effluent TSS concentration for the ETP discharge was set to the maximum allowable TSS concentration of 15 mg/L specified in the Metal and Diamond Mining Effluent Regulations while effluent TSS concentration for the STP discharge was set to the maximum allowable TSS concentration of 25 mg/L, which conforms to the Saskatchewan Waterworks and Sewage Works Regulations.
- The lake water temperatures were based on the average winter and July measured temperatures at the outlet of Patterson Lake (Attachment 10A-1, Table 10A-1-6).
- The winter treated effluent temperatures were assumed to be 8.5°C based on the use of a heat trace in the pipeline to prevent freezing.
- As the ETP and STP storage ponds are expected the be similar to a small lake in terms of atmospheric heating and cooling, the warmest expected summer effluent temperatures were assumed to be equal to the highest measured water temperature in Lake D (23.0°C).
- The lake DO concentrations were based on the average DO saturation levels in the top 6 m of the water column for the profiles measured in Patterson Lake. The average winter and summer DO saturation levels were 93% and 96%, respectively.
- The effluent DO concentrations for the ETP and STP were assumed to be 80% saturation, based on a minimum effluent DO concentration that could be maintained with an aeration device, if required.
- The assumed DO concentrations for the lake and treated effluent were estimated based on the assumed water temperatures and saturation levels using a calculation method from literature (Wells 2019).

Table 10A-35: Summary of Additional Water Quality Constituent Assumptions

Parameter	Unit	ETP Diffuser		STP Outfall	
		Winter	Summer	Winter	Summer
TSS, lake[(a)]	mg/L	1.0	1.0	1.0	1.0
TSS, treated effluent	mg/L	15.0[(b)]	15.0[(b)]	25.0[(c)]	25.0[(c)]
Water temperature, lake[(d)]	°C	0.2	17.4	0.2	17.4
Water temperature, effluent	°C	8.5[(de)]	23.0[(f)]	8.5[(e)]	23.0[(f)]
DO, lake[(g)]	mg/L	14.7	10.0	14.7	10.0
DO, treated effluent[(g)]	mg/L	11.8	8.9	11.8	8.9

a) TSS concentration in Patterson Lake based on average measured TSS values (Attachment 10A-1, Table 10A-1-7).
b) TSS concentration of treated effluent for ETP based on the maximum allowable TSS concentration specified in the Metal and Diamond Mining Effluent Regulations.
c) TSS concentration of treated effluent for STP based on the maximum allowable TSS concentration for sewage treatment plants (WSA 2012, Saskatchewan Regulations 2020).
d) Winter and summer temperature of the lake based on the monthly temperature data.
e) Winter effluent temperature based on the diffuser design study (heat trace; Golder 2019).
f) Summer effluent temperature based on highest measured temperature in Lake D (Attachment 10A-1, Table 10A-1-20).
g) Dissolved oxygen concentration calculated using a reference equation (Wells 2019).
DO = dissolved oxygen; TSS = total suspended solids; ETP = effluent treatment plant; STP = sewage treatment plant.

Treated effluent concentrations at the edge of the RMZs for TSS, water temperature, and DO were predicted using the equation in Section 10A7.4 Estimated Concentrations at the Edge of the Regulated Mixing Zones, with the assumption that all the additional parameters are conservative. The results, summarized in Table 10A-36, provide the following conclusions:

- Increases in TSS concentrations at the edge of the mixing zones are predicted to be less than 1 mg/L.
- Increases in water temperature at the edge of the mixing zones are predicted to be less than 1°C.
- Decreases in DO concentrations at the edge of the mixing zones are predicted to be less than 0.1 mg/L.

The preceding conclusions suggest that the discharges of treated effluent from the ETP and STP are expected to have negligible effects on TSS, water temperature, and DO at the edge of the RMZ.

Table 10A-36: Predicted Total Suspended Solids, Water Temperature, and Dissolved Oxygen at the Edge of the Mixing Zones

Parameter	Unit	ETP Diffuser		STP Outfall	
		Winter	Summer	Winter	Summer
TSS	mg/L	1.4	1.4	1.1	1.1
Water temperature	°C	0.48	17.59	0.22	17.41
DO	mg/L	14.6	10.0	14.7	10.0

DO = dissolved oxygen; TSS = total suspended solids; ETP = effluent treatment plant; STP = sewage treatment plant.

10A7.5 Predicted Constituent of Potential Concern Concentrations near Discharge Locations

Projected concentrations of selected COPCs at the edge of the RMZs of the ETP and STP discharges for the Application Case and the reasonable upper bound sensitivity scenario were calculated based on the dilution factors predicted by the NFWQM and the equation presented in Section 10A7.4. Sulphate, ammonia, total phosphorus, cobalt, copper, uranium, and chloride were selected for this modelling, as they are parameters that are predicted to have elevated concentrations in effluent relative to the receiving environment or expected to be of interest to reviewers and other EA disciplines. For the STP modelling, results are discussed for nitrate, ammonia, and phosphorus, which are frequently of concern in treated STP discharges.

10A7.5.1 Effluent Treatment Plant Diffuser

Projected concentrations for the selected COPCs are presented in Figure 10A-8 to Figure 10A-23 for the modelled scenarios used in the sensitivity analysis (Section 10A7.3.3) and include:

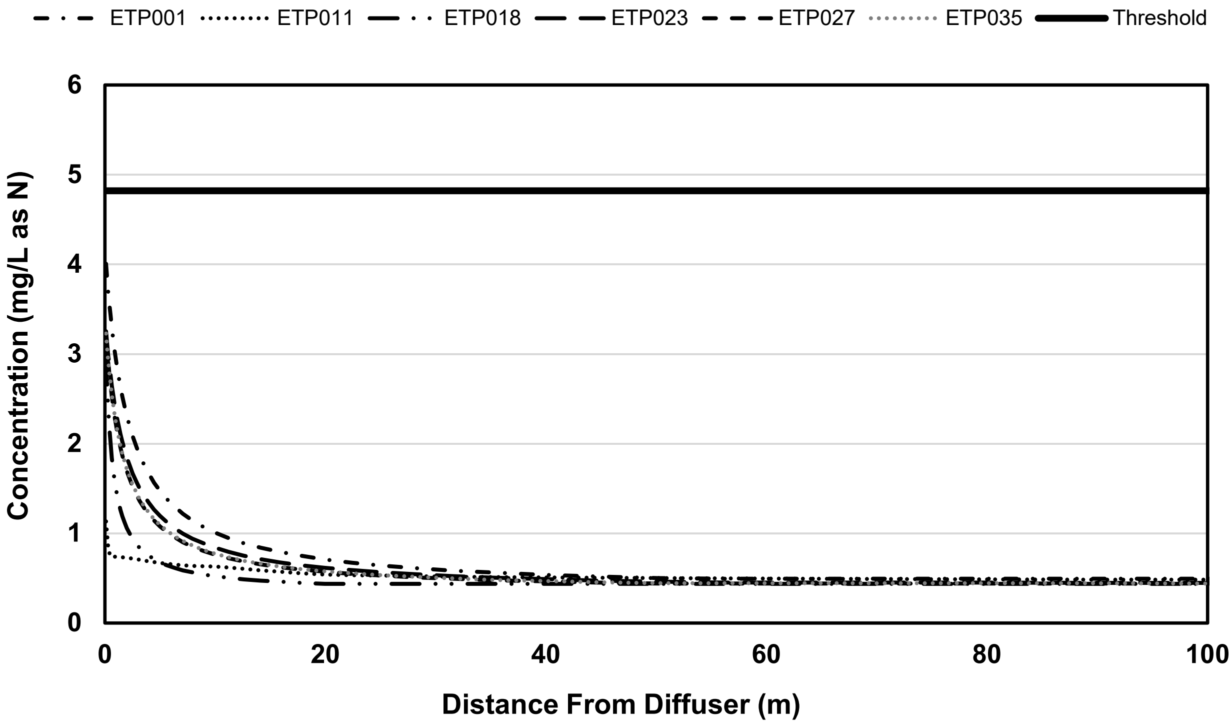
- winter condition (ETP-1): effluent temperature of 8.5°C, ambient current speed of 0.009 m/s, and ambient temperature of 0°C; winter condition (ETP-1): effluent temperature of 8.5°C, ambient current speed of 0.009 m/s, and ambient temperature of 0°C;
- open water condition with no stratification (ETP-11): effluent temperature of 20°C, ambient current speed of 0.079 m/s, and ambient temperature of 5°C; open water condition with no stratification (ETP-11): effluent temperature of 20°C, ambient current speed of 0.079 m/s, and ambient temperature of 5°C;
- open water condition with no stratification (ETP-18): effluent temperature of 8.5°C, ambient current speed of 0.009 m/s, and ambient temperature of 20°C; open water condition with no stratification (ETP-18): effluent temperature of 8.5°C, ambient current speed of 0.009 m/s, and ambient temperature of 20°C;
- open water condition with no stratification (ETP-23): effluent temperature of 8.5°C, ambient current speed of 0.079 m/s, and ambient temperature of 5°C; open water condition with no stratification (ETP-23): effluent temperature of 8.5°C, ambient current speed of 0.079 m/s, and ambient temperature of 5°C;
- open water condition with stratification (ETP-27): effluent temperature of 8.5°C, ambient current speed of 0.009 m/s, and stratification depth of 4 m; and open water condition with stratification (ETP-27): effluent temperature of 8.5°C, ambient current speed of 0.009 m/s, and stratification depth of 4 m; and
- open water condition with stratification (ETP-35): effluent temperature of 8.5°C, ambient current speed of 0.079 m/s, and stratification depth of 6 m; and open water condition with stratification (ETP-35): effluent temperature of 8.5°C, ambient current speed of 0.079 m/s, and stratification depth of 6 m.

The modelled results were compared to the water quality thresholds at the end of Operations (e.g., adjusted for the predicted increase in hardness for sulphate and cobalt) and the indicate the following:

- Total ammonia concentrations are below the Project threshold (4.8 milligrams per litre as nitrogen [mg/L as N]) for the Application Case (Figure 10A-8) and the reasonable upper bound sensitivity scenario (Figure 10A-10). The ammonia threshold of 4.8 mg/L was calculated based on a summer pH of 7 and temperature of 20°C, which represents the most conservative threshold conditions. The projected ammonia concentrations at the edge of the proposed RMZ (i.e., 100 m from the diffuser) ranged from 0.26 mg/L to 0.46 mg/L for the Application Case and the reasonable upper bound sensitivity scenario. Un-ionized ammonia is similarly predicted to remain below the Project threshold in both scenarios (Figure 10A-9 and Figure 10A-11).
- Chloride concentrations are below the Project threshold (i.e., 120 mg/L) for the Application Case (Figure 10A-12) and slightly above the threshold for the reasonable upper bound sensitivity scenarios (Figure 10A-13). The projected chloride concentrations at the edge of the proposed RMZ ranged from 2.9 mg/L to 5.5 mg/L for the Application Case and from 66.9 mg/L to 134.9 mg/L for the reasonable upper bound sensitivity scenario.

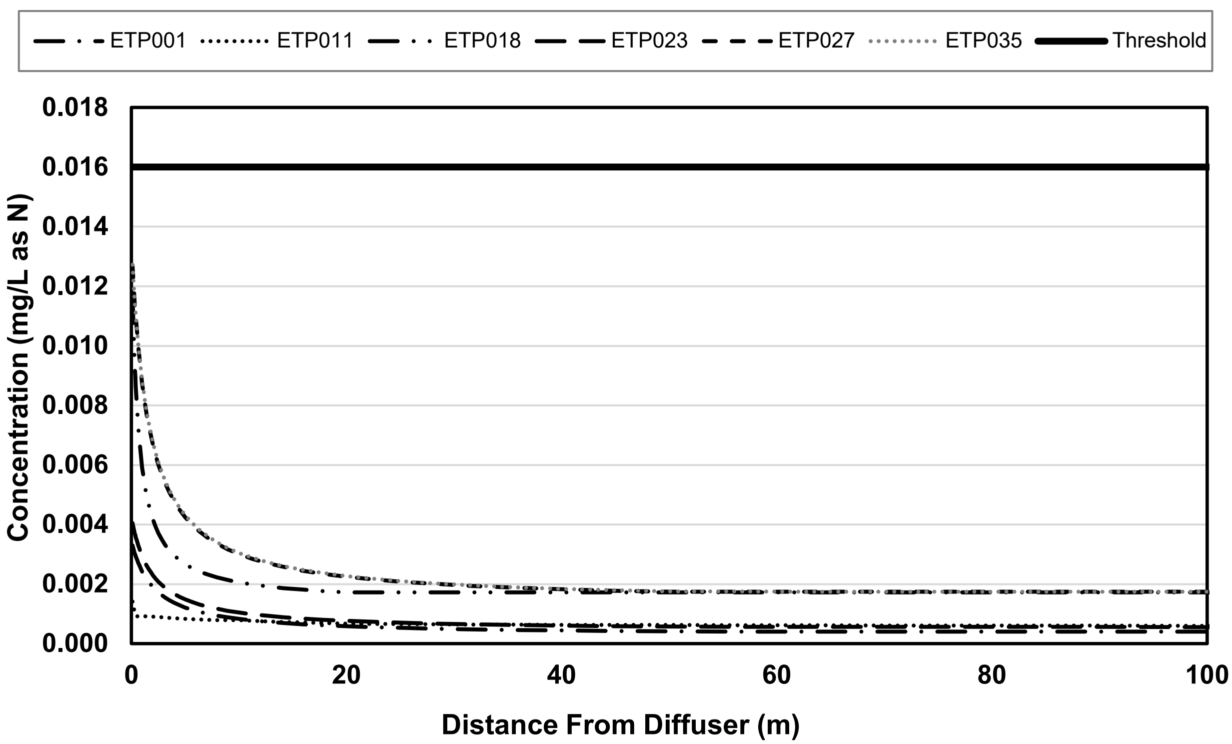
- Total phosphorus concentrations are below the Project threshold (i.e., 0.02 mg/L) beyond 2.5 m from the diffuser for the Application Case (Figure 10A-14) and beyond 30 m from the diffuser for the reasonable upper bound sensitivity scenario (Figure 10A-15). The projected phosphorus concentrations at the edge of the proposed RMZ ranged from 0.007 mg/L to 0.010 mg/L for the Application Case and from 0.010 mg/L to 0.017 mg/L for the reasonable upper bound sensitivity scenario.
- Sulphate concentrations are below the Project threshold (i.e., 429 mg/L) beyond 20 m from the diffuser for both Application Case (Figure 10A-16) and reasonable upper bound sensitivity scenario (Figure 10A-17). The projected sulphate concentrations at the edge of the proposed RMZ ranged from 108 mg/L to 285 mg/L for the Application Case and from 108 mg/L to 286 mg/L for the reasonable upper bound sensitivity scenario.
- Cobalt concentrations are below the Project threshold (i.e., 0.0011 mg/L) beyond 10 m from the diffuser for the Application Case (Figure 10A-18) and the reasonable upper bound sensitivity scenario (Figure 10A-19). The projected cobalt concentrations at the edge of the proposed RMZ ranged from 0.00019 mg/L to 0.00042 mg/L for the Application Case and from 0.00020 mg/L to 0.00044 mg/L for the reasonable upper bound sensitivity scenario.
- Copper concentrations are below the Project threshold (i.e., 0.002 mg/L) beyond 3 m from the diffuser for the Application Case (Figure 10A-20) and the reasonable upper bound sensitivity scenario (Figure 10A-21). The projected copper concentrations at the edge of the proposed RMZ ranged from 0.00024 mg/L to 0.00047 mg/L for the Application Case and the reasonable upper bound sensitivity scenario.
- Uranium concentrations are below the Project threshold (i.e., 0.015 mg/L) for the Application Case (Figure 10A-22) and beyond 3 m from the diffuser for the reasonable upper bound sensitivity scenario (Figure 10A-23). The projected uranium concentrations at the edge of the proposed RMZ ranged from 0.00072 mg/L to 0.00183 mg/L for the Application Case and from 0.00164 mg/L to 0.00348 mg/L for the reasonable upper bound sensitivity scenario.

Figure 10A-8: Predicted Attenuation of Total Ammonia Concentrations from the Effluent Treatment Plant Discharge Location for a Subset of Modelled Discharge Scenarios (Application Case)



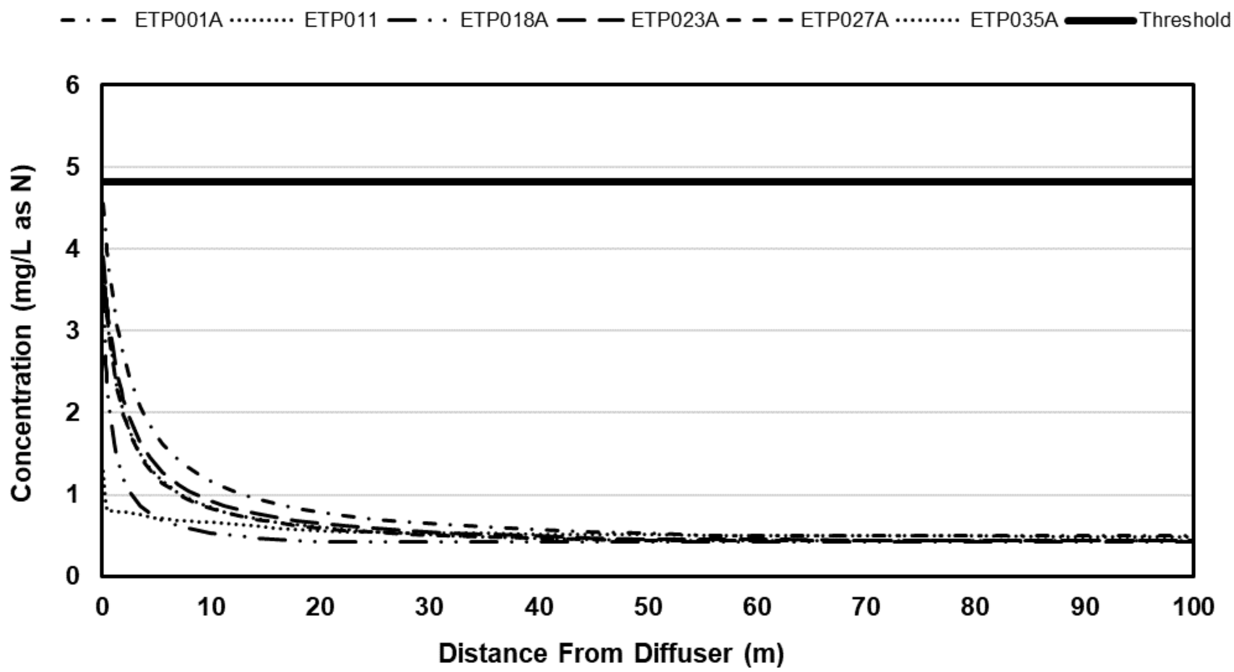
ETP = effluent treatment plant.

Figure 10A-9: Predicted Attenuation of Un-ionized Ammonia Concentrations from the Effluent Treatment Plant Discharge Location for a Subset of Modelled Discharge Scenarios (Application Case)



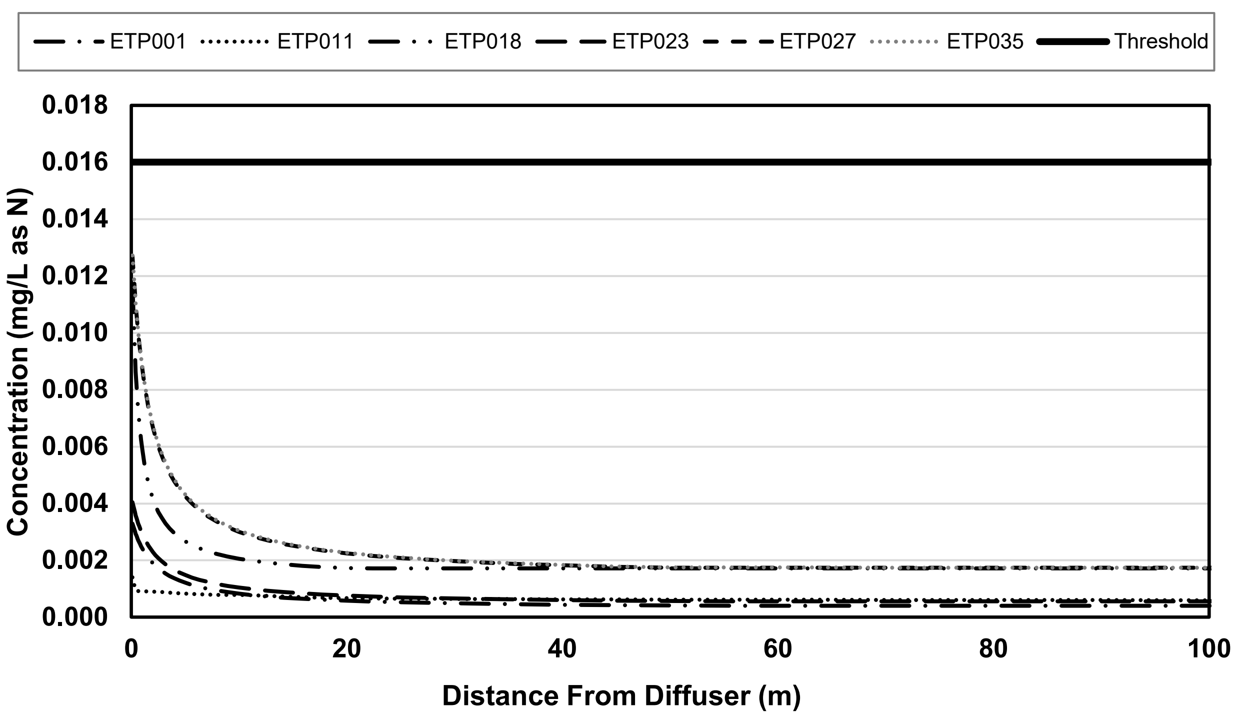
ETP = effluent treatment plant.

Figure 10A-10: Predicted Attenuation of Total Ammonia Concentrations from the Effluent Treatment Plant Discharge Location for a Subset of Modelled Discharge Scenarios (Reasonable Upper Bound Sensitivity Scenario)



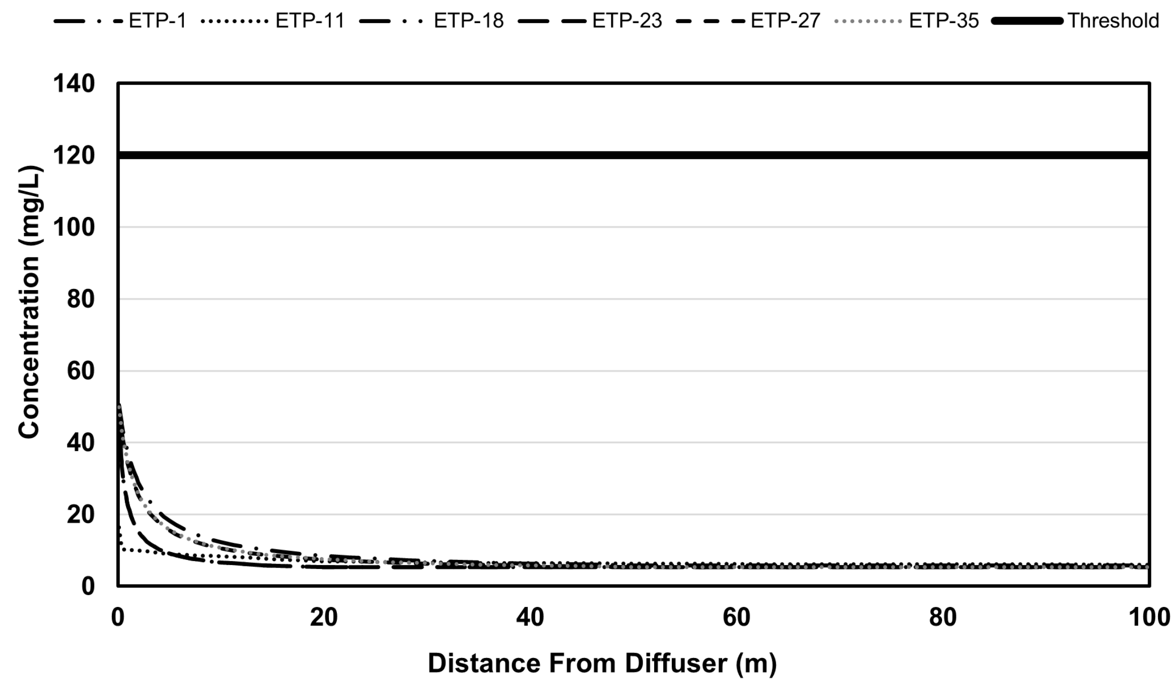
ETP = effluent treatment plant.

Figure 10A-11: Predicted Attenuation of Un-ionized Ammonia Concentrations from the Effluent Treatment Plant Discharge Location for a Subset of Modelled Discharge Scenarios (Reasonable Upper Bound Sensitivity Scenario)



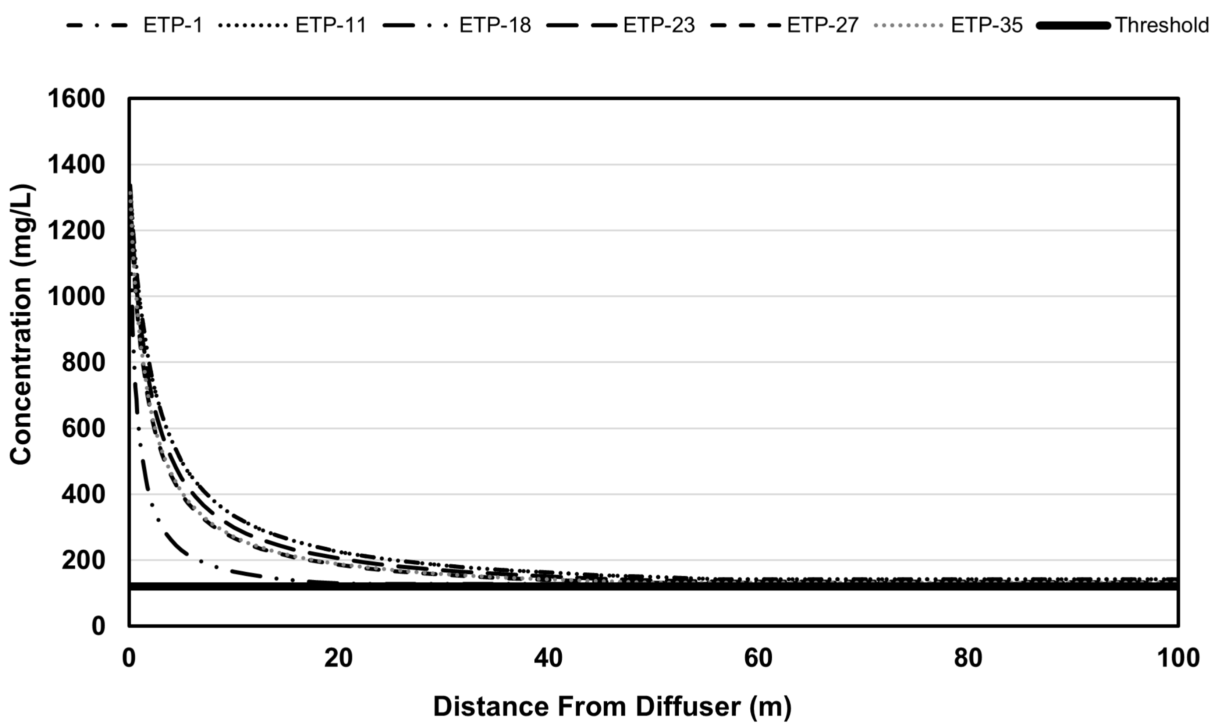
ETP = effluent treatment plant.

Figure 10A-12: Predicted Attenuation of Chloride Concentrations from the Effluent Treatment Plant Discharge Location for a Subset of Modelled Discharge Scenarios (Application Case)



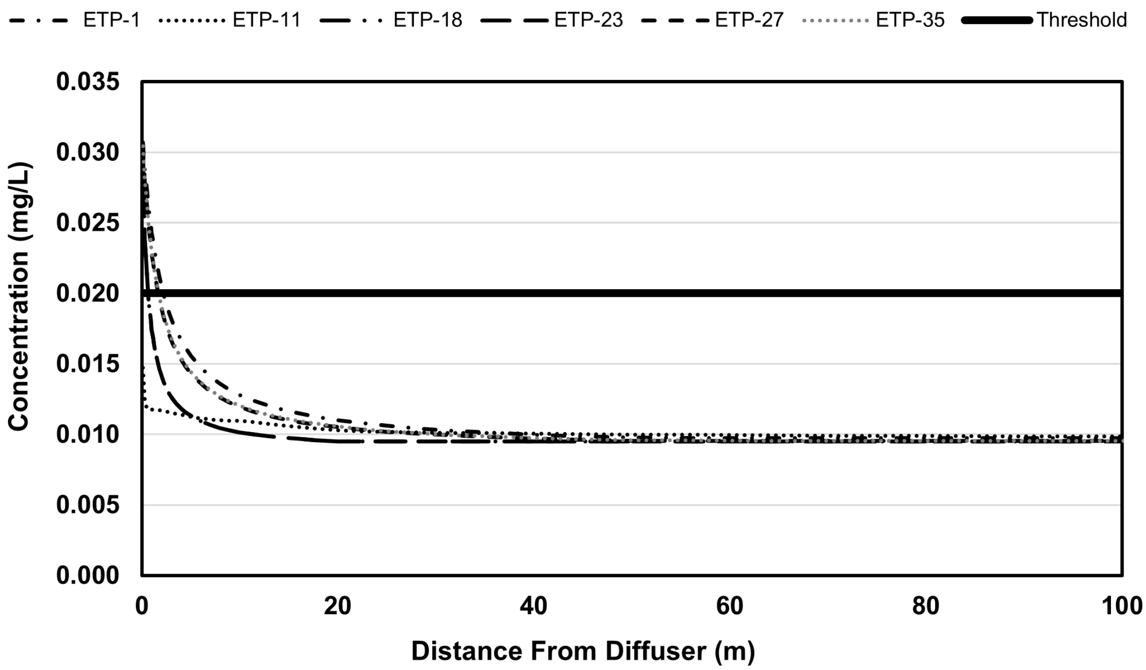
ETP = effluent treatment plant.

Figure 10A-13: Predicted Attenuation of Chloride Concentrations from the Effluent Treatment Plant Discharge Location for a Subset of Modelled Discharge Scenarios (Reasonable Upper Bound Sensitivity Scenario)



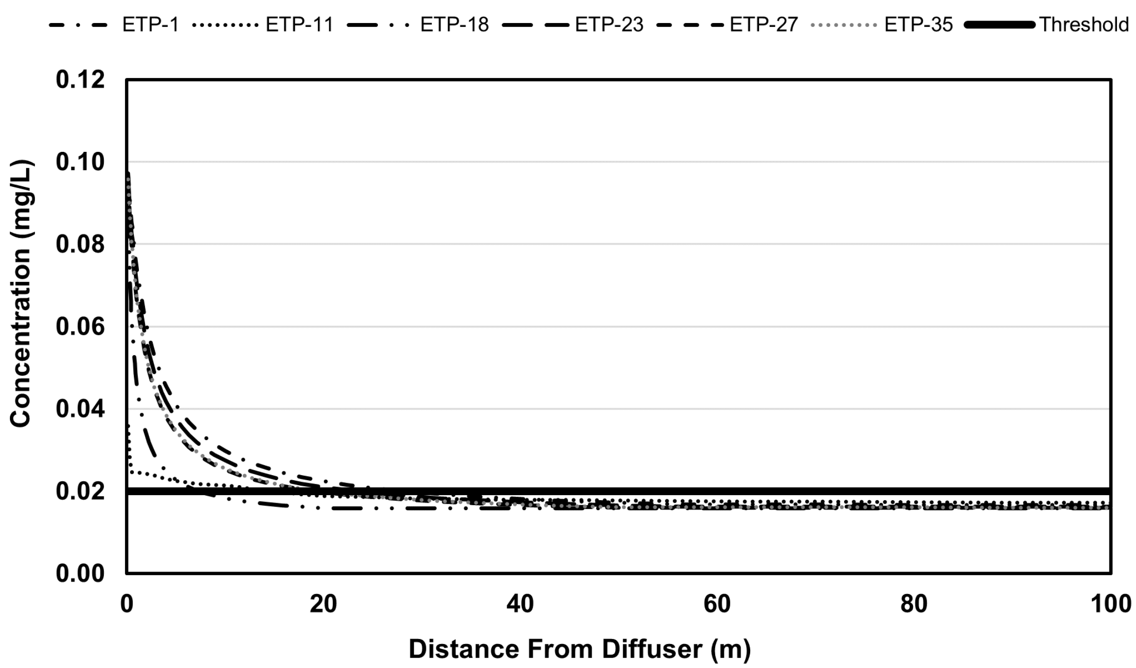
ETP = effluent treatment plant.

Figure 10A-14: Predicted Attenuation of Total Phosphorus Concentrations from the Effluent Treatment Plant Discharge Location for a Subset of Modelled Discharge Scenarios (Application Case)



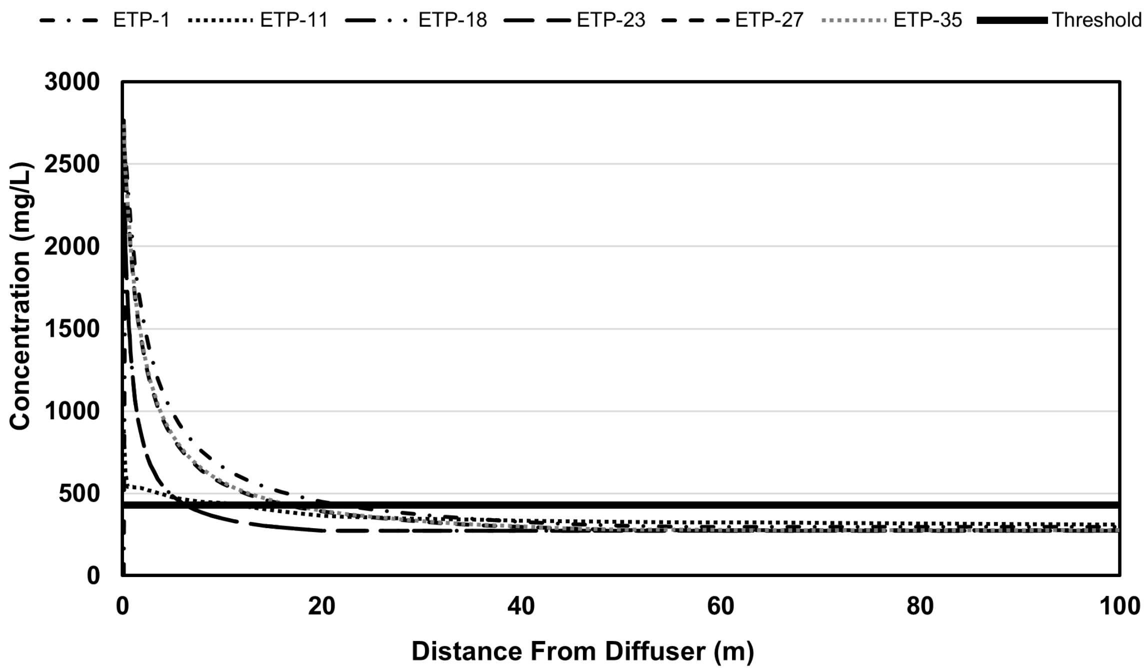
ETP = effluent treatment plant.

Figure 10A-15: Predicted Attenuation of Total Phosphorus Concentrations from the Effluent Treatment Plant Discharge Location for a Subset of Modelled Discharge Scenarios (Reasonable Upper Bound Sensitivity Scenario)



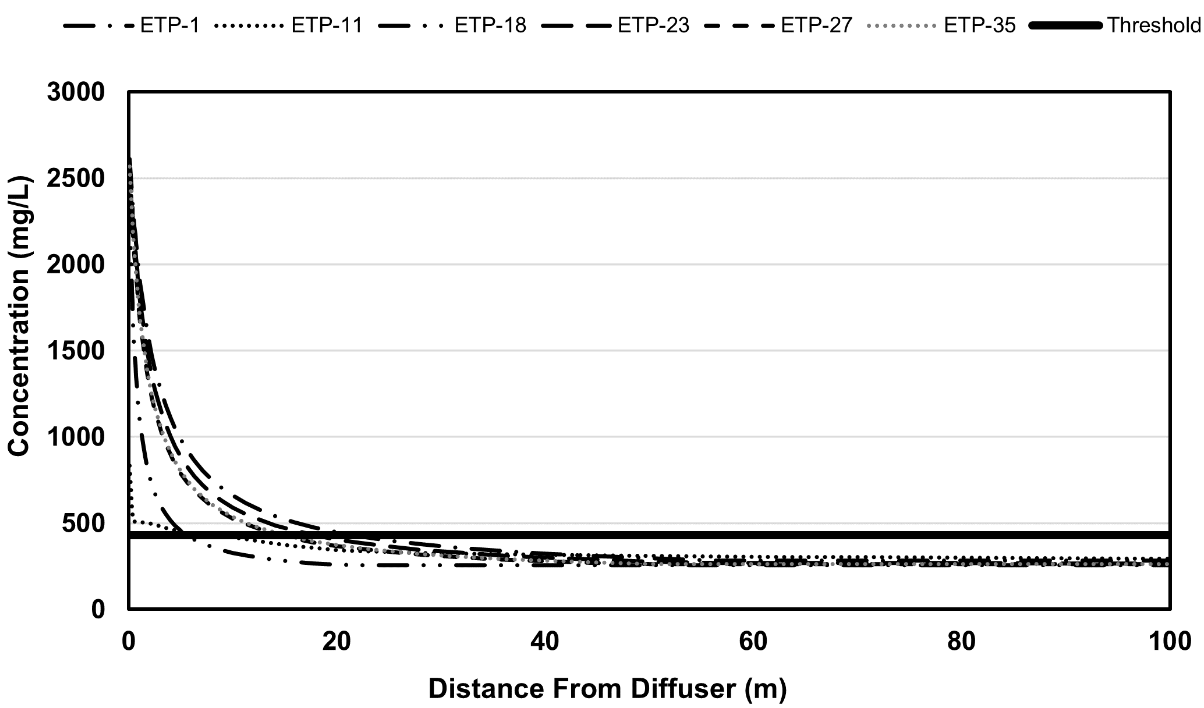
ETP = effluent treatment plant.

Figure 10A-16: Predicted Attenuation of Sulphate Concentrations from the Effluent Treatment Plant Discharge Location for a Subset of Modelled Discharge Scenarios (Application Case)



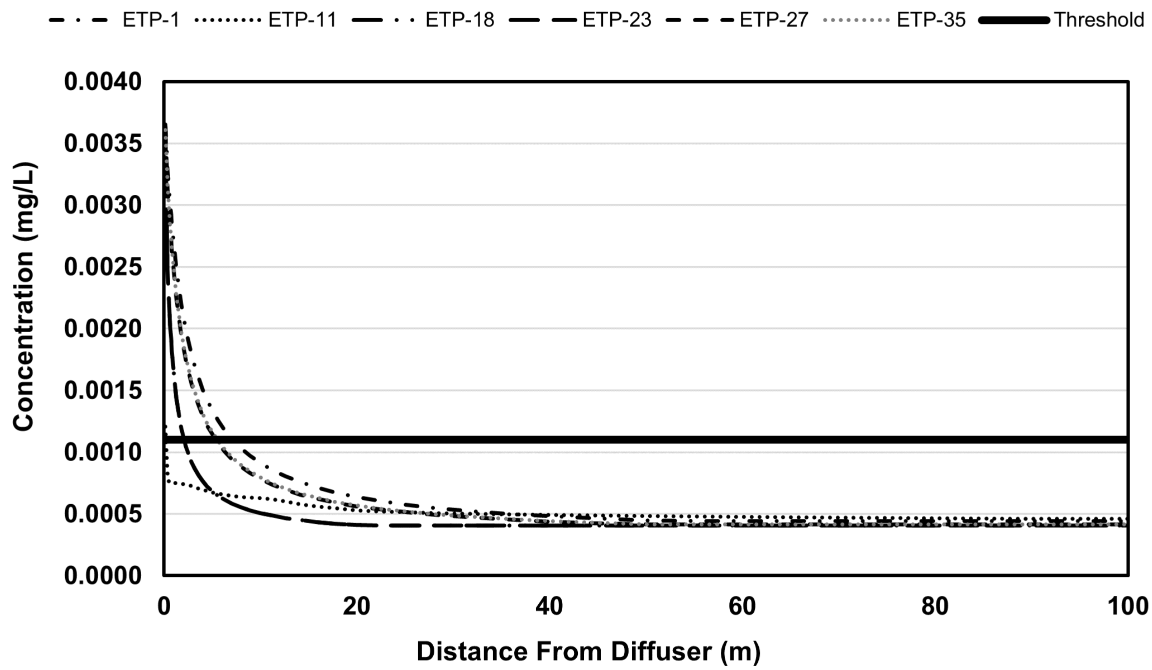
ETP = effluent treatment plant.

Figure 10A-17: Predicted Attenuation of Sulphate Concentrations from the Effluent Treatment Plant Discharge Location for a Subset of Modelled Discharge Scenarios (Reasonable Upper Bound Sensitivity Scenario)



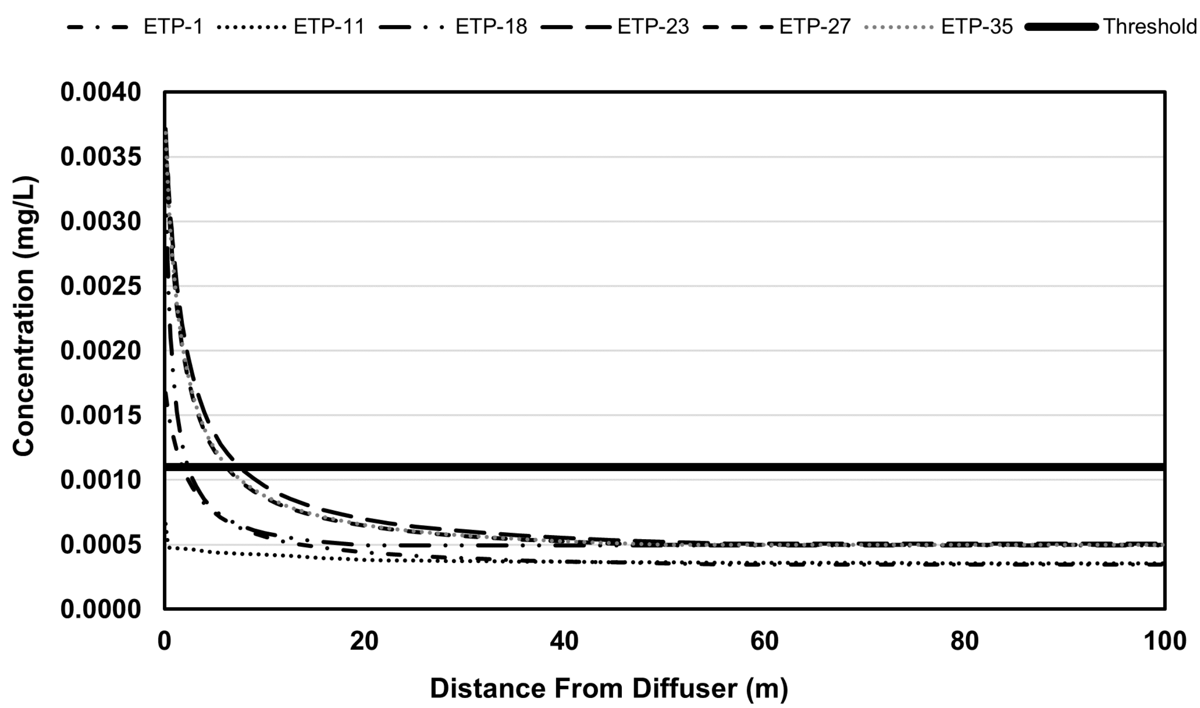
ETP = effluent treatment plant.

Figure 10A-18: Predicted Attenuation of Cobalt Concentrations from the Effluent Treatment Plant Discharge Location for a Subset of Modelled Discharge Scenarios (Application Case)



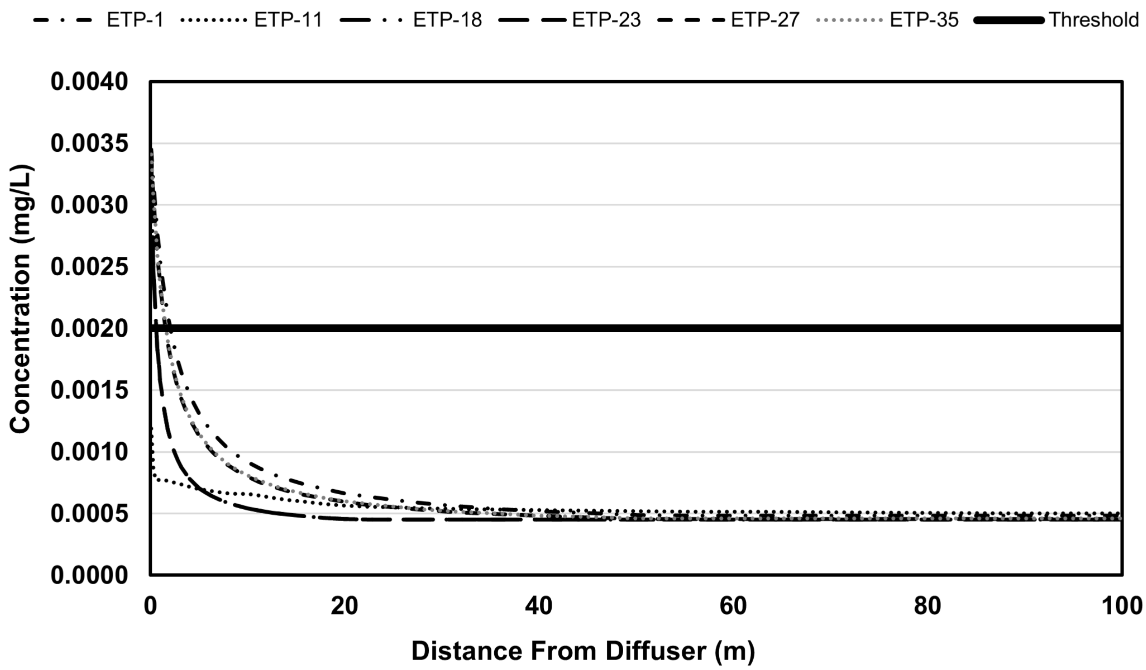
ETP = effluent treatment plant.

Figure 10A-19: Predicted Attenuation of Cobalt Concentrations from the Effluent Treatment Plant Discharge Location for a Subset of Modelled Discharge Scenarios (Reasonable Upper Bound Sensitivity Scenario)



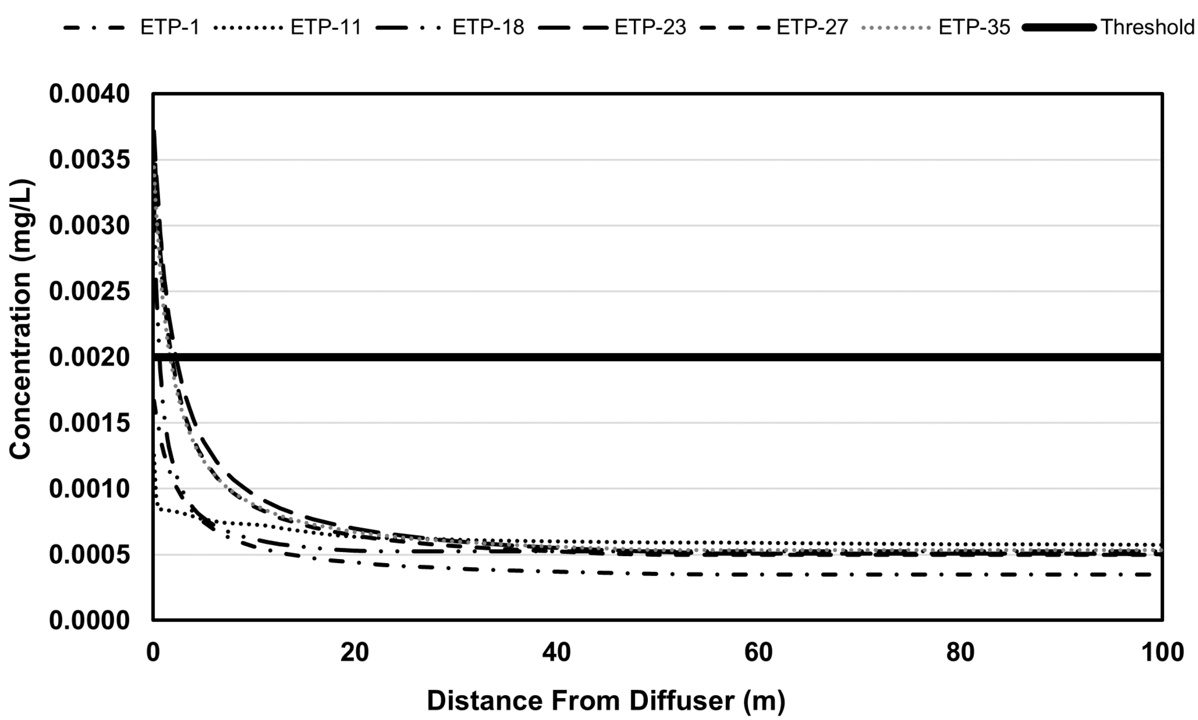
ETP = effluent treatment plant.

Figure 10A-20: Predicted Attenuation of Copper Concentrations from the Effluent Treatment Plant Discharge Location for a Subset of Modelled Discharge Scenarios (Application Case)



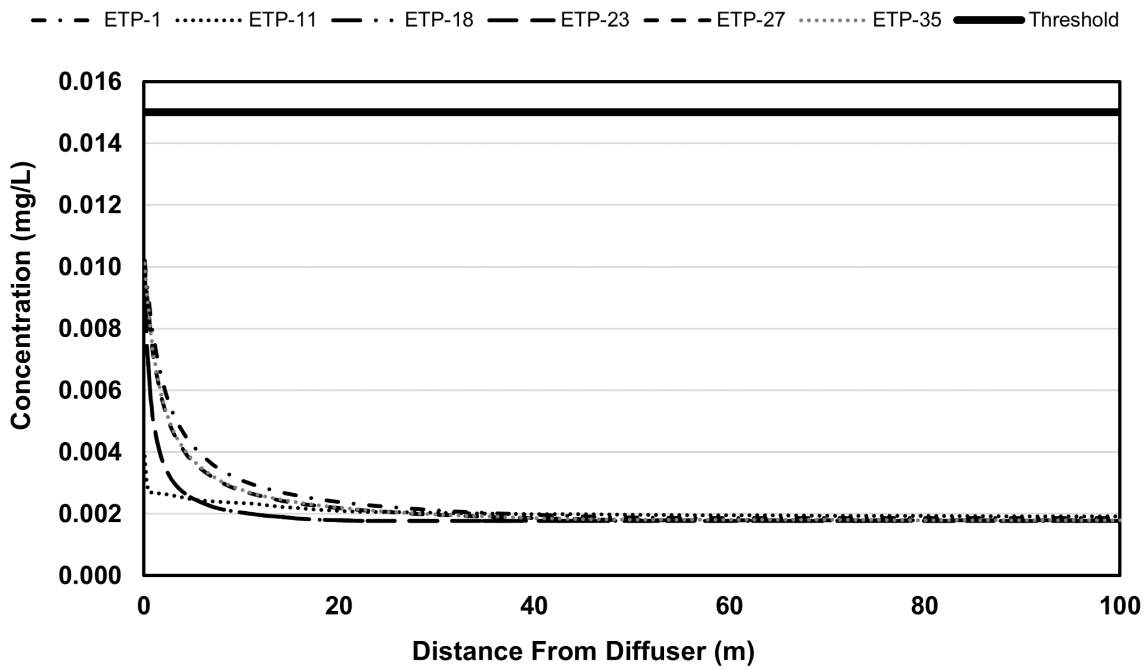
ETP = effluent treatment plant.

Figure 10A-21: Predicted Attenuation of Copper Concentrations from the Effluent Treatment Plant Discharge Location for a Subset of Modelled Discharge Scenarios (Reasonable Upper Bound Sensitivity Scenario)



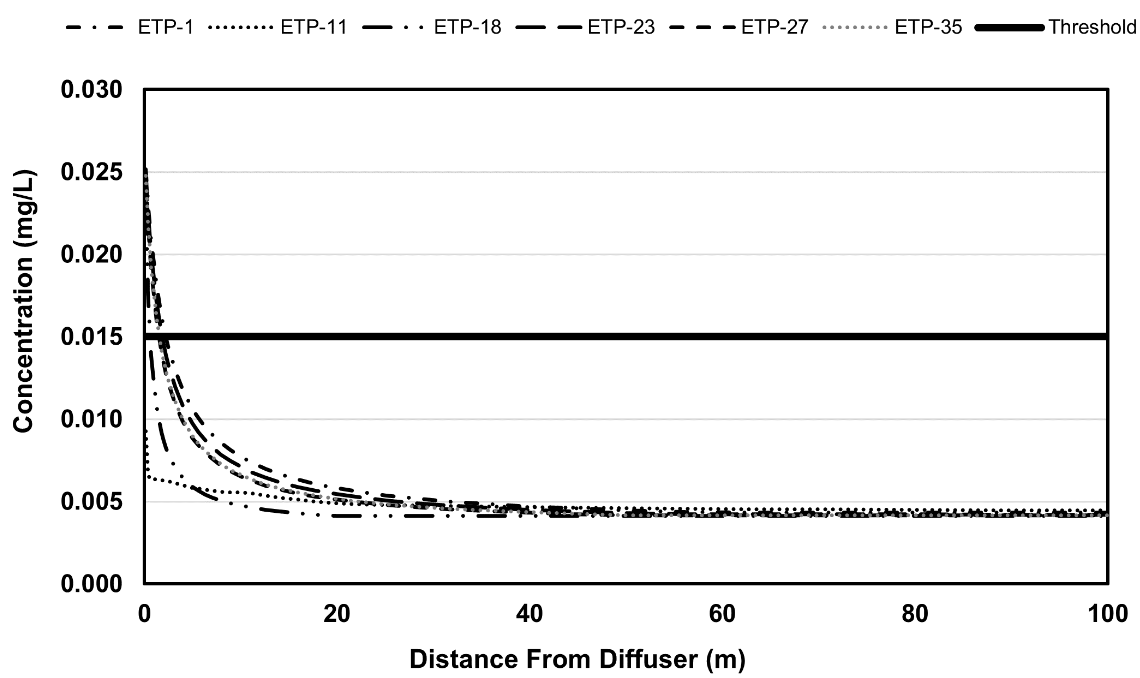
ETP = effluent treatment plant.

Figure 10A-22: Predicted Attenuation of Uranium Concentrations from the Effluent Treatment Plant Discharge Location for a Subset of Modelled Discharge Scenarios (Application Case)



ETP = effluent treatment plant.

Figure 10A-23: Predicted Attenuation of Uranium Concentrations from the Effluent Treatment Plant Discharge Location for a Subset of Modelled Discharge Scenarios (Reasonable Upper Bound Sensitivity Scenario)



ETP = effluent treatment plant.

10A7.5.2 Sewage Treatment Plant Outfall

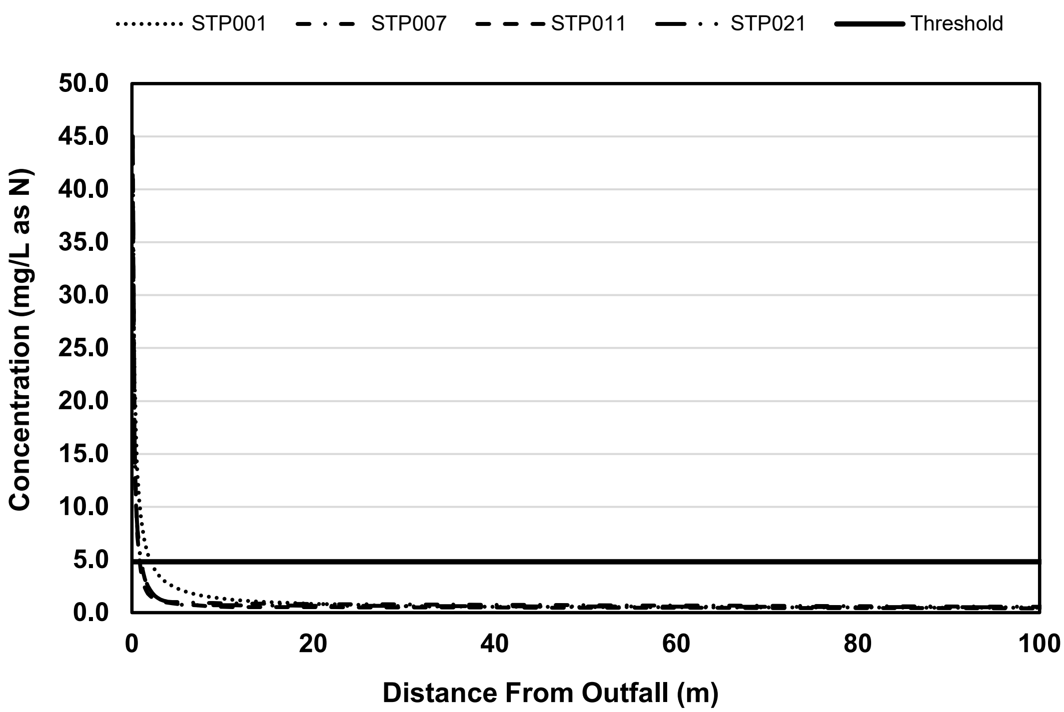
Projected concentrations of nitrate, ammonia, and total phosphorus are presented in Figure 10A-24 to Figure 10A-31 for the modelling scenarios used in the sensitivity analysis (Section 10A3.3, Mine Hydraulic Infrastructure) and include:

- winter condition (STP-1): effluent temperature of 8.5°C, ambient current speed of 0.001 m/s, and ambient temperature of 0°C;
- open water condition with no stratification (STP-7): effluent temperature of 20°C, ambient current speed of 0.042 m/s, and ambient temperature of 5°C;
- open water condition with no stratification (STP-11): effluent temperature of 20°C, ambient current speed of 0.079 m/s, and ambient temperature of 5°C; and
- open water condition with no stratification (STP-21): effluent temperature of 8.5°C, ambient current speed of 0.042 m/s, and ambient temperature of 15°C.

The modelled results indicate the following:

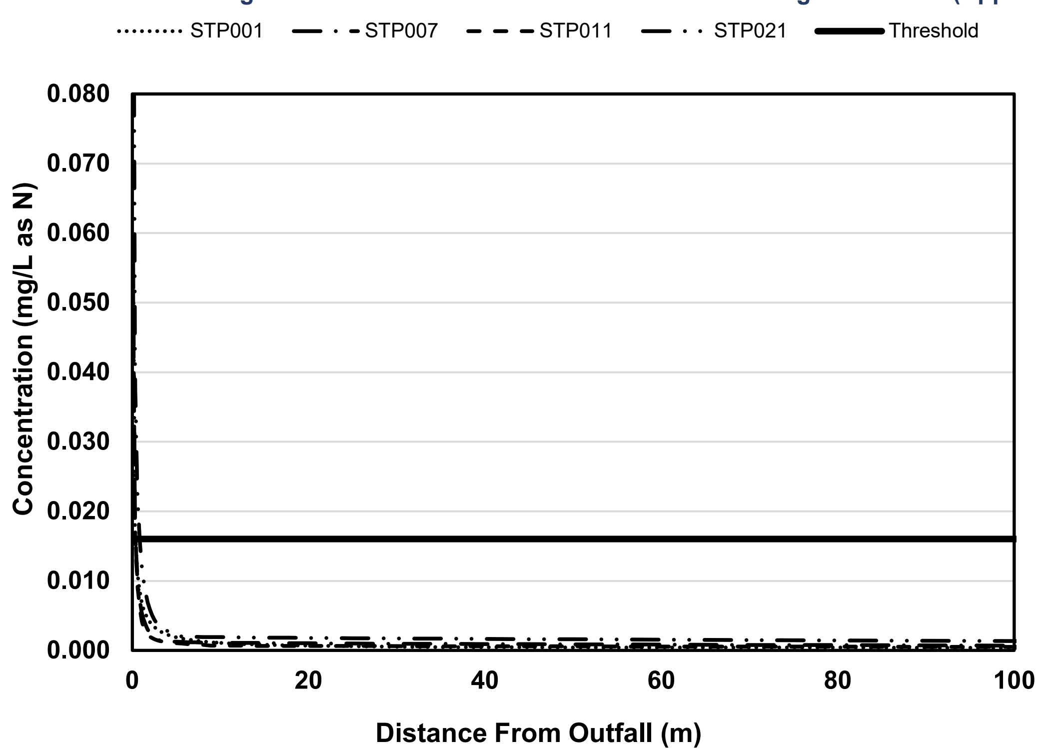
- Ammonia concentrations are below the Project threshold (i.e., 4.8 mg/L as N) beyond 5 m from the outfall for the Application Case (Figure 10A-24) and reasonable upper bound sensitivity scenario (Figure 10A-26). The ammonia threshold of 4.8 mg/L was calculated based on a summer pH of 7 and temperature of 20°C, which represents the most conservative threshold condition. The projected ammonia concentrations at the edge of the proposed RMZ ranged from 0.18 mg/L to 0.43 mg/L for the Application Case and from 0.18 mg/L to 0.44 mg/L for the reasonable upper bound sensitivity scenario. Un-ionized ammonia is similarly predicted to remain below the Project threshold in both scenarios (Figure 10A-25 and Figure 10A-27).
- Nitrate concentrations are below the Project threshold (i.e., 3 mg/L as N) for the Application Case (Figure 10A-28) and reasonable upper bound sensitivity scenario (Figure 10A-29). The projected nitrate concentrations at the edge of the proposed RMZ ranged from 0.7 mg/L to 0.32 mg/L for the Application Case and from 0.08 mg/L to 0.34 mg/L for the reasonable upper bound sensitivity scenario.
- Total phosphorus concentrations are below the Project threshold (i.e., 0.02 mg/L) beyond 50 m from the outfall for the Application Case (Figure 10A-30) and reasonable upper bound sensitivity scenario (Figure 10A-31). The projected phosphorus concentrations at the edge of the proposed RMZ ranged from 0.008 mg/L to 0.011 mg/L for the Application Case and from 0.009 mg/L to 0.016 mg/L for the reasonable upper bound sensitivity scenario.

Figure 10A-24: Predicted Attenuation of Total Ammonia Concentrations from the Sewage Treatment Plant Discharge Location for a Subset of the Modelled Discharge Scenarios (Application Case)



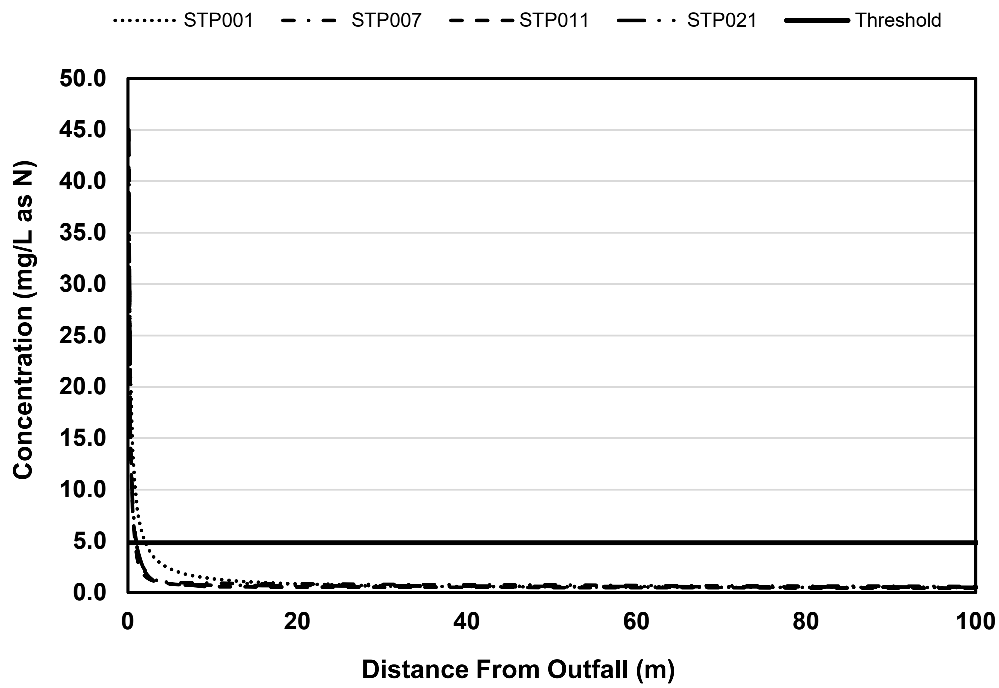
STP = sewage treatment plant.

Figure 10A-25: Predicted Attenuation of Un-ionized Ammonia Concentrations from the Sewage Treatment Plant Discharge Location for a Subset of the Modelled Discharge Scenarios (Application Case)



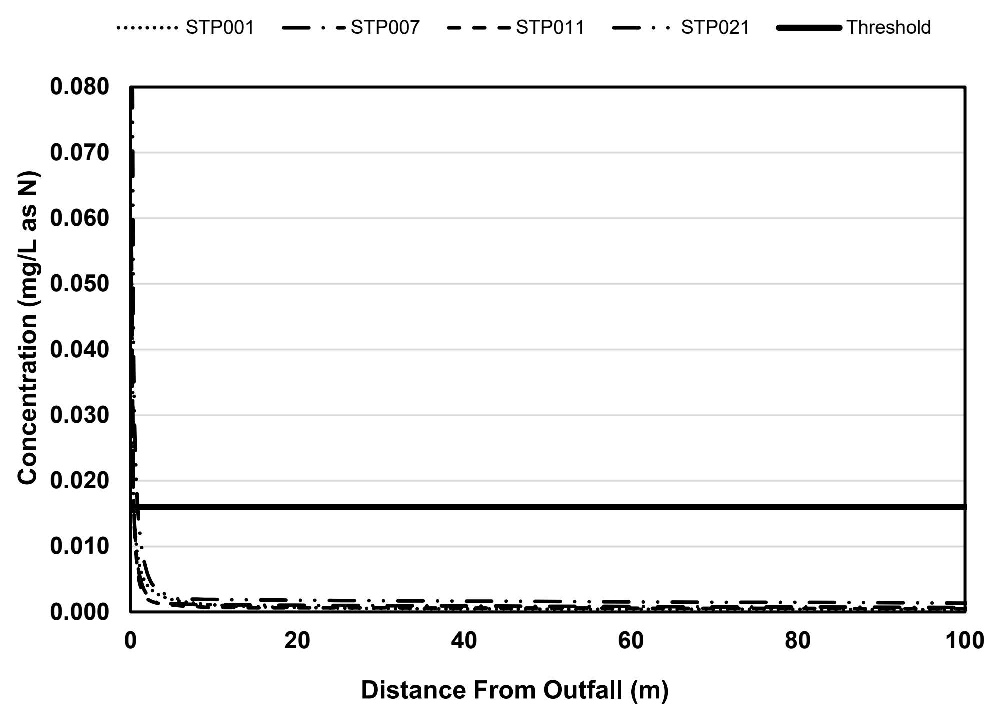
STP = sewage treatment plant.

Figure 10A-26: Predicted Attenuation of Total Ammonia Concentrations from the Sewage Treatment Plant Discharge Location for a Subset of the Modelled Discharge Scenarios (Reasonable Upper Bound Sensitivity Scenario)



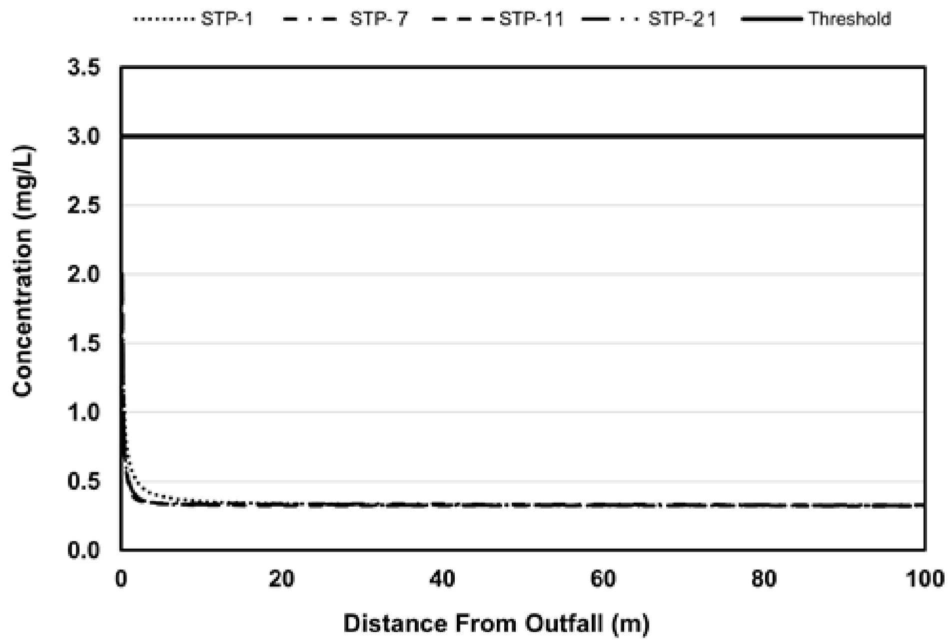
STP = sewage treatment plant.

Figure 10A-27: Predicted Attenuation of Un-ionized Ammonia Concentrations from the Sewage Treatment Plant Discharge Location for a Subset of the Modelled Discharge Scenarios (Reasonable Upper Bound Sensitivity Scenario)



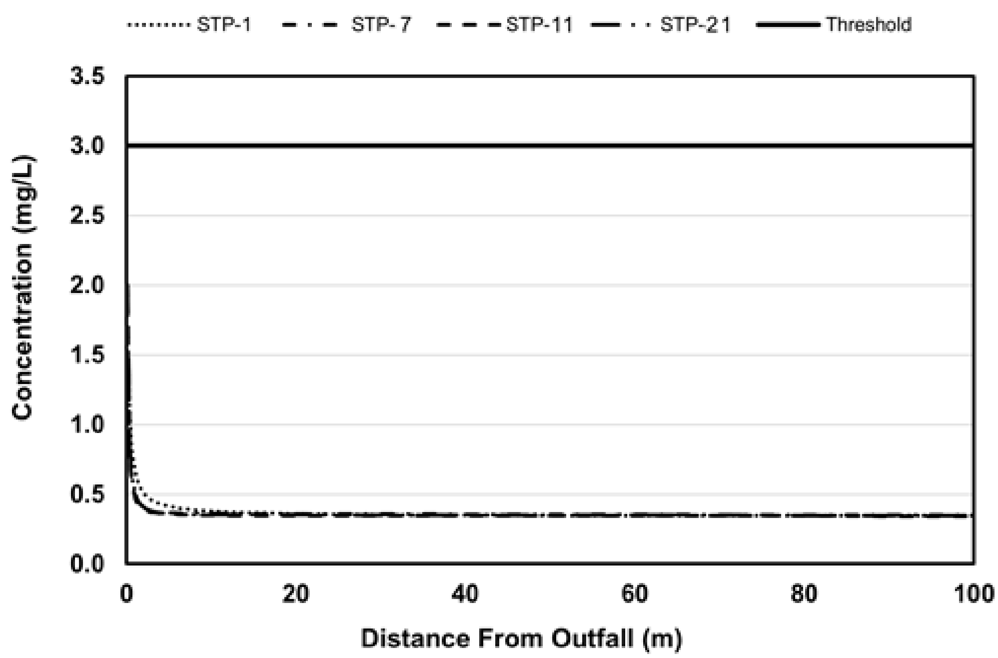
STP = sewage treatment plant.

Figure 10A-28: Predicted Attenuation of Nitrate Concentrations from the Sewage Treatment Plant Discharge Location for a Subset of the Modelled Discharge Scenarios (Application Case)



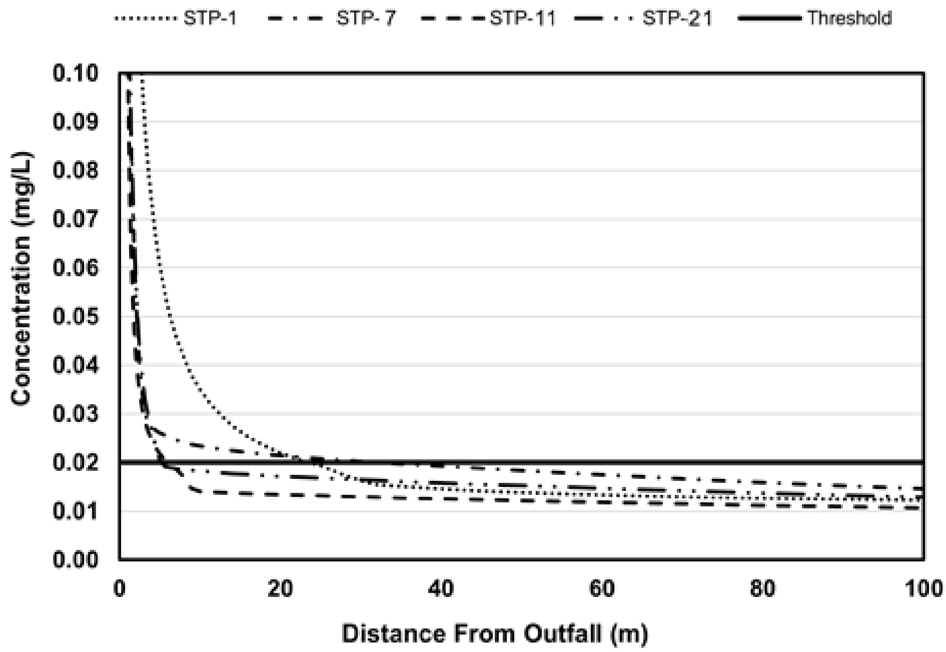
STP = sewage treatment plant.

Figure 10A-29: Predicted Attenuation of Nitrate Concentrations from the Sewage Treatment Plant Discharge Location for a Subset of the Modelled Discharge Scenarios (Reasonable Upper Bound Sensitivity Scenario)



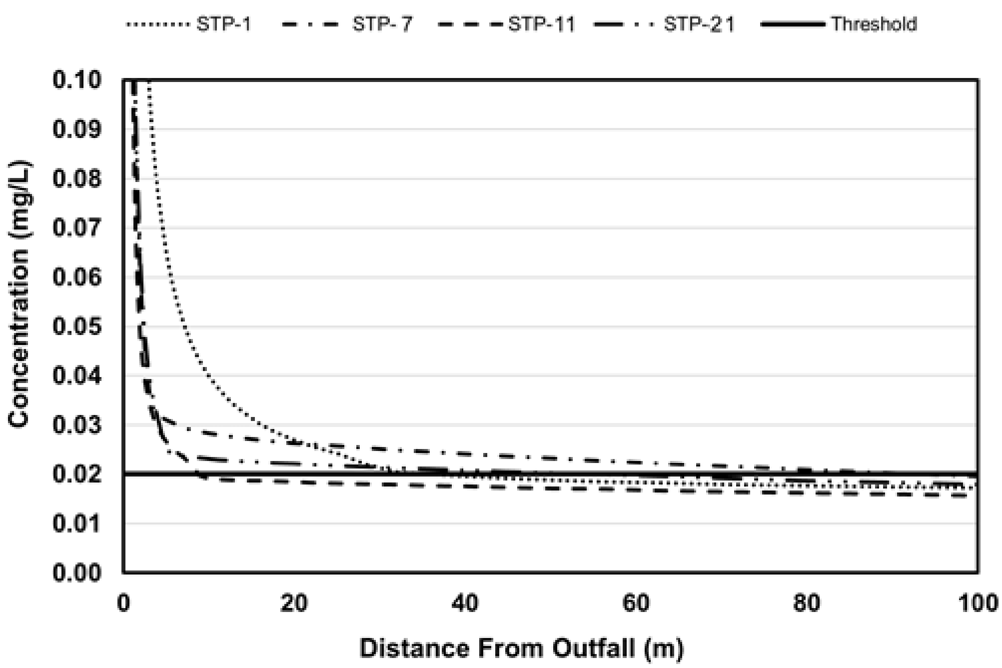
STP = sewage treatment plant.

Figure 10A-30: Predicted Attenuation of Total Phosphorus Concentrations from the Sewage Treatment Plant Discharge Location for a Subset of the Modelled Discharge Scenarios (Application Case)



STP = sewage treatment plant.

Figure 10A-31: Predicted Attenuation of Total Phosphorus Concentrations from the Sewage Treatment Plant Discharge Location for a Subset of the Modelled Discharge Scenarios (Reasonable Upper Bound Sensitivity Scenario)



STP = sewage treatment plant.

10A8 MODELLING CONFIDENCE AND UNCERTAINTY

Primary factors affecting confidence in the predictions made in the water quality modelling include:

- availability and accuracy of baseline data;
- accuracy and certainty in the source terms;
- accuracy and certainty of the models and modelling software; and
- level of understanding of baseline conditions and range of natural and seasonal variation.

Uncertainty was managed by:

- completing quality assurance and quality control of baseline data;
- using known constituent concentrations for similar site analogues when the information was unknown;
- calibrating the models to measured data; and
- conducting sensitivity analysis on key parameters.

As with all modelling approaches to forecast future water quality conditions, the predictions made in this assessment incorporate some degree of uncertainty. As a result, the precautionary approach was applied to address uncertainty in the use of the baseline water quality data, especially with respect to values below detection limits, and in the RSWQM and NFWQM.

The surface water quality modelling utilized output data from models developed by other environmental disciplines in the EIS: the regional hydrology model (Section 9, Hydrology), the air quality dispersion model (Section 7.2, Air Quality), and the groundwater solute transport model (Section 8, Hydrogeology). As such, any uncertainties and conservatisms in those models are carried forward into the surface water quality modelling. Information on how uncertainty and conservatism were incorporated into the development of these other models can be found in the relevant EIS sections. Similarly, information and conservatism related to the SWWBM can be found in TSD XVIII.

10A8.1 Existing Conditions Water Quality Data

Analytical data that are reported as below detection or close to the detection limit have added uncertainty in the surface water quality modelling. Constituent concentrations reported as less than five times the detection limit may also be less precise than concentrations greater than five times the detection limit due to analytical method limitations. The average concentration was used as the Base Case input concentrations for COPCs in the water quality models. To calculate the baseline average, half of the detection limit was used for constituent data reported as below the detection limit. This consideration provides a measure of conservatism so that modelling projections are unlikely to underestimate future conditions.

10A8.2 Near-Field Water Quality Model

The NFWQM estimated the mixing of effluent within a 200 m radius of the ETP diffuser and STP outfall and the dilution factors within 100 m from the ETP diffuser and STP outfall utilizing the following input data:

- physical and chemical characteristics of Patterson Lake based on measured baseline data;

- physical and chemical characteristics of the ETP and STP effluents based on predictions from the SWWBM (ETP) and design information (STP); and
- assumed designs of the ETP diffuser and STP outfall.

Several characteristics of the receiving waterbody (i.e., Patterson Lake) combine to affect the movement and spread of a plume and the performance of a diffuser. These characteristics include water depth, lake currents, water temperature, and chemistry (i.e., TDS), and ice cover. To address the uncertainty of the receiving waterbody behaviour, a total of 35 scenarios for the ETP and 26 scenarios for the STP were considered in the model to assess the performance of the ETP diffuser and STP outfall designs in terms of dilution provided at the edge of the RMZ under a variety of ambient conditions. These scenarios were developed by considering measured lake currents, water depth, and water temperature and predicted dissolved solids to confidently address different receiving waterbody behaviours in the calculations and results.

A sensitivity analysis was also completed to assess the robustness of the outfall/diffuser designs in terms of the dilution provided. The sensitivity analysis included variations in effluent flow rates for the STP and ETP and TDS concentration in the ETP effluent.

10A8.3 Regional Surface Water Quality Model

The RSWQM utilized output data from other four other models: the regional hydrology model (Section 9), the SWWBM (Annex XVIII), the air quality dispersion model (Section 7.2), and TSD XIV. As such, Application Case outputs from these models, based on reasonably conservative source terms and assumptions, were used in the Application Case model, and upper bound outputs were used in the reasonable upper bound sensitivity scenario to address uncertainty associated with the model outputs.

As discussed in Section 10A6.4.2, Reasonably Foreseeable Development Case, an RFD Case was conducted using the RSWQM. This assessment case required assumptions related to the expected treated effluent discharge quality, treated sewage discharge quality, and site runoff quality from the Fission Patterson Lake South Property. At the time of the surface water quality for the EIS, conservative assumptions were made in predicting the water quality of direct and indirect surface water inputs to Patterson Lake because the Fission Patterson Lake South Property project has not yet been approved and applicable data are not yet publicly available. For example, the treated effluent quality from the Fission Patterson Lake South Property was assumed to be equal to the median treated effluent quality from the Project. The estimated surface runoff quality from the Fission Patterson Lake South Property waste rock storage facility and above-ground tailings management facility was conservatively assumed to be equal to the median treated effluent quality from the Project.

10A9 KEY FINDINGS

The overall objective of this report was to document surface water quality modelling completed in support of the EA and the results. More specifically, the key goals of the surface water quality modelling work completed were to:

- characterize existing surface water quality conditions, including natural seasonal variation;
- predict the magnitude, extent, and duration of the effects of Project-related activities on the receiving environment; and
- assess the dilution performance of the outfall/diffuser for the ETP and STP within the RMZ for each of the discharge locations under a range of ambient conditions and treated effluent cases.

These goals were met by developing the RSWQM and NFWQM, and each were run to address a range of anticipated conditions throughout the Project lifespan and far future.

The key findings from the RSWQM are:

- Concentrations of COPCs are projected to increase above Base Case in the receiving environment during the Project lifespan and in the far-future projection.
- All COPCs in the receiving environment during the Project lifespan are projected to remain below the Project thresholds for the Application Case and the reasonable upper bound sensitivity scenario.
- Atmospheric deposition would contribute small incremental changes to COPC concentrations in the waterbodies surrounding the Project during its lifespan.
- The primary driver of incremental changes to COPC concentrations in the receiving environment during the Project lifespan is discharge of treated effluent and treated sewage effluent from the ETP and STP, respectively. These incremental changes are most pronounced in Patterson Lake and attenuate with distance downstream.
- All COPCs in the receiving environment during the far future, except cobalt and copper, are projected to remain below the applicable Project thresholds for the Application Case and the reasonable upper bound sensitivity scenario. These exceedances are a result of sustained mass loads that are predicted to begin approximately 150 years after the decommissioning of the Project.
- The primary driver of changes to COPC concentrations in the receiving environment during the far future is groundwater inflows to Patterson Lake that are influenced by surface water infiltration and constituent mobilization from remaining Project infrastructure (i.e., WRSAs and underground workings, which includes the UGTMF). These changes are most pronounced in Patterson Lake and attenuate with distance downstream.

The key findings from the NFWQM are:

- For the design specifications provided for the ETP and STP discharge locations, effective mixing of the treated effluent discharges occurred within a distance of less than 50 m from each discharge location. The predicted dilution factor at a distance of 100 m was only slightly higher than at 50 m.
- For all cases and sensitivity scenarios, COPCs were below their respective Project thresholds within the 100 m RMZ boundary for the ETP and STP discharge locations, except for chloride from the ETP diffuser for the reasonable upper bound sensitivity scenario.
- The presence and depth of a thermocline in the vicinity of the diffuser had a minor influence on the dilution factor at the boundary of the RMZ for the ETP diffuser.
- Changes in the density due to variations on water temperature and TDS concentration had a minor influence on dilution factor at the boundary of the RMZ for the ETP diffuser and the STP outfall.
- The discharges of treated effluent from the ETP and STP are expected to have negligible effects on TSS, water temperature, and DO at the edge of the RMZ.

10A10 CLOSING

WSP Canada Inc. (WSP, formerly known as Golder Associates Ltd. [Golder]) is pleased to submit this report to NexGen in support of the environmental assessment for the Rook I Project. For details on the limitations and use of information presented in this report, please refer to the Study Limitations subsection following this page. If you have any questions or require additional details related to this study, please contact the undersigned.

WSP Canada Inc.

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Fellow, Technical Director - Surface Water

RP/DL/JB/jlb/jr

STUDY LIMITATIONS

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Attachment 10A-1 Background Surface Water Quality Characterization

Abbreviations and Units of Measure

Abbreviation	Definition
CanNorth	Canada North Environmental Services Limited Partnership
CCME	Canadian Council of Ministers of the Environment
COPC	constituent of potential concern
DO	dissolved oxygen
DOC	dissolved organic carbon
EA	Environmental Assessment
LSA	local study area
NexGen	NexGen Energy Ltd
pH	potential of hydrogen
Project	Rook I Project
RSA	regional study area
TSS	total suspended solids
WSP	WSP Canada Inc.

Unit	Definition
%	percent
µg/L	microgram per litre
km	kilometre
km^2	square kilometre
m	metre
masl	metres above sea level
mg/L	milligrams per litre
mg/L as N	milligrams per litre as nitrogen
Mm^3	million cubic metres

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10A-1-1 INTRODUCTION

10A-1-1.1 Context

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 Northern Village of La Loche, and 640 km northwest of the city of Saskatoon. 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. Patterson Lake is at the interface of the Boreal Shield and Boreal Plain ecozones. Access to the Project would be from an existing road off Highway 955, with on-site worker accommodation serviced by fly-in/fly-out access.

A background surface water quality characterization was completed to support the description of existing conditions for the surface water quality effects assessment in Section 10, Surface Water Quality, of the Environmental Impact Statement. This characterization also supported the derivation of background water chemistry inputs for the receiving environment water quality modelling for the Project (Appendix 10A) to represent the Base Case for the Environmental Assessment (EA). This document describes the baseline conditions of 11 lakes and five stream sites in the upper Clearwater River watershed and nearby region based on available data collected from 2015 to 2020. Most of the sampled waterbodies and watercourse sites (i.e., 12 in total) are within the Clearwater River watershed within the Project influence. The remaining four lakes are outside of the Clearwater River watershed and Project influence; these lakes were characterized as reference lakes. The water chemistry is evaluated for selected constituents of potential concern (COPCs), which are a list of focus constituents that have potential to pose a risk to aquatic or human health identified through a screening process. This list of constituents was developed for the residual effects analysis of the Environmental Impact Statement.

10A-1-1.2 Objectives

The objective of this document is to provide an overview of the baseline conditions of key waterbodies (i.e., lakes) and watercourses (i.e., streams and rivers) within the surface water quality local study area (LSA; Figure 10A-1-1) of the Project and characterize the baseline water quality conditions for the surface water quality modelling completed as part of the EA for the Project. The baseline characterization was achieved through the following:

- Characterizing the baseline physico-chemical (e.g., colour, turbidity, solids concentration) water quality conditions of the waterbodies and watercourse sites, (e.g., dissolved oxygen [DO], pH, temperature, specific conductivity, turbidity) and the presence of seasonal stratification (i.e., development of distinct layers through the water column caused by a change of temperature or chemical composition).
- Characterizing the background water chemistry of the waterbodies and watercourse sites based on seasonal surveys of a comprehensive list of parameters, including major ions, nutrients, metals, and radionuclides.
- Defining the background water quality for selected COPCs identified in Appendix 10A, Surface Water Quality Modelling Report, completed for the EA and comparing these data to the Project water quality thresholds.

- Characterizing the seasonal temperature, pH, and un-ionized ammonia[1] concentrations in Patterson Lake. The characterization of temperature and pH is necessary to determine the fraction of un-ionized ammonia in water. Un-ionized ammonia is modelled instead of total ammonia, which is typically reported in water quality monitoring documents, as water quality criteria for this Project are expressed in terms of the un-ionized component.

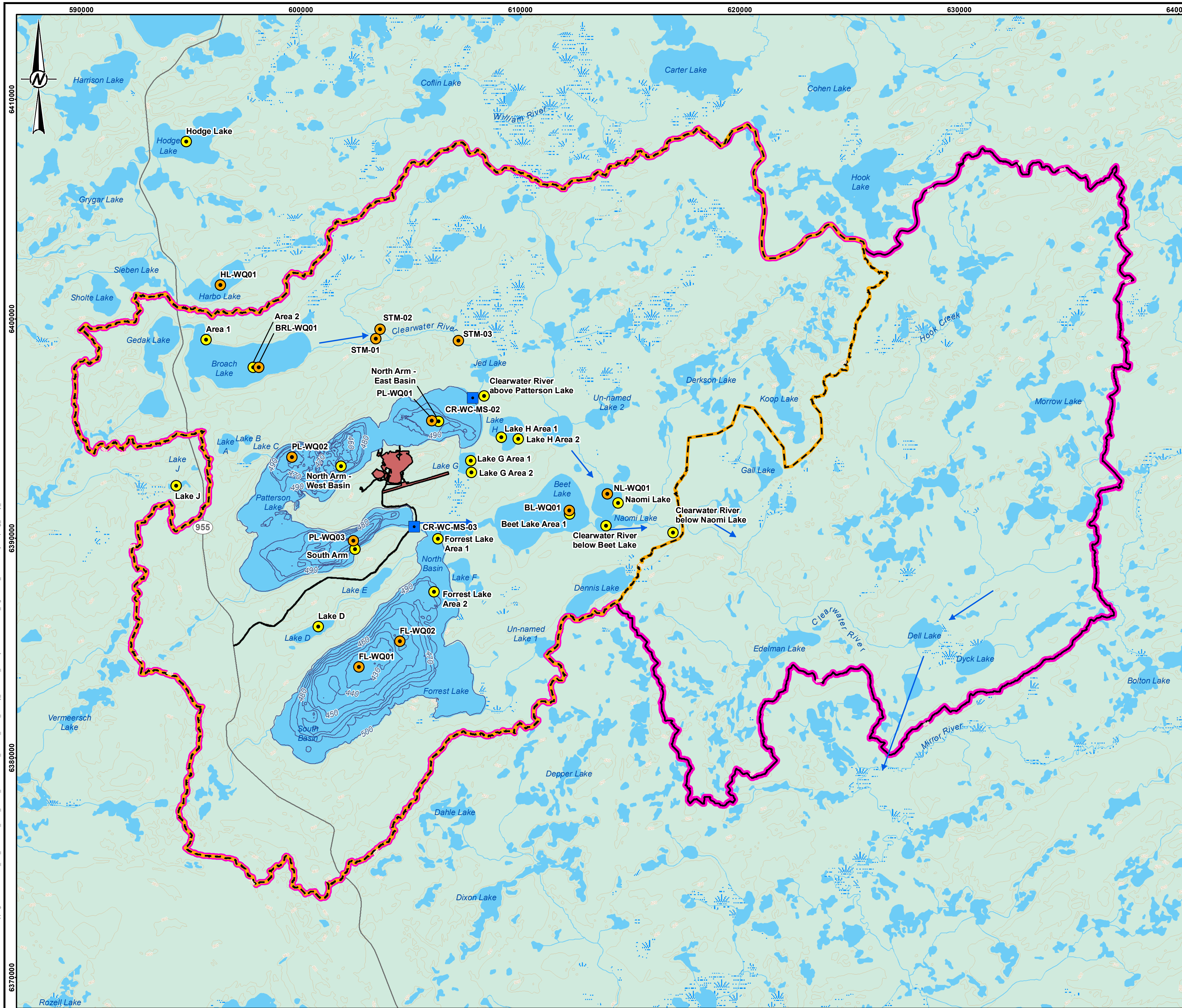
10A-1-1.3 Study Area

The proposed Project is located adjacent to Patterson Lake near the headwaters of the Clearwater River system in northwestern Saskatchewan. Patterson Lake is one of the headwater lakes immediately downstream of Broach Lake (Figure 10A-1-1). The Clearwater River has a large watershed within the Athabasca River Basin that is approximately 30,800 km^2 at its confluence with the Athabasca River at Fort McMurray in northeast Alberta. The total length of the river is about 326 km from its headwaters at Broach Lake in Saskatchewan to the Athabasca River, and it is designated as a Heritage River (CHRS 2018). It flows through three surficial-geological regions starting with the sedimentary Athabasca Basin, through exposed Canadian Shield starting below the Mirror River confluence and ending below its Highway 955 crossing, and the Interior Plains in the lower reach of the river.

The upper reach of the Clearwater River flows from Broach Lake through a series of lakes including Patterson Lake, Forrest Lake, Beet Lake, and Naomi Lake in order from upstream to downstream (Figure 10A-1-1). This portion of the upper Clearwater River watershed represents the surface water quality LSA. From Naomi Lake, the Clearwater River flows another 20 km southeast before reaching the Mirror River confluence. The Clearwater River between Naomi Lake and Dell Lake transitions to intermittent braiding of multiple channels interrupted by occasional riffles and rapids. Between Dell Lake and the Mirror River confluence, the Clearwater River is broad and shallow. Below the Mirror River confluence, the Clearwater River deepens with higher flow volumes from the Mirror River, and the channel form changes to meandering within a well-defined river valley. Farther downstream, the Clearwater River flows through Lloyd Lake, which is just upstream of the Clearwater River Provincial Park; the downstream end of the park is at the Saskatchewan-Alberta border. The limit of the regional study area (RSA) is above the Mirror River confluence.

Based on hydrological characteristics of the region and a high-level framing of the potential direct effects of the Project, the LSA is defined as the Clearwater River watershed to the Naomi Lake outlet (Section 9, Figure 9A-1). The Clearwater River watershed above the Naomi Lake outlet drains an area of 685 km^2. Direct effects on hydrology may include changes to flows or water levels. The RSA for hydrology includes waterbodies and watercourses within the Clearwater River watershed above the Mirror River confluence, which includes the LSA (Section 9, Figure 9A-1). The Clearwater River watershed above the Mirror River confluence drains an area of 1,076 km^2. The spatial extent of the Clearwater River watershed above the Mirror River confluence is expected to provide an ecologically relevant RSA for the EA. The RSA spans an area that provides habitat requirements for a discernible population unit for large-bodied fish species where cumulative effects may occur.

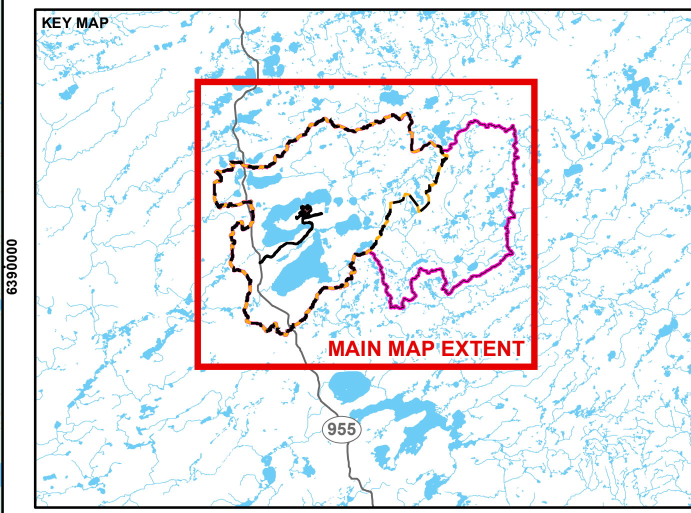
[1] In water, total ammonia is the sum of the un-ionized and ionized ammonia species. The fraction of un-ionized and ionized ammonia varies with the pH and temperature of the water. Total ammonia is typically measured in laboratory analysis from sampled data as the un-ionized component is dependent on in situ conditions.



LEGEND

- BATHYMETRY CONTOUR ELEVATION (10 m INTERVAL)
- ELEVATION CONTOUR (20 m INTERVAL)
- FLOW DIRECTION
- SECONDARY HIGHWAY
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED AREA
- PROPOSED PROJECT FOOTPRINT
- GAUGE STATION
- CANNORTH SAMPLING LOCATION (2018-2020)
- PGL ENVIRONMENTAL LABORATORIES GROUP SAMPLING LOCATION (2015-2016)
- SURFACE WATER QUALITY LOCAL STUDY AREA
- SURFACE WATER QUALITY REGIONAL STUDY AREA

KEY MAP



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REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
2. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
3. FORREST LAKE BATHYMETRY CONTOURS DERIVED FROM JUNE 2019 BATHYMETRY SURVEY DATA. PATTERSON LAKE BATHYMETRY CONTOURS DERIVED FROM DATA COLLECTED BY NEXGEN, 2016.

PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

ROOK I PROJECT BACKGROUND SURFACE WATER QUALITY SAMPLING LOCATIONS

CONSULTANT

wsp

PROJECT		20144150	PHASE	3106 - 3
DESIGN	IC	2021-05-17	SCALE AS SHOWN	REV. 0
GIS	LMS	2024-02-06		
CHECK	IC	2024-02-06	**FIGURE 10A-1-1**	
REVIEW	GVA	2024-02-06		

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10A-1-2 FIELD MONITORING

The available water quality baseline dataset comprises field and laboratory data from field surveys conducted by PGL Environmental and Canada North Environmental Services (CanNorth). The field data included physico-chemical parameters such as temperature, pH, specific conductivity, DO, and turbidity, and the laboratory data included major ions, nutrients, metals, and radionuclides. As described in Section 9, Hydrology, an in situ temperature monitoring program was also conducted by Golder Associates Ltd. (now WSP Canada Inc.[WSP]) to provide continuous records of temperature at selected locations within the LSA. The following subsections further describe the field surveys, laboratory analyses, and temperature monitoring for the baseline surface water quality monitoring program.

10A-1-2.1 Field Surveys

A total of 13 field surveys for water quality sampling were carried out between November 2015 and October 2020 by PGL Environmental and CanNorth (Table 10A-1-1). PGL Environmental conducted the first two surveys in 2015 and 2016, and all subsequent surveys were conducted by CanNorth (Annex V.1 Aquatic Environment Baseline Report). During each of the field surveys, water column profile measurements of temperature, DO, pH, specific conductivity, and turbidity were collected at each sampling location, and water samples were collected from one or more depths for laboratory analyses. The dates of the field surveys and the samples collected from each lake are summarized in Table 10A-1-1.

Field surveys were undertaken on a seasonal basis to characterize seasonal variability. The timing of the seasonal surveys was as follows:

- winter: February or March;
- spring: May or June;
- summer: July or August; and
- fall: September to November.

The first survey conducted by PGL Environmental from 10 November 2015 to 12 November 2015 included Broach Lake, Patterson Lake, Forrest Lake, and Beet Lake. The second PGL Environmental survey conducted from 11 March 2017 to 17 March 2016 was expanded to include Clearwater River below Broach Lake, Clearwater River above Patterson Lake, Clearwater River below Patterson Lake, Clearwater River, and Harbo Lake (Annex V.1). The sampling stations used by PGL Environmental are identified as orange circles in Figure 10A-1-1.

The subsequent field surveys by CanNorth were conducted from May 2018 to September 2020. The sampling stations used by CanNorth included all the lakes surveyed by PGL Environmental, with the addition of Naomi Lake, Lake H, Lake G, and the Clearwater River below Beet Lake in the spring of 2018, Hodge Lake in the summer 2018, and Lake D and Lake J in winter of 2019. Clearwater River below Broach Lake, Clearwater River below Patterson Lake, and Harbo Lake were removed from the baseline study after 2016. The CanNorth stations are identified yellow circles in Figure 10A-1-1.

Quality assurance and quality control procedures, including collection of duplicate samples, were included in the PGL Environmental and CanNorth sampling surveys.

In total, 12 lakes and stream sites were sampled along the Clearwater River flow path as they may be affected by the Project: Broach Lake, Clearwater River above Broach Lake, Clearwater River above Patterson Lake, Lake H, Lake G, Patterson Lake, Forrest Lake, Clearwater River below Patterson Lake, Beet Lake, Clearwater River below Beet Lake, Naomi Lake, and Clearwater River below Naomi Lake.

Four lakes outside of the Clearwater River flow path (i.e., Harbo Lake, Hodge Lake, Lake D, and Lake J) were sampled to characterize lakes outside of the influence of the proposed Project; these lakes are referred to as reference lakes.

Table 10A-1-1: Water Quality Sampling Dates, Locations, and Survey Activity

Waterbody and Watercourse	Sampling Event													Sampling Events
	Fall 2015 (10 to 12 Nov)[a]	Winter 2016 (11 to 17 Mar)[a]	Spring 2018 (17 to 29 May)[b]	Summer 2018 (5 to 22 Aug)[b]	Fall 2018 (19 Sep to 15 Oct)[b]	Winter 2019 (20 to 25 Feb)[b]	Spring 2019 (17 to 30 May)[b]	Summer 2019 (18 Jul to 1 Aug)[b]	Fall 2019 (19 Sep to 3 Oct)[b]	Winter 2020 (17 to 25 Mar)[b]	Spring 2020 (6 May to 8 Jun)[b]	Summer 2020 (5 Jun to 29 Jul)[b]	Fall 2020 (13 to 26 Sep)[b]	
Broach Lake	▪ WQS	▪ WQS (surface, middle, and bottom) ▪ PROFILES	▪ WQS ▪ PROFILES (AREA 1)	▪ WQS ▪ PROFILES (AREA 1)	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	13
Clearwater River below Broach Lake	n/d	▪ WQS	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	1
Clearwater River above Patterson Lake	n/d	▪ WQS	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	12
Lake H	n/d	n/d	▪ WQS	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS	▪ WQS	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	11
Lake G	n/d	n/d	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS	▪ WQS ▪ PROFILES	▪ WQS	▪ WQS	▪ WQS	▪ WQS	▪ WQS	▪ WQS	▪ WQS	11
Patterson Lake, northeast	▪ WQS	▪ WQS (surface, middle, and bottom) ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS ▪ PROFILES	13
Patterson Lake, north	▪ WQS	▪ WQS (surface, middle, and bottom) ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	13
Patterson Lake, east	▪ WQS	▪ WQS (surface, middle, and bottom) ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	13
Clearwater River below Patterson Lake	n/d	▪ WQS	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	1
Forrest Lake – North Basin	▪ WQS	▪ WQS (surface, middle, and bottom) ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	13
Forrest Lake – South Basin	▪ WQS	▪ WQS (surface, middle, and bottom) ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS (surface, middle, and bottom) ▪ PROFILES	▪ WQS (surface, middle, and bottom) ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	13
Beet Lake	▪ WQS	▪ WQS (surface, middle, and bottom) ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS PROFILES	▪ WQS ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS ▪ PROFILES	13
Clearwater River below Beet Lake	n/d	n/d	▪ WQS ▪ PROFILES	▪ WQS PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	11
Naomi Lake	n/d	n/d	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS PROFILES	▪ WQS ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS ▪ PROFILES	11
Clearwater River below Naomi Lake	n/d	▪ WQS	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	12
Hodge Lake	n/d	n/d	n/d	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	▪ WQS (surface and bottom) ▪ PROFILES	9
Harbo Lake	n/d	▪ WQS (surface and bottom) ▪ PROFILES	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	1
Lake D	n/d	n/d	n/d	n/d	n/d	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	8
Lake J	n/d	n/d	n/d	n/d	n/d	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	▪ WQS ▪ PROFILES	8

a) Samples collected by PGL Environmental.
b) Samples collected by CanNorth.
n/d = no samples were collected; WQS = water quality sampling; PROFILES = Water column profile measurements; CanNorth = Canada North Environmental Services Limited Partnership.

10A-1-2.2 Laboratory Analysis

Samples collected throughout the baseline study period were submitted to commercial analytical laboratories for the analysis of major ions, nutrients, metals, and radionuclides. The specific parameters are listed in Table 10A-1-2. The laboratory analysis of the samples collected in winter 2015 was performed by ALS Environmental, with the samples collected between 2016 to 2020 analyzed by SRC Group Environmental Analytical Laboratories. Quality assurance and quality control procedures were followed by the analytical laboratories consistent with professional standards and commercial labs.

Table 10A-1-2: Parameters Analyzed from Water Quality Field Sampling

Parameter Category	Parameter
Physical parameters	pH, specific conductivity, TSS, TDS, hardness, alkalinity
Nutrients	Ammonia (total) as N, nitrate as N, total phosphorus, and DOC
Major ions	Bicarbonate, calcium, chloride, magnesium, potassium, sodium, sulphate
Total and dissolved metals	Aluminum, arsenic, barium, beryllium, boron, cadmium, chromium, cesium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, tellurium, thorium, tin, titanium, uranium, vanadium, zinc
Radionuclides	Lead-210, polonium-210, radium-226, thorium-230, caesium-137

TSS = total suspended solids; TDS = total dissolved solids; DOC = dissolved organic carbon; N = nitrogen.

10A-1-2.3 In Situ Temperature Monitoring

In situ temperature monitoring was conducted at the inlet (CR-WC-MS-02) and outlet (CR-WC-MS-03) of Patterson Lake as part of a hydrometric monitoring program conducted between August 2018 and September 2020 (Section 9). The stations are presented in Figure 10A-1-1. Monitoring was completed using Solinst level loggers installed between 0.5 m to 1.0 m beneath the water surface. The loggers collected continuous water temperature measurements. Additional information on the monitoring method is presented in Annex IV.2, Hydrometric Monitoring Characterization Report.

10A-1-3 WATER QUALITY CHARACTERIZATION

The water quality of key waterbodies and watercourse sites was characterized to provide a basis of the existing conditions for the water quality modelling and the EA. The subsections below present water quality thresholds, general observations of the water quality in the LSA, a summary of the waterbodies and watercourse sites, and the inputs to the receiving environment water quality models in the form of average concentrations (Appendix 10A).

The measured background water quality concentrations were also compared to the Project long-term thresholds for the protection of aquatic life. The pH was compared to Canadian Council for Minsters of the Environment (CCME) guidelines (CCREM 1996). For some parameters, water quality concentrations can periodically or consistently exceed thresholds due to naturally occurring processes.

To characterize the existing water quality, the sampled field surveys results were analyzed. Detailed water quality data tables for each waterbody and watercourse site are provided in Attachment 10A-1a, Detailed Surface Water Quality Tables, and box plots showing the graphical representation of spread of the measured data for each parameter are provided in Attachment 10A-1b, Surface Water Quality Summary Statistic Plots. Attachment 10A-1c, Lake Physico-chemical Water Column Profile Plots, shows the physico-chemical water column profile measurements of temperature, DO, specific conductivity, and pH.

10A-1-3.1 Water Quality Thresholds

The water quality chronic (long-term) thresholds for the protection of aquatic life were generally based on the Canadian Environmental Quality Guidelines for the Protection of Aquatic Life (CCME 2019, 2023) and Saskatchewan's provincial objectives (WSA 2015, 2017). Where no guidelines or objectives were available from CCME or Saskatchewan, provincial objectives from British Columbia (BC MOE 2019; BC MWLAP 2004), Ontario (MOEE 1994a), and the Federal Environmental Quality Guidelines (Environment Canada 1999) were used. The thresholds for the radionuclides were provided by the environmental risk assessment for the Project (TSD XXI, Environmental Risk Assessment), as neither CCME nor provincial guidelines are available.

Table 10A-1-3 provides a summary of the CCME guidelines, provincial water quality objectives, and the selected chronic (long-term) thresholds for the constituents considered. Table 10A-1-4 presents the water quality objectives for total ammonia for the protection of aquatic life. The water quality guidelines and thresholds for drinking water are presented in Table 10A-1-5, which are presented as the drinking water constituent concentration. These guidelines and thresholds were developed based on Health Canada's guidelines for Canadian drinking water quality (Health Canada 2019, 2020). For parameters with no federal guidelines, the World Health Organization guidelines for drinking water quality were selected (WHO 2017).

Table 10A-1-3 and Table 10A-1-5 also identify the parameters that were selected as COPCs. The selected thresholds were carried forward for use in the surface water quality assessment as measurement indicators.

Table 10A-1-3: Canadian Council for Ministers of the Environment Guidelines, Saskatchewan Provincial Objectives, and Selected Water Quality Thresholds

<table>
<tr><th>Parameter</th><th>Unit</th><th colspan="2">CCME: Long Term (Chronic)[a][d]</th><th colspan="2">Provincial Objectives (Chronic)[b][d]</th><th>Selected Threshold</th><th>Selected as COPC</th></tr>
<tr><td>pH</td><td>n/a</td><td colspan="2">6.5-9.0</td><td colspan="2">6.5-9.0</td><td>6.5-9.0</td><td>n/a</td></tr>
<tr><td>Temperature</td><td>°C</td><td colspan="5">Thermal additions should not alter thermal stratification or turnover dates, exceed maximum weekly average temperatures, nor exceed maximum short-term temperatures</td><td>n/a</td></tr>
<tr><td>TSS</td><td>mg/L</td><td colspan="2">Background + 5</td><td colspan="2">n/c</td><td>Background + 5</td><td>n/a</td></tr>
<tr><td colspan="8">Major Ions</td></tr>
<tr><td>Bicarbonate</td><td>mg/L</td><td colspan="2">n/c</td><td colspan="2">n/c</td><td>n/c</td><td>n/a</td></tr>
<tr><td>Calcium</td><td>mg/L</td><td colspan="2">n/c</td><td colspan="2">n/c</td><td>n/c</td><td>n/a</td></tr>
<tr><td>Chloride</td><td>mg/L</td><td colspan="2">120</td><td colspan="2">n/c</td><td>120</td><td>Yes</td></tr>
<tr><td>Fluoride</td><td>mg/L</td><td colspan="2">0.12</td><td colspan="2">n/c</td><td>n/c</td><td>n/a</td></tr>
<tr><td>Magnesium</td><td>mg/L</td><td colspan="2">n/c</td><td colspan="2">n/c</td><td>n/c</td><td>n/a</td></tr>
<tr><td>Sodium</td><td>mg/L</td><td colspan="2">n/c</td><td colspan="2">n/c</td><td>n/c</td><td>n/a</td></tr>
<tr><td>Sulphate</td><td>mg/L</td><td colspan="2">n/a</td><td><30 mg/L as $CaCO_3$
31 mg/L - 75 mg/L as $CaCO_3$
76 mg/L - 180 mg/L as $CaCO_3$
181 mg/L - 250 mg/L as $CaCO_3$
>250 mg/L as $CaCO_3$</td><td>128 mg/L[e]
218 mg/L[e]
309 mg/L[e]
429 mg/L[e]
site-specific[e]</td><td>128[f]</td><td>Yes</td></tr>
<tr><td>Ammonia (un-ionized; NH_3 as N)</td><td>µg/L</td><td colspan="5">15.6</td><td>Yes</td></tr>
<tr><td>Ammonia as N (total)</td><td>mg/L</td><td colspan="5">Function of un-ionized ammonia, pH, and temperature[g]</td><td>Yes</td></tr>
<tr><td>DOC</td><td>mg/L</td><td colspan="4">n/c</td><td>n/c</td><td>n/a</td></tr>
<tr><td>Nitrate (NO_3 as N)</td><td>mg/L</td><td colspan="2">3.0</td><td colspan="2">n/c</td><td>3.0</td><td>Yes</td></tr>
<tr><td>Total phosphorus</td><td>mg/L</td><td colspan="2">Ultra-oligotrophic: <0.004 mg/L
Oligotrophic: 0.004 mg/L - 0.01 mg/L
Mesotrophic: 0.01 mg/L - 0.02 mg/L
Meso-eutrophic: 0.02 mg/L - 0.035 mg/L
Eutrophic: 0.035 mg/L - 0.1 mg/L
Hyper-eutrophic: >0.1 mg/L</td><td colspan="2">0.02[h]</td><td>0.02[h]</td><td>Yes</td></tr>
<tr><td>Aluminum</td><td>mg/L</td><td><6.5 pH
≥6.5 pH</td><td>0.005 mg/L
0.1 mg/L</td><td><6.5 pH, <4 mg/L calcium, <2 mg/L DOC
≥6.5 pH, ≥4 mg/L calcium, ≥2 mg/L DOC</td><td>0.005 mg/L
0.1 mg/L</td><td>0.1[i]</td><td>Yes</td></tr>
<tr><td>Arsenic</td><td>mg/L</td><td colspan="2">0.005</td><td colspan="2">0.005</td><td>0.005</td><td>Yes</td></tr>
<tr><td>Barium</td><td>mg/L</td><td colspan="2">n/c</td><td colspan="2">n/c</td><td>n/c</td><td>n/a</td></tr>
</table>

Table 10A-1-3: Canadian Council for Ministers of the Environment Guidelines, Saskatchewan Provincial Objectives, and Selected Water Quality Thresholds

Parameter	Unit	CCME: Long Term (Chronic)[(a)(d)]		Provincial Objectives (Chronic)[(b)(d)]		Selected Threshold	Selected as COPC
Beryllium	mg/L	n/c		0.011		0.011	n/a
Boron	mg/L	15		n/c		n/c	n/a
Cadmium	mg/L	<17 mg/L as $CaCO_3$ 17 mg/L - 280 mg/L as $CaCO_3$ >280 mg/L as $CaCO_3$	0.00004 mg/L $10^{\{0.83(\log(hardness))-2.46\}}$ 0.00037 mg/L	<17 mg/L as $CaCO_3$ 17 mg/L - 280 mg/L as $CaCO_3$ >280 mg/L as $CaCO_3$	0.00004 mg/L $10^{\{0.83(\log(hardness))-2.46\}}$ 0.00037 mg/L	0.00004[(j)]	Yes
Cesium	mg/L	n/c		n/c		n/c	n/a
Chromium	mg/L	Chromium, hexavalent: 0.001 mg/L Chromium, trivalent: 0.0089 mg/L		Chromium, hexavalent: 0.001 mg/L		0.001	Yes
Cobalt	mg/L	n/c		exp{(0.414[ln(hardness)] – 1.887}[(l)]		exp{(0.414[ln(hardness)] – 1.887}[(l)]	Yes
Copper	mg/L	<82 mg/L as $CaCO_3$ 82 mg/L - 180 mg/L as $CaCO_3$ >180 mg/L as $CaCO_3$	0.002 mg/L $0.2*e^{\{0.8545[\ln(hardness)]-1.465\}}$ 0.004 mg/L	<120 mg/L as $CaCO_3$ 120 mg/L - 180 mg/L as $CaCO_3$ >180 mg/L as $CaCO_3$	0.002 mg/L 0.003 mg/L 0.004 mg/L	0.002[(j)]	Yes
Iron	mg/L	0.3		0.3		0.3	Yes
Lead	mg/L	≤60 mg/L as $CaCO_3$ 60 – 180 mg/L as $CaCO_3$ >180 mg/L as $CaCO_3$	0.001 mg/L $0.2*e^{\{1.273[\ln(hardness)]-4.705\}}$ 0.007 mg/L	≤60 mg/L as $CaCO_3$ 60 mg/L - 120 mg/L as $CaCO_3$ 120 mg/L - 180 mg/L as $CaCO_3$ >180 mg/L as $CaCO_3$	0.001 mg/L 0.002 mg/L 0.004 mg/L 0.007 mg/L	0.001[(j)]	Yes
Manganese	mg/L	Calculated using the CCME calculator for manganese in Appendix B and is based on hardness and pH (CCME 2019)		n/a		0.26[(j,m)]	Yes
Mercury	mg/L	0.000026		0.000026		0.000026	Yes
Molybdenum	mg/L	0.073		7.6[(n)]		7.6[(n)]	Yes
Nickel	mg/L	≤60 mg/L as $CaCO_3$ 60 mg/L - 180 mg/L as $CaCO_3$ >180 mg/L as $CaCO_3$	0.025 mg/L $0.2*e^{\{0.76[\ln(hardness)]+1.06\}}$ 0.150 mg/L	≤60 mg/L as $CaCO_3$ 60 mg/L - 120 mg/L as $CaCO_3$ 120 mg/L - 180 mg/L as $CaCO_3$ >180 mg/L as $CaCO_3$	n/a	0.025[(j)]	Yes
Selenium	mg/L	0.001		0.001		0.001	Yes
Strontium	mg/L	n/c		7[(o)]		7[(o)]	Yes
Tin	mg/L	n/c		n/c		n/c	n/a
Titanium	mg/L	n/c		n/c		n/c	n/a
Uranium	mg/L	0.015		0.015		0.015	Yes
Vanadium	mg/L	n/c		0.12[(l)]		0.12[(l)]	Yes

Table 10A-1-3: Canadian Council for Ministers of the Environment Guidelines, Saskatchewan Provincial Objectives, and Selected Water Quality Thresholds

Parameter	Unit	CCME: Long Term (Chronic)[a][d]	Provincial Objectives (Chronic)[b][d]	Selected Threshold	Selected as COPC
Zinc (dissolved)	mg/L	0.007	0.03	0.007	Yes
Radionuclides					
Lead-210	Bq/L	n/c	n/c	22[p]	Yes
Polonium-210	Bq/L	n/c	n/c	13.5[p]	Yes
Radium-226	Bq/L	n/c	n/c	0.11[p]	Yes
Thorium-230	Bq/L	n/c	n/c	95[p]	Yes

a) CCME 2023.
b) WSA 2015.
c) Short-term exposure <24 hours.
d) Long-term exposure or inputs lasting between 24 hours to 30 days.
e) BC MOE 2019.
f) 128 mg/L for all lakes excluding Patterson Lake based on hardness in the LSAs that is consistently 17 mg/L as $CaCO_3$ or less. Patterson Lake's guideline would vary over time based on the measured hardness in the lake.
g) Total ammonia based on un-ionized ammonia guideline that is adjusted for ambient pH and water temperature as provided in Table10A-1-4.
h) MOEE 1994b.
i) Guideline is variable per lake. Listed threshold is based on a pH range of approximately 7.2 to 7.5 and a hardness range of 10 to 24 mg/L as $CaCO_3$.
j) Based on hardness in the LSAs that is consistently 17 mg/L as $CaCO_3$ or less.
k) BC MWLAP 2004.
l) Federal Environmental Quality Guidelines. The water quality guideline shown is based on a hardness value of 52 mg/L as $CaCO_3$, which is the lowest hardness applicable to the guideline (Environment Canada 2017; Government of Canada 2021).
m) Guideline is variable per lake. Example based on the pH guideline range of approximately 6.3 to 6.9 for Patterson Lake.
n) BC MOE 2021.
o) Health Canada 2019.
p) TSD XXI Environmental Risk Assessment.
n/c = no guideline or criteria specified; n/a = not applicable; N = nitrogen; DOC = dissolved organic carbon; < = less than; > = greater than; ≤ = less than or equal to; $CaCO_3$ = calcium carbonate; Bq/L = becquerels per litre; TSS = total suspended solids; LSA = local study area; CCME = Canadian Council of Ministers of the Environment; COPC = constituent of potential concern.

Table 10A-1-4: Canadian Council for Minsters of the Environment Water Quality Guidelines for Total Ammonia for the Protection of Aquatic Life (in mg/L as Nitrogen)

Temperature (°C)	pH							
	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5
0	190	60.0	19.0	6.02	1.92	0.616	0.206	0.035
5	126	39.7	12.6	3.98	1.27	0.413	0.141	0.028
10	83.9	26.6	8.47	2.68	0.855	0.282	0.100	0.024
15	57.3	18.1	5.74	1.83	0.588	0.197	0.073	0.021
20	39.5	12.5	3.96	1.27	0.410	0.141	0.055	0.020
25	27.6	8.72	2.77	0.888	0.291	0.103	0.044	0.018
30	19.5	6.17	1.97	0.631	0.211	0.077	0.035	0.017

Note: The presented guideline values (expressed as mg/L as nitrogen) are based on the reported guideline values (CCME 2010) multiplied by a factor of 0.8224 to convert the reported guideline values from mg/L NH_3 to mg/L NH_3 as nitrogen.
mg/L NH_3 = milligrams per litre of ammonia.

Table 10A-1-5: Drinking Water Quality Guidelines and Water Quality Thresholds

Parameter	Unit	Health Canada[a,b]	World Health Organization[c]	Selected Project Threshold	Selected as COPC
Major Ions					
Bicarbonate	mg/L	n/a	n/a	n/a	n/c
Calcium	mg/L	n/a	n/a	n/a	n/c
Chloride	mg/L	250[d]	n/a	250	Yes
Magnesium	mg/L	0.12	n/a	0.12	n/c
Sodium	mg/L	n/a	n/a	n/a	n/c
Sulphate	mg/L	500[d]	n/a	500	Yes
Nutrients					
Ammonia as N	mg/L	n/a	n/a	n/a	n/c
Nitrate as N	mg/L	10	11	10	Yes
Total phosphorus	mg/L	n/a	n/a	n/a	n/c
Total Metals (unless otherwise noted, all metals are reported as total)					
Aluminum	mg/L	0.1	n/a	0.1	Yes
Arsenic	mg/L	0.01	0.01	0.01	Yes
Cadmium	mg/L	0.007	0.003	0.007	Yes
Cobalt	mg/L	n/a	n/a	n/a	n/c
Chromium[e]	mg/L	0.05	0.05	0.05	Yes
Copper	mg/L	2	2	2	Yes
Iron	mg/L	0.3[d]	n/a	0.3	Yes
Molybdenum	mg/L	n/a	n/a	n/a	n/c
Lead	mg/L	0.005	0.01	0.005	Yes
Manganese	mg/L	0.12	n/a	0.12	Yes
Mercury	mg/L	0.001	0.006	0.001	Yes
Nickel	mg/L	n/a	0.07	0.07	Yes
Selenium	mg/L	0.05	0.04	0.05	Yes
Strontium	mg/L	7	n/a	7	Yes
Uranium	mg/L	0.02	0.03	0.02	Yes
Vanadium	mg/L	n/a	n/a	n/a	n/c
Zinc	mg/L	5	n/a	5	Yes

Table 10A-1-5: Drinking Water Quality Guidelines and Water Quality Thresholds

Parameter	Unit	Health Canada[a,b]	World Health Organization[c]	Selected Project Threshold	Selected as COPC
Radionuclides					
Lead-210	Bq/L	0.2	0.1	0.2	Yes
Polonium-210	Bq/L	n/a	0.1	0.1	Yes
Radium-226	Bq/L	0.5	0.1	0.5	Yes
Thorium-230	Bq/L	n/a	1	1	Yes

a) Health Canada 2020.
b) Maximum acceptable concentration provided unless otherwise indicated.
c) WHO 2017.
d) Guideline is an aesthetic objective.
e) Guidelines are for total chromium.
n/c = no guideline or criteria specified; Bq/L = becquerels per litre; n/a = not applicable; COPC = constituent of potential concern; N = nitrogen.

10A-1-3.2 General Observations

Water quality data were collected at 11 waterbodies and five watercourse sites within and near the LSA. General observations of the physico-chemical conditions and concentrations of major ionic composition, nutrients and relative trophic status, metals, and radionuclides in small and large lakes were made based on a review of the sampled data and the CanNorth baseline characterization (Annex V.1).

General observations of the physico-chemical conditions of the sampled lakes are presented in Table 10A-1-6 and summarized as follows:

- **Clarity**: The lakes typically have high water clarity based on relatively low measurements of total suspended solids (TSS; less than 10 mg/L), turbidity (less than five nephelometric turbidity units), and colour.
- **Thermal stratification**[2]: The deeper lakes (i.e., greater than 20 m in depth) demonstrated thermal stratification during the late spring to early fall and exhibited bi-annual lake turnover events in early spring and early winter. Despite the occurrences of thermal stratification, no discernible chemical stratification was observed.
- **Dissolved oxygen**: The lakes have a large range of DO through the water columns, with measurements between 2 mg/L and 15 mg/L. The surface waters of the lakes have well-oxygenated waters throughout the year, with measurements above 8 mg/L throughout the year. Low DO concentrations were limited to measurements within the lower portion of the water column (i.e., within a few metres of the bottom) in deeper lake basins. The lakes demonstrating thermal stratification experienced seasonal decreasing DO with depth, especially in winter and summer.
- **pH**: Lake pH was typically circumneutral (between 6.5 and 7.5); however, in some lakes, occurrences of slightly acidic pH (i.e., down to 5.83 in winter / early spring conditions) and slightly alkaline pH (i.e., up to 8.20 during summer conditions) were measured.

[2] Separation of distinct layers through the water column based on different temperature; the water column can also be separated based on chemical composition.

Table 10A-1-6: Summary Parameters for Sampled Lakes

Waterbody	Sampling Area	Maximum Depth (m)[(a)]	Approximate Summer Thermocline Depth (m)[(b)]	DO Range, Water Column (mg/L)[(c)]	Maximum Recorded Temperature, Water Column (˚C)	Minimum Recorded Temperature, Water Column (˚C)	Specific Conductivity Range, Water Column (µS/cm)	pH Range, Water Column
Broach Lake	n/a	82.5	16	0.7 - 14.9	16.0	2.9	36.2 - 77.3	6.2 - 7.7
Lake H[(d)]	1	0.6	[(e)]	8 - 10	22.5	3.9[(c)]	32.6 - 117.0	6.9 - 7.8
	2	8.2		0.2 - 12.2	20.0	3.7		6.0 - 8.0
Lake G[(f)]	1	0.8	[(e)]	8 - 9	22.7	6.8	35.0 - 121.7	6.5 - 7.4
	2	3.4		0.2 - 12.3	20.9	1.1		6.4 - 8.2
Patterson Lake	North Arm – East Basin	25	14	0.1 - 14.3	20.3	0.3	24.9 - 70.1	5.8 - 7.6
	North Arm – West Basin	53	14	0.7 - 13.7	18.8	0.3	3.6 - 85.9	6.5 - 7.7
	South Arm	50	14	0.3 - 14.4	19.8	0.1	36.5 - 56.7	6.1 - 7.5
Forrest Lake	North Basin	1	[(e)]	8.7 - 13.7	22.4	0.2	37.7 - 54.4	6.4 - 8.2
	South Basin	84.7	13	9.0 - 14.1	17.0	0.2	35.3 - 55.0	5.8 - 7.9
Beet Lake	n/a	33.7	13	0.5 - 12.8	18.7	1.0	42.2 - 95.6	5.9 - 7.7
Naomi Lake	n/a	5	[(e)]	4.4 - 11.9	29.2	1.7	17.5 - 59.4	5.9 - 7.5
Hodge Lake	n/a	45.6	12	6.6 - 14.2	17.6	2.1	25.8 - 33.0	5.8 - 7.1
Harbo Lake	n/a	30	[(g)]	10 - 13.2	2.7[(g)]	1.1	20.5 - 25.4	6.4 - 6.6
Lake D	n/a	4.0	[(e)]	0.5 - 10.6	23.0	2.9	39.5 - 84.0	6.5 - 8.1
Lake J	n/a	2.5	[(e)]	0.8 - 10.1	23.0	1.6	5.1 - 34.9	5.8 - 7.0

a) Maximum depth from bathymetric survey; if no bathymetric survey was available, the maximum depth measured during the field surveys.

b) Value presented was the approximate location of the middle of the thermocline recognizing that the thermocline was typically 3 m to 5 m thick.

c) The DO in surveyed lakes was typically high (6 mg/L to 13 mg/L) in the top and middle sections of the water column, with low concentrations (less than 4 mg/L) occasionally present near the bottom.

d) Area 1 of Lake H was sampled twice in May, July, and September. No winter sampling was done.

e) No thermocline was measured or present.

f) Area 1 of Lake G was sampled twice in May, July, and September, and once in June. No winter sampling was conducted.

g) Harbo Lake was sampled in March. Only winter sampling was done.

n/a = not applicable; µS/cm = microsiemens per centimetre; DO = dissolved oxygen.

Observations of major ions and nutrient concentrations can be summarized as follows:

- **Dissolved solids**: All sampled waterbodies and watercourse sites had low total dissolved solids with average concentrations ranging from 32 mg/L to 60 mg/L.
- **Dominant ions**: The dominant major ions are calcium and bicarbonate.
- **Hardness**: The waters of the lakes and streams can be characterized as soft waters, with the average ranging from 9.0 mg/L to 18.1 mg/L as calcium carbonate ($CaCO_3$).
- **Nutrient status**: Trophic status was defined using total phosphorus only based on CCME classification (CCME 2004). All lakes except Lake G were characterized as oligotrophic based on their low total phosphorus concentration (less than 10 µg/L). In addition, the average range of nitrate measured as nitrogen was less than 0.010 mg/L to 0.43 mg/L, and average total ammonia is less than 0.01 mg/L to 0.15 mg/L.
- **Dissolved organic carbon (DOC)**: The measured range of DOC is 2.4 mg/L to 13 mg/L. Dissolved organic carbon was included in the background surface water quality characterization as DOC is used as a modifier for water quality thresholds (e.g., Saskatchewan provincial chronic objective for total aluminum [Table 10A-1-3]).

Observations of total metals and radionuclides concentration include:

- Total metals concentrations are generally low (i.e., at or below the detection limit), which is similar throughout the LSA. The exception to this is total iron. Iron was measured above the Project threshold in the majority of the waterbodies and watercourse sites:
  - Measured iron concentrations exceeding the Project threshold of 300 µg/L were reported for many of the waterbodies and watercourse sites in the LSA. The average concentration of iron in Clearwater River below Broach Lake, Clearwater River above Patterson Lake, Patterson Lake, Lake H, Lake G, Naomi Lake, and Clearwater River below Naomi Lake exceeded the Project threshold.
  - Iron concentrations are highest upstream of Patterson Lake (i.e., Clearwater River above Patterson Lake, Lake H, Lake G) and downstream of Clearwater River below Beet Lake (i.e., Naomi Lake and Clearwater River below Naomi Lake).
  - Elevated concentrations of iron were generally associated with higher concentrations of TSS.
- Metals consistently measured below detection include beryllium, boron, cadmium, cesium, chromium, cobalt, copper, molybdenum, nickel, selenium, tin, uranium, and vanadium.
- Most measured radionuclides (i.e., lead-210, polonium-210, and thorium-230) were undetected in sampled waterbodies and watercourse sites in the LSA. Radium-226 concentrations were sometimes detected within the LSA but were well below the Project threshold.

10A-1-3.3 Summary of Each Major Waterbody and Watercourse Site in the Local Study Area

The following subsections provide a description of the waterbodies and watercourse sites within the LSA that were sampled. A summary of notable observations that differ from the general observations and parameters above thresholds are presented. The waterbodies and watercourse sites are presented from upstream to downstream. Four lakes outside of the Clearwater River flow path (i.e., Harbo Lake, Hodge Lake, Lake D, and Lake J) were sampled to characterize reference lakes.

10A-1-3.3.1 Broach Lake and Clearwater River below Broach Lake

Broach Lake lies near the headwaters of the Clearwater River (CHRS 2018) and is located 5.3 km northwest of the Project (Figure 10A-1-1). The lake is roughly rectangular measuring 5.8 km west to east, and 1.8 km north to south. It has one main inflow along its west shoreline, and its outflow is at the east end of the lake. The lake gets gradually deeper to the west, with a maximum depth of 82.5 m (Annex V.1). The lake has a total water volume of 242 million cubic metres (Mm^3), and a surface area of 9.3 km^2 (Annex V.1). Broach Lake watershed at its outflow is 56.4 km^2. The retention time for this waterbody is estimated to be 25 years.

Broach Lake was sampled 12 times for water quality between March 2016 to September 2020. Water quality samples were taken at two locations within Broach Lake: at Area 1, located in the northwestern shallow portion of the lake near the inflow (i.e., approximately 5 m deep), and at Area 2, located near the middle of the lake (Figure 10A-1-1). The lake develops ice-cover over the winter season; an ice thickness of 0.76 m was measured in February 2019.

Clearwater River below Broach Lake was only sampled in the spring of 2016 at three different locations to capture the water quality of the upstream catchment and its confluence.

The available background water quality dataset for Broach Lake and Clearwater River below Broach Lake is presented in Attachment 10A-1a, Table 10A-1a-1 and Table 10A-1a-2, respectively. Physico-chemical water column profile measurements are presented in Attachment 10A-1c, Figure 10A-1c-1 and Figure10A-1c-2. Notable observations for the water quality in Broach Lake include:

- The pH recorded in the field was outside the CCME range of 6.5 to 9.0 (CCREM 1996) in Broach Lake in four instances (winter 2016, pH: 6.30; spring 2018, pH: 6.30; summer 2019, pH: 6.30; spring 2020, pH: 6.19).
- Manganese was above the Project threshold of 260 µg/L for two instances in Broach Lake:
  - winter 2019: 310 µg/L; and
  - spring 2019: 1,440 µg/L.
- Iron was above the Project threshold of 300 µg/L in spring 2016 in Clearwater River below Broach Lake.

10A-1-3.3.2 Clearwater River above Patterson Lake

The Clearwater River flows from Jed Lake to the northeast section of Patterson Lake North Arm – East Basin via a shallow creek (Figure 10A-1-1). The creek was sampled 12 times between spring 2016 and fall 2020. The measured water depth in the creek ranged between 0.4 m and 0.8 m (Annex V.1).

Available water chemistry data for Clearwater River above Patterson Lake are presented in Attachment 10A-1a, Table 10A-1a-2. Notable observations for the water quality in Clearwater River above Patterson Lake include:

- The pH recorded in the field was outside the CCME range of 6.5 to 9.0 (CCREM 1996) in winter 2019 (pH: 6.42).
- The majority of iron concentrations were above the median of all samples in the LSA of 55 µg/L (Attachment 10A-1b, Figure 10A-1b-24) and above the Project threshold of 300 µg/L. The average iron concentration was 410 µg/L.
- Aluminum concentrations were greater in Clearwater River above Patterson Lake than most of the waterbodies and watercourse sites in the LSA, with its 25th and 75th percentile ranging from 17.5 µg/L to 38.5 µg/L, compared to the median of all samples in the LSA of 4.0 µg/L.

10A-1-3.3.3 Lake H and Lake G

Lake H and Lake G are two small round-shaped waterbodies located along the east shore of the Patterson Lake North Arm – East Basin (Figure 10A-1-1). Lake G outflows to Patterson Lake via a channel and most of its watershed is wetland. Lake H has no documented surface inflow or outflow to Patterson Lake, even though it is only 50 m from the shoreline of Patterson Lake. The maximum depth measured in Lake H is 8.2 m and Lake G has a maximum depth of 3.4 m (Annex V.1). Both lakes develop ice-cover during the winter season; an ice thickness of 0.6 m was measured in both lakes February 2019.

Lake H and Lake G have been sampled seven times between spring 2018 and fall 2019 and were sampled in two locations per lake.

Available water chemistry data for Lake H and Lake G are presented in Attachment 10A-1a, Table 10A-1a-4 and Table 10A-1a-5, respectively. Lake profiles are presented in Attachment 10A-1c, Figure 10A-1c-3 and Figure 10A-1c-4. Notable observations for the Lake H and Lake G include:

- Total phosphorus concentrations of 20 µg/L were measured in the fall and winter in Lake G on three instances. Lake G was the only lake characterized as mesotrophic in the LSA according to CCME classification (CCME 2004).
- One instance of elevated total phosphorus levels (20 µg/L) was measured in summer 2018 in Lake H.
- The pH recorded in the field in Lake H was outside the CCME range of 6.5 to 9.0 (CCREM 1996) in winter 2020 (pH: 5.97).
- Iron in Lake H and Lake G was generally higher than the majority of the waterbodies and watercourse sites in the LSA and was above the Project threshold of 300 µg/L on three instances in Lake H (winter 2019: 1,380 µg/L; winter 2020: 2,080 µg/L; spring 2020: 390 µg/L) and eight instances in Lake G (spring 2018: 500 µg/L; winter 2019: 2,440 µg/L; spring 2019: 400 µg/L; summer 2019: 350 µg/L; winter 2020: 1,720 µg/L; spring 2020: 760 µg/L; summer 2020: 390 µg/L; fall 2020: 350 µg/L).
- Aluminum concentrations were greater than most waterbodies and watercourse sites in the LSA, with its 25th percentile and 75th percentile ranging from 7.9 µg/L to 18.7 µg/L, compared to the median of all samples in the LSA of 4.0 µg/L.

10A-1-3.3.4 Patterson Lake and Clearwater River below Patterson Lake

Patterson Lake is separated in three distinct regions: Patterson Lake North Arm – East Basin, Patterson Lake North Arm – West Basin, and Patterson Lake South Arm (Figure 10A-1-1). The lake is in a c-shape, where the primary flow pathways enter the lake at the northeast (North Arm – East Basin) and travel west (North Arm – West Basin) and south to outflow at the eastern side of the southern leg of the c-shape (South Arm; Figure 10A-1-1). The Patterson Lake outlet flows to Forrest Lake via Clearwater River (Clearwater River below Patterson Lake). Patterson Lake has a water surface elevation of 498.69 metres above sea level (masl), a total water volume of 532 Mm^3, and a surface area of 37.4 km^2. Patterson Lake watershed at its outflow is 264 km^2. Based on the average inflows into the lake and its volume, the retention time for this waterbody is estimated to be 12.7 years (Section 9.3, Table 9.3-2). The water quality for Patterson Lake is characterized for each of its regions due to the size and morphometry of the lake and as different Project activities are proposed to occur in the basins (e.g., water intake pipes in the North Arm – East Basin and discharge pipes in the North Arm – West Basin).

The North Arm – East Basin with a maximum depth of approximately 24.0 m is the smallest and shallowest basin of Patterson Lake, representing 24% of the total surface area and 12% of the total volume (Section 9.3, Table 9.3-2). It is separated from North Arm – West Basin by a narrow and shallow sand bar with spit formations forming on either side (Section 9.3, Table 9.3-2). The North Arm – West Basin and South Arm are connected up to a depth of approximately 8 m. The North Arm – West Basin has a minimum bed elevation of 446.04 masl with two distinct deep regions; the maximum depth is about 52.7 m (Section 9.3, Table 9.3-2). The volume of the Patterson Lake North Arm – West Basin represents 44% of the total volume of the lake. The South Arm possesses the deepest region within the narrow arm; the deepest point in the South Arm is 449.29 masl, corresponding to a maximum depth of about 49.4 m. The volume of Patterson Lake represented by the South Arm is 44%.

Water quality samples were collected in all three lake regions. The three regions were sampled individually in 13 events between November 2015 and September 2020. Some events included sampling at different depths. Water column profiles were also measured for DO, temperature, pH, and specific conductivity on 12 separate occasions. Clearwater River below Patterson Lake was sampled once in the spring 2016. All three basins of Patterson Lake were considered oligotrophic lake based on low total phosphorus concentrations (less than 10 µg/L). The lake freezes over during the winter with a measured ice thickness of 0.7 m in February 2019.

Available water chemistry data for Patterson Lake are presented in Attachment 10A-1a, Table 10Aa-1-6 to Table 10A-1a-8. Sampled data from Clearwater River below Patterson Lake are presented in Attachment 10A-1a, Table 10A-1a-9. Lake profiles are presented in Attachment 10A-1c, Figure 10A-1c-5 to Figure 10A-1c-7.

Notable observations for the three Patterson Lake basins include:

North Arm – East Basin:

- The pH recorded in the field was outside the CCME pH range of 6.5 to 9.0 (CCREM 1996) on four instances (winter 2016, pH 6.17 to 6.29; summer 2019, pH: 5.85; winter 2020, pH: 6.49; summer 2020, pH: 6.27).
- Some parameter concentrations were notably higher in the North Arm – East Basin compared to the rest of the regions of Patterson Lake, including aluminum, iron, manganese, mercury, and zinc.
- Iron and nickel were measured above their Project thresholds (i.e., 300 µg/L and 25 µg/L, respectively):
  - iron: summer 2018: 570 µg/L and summer 2020: 790 µg/L; and
  - nickel: winter 2016: 28 µg/L.

North Arm – West Basin:

- The pH recorded in the field was outside the CCME pH range of 6.5 to 9.0 (CCREM 1996) in winter 2016 (pH 6.07).
- Iron was above the Project threshold of 300 µg/L in winter 2019 (470 µg/L).

South Arm:

- Some parameter concentrations were notably higher in the South Arm compared to the rest of the Patterson Lake basins, including hardness, sulphate, chloride, calcium, magnesium, and sodium.
- The pH recorded in the field was outside the CCME pH range of 6.5 to 9.0 (CCREM 1996) in four instances (winter 2016, pH: 6.11-6.33; fall 2019, pH: 6.40; winter 2020, pH: 6.49; fall 2020, pH: 6.27-6.40).

- Arsenic and nickel were measured above their Project thresholds (i.e., 5 µg/L and 25 µg/L, respectively):
  - arsenic: winter 2015: 23.1 µg/L; and
  - nickel: winter 2016: 26.0 µg/L.

10A-1-3.3.5 Forrest Lake

Forrest Lake can be considered as two basins: North Basin and South Basin (Annex IV.5, Forrest Lake Mixing Study Report). The North Basin is a small, shallow reservoir separated by a sandy shallow sill from the South Basin. Water depths over the sill are typically less than 1.0 m. The North Basin is located along the primary flow pathway of the Clearwater River. The South Basin is by far the larger of the two basins; by volume, the South Basin comprises approximately 99.95% of the total lake volume and 97.5% of the surface area, while the North Basin accounts for only 0.05% of the lake volume and 2.5% of the surface area. The maximum depth of the South Basin is approximately 84.7 m deep, whereas the North Basin is relatively shallow with an average depth of around 1.0 m (Annex V.1). The lake develops ice-cover during the winter; the ice thickness was measured between 0.3 m and 0.6 m in February 2019.

A total watershed area of 445 km^2 drains to the outlet of Forrest Lake. In addition to inflows from the Clearwater River, Forrest Lake receives inflows from four other tributaries of note: Lake E, Lake F, Dennis Lake, and an unnamed tributary at the southwest corner. Lake E flows via E Creek into the west side of the North Basin and drains an area of 15 km^2. Lake F flows via F Creek and drains 13 km^2 into the east side of the South Basin just south of the sand bar. An unnamed tributary flows into the southwest corner of Forrest Lake and is gauged by CR-WC-TI-01 and drains an area of 35 km^2 (Figure 10A-1-1). Dennis Lake flows via Dennis Creek into the east side of the South Basin and drains an area of 10.4 km^2.

Water quality samples were collected in the two basins of Forrest Lake (Figure 10A-1-1). Both basins were sampled on 13 events between November 2015 and September 2020. The samples were collected at the top and bottom of the water column on three occasions in the South Basin (to a maximum depth of 23 m), and one occasion in the North Basin. Water column profiles were also measured for DO, temperature, pH, and specific conductivity on 11 separate occasions in the North Basin and South Basin. The first sampling event (March 2016) performed the profiles in areas in the South Basin deeper than the sampling done thereafter.

Available water chemistry data for Forrest Lake are presented in Attachment 10A-1a, Table 10A-1a-10 and Table 10A-1a-11. Lake profiles are presented in Attachment 10A-1c, Figure 10A-1c-8 and Figure10A-1c- 9.

Notable observations for the two Forrest Lake basins include:

North Basin:

- The pH recorded in the field was outside the CCME pH range of 6.5 to 9.0 (CCREM 1996) in winter 2016 (pH 6.45).
- Some parameter concentrations were higher in the Forrest Lake North Basin compared to the South Basin, including un-ionized ammonia, aluminum, iron, and manganese.

South Basin:

- Some parameters were higher in the South Basin compared to the North Basin, including chloride, sulphate, magnesium, sodium, and zinc.
- Measured hardness and fluoride concentrations are the highest of the waterbodies and watercourse sites sampled in the LSA.
- The pH recorded in the field was outside the CCME pH range of 6.5 to 9.0 (CCREM 1996) in spring 2016 (pH: 5.83 to 6.35).
- Lead was measured above the Project threshold of 1 µg/L in spring 2016 (4 µg/L).

10A-1-3.3.6 Beet Lake and Clearwater River below Beet Lake

Beet Lake is located along the primary flow path of the Clearwater River between Forrest Lake and Naomi Lake (Figure 10A-1-1). The Forrest Lake outflow flows to the east of Beet Lake via Clearwater River. Beet Lake outflows west via the Clearwater River to Naomi Lake. Clearwater River downstream of Forrest Lake is the main flow source and Beet Lake has no other major tributaries. It is a rectangular-shaped waterbody measuring approximately 4.3 km from west to east and 2.0 km north to south. Beet Lake has a maximum depth of 33.7 m while the Clearwater River below Beet Lake is on average 1.0 m deep (Annex V.1). The lake and downstream river develop ice-cover during the winter season; in Beet Lake and Clearwater River below Beet Lake, ice thicknesses of 0.65 m and 0.07 m, respectively, were measured in February 2019.

Beet Lake was sampled 17 times between November 2015 to September 2020. The sampling location is on the eastern side of the lake (Figure 10A-1-1). Due to the depth of Beet Lake, field sampling in spring 2016 and summer 2019 included surface and bottom depth samples. The Clearwater River below Beet Lake was sampled eight times between May 2018 and October 2019.

Available water chemistry data for Beet Lake and Clearwater River below Beet Lake are presented in Attachment 10A-1a, Table 10A-1a-12, and Table 10A-1a-13, respectively. Lake profiles are presented in Attachment 10A-1c, Figure 10A-1c-10.

Notable observations for Beet Lake and Clearwater River below Beet Lake include:

- The pH recorded in the field in Beet Lake was outside the CCME pH range of 6.5 to 9.0 (CCREM 1996) on five instances (spring 2016, pH: 5.94-6.38; summer 2019, pH: 6.28; summer 2020, pH: 6.48).
- Iron and lead were measured above their Project thresholds (i.e., 300 µg/L and 1 µg/L, respectively):
  - iron: winter 2020: 800 µg/L; and
  - lead: winter 2020: 1.3 µg/L.

The water quality in Clearwater River below Beet Lake was representative of the water quality in Beet Lake. Variations in some parameters (i.e., increased copper, nitrate, nickel, sulphate, sodium, and zinc concentrations compared to Beet Lake) during the 2019 winter are likely explained by a lower flow, or no flow at all, of water from the lake to the creek during the winter months due to ice formation.

10A-1-3.3.7 Naomi Lake

Naomi Lake is located downstream of Beet Lake along the Clearwater River flow path (Figure 10A-1-1). The lake is subdivided in two basins by a relatively shallow narrows oriented east–west. The maximum depth of Naomi Lake is approximately 5.7 m (Annex V.1). Clearwater River flows through the south basin. Naomi Creek and an unnamed tributary flow into the north basin of Naomi Lake. Its outlet is located to the southwest of the lake and flows to Clearwater River. The lake develops ice-cover during the winter season, with an ice thickness of 0.7 m measured in February 2019.

Water quality samples were taken from the eastern side of Naomi Lake (Figure 10A-1-1). Naomi Lake was sampled seven times between May 2018 to October 2019.

Available water chemistry data for Naomi Lake are presented in Attachment 10A-1a, Table 10A-1a-14. Lake profiles are presented in Attachment 10A-1c, Figure 10A-1c-11.

Notable observations for Naomi Lake include:

- The pH recorded in the field was outside the CCME pH range of 6.5 to 9.0 (CCREM 1996) on three instances (winter 2020, pH: 5.93; summer 2020, pH: 6.31; fall 2020, pH: 6.25).
- Iron was consistently measured above the Project threshold of 300 µg/L, ranging from 350 µg/L to 1,260 µg/L; the average concentration of iron is 826 µg/L.
- Aluminum concentrations were greater than most waterbodies and watercourse sites in the LSA, with the 25th percentile and 75th percentile ranging from 19.5 µg/L to 43.0 µg/L, compared to the median of all samples in the LSA of 4.0 µg/L.
- Titanium concentrations were greater than most waterbodies and watercourse sites in the LSA, with the 25th and 75th percentile ranging from 0.3 µg/L to 0.6 µg/L, compared to the majority of all samples in the LSA being below the detection limit of 0.2 µg/L.

The iron concentration in Naomi Lake was consistently higher than the Project threshold and higher than the measured values in waterbodies and watercourse sites in the LSA. The iron concentration flowing into Naomi Lake from Clearwater River below Beet Lake had a much lower concentration (i.e., measured range between 22 µg/L to 190 µg/L), suggesting that the source of iron is naturally occurring in Naomi Lake or coming from the tributary to the north.

10A-1-3.3.8 Clearwater River Downstream of Naomi Lake

The Clearwater River downstream of Naomi Lake (Figure 10A-1-1) is ice-covered during the winter season; an ice thickness of 0.70 m was measured in February 2019.

The Clearwater River below Naomi Lake was sampled on eight occasions between spring 2016 and fall 2019 (Figure 10A-1-1).

Available water chemistry data for the Clearwater River downstream of Naomi Lake are presented in Attachment 10A-1a, Table 10A-1a-15.

Notable observations for Clearwater River below Naomi Lake include:

- The pH recorded in the field was outside the CCME pH range of 6.5 to 9.0 (CCREM 1996) on three instances (winter 2016, pH: 6.38; winter 2019, pH: 6.4; winter 2020, pH: 5.7).
- Iron was also consistently measured above the Project threshold of 300 µg/L, ranging from 340 µg/L to 1,200 µg/L; the average concentration of iron is 412 µg/L.
- The average concentration of iron in the Clearwater River below of Naomi Lake is lower than the average iron concentration in Naomi Lake.
- Titanium concentrations were greater than most waterbodies and watercourse sites in the LSA, with the 25th and 75th percentile ranging from 0.3 µg/L to 0.6 µg/L, compared to the majority of all samples in the LSA being below the detection limit of 0.2 µg/L.

As water quality samples for Naomi Lake are collected in the northern part of the lake, which is not part of the main flow path of the Clearwater River, iron concentrations in the northern area of Naomi Lake are likely sourced from the tributaries that flow into this portion of the lake. Clearwater River below Beet Lake does not exhibit the same iron exceedances as Clearwater River below Naomi Lake.

10A-1-3.3.9 Reference Lakes

Four additional lakes comprise reference lakes for the Project (i.e., Harbo Lake, Hodge Lake, Lake D, and Lake J). These lakes are not within the flow path of the Clearwater River and have been selected to characterize the water quality outside of any potential Project influence and to support the assessment of potential effects to surface water quality and sediment quality in lakes within the LSA from the deposition of air emissions from the Project. These lakes are found within a 15 km radius of the Project, and except for Lake D, lie outside of the LSA. These lakes were sampled between March 2016 and September 2020 for a total of 33 samples.

Harbo Lake is a small lake located to the north of Broach Lake. Harbo Lake has an area of approximately 2.46 km^2 and measures approximately 3.0 km from the southwest to northeastern shoreline. Water quality samples were collected once in spring 2016 from the middle of Harbo Lake (Figure 10A-1-1). On the same occasion, profile measurements were collected for DO, pH, specific conductivity, and temperature.

Hodge Lake is a small lake located to the north of Harbo Lake. It has area of approximately 12.8 km^2 and measures 4.4 km between its farthest points. Water quality samples and profile measurements were collected from the middle of Hodge Lake (Figure 10A-1-1) on ten instances between summer 2018 and fall 2020. Hodge lake has a maximum depth of 45.6 m (Annex V.1).

Lake D is a small lake, with a surface area of 5.1 km^2, located to the northwest of Forrest Lake. Lake D drains to the North Basin of Forrest Lake. The lake measures 2.1 km between its farthest points. Water quality samples and profile measurements were collected from the middle of Lake D (Figure 10A-1-1) eight times from February 2019 to September 2020. The maximum measured depth at Lake D was 4.0 m (Annex V.1).

Lake J is a small lake located to the west of Patterson Lake with a surface area of 0.9 km^2. Water quality samples and profile measurements were collected from Lake J eight times from February 2019 to September 2020 (Figure 10A-1-1). The maximum recorded depth was 2.7 m (Annex V.1).

Available water chemistry data for the reference lakes are presented in Attachment 10A-1a, Table 10A-1a-18. Lake profiles are presented in Attachment 10A-1c, Figure 10A-1c-13 to Figure 10A-1c-16.

Notable observations for the reference lakes include:

- The pH recorded in the field was outside the CCME pH range of 6.5 to 9.0 (CCREM 1996) on 11 instances.
- The measured range of hardness, chloride, calcium, and strontium was greater than the measured range of the other lakes in the LSA:
  - The average hardness of the reference lakes ranges between 1 mg/L to 20 mg/L of calcium carbonate, with Lake J being the minimum. The median hardness of the lakes in the LSA is 15 mg/L as $CaCO_3$.
  - The average chloride measured in Hodge Lake is 1.9 mg/L, nearly four times larger than the median chloride concentration of the lakes in the LSA (0.5 mg/L).
  - The average calcium of the reference lakes ranged between 0.4 mg/L to 5.7 mg/L, with Lake J being the minimum. The median calcium of the lakes in the LSA is 3.7 mg/L.
  - The average strontium of the reference lakes ranged between 6 µg/L to 61 µg/L, with Lake J being the minimum and Hodge Lake the maximum. The median strontium concentration of the reference lakes in the LSA is 30 µg/L.

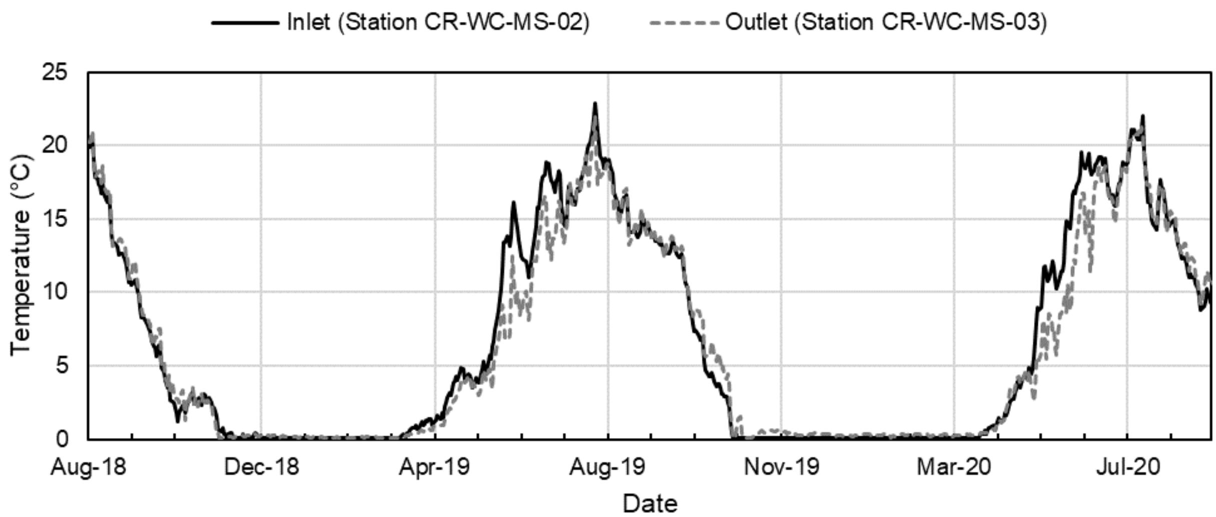
10A-1-3.4 Patterson Lake Seasonal Temperature and Un-ionized Ammonia

Additional modelling input data for background water quality conditions was required for Patterson Lake due to the potential for direct Project effects. Seasonal surface water temperatures needed to be defined, as well as seasonal un-ionized ammonia ratios relative to these seasonal temperature variations. The fraction of the total ammonia that is un-ionized ammonia is required as the Project threshold for ammonia is in terms of un-ionized ammonia and the water quality samples are typically reported as total ammonia. The un-ionized portion of total ammonia is temperature and pH dependent.

The temporal surface water temperature regime of Patterson Lake was characterized using continuous hydrometric measurements from the inlet and outlet of Patterson Lake North Basin. These data were collected from August 2018 until September 2020 (Figure 10A-1-2). Seasonal temperature trends include:

- The lake surface temperature followed a unimodal distribution (i.e., having one peak per year), with peak temperatures occurring in the summer, in late July, and early August.
- The average maximum surface water temperature recorded between 2018 and 2020 was 22.5°C.
- The winter surface water temperatures (i.e., near freezing) at the inlet and outlet during the winter, coinciding with ice-cover, started in early November, and persisted to late March.

Figure 10A-1-2: Average Daily Surface Temperature Measured at Patterson Lake Station CR-WC-MS-02 and CR-WB-MS-03



The proportion of seasonal un-ionized ammonia relative to total ammonia concentrations in Patterson Lake was computed using average monthly temperatures and average seasonal pH measurements from the logged temperatures described above and field pH measurements from the surveys conducted in Patterson Lake (Table 10A-1-7). The average monthly temperature of Patterson Lake was taken as the average between the inlet and outlet temperatures. As the pH of water is the negative logarithm of the hydrogen ion concentration, the seasonal average the field collected pH was converted to hydrogen ion, seasonally averaged, and then converted back to pH values.

Seasons were broken down as follows:

- winter: December, January, February;
- spring: March, April, May;
- summer: June, July, August; and
- fall: September, October, November.

Table 10A-1-7: Summarized Monthly Average Temperature, pH, and Un-ionized Ammonia Fraction for Patterson Lake

Month	Inlet Mean Temperature (°C)	Outlet Mean Temperature (°C)	Mean Temperature (°C)	Seasonally Averaged pH	Percentage of Un-ionized Ammonia[(a)]
Jan	0.1	0.1	0.1	6.8	0.055%
Feb	0.1	0.1	0.1	6.8	0.055%
Mar	0.4	0.3	0.3	6.5	0.027%
Apr	2.6	2.1	2.3	6.5	0.032%
May	7.8	5.9	6.9	6.5	0.046%
June	15.0	11.0	13.0	6.7	0.12%
July	18.0	17.0	18.0	6.7	0.18%
Aug	16.0	16.0	16.0	6.7	0.16%
Sept	11.0	11.0	11.0	6.9	0.16%
Oct	2.7	3.2	2.9	6.9	0.086%
Nov	0.34	0.3	0.3	6.9	0.069%
Dec	0.1	0.2	0.2	6.8	0.055%

a) Calculated with the monthly mean total ammonia and temperature and seasonally averaged pH.

10A-1-3.5 Defining the Background Water Chemistry Inputs

All sampled data were compiled to characterize the existing background water quality of the waterbodies and watercourse sites in the LSA for use as the background surface water quality model inputs for each lake in the Regional Surface Water Quality Model. The focus parameters for the water quality modelling are limited to those parameters for which Project threshold concentrations were established. Attachment 10A-1a lists all available data for each waterbody and watercourse sites in the LSA. Table 10A-1-8 presents the average concentrations of the COPCs of the lakes in the water quality LSA for relevant modelling nodes. The average concentrations derived for Patterson Lake and Forrest Lake were assigned to their respective basins.

For the calculation of average concentrations, sample results reported less than a detection limit were assigned a value of half the detection limits. Attachment 10A-1a also includes other water quality statistical summary information. For the calculation of minima, maxima, 25th percentile, and 95th percentile, results that were reported as less than a detection limit were assigned a value equal to the detection limit.

Table 10A-1-8: Average Water Quality Data for Parameters with Project-specific Thresholds Used as Background Water Quality Inputs at Assessment Nodes in the Surface Water Quality Modelling for the Receiving Environment

Model Parameters	Units	Broach Lake	Lake G	Lake H	Clearwater River above Patterson Lake	Patterson Lake North Arm – East Basin	Patterson Lake North Arm – West Basin	Patterson Lake South Arm	Forrest Lake North Basin	Forrest Lake South Basin	Beet Lake	Clearwater River below Beet Lake	Naomi Lake[a]	Reference Lakes
Nutrients														
Total ammonia (as nitrogen)	mg/L	0.02	0.1	0.1	0.01	0.03	0.02	0.01	0.01	0.01	0.03	0.01	0.01	0.02
Un-ionized ammonia (as nitrogen)[b]	mg/L	0.00056[c]	0.0063[d]	0.0028[e]	0.00006[f]	0.00047[g]	0.00034[h]	0.00010[i]	0.00023[j]	0.00021[k]	0.00058[l]	0.00009[m]	0.00013[n]	0.00066[o]
Nitrate (as nitrogen)	mg/L	0.02	0.04	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01
Total phosphorus	mg/L	0.005	0.012	0.006	0.005	0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Major Ions														
Calcium	mg/L	3.8	4.0	3.7	2.6	3.1	3.6	3.9	4.1	4.5	4.2	2.5	4.2	3.5
Chloride	mg/L	0.41	0.10	0.20	0.30	0.41	0.53	0.57	0.63	0.78	0.63	0.50	0.65	0.59
Magnesium	mg/L	1.3	1.8	1.6	0.8	1.0	1.2	1.4	1.5	1.7	1.6	0.7	1.6	1.2
Sodium	mg/L	1.6	1.9	1.9	1.2	1.3	1.4	1.4	1.6	2.0	1.7	1.0	1.7	1.4
Sulphate	mg/L	1.9	1.3	0.3	1.2	1.2	1.5	1.6	1.6	1.7	1.6	0.6	1.6	1.2
Total Metals														
Aluminum	µg/L	1.8	7.4	14.9	27.5	4.4	3.0	2.0	6.5	2.0	2.1	31.9	7.4	24.4
Arsenic	µg/L	0.14	0.07	0.16	0.14	0.10	0.09	1.31	0.13	0.17	0.11	0.19	0.11	0.13
Cadmium	µg/L	0.005	0.007	0.005	0.007	0.007	0.006	0.005	0.007	0.006	0.005	0.007	0.006	0.007
Cobalt	µg/L	0.05	0.05	0.05	0.05	0.06	0.07	0.06	0.05	0.08	0.05	0.05	0.05	0.06
Chromium	µg/L	0.24	0.25	0.25	0.25	0.28	0.25	0.28	0.24	0.27	0.24	0.25	0.25	0.29
Copper	µg/L	0.11	0.26	0.10	0.12	0.14	0.12	0.14	0.28	0.14	0.19	0.16	0.10	0.12
Iron	µg/L	28	**689**	**430**	**410**	195	51	16.1	43	24	107	**826**	93	**412**
Mercury	µg/L	0.0016	0.0021	0.0020	0.0013	0.0018	0.0013	0.0013	0.0009	0.0011	0.0012	0.0021	0.0010	0.0011
Manganese	µg/L	104.1	66.9	41.1	11.2	33.1	14.5	21.1	9.4	3.9	83.2	48.3	12.0	27.2
Molybdenum	µg/L	0.07	0.05	0.05	0.07	0.05	0.05	0.05	0.07	0.05	0.05	0.05	0.05	0.06
Nickel	µg/L	0.06	0.06	0.05	0.08	2.61	0.06	2.13	0.10	0.08	0.14	0.08	0.08	0.07
Lead	µg/L	0.05	0.05	0.07	0.05	0.06	0.05	0.06	0.06	0.28	0.19	0.07	0.05	0.07
Selenium	µg/L	0.05	0.05	0.05	0.05	0.06	0.05	0.06	0.06	0.06	0.05	0.05	0.05	0.06
Strontium	µg/L	37	25	14	26	28	30	31	32	32	32	24	31	29
Uranium	µg/L	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.06
Vanadium	µg/L	0.06	0.05	0.05	0.16	0.06	0.06	0.07	0.06	0.06	0.06	0.15	0.05	0.12
Zinc (dissolved)	µg/L	0.80	1.71	0.95	0.82	0.88	0.74	0.70	0.77	0.98	0.57	0.92	0.86	0.57

Table 10A-1-8: Average Water Quality Data for Parameters with Project-specific Thresholds Used as Background Water Quality Inputs at Assessment Nodes in the Surface Water Quality Modelling for the Receiving Environment

Model Parameters	Units	Broach Lake	Lake G	Lake H	Clearwater River above Patterson Lake	Patterson Lake North Arm – East Basin	Patterson Lake North Arm – West Basin	Patterson Lake South Arm	Forrest Lake North Basin	Forrest Lake South Basin	Beet Lake	Clearwater River below Beet Lake	Naomi Lake[(a)]	Reference Lakes
Radionuclides														
Lead-210	Bq/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Polonium-210	Bq/L	0.003	0.005	0.005	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.003	0.003	0.003
Radium-226	Bq/L	0.003	0.005	0.003	0.004	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Thorium-230	Bq/L	0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.005	0.005	0.005	0.006

Note:
Shaded and **Bold** indicates that the value is greater than the Project threshold.
a) Baseline water quality for Naomi Lake was characterized by measured water quality data from Clearwater River below Beet Lake, as the Naomi Lake monitoring station is in a basin that is not on the main flow path of the Clearwater River; Clearwater River below Beet Lake flows through Naomi Lake.
b) Function of total ammonia, pH, and temperature.
c) Calculated based on the maximum fraction factor derived from individual samples using pH = 7.9, temp = 18.8°C.
d) Calculated based on the maximum fraction factor derived from individual of samples using pH = 8.2, temp = 20.9°C.
e) Calculated based on the maximum fraction factor derived from individual of samples using pH = 7.8, temp = 20.9°C.
f) Calculated based on the maximum fraction factor derived from individual of samples using pH = 7, temp = 25.7°C.
g) Calculated based on the maximum fraction factor derived from individual of samples using pH = 7.6, temp = 20.3°C.
h) Calculated based on the maximum fraction factor derived from individual of samples using pH = 7.7, temp = 17.7°C.
i) Calculated based on the maximum fraction factor derived from individual of samples using pH = 7.4, temp = 19.8°C.
j) Calculated based on the maximum fraction factor derived from individual of samples using pH = 7.7, temp = 22.4°C.
k) Calculated based on the maximum fraction factor derived from individual of samples using pH = 7.9, temp = 14.5°C.
l) Calculated based on the maximum fraction factor derived from individual of samples using pH = 7.8, temp = 18.2°C.
m) Calculated based on the maximum fraction factor derived from individual of samples using pH = 7.2, temp = 24.3°C.
n) Calculated based on the maximum fraction factor derived from individual of samples using pH = 7.5, temp = 20.5°C.
o) Calculated based on the maximum fraction factor derived from individual of samples using pH = 8.1, temp = 14°C.

10A-1-4 CONCLUSION

The baseline characterization of the waterbodies and watercourse sites within the Project footprint was completed to support the surface water quality component of the EA for the Project. The characterization also provided for the derivation of background water chemistry input for the water quality modelling of specific lakes included as assessment nodes in the receiving environment. In addition to the background water chemistry, background seasonal temperature and un-ionized ammonia input were derived specifically for Patterson Lake.

10A-1-5 CLOSURE

WSP is pleased to submit this report to NexGen in support of the environmental assessment for the Rook I Project. For details on the limitations and use of information presented in this report, please refer to the Study Limitations subsection following this page. If you have any questions or require additional details related to this study, please contact the undersigned.

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STUDY LIMITATIONS

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Attachment 10A-1a Detailed Surface Water Quality Tables

Table 10A-1a-1 : Broach Lake

Parameter	Unit	Project Threshold	Fall 2015 11-Nov-15 Broach Lake (Area 1)	Winter 2016 16-Mar-16 Broach Lake (Area 1) Top 1	Winter 2016 16-Mar-16 Broach Lake (Area 1) Mid 33	Winter 2016 16-Mar-16 Broach Lake (Area 1) Bottom 65	Spring 2018 25-May-18 Broach Lake (Area 1)	Summer 2018 05-Aug-18 Broach Lake (Area 1)	Fall 2018 23-Sep-18 Broach Lake Area 2	Winter 2019 24-Feb-19 Broach Lake Area 2	Spring 2019 24-May-19 Broach Lake Area 2
Field Parameters											
pH (Field)	-	6.5 - 9.0[a]	7.41	6.82	6.64	**6.30**	**6.30**	7.90	6.50	7.00	6.70
Temperature (Field)	°C		2.3	0.8	3.0	3.3	9.3	18.8	5.9	2.9	4.0
Specific Conductivity (Field)	µS/cm		45.9	55.7	46.8	49.8	37.8	38.6	38.2	39.6	48.6
Turbidity	NTU		-	0.3	0.4	0.4	-	-	-	-	-
General Parameters											
pH	-	6.5 - 9.0[a]	6.84	7.42	7.31	7.23	7.49	7.36	7.52	7.00	7.32
Specific Conductivity (Lab)	µS/cm		43	45	39	40	31	31	31	37	42
Total Solids, Dissolved	mg/L		-	42	38	39	41	43	30	49	48
Total Solids, Suspended	mg/L	8.3	<1	1	1	1	2	2	<1	<1	<1
Hardness	mg/L $CaCO_3$		18	16	14	14	13	14	15	16	16
Alkalinity	mg/L $CaCO_3$		21	-	-	-	22	17	14	17	26
Nutrients											
Total Ammonia as N	mg/L		-	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.09	0.18
Ammonia as N (un-ionized)[b]	µg/L	16	-	<0.006	<0.005	<0.002	<0.004	0.60	<0.004	0.09	0.10
Dissolved Organic Carbon	mg/L	-	-	-	-	-	1.9	1.9	1.8	2.1	1.7
Nitrate (as N)	mg/L	2.90	<0.50[c]	-	-	-	<0.01	<0.01	0.04	0.07	<0.01
Phosphorus	mg/L	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Major Ions											
Bicarbonate	mg/L		25.6	-	-	-	26.8	20.7	17.1	20.7	31.7
Calcium	mg/L		3.9	4.1	3.6	3.7	3.4	3.6	3.8	4.2	4.2
Chloride	mg/L	120	<1[c]	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Fluoride	mg/L		<0.10[c]	0.07	0.07	0.07	0.06	0.05	0.07	0.05	0.05
Magnesium	mg/L		1.5	1.4	1.2	1.3	1.2	1.2	1.3	1.4	1.3
Sodium	mg/L		1.6	1.7	1.5	1.5	1.6	1.5	1.6	1.7	1.6
Sulphate	mg/L	128[e]	-	2.2	1.9	1.9	1.9	1.9	2.1	2.0	1.8
Total Metals											
Aluminum	µg/L	100	<3	-	-	-	5.8	1.6	<0.5	0.8	2.1
Arsenic	µg/L	5	0.1	0.1	0.1	0.1	0.1	0.5	0.2	0.2	0.2
Barium	µg/L		8.4	15.0	14.0	14.0	14.0	14.0	16.0	24.0	41.0
Beryllium	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Boron	µg/L		<10	<10	<10	<10	<10	<10	<10	10	<10
Cadmium	µg/L	0.017[e]	<0.005	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cesium	µg/L		<0.01	-	-	-	-	-	-	<0.1	<0.1
Chromium	µg/L	1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cobalt	µg/L	0.5[f]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Copper	µg/L	2[e]	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Iron	µg/L	300	61	3	5	13	36	26	28	87	120
Lead	µg/L	1[e]	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	µg/L	260	16.5	1.8	4.6	13.0	16.0	7.9	36.0	**310**	**1440**
Mercury	µg/L	0.026	-	0.001	0.001	0.001	0.003	0.002	<0.001	0.004	0.002
Molybdenum	µg/L	31,000	0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	0.2
Nickel	µg/L	25[e]	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium	µg/L	1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Strontium	µg/L		32	40	36	35	35	35	36	40	39
Tin	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.1	<0.1
Titanium	µg/L		<0.3	<0.2	<0.2	<0.2	<0.2	0.5	<0.2	<0.2	<0.2
Uranium	µg/L	15	<0.01	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	µg/L	120	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	µg/L	7	<3	<0.5	<0.5	1.0	<0.5	1.2	2.7	<0.5	2.4
Radionuclides											
Lead-210	Bq/L	22	<0.037	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Polonium-210	Bq/L	13.5	<0.019	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Radium-226	Bq/L	0.11	<0.01	<0.005	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	0.005
Thorium-230	Bq/L	95	<0.0074	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Parameter	Summer 2019 18-Jul-19 Broach Lake Area 2 Top 5	Summer 2019 18-Jul-19 Broach Lake Area 2 Bottom 35	Fall 2019 25-Sep-19 Broach Lake Area 2 Top 8	Fall 2019 25-Sep-19 Broach Lake Area 2 Bottom 49	Winter 2020 19-Mar-20 Broach Lake Area 2	Spring 2020 02-Jun-20 Broach Lake Area 2	Summer 2020 22-Jul-20 Broach Lake Area 2 Top 5	Summer 2020 22-Jul-20 Broach Lake Area 2 Bottom 44	Fall 2020 19-Sep-20 Broach Lake Area 2 Top 10	Fall 2020 13-Sep-20 Broach Lake Area 2 Bottom 50
Field Parameters										
pH (Field)	6.98	**6.30**	7.68	6.67	**6.19**	7.13	7.51	7.02	7.17	6.70
Temperature (Field)	16.0	4.8	12.5	4.8	2.9	4.1	15.8	4.6	10.7	4.5
Specific Conductivity (Field)	39.2	39.8	38.0	39.2	39.6	41.2	37.9	38.6	37.5	38.7
Turbidity	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.6
General Parameters										
pH	7.38	7.28	7.51	7.39	7.00	7.37	7.45	7.34	7.30	7.21
Specific Conductivity (Lab)	32	35	32	32	34	35	32	32	30	31
Total Solids, Dissolved	39	43	38	35	55	39	20	23	39	42
Total Solids, Suspended	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hardness	15	15	14	15	15	14	14	15	14	14
Alkalinity	14	16	23	21	17	25	16	16	20	16
Nutrients										
Total Ammonia as N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.02
Ammonia as N (un-ionized)[b]	<0.03	<0.002	<0.1	<0.006	<0.002	<0.02	<0.09	0.03	<0.03	0.01
Dissolved Organic Carbon	2.5	2.2	1.9	1.6	1.9	1.8	1.7	1.7	1.6	1.5
Nitrate (as N)	<0.01	0.06	<0.01	0.03	0.06	0.01	<0.01	0.02	<0.01	0.02
Phosphorus	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
Major Ions										
Bicarbonate	17.1	19.5	28.0	25.6	20.7	30.5	19.5	19.5	24.4	19.5
Calcium	3.8	3.9	3.8	4.0	3.9	3.7	3.7	3.8	3.6	3.7
Chloride	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4
Fluoride	0.08	0.08	0.05	0.05	0.05	0.04	0.04	0.03	0.04	0.04
Magnesium	1.3	1.3	1.2	1.2	1.3	1.2	1.2	1.3	1.2	1.2
Sodium	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.6
Sulphate	1.9	2.0	1.8	1.9	1.9	1.9	1.9	1.9	1.8	1.9
Total Metals										
Aluminum	1.9	1.3	2.3	2.4	0.8	0.7	2.5	0.9	1.7	2.2
Arsenic	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Barium	14.0	15.0	14.0	16.0	17.0	16.0	14.0	16.0	15.0	16.0
Beryllium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Boron	<10	10	<10	<10	<10	<10	<10	<10	<10	<10
Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cesium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cobalt	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Copper	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Iron	9	9	16	19	23	15	12	11	18	13
Lead	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	3.2	11.0	5.7	30.0	20.0	22.0	5.4	11.0	8.0	16.0
Mercury	0.006	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum	0.1	0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	0.1	<0.1
Nickel	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Strontium	36	36	36	37	41	38	36	37	36	37
Tin	0.3	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Titanium	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Uranium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	1.2	1.2	<0.5	<0.5	<0.5	<1.3	<0.5	<0.5	<0.5	<0.5
Radionuclides										
Lead-210	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Polonium-210	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Radium-226	<0.005	<0.005	0.006	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	0.006
Thorium-230	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Parameter	# of Samples	# < MDL	# Above Threshold	SD	Minimum	25th Percentile	Average[d]	95th Percentile	Maximum
Field Parameters									
pH (Field)	19	0	4	0.48	**6.19**	6.57	6.86	7.70	7.90
Temperature (Field)	19	0	N/A	5.2	0.8	3.1	7.1	16.3	18.8
Specific Conductivity (Field)	19	0	N/A	5.0	37.5	38.4	41.4	50.4	55.7
Turbidity	13	0	N/A	0.1	0.3	0.3	0.4	0.5	0.6
General Parameters									
pH	19	0	0	0.18	6.84	7.26	7.30	7.51	7.52
Specific Conductivity (Lab)	19	0	N/A	4.55	30.0	31.5	34.9	43.2	45.0
Total Solids, Dissolved	18	0	N/A	8.19	20.0	38.0	39.1	49.9	55.0
Total Solids, Suspended	18	14	0	0	1	1	1	2	2
Hardness	19	0	N/A	1	13	14	15	16	18
Alkalinity	16	0	N/A	4	14	16	19	25	26
Nutrients									
Total Ammonia as N	18	13	N/A	0.04	0.01	0.010	0.02	0.1	0.2
Ammonia as N (un-ionized)[b]	18	13	0	0.1	0.002	0.004	0.05	0.2	0.6
Dissolved Organic Carbon	15	0	N/A	0.2	1.5	1.7	1.9	2.3	2.5
Nitrate (as N)	15	8	0	0.02	0.01	0.01	0.02	0.06	0.07
Phosphorus	19	18	0	0.00	0.01	0.01	0.005	0.01	0.01
Major Ions									
Bicarbonate	16	0	N/A	4.48	17.1	19.5	22.9	30.8	31.7
Calcium	19	0	N/A	0.205	3.4	3.7	3.8	4.2	4.2
Chloride	18	1	0	0.02	0.4	0.4	0.4	0.4	0.5
Fluoride	13	1	N/A	0.02	0.03	0.04	0.06	0.08	0.08
Magnesium	19	0	N/A	0.086	1.2	1.2	1.3	1.4	1.5
Sodium	19	0	N/A	0.056	1.5	1.6	1.6	1.7	1.7
Sulphate	18	0	0	0.1	1.8	1.9	1.9	2.1	2.2
Total Metals									
Aluminum	16	2	0	1.2	0.5	0.9	1.8	3.7	5.8
Arsenic	19	0	0	0.1	0.1	0.1	0.1	0.2	0.5
Barium	19	0	N/A	6.4	8.4	14.0	16.5	25.7	41.0
Beryllium	19	19	N/A	0.0	0.1	0.1	0.05	0.1	0.1
Boron	19	17	N/A	0	10	10	5.5	10	10
Cadmium	19	19	0	0.001	0.01	0.01	0.005	0.01	0.01
Cesium	13	13	N/A	0.02	0.01	0.1	0.05	0.1	0.1
Chromium	19	19	0	0.09	0.1	0.5	0.2	0.5	0.5
Cobalt	19	19	0	0.0	0.1	0.1	0.05	0.1	0.1
Copper	19	19	0	0.07	0.2	0.2	0.1	0.2	0.5
Iron	19	0	0	29	3	12	28	90	120
Lead	19	19	0	0.01	0.1	0.1	0.05	0.1	0.1
Manganese	19	0	2	321.9	1.8	6.8	104	423	**1440**
Mercury	18	9	0	0.0014	0.001	0.001	0.002	0.004	0.006
Molybdenum	19	11	0	0.03	0.1	0.1	0.07	0.1	0.2
Nickel	19	19	0	0.09	0.1	0.1	0.06	0.1	0.5
Selenium	19	19	0	0.01	0.1	0.1	0.05	0.1	0.1
Strontium	19	0	N/A	2	32	36	37	40	41
Tin	19	16	N/A	0.2	0.1	0.1	0.1	0.4	1.1
Titanium	19	18	N/A	0.07	0.2	0.2	0.1	0.3	0.5
Uranium	19	19	0	0.02	0.01	0.1	0.05	0.1	0.1
Vanadium	19	19	0	0.09	0.1	0.1	0.06	0.1	0.5
Zinc	19	12	0	0.8	0.5	0.5	0.8	2.7	3.0
Radionuclides									
Lead-210	19	19	0	0.004	0.02	0.02	0.01	0.02	0.04
Polonium-210	19	19	0	0.003	0.005	0.005	0.003	0.006	0.019
Radium-226	19	14	0	0.001	0.005	0.005	0.003	0.006	0.010
Thorium-230	19	18	0	0.005	0.01	0.01	0.006	0.01	0.03

Note:

Shaded & Bold indicates that the value is greater than the most stringent applicable SEQG or CCME Guideline.

Yellow Shaded indicates that guideline is hardness dependant.

a) No project threshold for pH; CCME guideline range presented (CCME 1996).

b) Fraction of unionized ammonia calculated based on total ammonia (as N), pH and temperature.

c) Not considered in statistics as MDL is order of magnitudes larger than remaining samples value or MDL.

d) Computed with half of MDL value.

e) Threshold was calculated for cadmium, copper, lead, nickel, and sulphate based on the maximum hardness observed within the RSA (21 mg/L $CaCO_3$).

f) Threshold for cobalt was calculated using the following formula: exp(0.414(ln(hardness))-1.887), where hardness is in mg/L $CaCO_3$ and the resulting cobalt threshold is in µg/L. Hardness value used in calculation is the 95th percentile hardness value for each lake.

MDL = method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; Bq/L = becquerel per litre; µS/cm = microsiemens per centimeter; NTU = nephelometric turbidity unit.

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Table 10A-1a-2 : Clearwater River below Broach Lake

Field Program		Project Threshold	Winter 2016			# of Samples	# < MDL	# Above Threshold	SD	Minimum	Average[c]	Maximum
Sampling Date			17-Mar-16									
Sampling Location			STM-01 (West)	STM-02 (North)	STM-03 (East)							
Depth												
Depth (m)												
Field Parameters												
pH (Field)	-	6.5 - 9.0[a]	6.82	6.82	6.82	3	-	0	0.00	6.82	6.82	6.82
Temperature (Field)	°C		0.8	0.8	0.8	3	-	N/A	0.0	0.8	0.8	0.8
Specific Conductivity (Field)	µS/cm		-	-	-	0	-	-	-	-	-	-
Turbidity	NTU		-	-	-	0	-	-	-	-	-	-
General Parameters												
pH	-	6.5 - 9.0[a]	7.34	**6.47**	7.03	3	0	1	0.44	**6.47**	6.95	7.34
Specific Conductivity (Lab)	µS/cm		46	20	37	3	0	N/A	13	20	34	46
Total Solids, Dissolved	mg/L		40	27	35	3	0	3	7	27	34	40
Total Solids, Suspended	mg/L	8.3	1	1	2	3	0	N/A	1	1	1	2
Hardness	mg/L $CaCO_3$		17	7	13	3	0	N/A	5	7	12	17
Alkalinity	mg/L $CaCO_3$		-	-	-	0	-	-	-	-	-	-
Nutrients												
Total Ammonia as N	mg/L		<0.01	0.04	<0.01	3	2	N/A	0.02	0.04	0.02	0.04
Ammonia as N (un-ionized)[b]	µg/L	16	<0.006	0.02	<0.01	3	2	0	0.01	0.02	0.01	0.02
Dissolved Organic Carbon	mg/L		-	-	-	0	-	-	-	-	-	-
Nitrate (as N)	mg/L	2.90	-	-	-	0	-	-	-	-	-	-
Phosphorus	mg/L	0.02	<0.01	0.02	<0.01	3	2	0	6	0.01	0.01	0.02
Major Ions												
Bicarbonate	mg/L		-	-	-	0	-	N/A	-	-	-	-
Calcium	mg/L		4.2	1.9	3.1	3	0	N/A	1.2	1.9	3.1	4.2
Chloride	mg/L	120	0.4	0.2	0.3	3	0	0	0.08	0.2	0.3	0.4
Fluoride	mg/L		0.06	0.03	0.04	3	0	N/A	0.01	0.03	0.04	0.06
Magnesium	mg/L		1.5	0.5	1.2	3	0	N/A	0.5	0.5	1.1	1.5
Sodium	mg/L		2.0	0.7	1.5	3	0	N/A	0.7	0.7	1.4	2.0
Sulphate	mg/L	128[d]	2.2	0.9	1.9	3	0	0	0.56	0.9	1.7	2.2
Total Metals												
Aluminium	µg/L	100	-	-	-	0	-	-	-	-	-	-
Arsenic	µg/L	5	0.1	0.1	0.1	3	0	0	0.0	0.1	0.1	0.1
Barium	µg/L		16	7.4	13	3	0	N/A	4.4	7.4	12.1	16.0
Beryllium	µg/L		<0.1	<0.1	<0.1	3	3	N/A	0.0	0.1	0.1	0.1
Boron	µg/L		10	10	10	3	2	N/A	0	10	10	10
Cadmium	µg/L	0.017[d]	0.01	0.01	0.01	3	1	0	0.00	0.01	0.01	0.01
Cesium	µg/L		-	-	-	0	-	-	-	-	-	-
Chromium	µg/L	1	<0.5	<0.5	<0.5	3	3	N/A	0.00	0.5	0.5	0.5
Cobalt	µg/L	0.5[e]	<0.1	0.1	<0.1	3	2	0	0.0	0.1	0.1	0.1
Copper	µg/L	2[d]	<0.2	<0.2	<0.2	3	3	0	0.0	0.2	0.2	0.2
Iron	µg/L	300	100	**610**	230	3	0	1	265	100	**313**	**610**
Lead	µg/L	1[d]	<0.1	<0.1	<0.1	3	3	0	0.0	0.1	0.1	0.1
Manganese	µg/L	260	3.5	12	7.3	3	0	0	4.3	3.5	7.6	12.0
Mercury	µg/L	0.026	0.001	0.001	0.001	3	3	0	0.000	0.001	0.001	0.001
Molybdenum	µg/L	31,000	<0.1	<0.1	<0.1	3	3	0	0.0	0.1	0.1	0.1
Nickel	µg/L	25[d]	<0.1	0.2	<0.1	3	2	0	0.06	0.1	0.1	0.2
Selenium	µg/L	1	<0.1	<0.1	<0.1	3	3	0	0.0	0.1	0.1	0.1
Strontium	µg/L		43	22	35	3	0	N/A	11	22	33	43
Tin	µg/L		<0.1	<0.1	<0.1	3	3	N/A	0.0	0.1	0.1	0.1
Titanium	µg/L		<0.2	1	0.3	3	1	N/A	0.4	0.2	0.5	1.0
Uranium	µg/L	15	<0.1	<0.1	<0.1	3	3	0	0.0	0.1	0.1	0.1
Vanadium	µg/L	120	<0.1	0.3	0.1	3	1	0	0.1	0.1	0.2	0.3
Zinc	µg/L	7	2.4	1	0.9	3	0	0	0.8	0.9	1.4	2.4
Radionuclides												
Lead-210	Bq/L	22	0.02	0.02	0.02	3	3	0	0.00	0.02	0.02	0.02
Polonium-210	Bq/L	13.5	0.005	0.005	0.005	3	3	0	0.000	0.005	0.005	0.005
Radium-226	Bq/L	0.11	0.005	0.005	0.005	3	3	0	0.000	0.005	0.005	0.005
Thorium-230	Bq/L	95	0.01	0.01	0.01	3	3	0	0.00	0.01	0.01	0.01

Note:

Shaded & Bold	indicates that the value is greater than the most stringent applicable SEQG or CCME Guideline.
Yellow Shaded	indicates that guideline is hardness dependant.

a) No project threshold for pH; CCME guideline range presented (CCME 1996).

b) Fraction of unionized ammonia calculated based on total ammonia (as N), pH and temperature.

c) Computed with half of MDL value.

d) Threshold was calculated for cadmium, copper, lead, nickel, and sulphate based on the maximum hardness observed within the RSA (21 mg/L $CaCO_3$).

e) Threshold for cobalt was calculated using the following formula: exp(0.414(ln(hardness))-1.887), where hardness is in mg/L $CaCO_3$ and the resulting cobalt threshold is in µg/L. Hardness value used in calculation is the 95th percentile hardness value for eac

MDL = method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; Bq/L = becquerel per litre; µS/cm = microsiemens per centimeter; NTU = nephelometric turbidity unit.

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Table 10A-1a-3 : Clearwater River above Patterson Lake

Field Program		Project Threshold	Winter 2016	Spring 2018	Summer 2018	Fall 2018	Winter 2019	Spring 2019	Summer 2019	Fall 2019	Winter 2020	Spring 2020	Summer 2020	Fall 2020	# of Samples	# < MDL	# Above Threshold	SD	Minimum	25th Percentile	Average[d]	95th Percentile	Maximum
Sampling Date			17-Mar-16	22-May-18	03-Aug-18	29-Sep-18	21-Feb-19	27-May-19	23-Jul-19	27-Sep-19	23-Mar-20	05-Jun-20	27-Jul-20	22-Sep-20									
Sampling Location			STM-04	Jed Creek	Jed Creek	Jed Creek	Jed Creek	Jed Creek	Jed Creek	Jed Creek	Jed Creek	Jed Creek	Jed Creek	Jed Creek									
Depth																							
Depth (m)																							
Field Parameters																							
pH (Field)	-	6.5 - 9.0[a]	-	6.52	7.07	7.08	**6.42**	6.90	7.00	7.15	7.03	6.75	6.73	6.52	11	0	1	0.25	**6.42**	6.62	6.83	7.11	7.15
Temperature (Field)	°C		-	16.7	19.6	3.8	0.1	16.7	25.7	9.7	0.1	13.6	19.5	10.0	11	0	N/A	8.0	0.1	6.8	12.3	22.7	25.7
Specific Conductivity (Field)	µS/cm		-	24.1	26.8	25.5	33.8	25.0	23.8	23.2	32.4	19.7	22.9	26.2	11	0	N/A	3.9	19.7	23.5	25.8	33.1	33.8
Turbidity	NTU		-	1.0	0.3	1.6	0.6	0.9	0.9	2.8	0.6	1.5	1.1	2.0	11	0	N/A	0.7	0.3	0.8	1.2	2.4	2.8
General Parameters																							
pH	-	6.5 - 9.0[a]	6.96	7.20	7.08	7.37	6.72	7.16	7.16	7.16	6.64	6.66	**6.46**	6.81	12	0	1	0.27	**6.46**	6.71	6.95	7.28	7.37
Specific Conductivity (Lab)	µS/cm		35	16	20	18	27	20	19	17	27	14	16	14	12	0	N/A	6	14	16	20	31	35
Total Solids, Dissolved	mg/L		34	38	39	54	54	40	35	34	49	36	25	32	12	0	N/A	9	25	34	39	54	54
Total Solids, Suspended	mg/L	8.3	1	2	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	12	6	0	0.4	1	1	1.0	2	2
Hardness	mg/L $CaCO_3$		12	8	9	10	12	10	10	9	12	7	9	8	11	0	N/A	1	7	9	9	12	12
Alkalinity	mg/L $CaCO_3$		-	12	11	14	16	13	7	12	12	14	13	6	11	0	N/A	3	6	12	12	15	16
Nutrients																							
Total Ammonia as N	mg/L		<0.01	<0.01	<0.01	0.03	0.02	<0.01	<0.01	<0.01	<0.01	0.01	0.01	<0.01	12	8	N/A	0.01	0.01	0.01	0.009	0.02	0.03
Ammonia as N (un-ionized)[b]	µg/L	16	<0.006[c]	<0.01	<0.04	0.04	0.004	<0.02	<0.06	<0.03	<0.009	0.01	0.02	<0.006	12	8	0	0.02	0.004	0.01	0.01	0.05	0.06
Dissolved Organic Carbon	mg/L		-	4.6	5.0	4.6	3.5	3.7	4.2	6.7	3.2	6.6	6.8	8.4	11	0	N/A	1.0	3.2	4.0	5.2	7.6	8.4
Nitrate (as N)	mg/L	2.90	-	<0.01	<0.01	<0.01	0.07	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	11	9	0	0.00	0.01	0.01	0.02	0.06	0.07
Phosphorus	mg/L	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	12	12	0	0.0	0.01	0.01	0.010	0.01	0.01
Major Ions																							
Bicarbonate	mg/L		-	14.6	13.4	17.1	19.5	15.9	8.5	14.6	14.6	17.1	15.9	7.3	11	0	N/A	3.44	7.3	14.0	14.4	18.3	19.5
Calcium	mg/L		3.1	2.1	2.6	2.6	3.3	2.6	2.8	2.6	3.1	2	2.4	2.3	12	0	N/A	0.38	2.0	2.4	2.6	3.2	3.3
Chloride	mg/L	120	0.3	0.4	0.3	0.3	0.4	0.3	0.3	0.3	0.4	0.2	0.2	0.2	12	0	0	0.00	0.2	0.3	0.3	0.4	0.4
Fluoride	mg/L		0.04	0.04	0.04	0.04	0.04	0.03	0.06	0.03	0.04	0.02	0.02	0.03	12	0	N/A	0.00	0.02	0.03	0.04	0.05	0.06
Magnesium	mg/L		1.1	0.7	0.7	0.8	1	0.8	0.8	0.7	1	0.6	0.7	0.6	12	0	N/A	0.16	0.6	0.7	0.8	1.0	1.1
Sodium	mg/L		1.4	1	1.2	1.2	1.4	1.2	1.2	1.1	1.3	0.9	1	0.9	12	0	N/A	0.17	0.9	1.0	1.2	1.4	1.4
Sulphate	mg/L	128[e]	1.7	1.2	1.2	1.2	1.6	1.2	1.2	1.1	1.5	1	1	1	12	0	0.0	0.0	1.0	1.1	1.2	1.6	1.7
Total Metals																							
Aluminum	µg/L	100	-	26.0	16.0	17.0	20.0	19.0	15.0	34.0	22.0	40.0	40.0	53.0	11	0	0	11.9	15.0	18.0	27.5	46.5	53.0
Arsenic	µg/L	5	0.1	0.2	0.2	0.2	0.1	0.1	0.2	0.2	<0.1	0.1	0.1	0.1	12	1	0	0.05	0.1	0.1	0.10	0.2	0.2
Barium	µg/L		11.0	8.2	9.8	9.0	12.0	8.0	8.4	9.5	12.0	7.4	9.5	9.2	12	0	N/A	1.4	7.4	8.4	9.5	12.0	12.0
Beryllium	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	12	N/A	0.0	0.1	0.1	0.10	0.1	0.1
Boron	µg/L		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	12	12	N/A	0	10	10	5	10	10
Cadmium	µg/L	0.017[e]	0.01	0.01	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	12	7	0	0.00	0.01	0.01	0.010	0.01	0.01
Cesium	µg/L		-	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8	8	N/A	0.0	0.1	0.1	0.10	0.1	0.1
Chromium	µg/L	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	12	12	0	0.0	0.5	0.5	0.3	0.5	0.5
Cobalt	µg/L	0.4[f]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	11	0	0.0	0.1	0.1	0.10	0.1	0.1
Copper	µg/L	2[e]	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	12	10	0	0.0	0.2	0.2	0.1	0.2	0.2
Iron	µg/L	300	300	**510**	250	**420**	**360**	**430**	270	**580**	270	**490**	**400**	**640**	12	0	8	122	250	293	**410**	**607**	**640**
Lead	µg/L	1[e]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	11	0	0.0	0.1	0.1	0.10	0.1	0.1
Manganese	µg/L	260	11.0	13.0		7.9	9.4	11.0	8.8	15.0	6.8	17.0	9.0	14.0	11	0	0	3.1	6.8	8.9	11.2	16.0	17.0
Mercury	µg/L	0.026	0.001	0.002	0.001	<0.001	0.002	0.001	0.002	0.001	<0.001	0.002	0.002	<0.001	12	3	0	0.0000	0.001	0.001	0.001	0.002	0.002
Molybdenum	µg/L	31,000	<0.1	<0.1	0.1	<0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	8	0	0.0	0.1	0.1	0.10	0.1	0.1
Nickel	µg/L	25[e]	0.1	<0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	12	4	0	0.0	0.1	0.1	0.10	0.1	0.1
Selenium	µg/L	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	11	0	0.0	0.1	0.1	0.10	0.1	0.1
Strontium	µg/L		33	24	28	25	31	25	26	25	32	20	25	23	12	0	N/A	4	20	25	26	32	33
Tin	µg/L		0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	11	N/A	0.1	0.1	0.1	0.10	0.2	0.3
Titanium	µg/L		0.2	0.4	0.3	0.3	0.4	0.3	0.3	0.4	0.3	0.3	0.3	0.4	12	0	N/A	0.10	0.2	0.3	0.3	0.4	0.4
Uranium	µg/L	15	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	11	0	0.0	0.1	0.1	0.10	0.1	0.1
Vanadium	µg/L	120	0.2	<0.3	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.1	<0.1	<0.1	<0.1	12	4	0	0.10	0.1	0.1	0.2	0.2	0.3
Zinc	µg/L	7	1.8	<0.5	1.4	<0.5	0.5	2.0	0.8	<0.5	0.6	0.5	1.2	<0.5	12	4	0	0.5	0.5	0.5	0.8	1.9	2.0
Radionuclides																							
Lead-210	Bq/L	22	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	12	11	0	0.00	0.02	0.02	0.01	0.02	0.02
Polonium-210	Bq/L	13.5	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	12	11	0	0.000	0.005	0.005	0.003	0.005	0.005
Radium-226	Bq/L	0.11	0.005	<0.005	0.01	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	0.01	<0.005	<0.005	12	8	0	0.002	0.005	0.005	0.004	0.010	0.010
Thorium-230	Bq/L	95	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	12	11	0	0.00	0.01	0.01	0.010	0.01	0.01

Note:

Shaded & Bold indicates that the value is greater than the most stringent applicable SEQG or CCME Guideline.

Yellow Shaded indicates that guideline is hardness dependant.

a) No project threshold for pH; CCME guideline range presented (CCME 1996).

b) Fraction of unionized ammonia calculated based on total ammonia (as N), pH and temperature.

c) Computed with surface temperature of Broach Lake on same day due to data not available.

d) Computed with half of MDL value.

e) Threshold was calculated for cadmium, copper, lead, nickel, and sulphate based on the maximum hardness observed within the RSA (21 mg/L $CaCO_3$).

f) Threshold for cobalt was calculated using the following formula: exp(0.414(ln(hardness))-1.887), where hardness is in mg/L $CaCO_3$ and the resulting cobalt threshold is in µg/L. Hardness value used in calculation is the 95th percentile hardness value for each lake.

MDL = method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; Bq/L = becquerel per litre; µS/cm = microsiemens per centimeter; NTU = nephelometric turbidity unit.

Table 10A-1a-4 : Lake H

Date		Project Threshold	Spring 2018	Summer 2018	Fall 2018	Winter 2019	Spring 2019	Summer 2019	Fall 2019	Winter 2020	Spring 2020	Summer 2020	Fall 2020	# of Samples	# < MDL	# Above Threshold	SD	Minimum	25th Percentile	Average[d]	95th Percentile	Maximum
Sampling Date			24-May-18	06-Aug-18	27-Sep-18	22-Feb-19	28-May-19	26-Jul-19	30-Sep-19	23-Mar-20	06-May-20	27-Jul-20	22-Sep-20									
Sampling Location			Lake H Area 1	Lake H Area 2	Lake H Area 2	Lake H Area 2	Lake H Area 2	Lake H Area 1	Lake H Area 1	Lake H Area 2	Lake H Area 1	Lake H Area 1	Lake H Area 1									
Depth																						
Depth (m)																						
Field Parameters																						
pH (Field)	-	6.5 - 9.0[a]	7.83	7.70	7.50	6.60	8.00	7.30	6.90	**5.97**	7.27	7.40	7.06	11	0	1	0.56	**5.97**	6.98	7.23	7.92	8.00
Temperature (Field)	°C		20.9	20.0	4.9	3.8	14.8	22.5	3.9	3.7	16.3	20.2	10.3	11	0	N/A	7.4	3.7	4.4	12.8	21.7	22.5
Specific Conductivity (Field)	µS/cm		37.0	38.8	38.1	44.5	40.4	37.1	38.2	73.7	35.5	35.7	39.9	11	0	N/A	10.4	35.5	37.1	41.7	59.1	73.7
Turbidity	NTU		1.2	0.7	1.3	4.8	1.5	1.5	2.5	4.6	3.2	3.1	1.7	11	0	N/A	1.3	0.7	1.4	2.4	4.7	4.8
General Parameters																						
pH	-	6.5 - 9.0[a]	7.57	7.37	7.56	7.37	7.47	7.42	7.47	6.68	6.95	6.93	7.28	11	0	0	0.28	6.68	7.12	7.28	7.57	7.57
Specific Conductivity (Lab)	µS/cm		30	32	32	53	34	34	32	54	30	29	29	11	0	N/A	8.71	29	30	35	54	54
Total Solids, Dissolved	mg/L		44	35	59	54	42	44	40	62	42	28	40	11	0	N/A	10	28	40	45	61	62
Total Solids, Suspended	mg/L	8.3	4	3	2	**14**	3	6	7	7	8	1	6	11	0	1	3	1	3	6	11	**14**
Hardness	mg/L $CaCO_3$		13	14	15	22	15	16	15	22	13	14	13	11	0	N/A	3	13	14	16	22	22
Alkalinity	mg/L $CaCO_3$		26	19	27	34	27	25	28	30	25	27	21	11	0	N/A	4	19	25	26	32	34
Nutrients																						
Total Ammonia as N	mg/L		<0.01	<0.01	<0.01	0.43	<0.01	0.01	<0.01	0.60	0.02	0.01	<0.01	11	6	N/A	0.20	0.01	0.01	0.1	0.5	0.60
Ammonia as N (un-ionized)[b]	µg/L	16	<0.3	<0.2	<0.04	0.19	<0.3	0.09	<0.009	-[c]	0.1	0.1	<0.02	10	6	0	0.10	0.009	0.05	0.09	0.30	0.30
Dissolved Organic Carbon	mg/L		7.8	7.6	8.8	9	6.6	9.9	7.4	9.6	7.2	7.0	7.0	11	0	N/A	1.1	6.6	7.1	8.0	9.8	9.9
Nitrate (as N)	mg/L	2.90	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	11	10	0	0.003	0.01	0.01	0.006	0.02	0.02
Phosphorus	mg/L	0.02	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	11	10	0	0.003	0.01	0.01	0.006	0.02	0.02
Major Ions																						
Bicarbonate	mg/L		31.7	23.2	32.9	41.5	32.9	30.5	34.1	36.6	30.5	32.9	25.6	11	0	N/A	4.68	23.2	30.5	32.0	39.0	41.5
Calcium	mg/L		3	3.3	3.5	5.4	3.6	3.8	3.6	5.4	3.2	3.2	3	11	0	N/A	0.82	3.0	3.2	3.7	5.4	5.4
Chloride	mg/L	120	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.1	0.2	0.2	11	0	0	0.04	0.1	0.2	0.2	0.3	0.3
Fluoride	mg/L		0.06	0.06	0.07	0.07	0.04	0.08	0.05	0.06	0.03	0.03	0.04	11	0	N/A	0.02	0.03	0.04	0.05	0.08	0.08
Magnesium	mg/L		1.3	1.5	1.5	2.1	1.5	1.6	1.5	2.1	1.3	1.4	1.3	11	0	N/A	0.27	1.3	1.4	1.6	2.1	2.1
Sodium	mg/L		1.7	1.8	1.9	2.4	1.8	2	1.8	2.3	1.6	1.6	1.5	11	0	N/A	0.27	1.5	1.7	1.9	2.4	2.4
Sulphate	mg/L	128[e]	0.4	0.2	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.3	11	0	0	0.06	0.2	0.3	0.3	0.4	0.4
Total Metals																						
Aluminum	µg/L	100	14.0	15.0	7.2	3.4	8.5	21.0	10.0	6.5	20.0	43.0	15.0	11	0	0	10.4	3.4	7.9	14.9	32.0	43.0
Arsenic	µg/L	5	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.1	<0.1	11	1	0	0.05	0.1	0.1	0.2	0.2	0.2
Barium	µg/L		1.1	1.1	1.0	2.9	1.0	1.5	1.1	3.4	3.0	1.1	1.5	11	0	N/A	0.9	1.0	1.1	1.7	3.2	3.4
Beryllium	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	11	N/A	0.0	0.1	0.1	0.05	0.1	0.1
Boron	µg/L		<10	10.0	<10	10.0	<10	10.0	<10	10.0	<10	<10	<10	11	7	N/A	0	10	10	7	10	10
Cadmium	µg/L	0.017[e]	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	11	10	0	0.00	0.01	0.01	0.005	0.01	0.01
Cesium	µg/L		-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8	8	N/A	0.0	0.1	0.1	0.05	0.1	0.1
Chromium	µg/L	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	11	11	0	0.0	0.5	0.5	0.3	0.5	0.5
Cobalt	µg/L	0.5[f]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	11	0	0.0	0.1	0.1	0.05	0.1	0.1
Copper	µg/L	2[e]	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	11	11	0	0.0	0.2	0.2	0.1	0.2	0.2
Iron	µg/L	300	140	120	56	**1380**	180	140	80	**2080**	**390**	93	76	11	0	3	636	56	87	**430**	**1730**	**2080**
Lead	µg/L	1[e]	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	9	0	0.03	0.1	0.1	0.07	0.2	0.2
Manganese	µg/L	260	13.0		12.0	130.0	16.0	22.0	19.0	140.0	22.0	24.0	13.0	10	0	0	47.2	12.0	13.8	41.1	135.5	140.0
Mercury	µg/L	0.026	0.002	0.008	<0.001	0.005	0.002	0.002	<0.001	<0.001	0.001	<0.001	<0.001	11	5	0	0.002	0.001	0.001	0.002	0.007	0.008
Molybdenum	µg/L	31,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	11	0	0.0	0.1	0.1	0.05	0.1	0.1
Nickel	µg/L	25[e]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	11	0	0.0	0.1	0.1	0.05	0.1	0.1
Selenium	µg/L	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	11	0	0.0	0.1	0.1	0.05	0.1	0.1
Strontium	µg/L		10	12	12	18	12	14	13	21	15	14	14	11	0	N/A	3	10	12	14	20	21
Tin	µg/L		<0.1	2.1	<0.1	0.8	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	9	N/A	0.6	0.1	0.1	0.3	1.5	2.1
Titanium	µg/L		<0.2	0.6	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	0.3	<0.2	<0.2	11	8	N/A	0.1	0.2	0.2	0.2	0.5	0.6
Uranium	µg/L	15	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	11	0	0.0	0.1	0.1	0.05	0.1	0.1
Vanadium	µg/L	120	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	11	0	0.0	0.1	0.1	0.05	0.1	0.1
Zinc	µg/L	7	0.8	1.1	<0.5	1.9	1.2	1.7	1.3	0.5	0.8	0.6	<0.5	11	2	0	0.5	0.5	0.6	0.9	1.8	1.9
Radionuclides																						
Lead-210	Bq/L	22	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.03	<0.02	11	10	0	0.004	0.02	0.02	0.01	0.03	0.03
Polonium-210	Bq/L	13.5	0.005	<0.005	<0.005	<0.005	0.010	0.007	0.006	<0.005	0.01	<0.008	<0.005	11	6	0	0.002	0.005	0.005	0.005	0.010	0.010
Radium-226	Bq/L	0.11	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.009	<0.005	<0.005	11	10	0	0.001	0.005	0.005	0.003	0.007	0.009
Thorium-230	Bq/L	95	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	11	11	0	0.00	0.01	0.01	0.005	0.01	0.01

Note:

Shaded & Bold	indicates that the value is greater than the most stringent applicable SEQG or CCME Guideline.
Yellow Shaded	indicates that guideline is hardness dependant.

a) No project threshold for pH; CCME guideline range presented (CCME 1996).

b) Fraction of unionized ammonia calculated based on total ammonia (as N), pH and temperature.

c) Unionized ammonia fraction could not be calculated due to pH being out of range.

d) Computed with half of MDL value.

e) Threshold was calculated for cadmium, copper, lead, nickel, and sulphate based on the maximum hardness observed within the RSA (21 mg/L $CaCO_3$).

f) Threshold for cobalt was calculated using the following formula: exp(0.414(ln(hardness))-1.887), where hardness is in mg/L $CaCO_3$ and the resulting cobalt threshold is in µg/L. Hardness value used in calculation is the 95th percentile hardness value for each lake.

MDL = method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; Bq/L = becquerel per litre; µS/cm = microsiemens per centimeter; NTU = nephelometric turbidity unit.

Table 10A-1a-5 : Lake G

Date		Project Threshold	Spring 2018	Summer 2018	Fall 2018	Winter 2019	Spring 2019	Summer 2019	Fall 2019	Winter 2020	Summer 2020		Fall 2020	# of Samples	# < MDL	# Above Threshold	SD	Minimum	25th Percentile	Average[c]	95th Percentile	Maximum
Sampling Date			24-May-18	07-Aug-18	28-Sep-18	22-Feb-19	28-May-19	26-Jul-19	28-Sep-19	23-Mar-20	05-Jun-20	27-Jul-20	22-Sep-20									
Sampling Location			Lake G Area 1	Lake G Area 2	Lake G Area 2	Lake G Area 2	Lake G Area 1	Lake G Area 1	Lake G Area 1	Lake G Area 2	Lake G Area 1	Lake G Area 1	Lake G Area 1									
Depth																						
Depth (m)																						
Field Parameters																						
pH (Field)	-	6.5 - 9.0[a]	7.19	8.20	7.40	6.50	7.20	7.38	6.60	**6.38**	7.07	7.16	6.50	11	0	1	0.51	**6.38**	6.55	7.05	7.80	8.20
Temperature (Field)	°C		20.2	20.9	3.0	2.8	17.9	22.7	6.8	1.1	15.3	20.3	10.1	11	0	N/A	7.9	1.1	4.9	12.8	21.8	22.7
Specific Conductivity (Field)	µS/cm		33.2	39.1	37.8	69.9	36.8	37.3	38.4	94.7	33.0	34.5	40.3	11	0	N/A	18.5	33.0	35.7	45.0	82.3	94.7
Turbidity	NTU		2.1	1.1	2.3	3.0	1.1	2.1	1.6	1.9	2.2	5.4	4.1	11	0	N/A	1.2	1.1	1.8	2.4	4.8	5.4
General Parameters																						
pH	-	6.5 - 9.0[a]	7.38	7.16	7.58	7.30	7.33	7.30	7.38	7.03	6.95	6.72	7.14	11	0	0	0.23	6.72	7.09	7.21	7.48	7.58
Specific Conductivity (Lab)	µS/cm		26	33	30	58	33	37	33	82	27	28	28	11	0	N/A	16	26	28	38	70	82
Total Solids, Dissolved	mg/L		84	50	67	88	37	58	41	114	42	33	45	11	0	N/A	24	33	42	60	101	114
Total Solids, Suspended	mg/L	8.3	4	6	3	<1	2	5	2	1	2	7	4	11	1	0	2	1	2	3	7	7
Hardness	mg/L $CaCO_3$		12	15	15	24	15	17	15	33	13	15	14	11	0	N/A	6	12	15	17	29	33
Alkalinity	mg/L $CaCO_3$		26	22	26	31	27	20	16	41	22	28	22	11	0	N/A	6	16	22	26	36	41
Nutrients																						
Total Ammonia as N	mg/L		<0.01	<0.01	0.03	0.51	0.03	0.04	0.25	0.65	0.02	0.03	0.03	11	2	N/A	0.22	0.01	0.03	0.15	0.58	0.65
Ammonia as N (un-ionized)[b]	µg/L	16	<0.06	<0.6	0.08	0.17	0.20	0.50	0.14	0.14	0.07	0.20	0.02	11	2	0	0.18	0.02	0.08	0.17	0.55	0.60
Dissolved Organic Carbon	mg/L		6.6	8.2	8.0	10.0	6.4	8.4	7.8	11.0	7.2	8.4	8.8	11	0	N/A	1.3	6.4	7.5	8.3	10.5	11.0
Nitrate (as N)	mg/L	2.90	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.18	<0.23	<0.01	<0.01	<0.01	11	8	0	0.08	0.01	0.01	0.04	0.21	0.23
Phosphorus	mg/L	0.02	<0.01	0.01	0.01	0.02	0.01	<0.01	0.01	0.02	0.01	0.01	0.02	11	2	0	0.004	0.01	0.01	0.01	0.02	0.02
Major Ions																						
Bicarbonate	mg/L		31.7	26.8	31.7	37.8	32.9	24.4	19.5	50.0	26.8	34.1	26.8	11	0	N/A	7.68	19.5	26.8	31.1	43.9	50.0
Calcium	mg/L		2.5	3.4	3.4	5.8	3.4	3.9	3.5	7.8	3.1	3.4	3.4	11	0	N/A	1.44	2.5	3.4	3.963	6.8	7.8
Chloride	mg/L	120	0.1	<0.1	<0.1	0.1	0.1	0.1	0.1	0.3	<0.1	<0.1	<0.1	11	5	0	0.06	0.1	0.1	0.1	0.2	0.3
Fluoride	mg/L		0.05	0.05	0.06	0.06	0.04	0.08	0.05	0.07	0.03	0.03	0.04	11	0	N/A	0.02	0.03	0.04	0.05	0.08	0.08
Magnesium	mg/L		1.3	1.6	1.7	2.4	1.6	1.8	1.6	3.3	1.3	1.5	1.3	11	0	N/A	0.569	1.3	1.4	1.763	2.85	3.3
Sodium	mg/L		1.6	1.8	1.8	2.3	1.7	1.9	1.6	3.9	1.3	1.4	1.4	11	0	N/A	0.691	1.3	1.5	1.881	3.1	3.9
Sulphate	mg/L	128[d]	1.3	1.1	1.2	1.2	1.1	1.1	1.2	3.0	0.9	1.0	0.9	11	0	0	0.6	0.9	1.1	1.3	2.2	3.0
Total Metals																						
Aluminum	µg/L	100	10	4.7	6.3	4.4	4.7	4.3	6.3	16	5.9	10	8.6	11	0	0	3.4	4.3	4.7	7.4	13.0	16.0
Arsenic	µg/L	5	<0.1	<0.1	<0.1	0.1	<0.1	0.1	<0.1	0.2	<0.1	<0.1	<0.1	11	8	0	0.03	0.1	0.1	0.07	0.2	0.2
Barium	µg/L		7.4	7.9	7.5	19	5.5	7.8	7	24	7.8	7.1	7.6	11	0	N/A	5.6	5.5	7.3	9.9	21.5	24.0
Beryllium	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	11	N/A	0.0	0.1	0.1	0.05	0.1	0.1
Boron	µg/L		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	11	11	N/A	0	10	10	5	10	10
Cadmium	µg/L	0.017[d]	0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	11	6	0	0.00	0.01	0.01	0.007	0.01	0.01
Cesium	µg/L		-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8	8	N/A	0.0	0.1	0.1	0.05	0.1	0.1
Chromium	µg/L	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	11	11	0	0.0	0.5	0.5	0.3	0.5	0.5
Cobalt	µg/L	0.6[e]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	10	0	0.0	0.1	0.1	0.05	0.1	0.1
Copper	µg/L	2[d]	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<1.9	<0.2	<0.2	<0.2	11	10	0	0.5	0.2	0.2	0.3	1.1	1.9
Iron	µg/L	300	**500**	260	260	**2440**	**400**	**350**	150	**1720**	**760**	**390**	**350**	11	0	8	690	150	305	**689**	**2080**	**2440**
Lead	µg/L	1[d]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	11	0	0.0	0.1	0.1	0.05	0.1	0.1
Manganese	µg/L	260	15.0	24.0	7.3	270.0	12.0	35.0	7.4	310.0	13.0	29.0	13.0	11	0	2	105.9	7.3	12.5	66.9	290.0	310.0
Mercury	µg/L	0.026	0.002	0.003	<0.001	0.005	0.002	0.002	0.001	0.003	0.002	0.002	<0.001	11	2	0	0.001	0.001	0.002	0.002	0.004	0.005
Molybdenum	µg/L	31,000	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	10	0	0	0.1	0.1	0.05	0.1	0.1
Nickel	µg/L	25[d]	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	9	0	0	0.1	0.1	0.06	0.1	0.1
Selenium	µg/L	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	11	0	0	0.1	0.1	0.05	0.1	0.1
Strontium	µg/L		19	24	22	35	20	24	20	50	20	22	22	11	0	N/A	9	19	20	25	43	50
Tin	µg/L		<0.1	0.3	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	9	N/A	0.1	0.1	0.1	0.1	0.4	0.4
Titanium	µg/L		0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	11	9	N/A	0.04	0.2	0.2	0.1	0.3	0.3
Uranium	µg/L	15	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	11	0	0.0	0.1	0.1	0.05	0.1	0.1
Vanadium	µg/L	120	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	11	0	0.0	0.1	0.1	0.05	0.1	0.1
Zinc	µg/L	7	2.1	<0.5	<0.5	0.9	2.7	5.6	1.4	3.4	0.7	1.3	<0.5	11	3	0	1.5	0.5	0.6	1.7	4.5	5.6
Radionuclides																						
Lead-210	Bq/L	22	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	0.03	<0.02	11	9	0	0.003	0.02	0.02	0.013	0.03	0.03
Polonium-210	Bq/L	13.5	<0.005	<0.005	0.006	<0.005	<0.005	0.008	0.008	<0.005	0.005	0.009	0.008	11	5	0	0.002	0.005	0.005	0.005	0.009	0.009
Radium-226	Bq/L	0.11	0.009	0.006	<0.005	0.005	<0.005	<0.005	0.007	<0.005	0.010	<0.005	<0.005	11	6	0	0.002	0.005	0.005	0.005	0.010	0.010
Thorium-230	Bq/L	95	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	11	11	0	0.00	0.01	0.01	0.005	0.01	0.01

Note:

Shaded & Bold	indicates that the value is greater than the most stringent applicable SEQG or CCME Guideline.
Yellow Shaded	indicates that guideline is hardness dependant

a) No project threshold for pH; CCME guideline range presented (CCME 1996).

b) Fraction of unionized ammonia calculated based on total ammonia (as N), pH and temperature.

c) Computed with half of MDL value.

d) Threshold was calculated for cadmium, copper, lead, nickel, and sulphate based on the maximum hardness observed within the RSA (21 mg/L $CaCO_3$).

e) Threshold for cobalt was calculated using the following formula: exp(0.414(ln(hardness))-1.887), where hardness is in mg/L $CaCO_3$ and the resulting cobalt threshold is in µg/L. Hardness value used in calculation is the 95th percentile hardness value for each lake.

MDL = method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; Bq/L = becquerel per litre; µS/cm = microsiemens per centimeter; NTU = nephelometric turbidity unit.

NexGen Energy Ltd.

Table 10A-1a-6 : Patterson Lake North Arm - East Basin

Field Program		Project Threshold	Fall 2015	Winter 2016			Spring 2018	Summer 2018	Fall 2018	Winter 2019	Spring 2019	
Sampling Date			10-Nov-15	11-Mar-16	11-Mar-16	11-Mar-16	22-May-18	03-Aug-18	29-Sep-18	20-Feb-19	28-May-19	28-May-19
Sampling Location			PL-WQ01	PL-WQ01	PL-WQ01	PL-WQ01	Patterson Lake North Arm - East	Patterson Lake North Arm - East	Patterson Lake North Arm - East	Patterson Lake North Arm - East	Patterson Lake North Arm - East	Patterson Lake North Arm - East
Depth			-	Surface	Mid	Bottom					Top	Bottom
Depth (m)			-	1.00	9.00	17.00					3	13
Field Parameters												
pH (Field)	-	6.5 - 9.0[a]	6.71	**6.29**	**6.17**	**6.17**	7.10	7.50	7.30	7.10	7.54	6.85
Temperature (Field)	°C		0.0	0.4	1.6	2.1	7.4	14.7	6.2	2.1	12.0	5.2
Specific Conductivity (Field)	µS/cm		35.6	107.0	85.5	85.9	32.1	31.8	31.3	39.9	31.0	31.1
Turbidity	NTU		0.6	3.0	3.0	1.2	1.1	0.9	1.1	0.2	0.8	1.0
General Parameters												
pH	-	6.5 - 9.0[a]	6.74	7.15	7.00	6.90	7.47	7.10	7.53	7.22	7.32	7.21
Specific Conductivity (Lab)	µS/cm		32	34	32	33	23	25	24	34	26	26
Total Solids, Dissolved	mg/L		24	34	34	34	35	33	39	52	17	29
Total Solids, Suspended	mg/L	8.3	<6	<1	<1	2	2	3	1	<1	2	2
Hardness	mg/L $CaCO_3$		13	12	11	12	11	12	12	16	12	12
Alkalinity	mg/L $CaCO_3$		33	35	33	31	16	14	10	22	16	24
Nutrients												
Total Ammonia as N	mg/L		-	0.02	0.02	0.06	<0.01	0.02	0.02	0.02	<0.01	0.04
Ammonia as N (un-ionized)[b]	µg/L	16	-	0.003	0.003	0.009	<0.02	0.200	0.050	0.020	<0.07	0.040
Dissolved Organic Carbon	mg/L		-	-	-	-	2.8	2.9	2.8	2.3	3.0	2.7
Nitrate (as N)	mg/L	2.90	<0.5[c]	-	-	-	0.02	<0.01	<0.01	0.03	<0.01	<0.01
Phosphorus	mg/L	0.02	<0.05[c]	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
Major Ions												
Bicarbonate	mg/L		40.2	42.7	40.2	37.8	19.5	17.1	12.2	26.8	19.5	29.3
Calcium	mg/L		3.36	3.2	2.9	3	2.8	3	3.1	4	3.2	3.2
Chloride	mg/L	120	<1[c]	0.4	0.4	0.4	0.4	0.4	0.4	0.6	0.4	0.4
Fluoride	mg/L		<0.1[c]	0.06	0.05	0.05	0.05	0.04	0.05	0.05	0.04	0.04
Magnesium	mg/L		1.1	1	1	1	0.9	1	1	1.4	1	1
Sodium	mg/L		1.37	1.4	1.3	1.3	1.3	1.3	1.3	1.5	1.3	1.3
Sulphate	mg/L	128[f]	-	1.3	1.3	1.3	1.3	1.2	1.2	1.6	1.2	1.2
Total Metals												
Aluminum	µg/L	100	5.9	-	-	-	9.8	3.8	2.7	0.6	3.8	3.3
Arsenic	µg/L	5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1
Barium	µg/L		8.6	9.1	9.4	10.0	10.0	11.0	8.4	10.0	9.2	10.0
Beryllium	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Boron	µg/L		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cadmium	µg/L	0.017[f]	<0.01	0.01	0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
Cesium	µg/L		0.01	-	-	-	-	-	-	<0.1	<0.1	<0.1
Chromium	µg/L	1	0.1	0.5	0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cobalt	µg/L	0.5[g]	0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Copper	µg/L	2[f]	0.5	0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Iron	µg/L	300	93	16	50	160	220	**570**	160	9	130	220
Lead	µg/L	1[f]	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	µg/L	260	12.9	0.9	7.1	28.0	30.0	130.0	21.0	2.4	17.0	24.0
Mercury	µg/L	0.026	-	0.001	0.001	0.001	0.004	0.003	<0.001	0.002	0.002	0.002
Molybdenum	µg/L	31,000	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	µg/L	25[f]	12.9	0.9	7.1	**28.0**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium	µg/L	1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Strontium	µg/L		31	31	30	30	27	27	27	32	27	27
Tin	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Titanium	µg/L		<0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Uranium	µg/L	15	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	µg/L	120	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	µg/L	7	5.2	0.6	0.6	<0.5	<0.5	1.5	<0.5	0.6	1.6	1.8
Radionuclides												
Lead-210	Bq/L	22	0.037	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Polonium-210	Bq/L	13.5	0.019	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Radium-226	Bq/L	0.11	0.01	<0.005	<0.005	0.009	<0.005	0.009	0.009	0.007	<0.005	<0.005
Thorium-230	Bq/L	95	<0.0074	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Field Program	Summer 2019		Fall 2019	Winter 2020	Spring 2020		Summer 2020		Fall 2020
Sampling Date	27-Jul-19	27-Jul-19	30-Sep-19	23-Mar-20	06-Jun-20	06-Jun-20	27-Jul-20	27-Jul-20	24-Sep-20
Sampling Location	Patterson Lake North Arm - East	Patterson Lake North Arm - East	Patterson Lake North Arm - East	Patterson Lake North Arm - East	Patterson Lake North Arm - East	Patterson Lake North Arm - East	Patterson Lake North Arm - East	Patterson Lake North Arm - East	Patterson Lake North Arm - East
Depth	Top	Bottom			Top	Bottom	Top	Bottom	
Depth (m)	4	14			5	15	7	18	
Field Parameters									
pH (Field)	7.59	**5.85**	7.20	**6.49**	7.53	6.92	7.13	**6.27**	6.97
Temperature (Field)	20.3	12.3	9.6	2.1	10.3	6.0	16.4	9.5	10.5
Specific Conductivity (Field)	29.2	28.1	31.2	33.5	29.5	31.3	29.3	31.2	28.9
Turbidity	0.7	2.2	1.1	0.5	1.1	1.1	1.2	2.2	1.2
General Parameters									
pH	7.32	7.17	7.20	6.80	7.12	7.00	**5.46**	7.23	7.17
Specific Conductivity (Lab)	26	26	25	27	24	26	23	24	22
Total Solids, Dissolved	34	33	30	45	37	30	32	37	35
Total Solids, Suspended	1	2	1	<1	<1	<1	2	2	<1
Hardness	13	12	12	12	11	11	11	11	11
Alkalinity	16	14	18	17	14	15	94	26	21
Nutrients									
Total Ammonia as N	0.02	0.05	0.02	<0.01	<0.01	0.02	0.02	0.19	0.02
Ammonia as N (un-ionized)[b]	0.300	-[d]	0.060	<0.003	<0.06	0.020	0.080	0.063	0.040
Dissolved Organic Carbon	3.6	3.0	2.8	3.3	3.6	3.4	3.2	3.8	3.4
Nitrate (as N)	<0.01	<0.01	<0.01	0.1	<0.01	0.03	<0.01	0.01	<0.01
Phosphorus	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
Major Ions									
Bicarbonate	19.5	17.1	21.9	20.7	17.1	18.3	114.6	31.7	25.6
Calcium	3.3	3.3	3.2	3.2	2.8	2.9	2.9	3	2.8
Chloride	0.4	0.4	0.4	0.5	0.3	0.3	0.4	0.4	0.4
Fluoride	0.06	0.06	0.04	0.04	0.04	0.03	0.03	0.02	0.03
Magnesium	1.1	1	1	1.1	0.9	0.9	0.9	0.9	1
Sodium	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2
Sulphate	1.2	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.1
Total Metals									
Aluminum	2.8	2.4	5	4.7	6.1	5.9	5.8	3.8	3.6
Arsenic	0.1	0.1	0.1	<0.1	0.1	0.1	<0.1	<0.1	0.1
Barium	7.5	11.0	8.8	11.0	10.0	11.0	8.4	13.0	8.6
Beryllium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Boron	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	<0.01
Cesium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cobalt	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Copper	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Iron	42	300	160	96	220	250	77	**790**	140
Lead	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	16.0	57.0	23.0	16.0	18.0	23.0	17.0	160.0	25.0
Mercury	0.004	0.007	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001
Molybdenum	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Strontium	28	28	28	31	28	28	27	27	26
Tin	0.3	1.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Titanium	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Uranium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	0.9	1.1	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Radionuclides									
Lead-210	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	0.03	<0.02
Polonium-210	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Radium-226	<0.005	0.009	0.007	<0.005	0.007	0.01	<0.005	<0.005	<0.005
Thorium-230	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Parameter	# of Samples	# < MDL	# Above Threshold	SD	Minimum	25th Percentile	Average[e]	95th Percentile	Maximum
Field Parameters									
pH (Field)	19	0	6	0.52	**5.85**	6.39	6.88	7.55	7.59
Temperature (Field)	18	0	0	5.5	0.4	2.9	8.3	17.0	20.3
Specific Conductivity (Field)	19	0	0	22.8	28.1	30.3	41.2	88.0	107.0
Turbidity	19	0	0	0.7	0.2	0.9	1.3	3.0	3.0
General Parameters									
pH	19	0	1	0.42	**5.46**	7.00	7.06	7.48	7.53
Specific Conductivity (Lab)	19	0	N/A	4	22	24	27	34	34
Total Solids, Dissolved	19	0	N/A	7	17	31	34	46	52
Total Solids, Suspended	19	5	0	1	1	1	2	3	6
Hardness	19	0	N/A	1	11	11	12	13	16
Alkalinity	19	0	N/A	18	10	16	22	41	94
Nutrients									
Total Ammonia as N	18	4	N/A	0.04	0.01	0.02	0.03	0.08	0.19
Ammonia as N (un-ionized)[b]	17	4	0	0.08	0.00	0.02	0.06	0.22	0.30
Dissolved Organic Carbon	15	0	N/A	0.4	2.3	2.8	3.1	3.7	3.8
Nitrate (as N)	15	11	0	0.02	0.01	0.01	0.02	0.05	0.10
Phosphorus	18	16	0	0.00	0.01	0.01	0.006	0.01	0.01
Major Ions									
Bicarbonate	19	0	N/A	25.9	17.1	19.2	30.2	69.0	115
Calcium	19	0	N/A	0.3	2.8	2.9	3.113	3.424	4
Chloride	18	1	0	0.06	0.3	0.4	0.4	0.5	0.6
Fluoride	18	1	N/A	0.01	0.02	0.04	0.04	0.06	0.06
Magnesium	19	0	N/A	0.112	0.9	0.95	1.01	1.13	1.4
Sodium	19	0	N/A	0.078	1.2	1.25	1.3	1.41	1.5
Sulphate	18	0	0	0.11	1.1	1.2	1.2	1.3	1.6
Total Metals									
Aluminum	16	0	0	2.0	0.6	3.2	4.4	7.0	9.8
Arsenic	19	3	0	0.02	0.1	0.1	0.1	0.1	0.2
Barium	19	0	N/A	1.3	7.5	8.7	9.7	11.2	13.0
Beryllium	19	19	N/A	0.0	0.1	0.1	0.05	0.1	0.1
Boron	19	19	N/A	0	10	10	5	10	10
Cadmium	19	13	0	0.00	0.01	0.01	0.007	0.01	0.01
Cesium	13	12	N/A	0.02	0.01	0.1	0.05	0.1	0.1
Chromium	19	15	0	0.09	0.1	0.5	0.3	0.5	0.5
Cobalt	19	15	0	0.0	0.1	0.1	0.06	0.1	0.1
Copper	19	15	0	0.07	0.2	0.2	0.1	0.2	0.5
Iron	19	0	2	187	9	85	195	**592**	**790**
Lead	19	15	0	0.01	0.05	0.1	0.06	0.1	0.1
Manganese	19	0	0	40.4	0.9	16.0	33.1	133.0	160.0
Mercury	18	7	0	0.002	0.001	0.001	0.002	0.004	0.007
Molybdenum	19	18	0	0.008	0.1	0.1	0.05	0.1	0.1
Nickel	19	15	1	6.8	0.1	0.1	2.6	14.4	**28.0**
Selenium	19	19	0	0.09	0.1	0.1	0.06	0.1	0.5
Strontium	19	0	N/A	2	26	27	28	31	32
Tin	19	17	N/A	0.2	0.1	0.1	0.1	0.4	1.1
Titanium	19	19	N/A	0.02	0.2	0.2	0.1	0.2	0.3
Uranium	19	19	0	0.0	0.1	0.1	0.05	0.1	0.1
Vanadium	19	19	0	0.09	0.1	0.1	0.06	0.1	0.5
Zinc	19	9	0	1.1	0.5	0.5	0.9	2.1	5.2
Radionuclides									
Lead-210	19	16	0	0.005	0.02	0.02	0.01	0.03	0.04
Polonium-210	19	18	0	0.003	0.005	0.005	0.003	0.006	0.019
Radium-226	19	10	0	0.002	0.005	0.005	0.005	0.010	0.010
Thorium-230	19	19	0	0.001	0.01	0.01	0.005	0.01	0.01

Note:

Shaded & Bold indicates that the value is greater than the most stringent applicable SEQG or CCME Guideline.

Yellow Shaded indicates that guideline is hardness dependant.

a) No project threshold for pH; CCME guideline range presented (CCME 1996).

b) Fraction of unionized ammonia calculated based on total ammonia (as N), pH and temperature.

c) Not considered in statistics as MDL is an order of magnitudes larger than remaining samples value or MDL.

d) Unionized ammonia fraction could not be calculated due to pH being out of range.

e) Computed with half of MDL value.

f) Threshold was calculated for cadmium, copper, lead, nickel, and sulphate based on the maximum hardness observed within the RSA (21 mg/L $CaCO_3$).

g) Threshold for cobalt was calculated using the following formula: exp(0.414(ln(hardness))-1.887), where hardness is in mg/L $CaCO_3$ and the resulting cobalt threshold is in µg/L. Hardness value used in calculation is the 95th percentile hardness value for each lake.

MDL = method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; Bq/L = becquerel per litre; µS/cm = microsiemens per centimeter; NTU = nephelometric turbidity unit.

Table 10A-1a-7 : Patterson Lake North Arm - West Basin

Field Program		Project Threshold	Fall 2015	Winter 2016			Spring 2018	Summer 2018	Fall 2018	Winter 2019	Spring 2019	Summer 2019		Fall 2019		Winter 2020	Spring 2020	Summer 2020		Fall 2020		# of Samples	# < MDL	# Above Threshold	SD	Minimum	25th Percentile	Average[d]	95th Percentile	Maximum
Sampling Date			10-Nov-15	14-Mar-16			22-May-18	02-Aug-18	29-Sep-18	20-Feb-19	27-May-19	27-Jul-19	27-Jul-19	30-Sep-19	30-Sep-19	20-Mar-20	06-Jun-20	27-Jul-20	27-Jul-20	24-Sep-20	24-Sep-20									
Sampling Location			PL-WQ02	PL-WQ02	PL-WQ02	PL-WQ02	Patterson Lake North Arm - West	Patterson Lake North Arm - West	Patterson Lake North Arm - West	Patterson Lake North Arm - West	Patterson Lake North Arm - West	Patterson Lake North Arm - West	Patterson Lake North Arm - West	Patterson Lake North Arm - West	Patterson Lake North Arm - West	Patterson Lake North Arm - West	Patterson Lake North Arm - West	Patterson Lake North Arm - West	Patterson Lake North Arm - West	Patterson Lake North Arm - West	Patterson Lake North Arm - West									
Depth				Surface	Mid	Bottom						Top	Bottom	Top	Bottom			Top	Bottom	Top	Bottom									
Depth (m)				1.00	9.00	17.00						5	19	9	24			5	22	8	24									
Field Parameters																														
pH (Field)	-	6.5 - 9.0[a]	7.13	**6.29**	**6.17**	**6.17**	7.10	7.70	7.30	6.60	7.28	7.46	6.47	7.32	6.56	6.87	7.25	7.71	6.85	7.24	6.59	19	0	4	0.48	**6.17**	6.58	6.95	7.70	7.71
Temperature (Field)	°C		-0.3	0.4	1.6	2.1	4.9	10.9	6.8	1.6	5.2	18.8	6.7	10.4	6.4	2.1	5.5	17.7	6.0	10.8	6.3	18	0	0	5.0	0.4	2.8	6.9	17.9	18.8
Specific Conductivity (Field)	µS/cm		40.1	107.0	85.5	85.9	38.9	38.1	37.7	35.2	38.0	39.6	38.9	38.0	38.6	39.0	38.2	37.5	37.6	36.9	37.5	19	0	0	20.4	35.2	37.7	46.7	88.0	107.0
Turbidity	NTU		0.6	3.0	3.0	1.2	0.4	0.2	0.4	2.1	0.6	0.3	0.4	0.4	0.4	0.2	0.6	1.9	1.9	0.4	0.5	19	0	0	0.9	0.2	0.4	1.0	3.0	3.0
General Parameters																														
pH	-	6.5 - 9.0[a]	6.76	7.23	7.105	6.94	7.57	7.26	7.59	6.96	7.41	7.42	7.31	7.52	7.42	7.06	7.09	**5.54**	**5.57**	7.33	7.22	19	0	2	0.56	**5.54**	7.01	7.07	7.57	7.59
Specific Conductivity (Lab)	µS/cm		37	34	32	33	30	30	31	29	33	32	32	32	32	32	33	32	32	30	31	19	0	0	2	29	31	32	34	37
Total Solids, Dissolved	mg/L		29	-	-	-	38	46	44	39	32	32	33	29	37	51	42	43	37	39	42	16	0	0	6	29	33	38	47	51
Total Solids, Suspended	mg/L	8.3	<6	<1	<1	2	<1	2	<1	2	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	19	13	0	1	1	1	1	2	6
Hardness	mg/L $CaCO_3$		15	12	11	12	13	14	15	13	15	15	15	15	15	14	14	14	14	14	14	19	0	0	1	11	14	14	15	15
Alkalinity	mg/L $CaCO_3$		36	35	33	31	22	18	22	15	20	14	21	22	22	18	18	98	90	21	13	19	0	0	23	13	18	29	91	98
Nutrients																														
Total Ammonia as N	mg/L		-	0.02	0.02	0.02	<0.01	<0.01	0.02	0.12	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	0.02	<0.01	<0.01	<0.01	18	11	N/A	0.03	0.01	0.01	0.02	0.06	0.12
Ammonia as N (un-ionized)[b]	µg/L	16	-	0.003	0.003	0.003	<0.02	<0.1	0.06	0.045	<0.02	<0.1	<0.004	<0.04	<0.005	0.04	<0.02	0.3	<0.01	<0.03	<0.005	18	11	0	0.07	0.003	0.005	0.04	0.13	0.30
Dissolved Organic Carbon	mg/L		-	-	-	-	2.4	2.1	2.2	3.0	2.0	2.5	2.6	3.3	2.1	2.6	2.4	2.2	1.8	2.0	1.9	15	0	N/A	0.4	1.8	2.1	2.3	3.1	3.3
Nitrate (as N)	mg/L	2.90	<0.5[c]	-	-	-	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	15	14	0	0.007	0.01	0.01	0.008	0.03	0.03
Phosphorus	mg/L	0.02	<0.05[c]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	18	19	0	0.00	0.01	0.01	0.005	0.01	0.01
Major Ions																														
Bicarbonate	mg/L		43.9	42.7	40.2	37.8	26.8	21.9	26.8	18.3	24.4	17.1	25.6	26.8	26.8	21.9	21.9	119.5	109.7	25.6	15.9	19	0	0	28.0	15.9	21.9	36.5	110.7	119.5
Calcium	mg/L		3.61	3.2	2.9	3	3.4	3.7	3.8	3.3	3.9	3.9	3.9	3.8	3.9	3.7	3.6	3.7	3.7	3.6	3.7	19	0	0	0.293	2.9	3.5	3.595	3.9	3.9
Chloride	mg/L	120	<1[c]	0.4	0.4	0.4	0.6	0.5	0.6	0.4	0.5	0.6	0.5	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.6	18	1	0	0.08	0.4	0.5	0.5	0.6	0.6
Fluoride	mg/L		<0.1[c]	0.06	0.05	0.05	0.05	0.05	0.06	0.04	0.04	0.07	0.07	0.05	0.05	0.05	0.04	0.04	0.03	0.04	0.04	18	1	N/A	0.01	0.03	0.04	0.05	0.07	0.07
Magnesium	mg/L		1.29	1	1	1	1.2	1.3	1.3	1.1	1.4	1.4	1.4	1.3	1.3	1.3	1.2	1.3	1.3	1.3	1.3	19	0	0	0.127	1	1.2	1.246	1.4	1.4
Sodium	mg/L		1.42	1.4	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	19	0	0	0.046	1.3	1.4	1.401	1.5	1.5
Sulphate	mg/L	128[e]	-	1.3	1.3	1.3	1.6	1.5	1.6	1.3	1.6	1.5	1.4	1.5	1.7	1.4	1.4	1.4	1.5	1.5	1.4	18	0	0	0.1	1.3	1.4	1.5	1.6	1.7
Total Metals																														
Aluminum	µg/L	100	10.7	-	-	-	16.0	2.3	1.5	2.5	0.8	1.6	0.8	3.1	2.2	<0.5	0.8	1.9	1.4	2.0	0.6	16	1	0	4.1	0.50	0.80	3.03	12.03	16.00
Arsenic	µg/L	5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	19	5	0	0.002	0.10	0.10	0.09	0.10	**0.11**
Barium	µg/L		10.5	9.1	9.4	10.0	9.5	9.4	9.4	12.0	9.8	8.6	9.8	8.6	11.0	9.7	9.7	8.2	9.7	8.4	10.0	19	0	0	0.9	8.20	9.25	9.62	11.10	12.00
Beryllium	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	19	0	0.0	0.10	0.10	0.05	0.10	0.10
Boron	µg/L		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	19	19	0	0	10	10	5	10	10
Cadmium	µg/L	0.017[e]	0.01	0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	19	14	0	0.001	0.01	0.01	0.006	0.01	0.01
Cesium	µg/L		0.01	-	-	-	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	13	12	0	0.02	0.01	0.1	0.05	0.1	0.1
Chromium	µg/L	1	0.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	19	18	0	0.06	0.2	0.5	0.2	0.5	0.5
Cobalt	µg/L	0.5[f]	<0.1	<0.2	<0.3	<0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	19	0	0.08	0.1	0.1	0.07	0.3	0.4
Copper	µg/L	2[e]	<0.5	<0.2	<0.3	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	19	19	0	0.08	0.2	0.2	0.12	0.4	0.5
Iron	µg/L	300	65	16	50	160	19	30	12	**470**	18	7	10	12	14	20	19	9	12	13	11	19	0	1	105	7	12	51	191	**470**
Lead	µg/L	1[e]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	19	0	0.0	0.1	0.1	0.05	0.1	0.1
Manganese	µg/L	260	17.7	0.9	7.1	28.0	28.0	21.0	10.0	-	27.0	4.3	9.0	5.6	23.0	6.9	35.0	4.0	15.0	6.0	13.0	18	0	0	9.9	0.9	6.2	14.5	29.1	35.0
Mercury	µg/L	0.026		0.001	0.001	0.001	0.002	0.003	<0.001	0.004	0.002	0.003	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	18	9	0	0.0009	0.001	0.001	0.001	0.003	0.004
Molybdenum	µg/L	31,000	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	18	0	0.005	0.1	0.1	0.05	0.1	0.1
Nickel	µg/L	25[e]	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	19	0	0.09	0.1	0.1	0.06	0.1	0.5
Selenium	µg/L	1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	18	0	0.01	0.1	0.1	0.05	0.1	0.1
Strontium	µg/L		31	31	30	30	30	29	30	29	30	30	31	30	31	32	32	30	31	29	31	19	0	0	0.87	29	30	30	32	32
Tin			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	18	0	0.02	0.1	0.1	0.06	0.1	0.2
Titanium			<0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	19	19	0	0.02	0.2	0.2	0.10	0.2	0.3
Uranium	µg/L	15	0.03	<0.1	<0.2	<0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	18	0	0.05	0.03	0.1	0.06	0.2	0.3
Vanadium	µg/L	120	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	19	0	0.09	0.1	0.1	0.06	0.1	0.5
Zinc	µg/L	7	<3	0.6	0.6	<0.5	<0.5	1	<0.5	2.8	1.6	0.7	0.8	0.9	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	19	9	0	0.7	0.5	0.5	0.7	2.8	3.0
Radionuclides																														
Lead-210	Bq/L	22	0.04	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	19	16	0	0.004	0.02	0.02	0.01	0.03	0.04
Polonium-210	Bq/L	13.5	0.019	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	19	18	0	0.003	0.005	0.005	0.003	0.006	0.019
Radium-226	Bq/L	0.11	0.010	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.006	0.007	<0.005	0.007	0.008	<0.005	<0.005	0.005	<0.005	19	12	0	0.001	0.005	0.005	0.004	0.008	0.010
Thorium-230	Bq/L	95	<0.0074	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	19	19	0	0.0006	0.01	0.010	0.005	0.010	0.01

Note:

Shaded & Bold indicates that the value is greater than the most stringent applicable SEQG or CCME Guideline.

Yellow Shaded indicates that guideline is hardness dependant.

a) No project threshold for pH; CCME guideline range presented (CCME 1996).

b) Fraction of unionized ammonia calculated based on total ammonia (as N), pH and temperature.

c) Not considered in statistics as MDL is an order of magnitudes larger than remaining samples value or MDL.

d) Computed with half of MDL value.

e) Threshold was calculated for cadmium, copper, lead, nickel, and sulphate based on the maximum hardness observed within the RSA (21 mg/L $CaCO_3$).

f) Threshold for cobalt was calculated using the following formula: exp(0.414(ln(hardness))-1.887), where hardness is in mg/L $CaCO_3$ and the resulting cobalt threshold is in µg/L. Hardness value used in calculation is the 95th percentile hardness value for each lake.

MDL = method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; Bq/L = becquerel per litre; µS/cm = microsiemens per centimeter; NTU = nephelometric turbidity unit.

NexGen Energy Ltd.

Attachment 10A-1a: Detailed Water Quality Tables

Table 10A-1a-8 : Patterson Lake South Arm

Field Program		Project Threshold	Fall 2015	Winter 2016			Spring 2018	Summer 2018	Fall 2018	Winter 2019	Spring 2019	Summer 2019		Fall 2019		Winter 2020	Spring 2020	Summer 2020		Fall 2020		# of Samples	# < MDL	# Above Threshold	SD	Minimum	25th Percentile	Average[d]	95th Percentile	Maximum
Sampling Date			12-Nov-15	11-Mar-16			22-May-18	02-Aug-18	29-Sep-18	21-Feb-19	27-May-19	27-Jul-19	27-Jul-19	30-Sep-19	30-Sep-19	20-Mar-20	06-Jun-20	28-Jul-20	28-Jul-20	25-Sep-20	25-Sep-20									
Sampling Location			PL-WQ03	PL-WQ03	PL-WQ03	PL-WQ03	Patterson Lake South Arm	Patterson Lake South Arm	Patterson Lake South Arm	Patterson Lake South Arm	Patterson Lake South Arm	Patterson Lake South Arm	Patterson Lake South Arm	Patterson Lake South Arm	Patterson Lake South Arm	Patterson Lake South Arm	Patterson Lake South Arm	Patterson Lake South Arm	Patterson Lake South Arm	Patterson Lake South Arm	Patterson Lake South Arm									
Depth				Surface	Mid	Bottom						Top	Bottom	Top	Bottom			Top	Bottom	Top	Bottom									
Depth (m)				1.00	22.00	42.60						5	29	12	36			4	31	11	36									
Field Parameters																														
pH (Field)	-	6.5 - 9.0[a]	7.25	**6.11**	**6.33**	6.90	7.10	7.40	7.30	6.90	7.20	7.40	6.50	7.30	**6.40**	**6.49**	7.53	6.92	7.13	**6.27**	**6.40**	19	0	6	0.44	**6.11**	**6.45**	6.89	7.41	7.53
Temperature (Field)	°C		2.4	0.1	2.0	2.8	8.9	19.8	7.0	2.3	5.4	18.5	6.8	10.5	6.6	2.1	10.3	6.0	16.4	9.5	5.8	19	0	0	5.5	0.1	2.6	7.5	18.6	19.8
Specific Conductivity (Field)	µS/cm		-	79.6	68.7	71.5	40.3	39.1	38.7	44.0	39.6	40.2	40.2	38.8	39.9	33.5	29.5	31.3	29.3	31.2	39.2	18	0	0	14.3	29.3	34.8	43.0	72.7	79.6
Turbidity	NTU		0.5	3.1	3.0	2.5	0.3	0.2	0.4	0.2	0.4	0.3	0.4	0.4	0.3	0.4	0.6	0.4	0.6	0.6	0.6	19	0	0	0.9	0.2	0.4	0.8	3.0	3.1
General Parameters																														
pH	-	6.5 - 9.0[a]	6.79	7.30	7.14	7.05	7.57	7.35	7.62	7.17	7.42	7.42	7.32	7.52	7.41	7.03	7.20	**5.52**	**5.65**	7.35	7.20	19	0	2	0.56	**5.52**	7.10	7.11	7.58	7.62
Specific Conductivity (Lab)	µS/cm		38	44	39	42	31	31	32	35	34	32	33	32	33	35	34	32	34	30	32	19	0	0	4	30	32	34	42	44
Total Solids, Dissolved	mg/L		29	-	-	-	36	41	45	35	33	38	33	32	38	54	37	30	34	35	38	16	0	0	6	29	33	37	47	54
Total Solids, Suspended	mg/L	8.3	<6	<1	<1	<1	<1	2.00	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	19	16	0	1	1	1	1	2	6
Hardness	mg/L $CaCO_3$		16	17	14	15	14	15	15	15	16	16	16	15	16	16	15	15	15	15	15	19	0	0	1	14	15	15	16	17
Alkalinity	mg/L $CaCO_3$		37	37	38	<20	22	22	24	12	25	22	25	24	24	36	18	103	78	23	17	19	1	0	22	12	22	31	80	103
Nutrients																														
Total Ammonia as N	mg/L		-	0.02	0.02	0.06	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	18	13	0	0.01	0.01	0.01	0.01	0.03	0.06
Ammonia as N (un-ionized)[b]	µg/L	16	-	0.002	0.004	0.05	<0.02	<0.1	0.06	<0.008	<0.02	<0.09	<0.005	<0.04	<0.004	<0.003	<0.06	<0.01	0.04	<0.003	<0.003	18	13	0	0.03	0.002	0.004	0.02	0.09	0.10
Dissolved Organic Carbon	mg/L		-	-	-	-	2.1	2.1	2.1	2.2	2.2	2.8	2.4	2.2	2.0	2.2	2.2	2.4	2.0	2.0	1.7	15	0	0	0.2	1.7	2.1	2.2	2.5	2.8
Nitrate (as N)	mg/L	2.90	<0.5[c]	-	-	-	<0.01	<0.01	<0.01	0.07	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	<0.01	0.02	15	13	0	0.02	0.01	0.01	0.01	0.06	0.07
Phosphorus	mg/L	0.02	<0.05[c]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	18	19	0	0.00	0.01	0.01	0.005	0.01	0.01
Major Ions																														
Bicarbonate	mg/L		45.1	45.1	46.3	-	26.8	26.8	29.3	14.6	30.5	26.8	30.5	29.3	29.3	43.9	21.9	125.6	95.1	28.0	20.7	18	0	0	26.9	14.6	26.8	39.8	99.7	125.6
Calcium	mg/L		3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	19	0	0	0.0	3.9	3.9	3.9	3.9	3.9
Chloride	mg/L	120	<1[c]	0.6	0.5	0.5	0.6	0.5	0.6	0.6	0.6	0.5	0.5	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.6	18	1	0	0.05	0.5	0.5	0.6	0.6	0.6
Fluoride	mg/L		<0.1[c]	0.07	0.06	0.06	0.06	0.05	0.06	0.05	0.04	0.07	0.07	0.05	0.05	0.05	0.04	0.04	0.03	0.04	0.04	18	1	0	0.01	0.03	0.04	0.05	0.07	0.07
Magnesium	mg/L		1.395	1.5	1.3	1.4	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.3	1.4	1.3	1.4	19	0	0	0.055	1.3	1.3	1.373	1.41	1.5
Sodium	mg/L		1.4	1.6	1.4	1.4	1.4	1.5	1.4	1.5	1.5	1.5	1.5	1.4	1.4	1.5	1.4	1.4	1.4	1.4	1.4	19	0	0	0.059	1.4	1.4	1.442	1.51	1.6
Sulphate	mg/L	128[e]	-	1.9	1.6	2.1	1.6	1.6	1.6	1.6	1.7	1.5	1.5	1.5	1.6	1.5	1.5	1.5	1.6	1.4	1.6	18	0	0	0.2	1.4	1.5	1.6	1.9	2.1
Total Metals																														
Aluminum	µg/L	100	<3	-	-	-	8.2	2.1	1.4	1.0	0.9	1.0	1.0	1.4	2.4	2.0	0.6	1.6	3.8	1.5	1.0	16	1	0	1.8	0.6	1.0	2.0	4.9	8.2
Arsenic	µg/L	5	**23.1**	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	19	2	1	5.1	0.1	0.1	1.3	2.4	**23.1**
Barium	µg/L		9.8	11.0	9.8	12.0	10.0	8.9	10.0	10.0	9.7	8.6	10.0	8.7	12.0	11.0	10.0	8.2	10.0	8.8	11.0	19	0	0	1.0	8.2	9.3	10.0	12.0	12.0
Beryllium	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	19	0	0.0	0.1	0.1	0.05	0.1	0.1
Boron	µg/L		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	<10	<10	19	18	0	0	10	10	5	10	10
Cadmium	µg/L	0.017[e]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	19	18	0	0.00	0.01	0.01	0.005	0.01	0.01
Cesium	µg/L		0.01	-	-	-	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	13	12	0	0.02	0.01	0.1	0.05	0.1	0.1
Chromium	µg/L	1	<0.1	0.5	0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	19	15	0	0.09	0.1	0.5	0.3	0.5	0.5
Cobalt	µg/L	0.5[f]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	15	0	0.0	0.1	0.1	0.06	0.1	0.1
Copper	µg/L	2[e]	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	19	15	0	0.07	0.2	0.2	0.1	0.2	0.5
Iron	µg/L	300	14	1	9	13	21	11	18	15	24	12	17	14	13	23	31	16	17	20	17	19	0	0	6.1	1.2	13.0	16.1	24.7	31.0
Lead	µg/L	1[e]	0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	15	0	0.01	0.1	0.1	0.06	0.1	0.1
Manganese	µg/L	260	10.2	0.8	2.8	26.0	30.0	5.1	21.0	13.0	37.0	5.2	14.0	8.0	26.0	91.0	42.0	3.7	23.0	8.4	34.0	19	0	0	20.5	0.8	6.6	21.1	46.9	91.0
Mercury	µg/L	0.026	-	0.001	0.001	0.001	0.002	0.005	<0.001	0.003	0.001	0.003	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	18	9	0	0.001	0.001	0.001	0.001	0.003	0.005
Molybdenum	µg/L	31.000	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	18	0	0.003	0.1	0.1	0.05	0.1	0.1
Nickel	µg/L	25[e]	<10.2	<0.8	<2.8	**26.0**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	15	1	6.1	0.1	0.1	2.1	11.8	**26.0**
Selenium	µg/L	1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	19	0	0.1	0.1	0.1	0.06	0.1	0.5
Strontium	µg/L		31	34	29	32	30	30	30	31	30	30	30	29	31	34	32	34	31	30	31	19	0	0	2	29	30	31	34	34
Tin	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	18	0	0.2	0.1	0.1	0.1	0.2	1.0
Titanium	µg/L		<0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	19	19	0	0.02	0.2	0.2	0.1	0.2	0.3
Uranium	µg/L	15	0.1	<0.1	<0.1	<0.1	<0.1	0.20	0.10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	16	0	0.03	0.1	0.1	0.06	0.1	0.2
Vanadium	µg/L	120	0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	18	0	0.09	0.1	0.1	0.07	0.1	0.5
Zinc	µg/L	7	<3	<0.5	0.6	<0.5	<0.5	2.0	0.6	0.6	1.9	1.1	0.7	0.8	1.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	19	10	0	0.7	0.5	0.5	0.7	2.1	3.0
Radionuclides																														
Lead-210	Bq/L	22	0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	19	18	0	0.004	0.02	0.02	0.01	0.02	0.04
Polonium-210	Bq/L	13.5	0.019	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.006	19	18	0	0.003	0.005	0.005	0.003	0.007	0.019
Radium-226	Bq/L	0.11	0.010	<0.005	<0.005	<0.005	<0.005	0.01	<0.005	<0.005	<0.005	<0.005	0.007	0.009	<0.005	<0.005	0.010	<0.005	<0.005	<0.005	<0.005	19	14	0	0.002	0.005	0.005	0.004	0.010	0.010
Thorium-230	Bq/L	95	<0.0074	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	19	19	0	0.0006	0.01	0.01	0.005	0.01	0.01

Note:

Shaded & Bold indicates that the value is greater than the most stringent applicable SEQG or CCME Guideline.

Yellow Shaded indicates that guideline is hardness dependant.

a) No project threshold for pH; CCME guideline range presented (CCME 1996).

b) Fraction of unionized ammonia calculated based on total ammonia (as N), pH and temperature.

c) Not considered in statistics as MDL is an order of magnitudes larger than remaining samples value or MDL.

d) Computed with half of MDL value.

e) Threshold was calculated for cadmium, copper, lead, nickel, and sulphate based on the maximum hardness observed within the RSA (21 mg/L $CaCO_3$).

f) Threshold for cobalt was calculated using the following formula: exp(0.414(ln(hardness))-1.887), where hardness is in mg/L $CaCO_3$ and the resulting cobalt threshold is in µg/L. Hardness value used in calculation is the 95th percentile hardness value for each lake.

MDL = method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; Bq/L = becquerel per litre; µS/cm = microsiemens per centimeter; NTU = nephelometric turbidity unit.

Table 10A-1a-9 : Clearwater River below Patterson Lake

Date		Project Threshold	Spring 2016	# of Samples	# < MDL	# Above Threshold
Sampling Date			17-Mar-16			
Sampling Location			STM-05			
Depth			-			
Depth (m)						
Field Parameters						
pH (Field)	-	6.5 - 9.0[a]	-	0	0	0
Temperature (Field)	°C		-	0	0	N/A
Specific Conductivity (Field)	µS/cm		-	0	0	N/A
Turbidity	NTU		-	0	0	N/A
General Parameters						
Specific Conductivity (Lab)	µS/cm		46	1	0	N/A
Total Solids, Dissolved	mg/L		39	1	0	N/A
Total Solids, Suspended	mg/L	8.3	5	1	0	N/A
Hardness	mg/L $CaCO_3$		18	1	0	N/A
Alkalinity	mg/L $CaCO_3$		20	1	0	0
Nutrients						
Total Ammonia as N	mg/L		0.01	1	1	N/A
Ammonia as N (un-ionized)[b]	µg/L	16	0.001[c]	1	0	0
Dissolved Organic Carbon	mg/L		-	-	-	-
Nitrate (as N)	mg/L	2.90	-	0	0	0
Phosphorus	mg/L	0.02	0.01	1	1	0
Major Ions						
Bicarbonate	mg/L		24.4	1	0	N/A
Calcium	mg/L		4.4	1	0	N/A
Chloride	mg/L	120	0.600	1	0	0
Fluoride	mg/L		0.05	1	0	N/A
Magnesium	mg/L		1.600	1	0	N/A
Sodium	mg/L		1.600	1	0	N/A
Sulphate	mg/L	128[d]	1.9	1	0	0
Total Metals						
Aluminium	µg/L	100	0.0	0	0	0
Arsenic	µg/L	5	0.1	1	0	0
Barium	µg/L		12.5	1	0	N/A
Beryllium	µg/L		<0.1	1	1	N/A
Boron	µg/L		<10	1	1	N/A
Cadmium	µg/L	0.017[d]	0.01	1	0	0
Cobalt	µg/L	0.5[e]	<0.1	1	1	N/A
Copper	µg/L	2[d]	<0.2	1	1	0
Iron	µg/L	300	203	1	0	0
Lead	µg/L	1[d]	0.1	1	0	0
Manganese	µg/L	260	7.5	1	0	N/A
Mercury	µg/L	0.026	0.001	1	1	0
Molybdenum	µg/L	31,000	<0.1	1	1	0
Nickel	µg/L	25[d]	<0.1	1	1	0
Selenium	µg/L	1	<0.1	1	1	0
Strontium	µg/L		36	1	0	N/A
Tin	µg/L		<0.1	1	0	N/A
Titanium	µg/L		0.2	1	0	N/A
Uranium	µg/L	15	<0.1	1	1	0
Vanadium	µg/L	120	<0.1	1	1	N/A
Zinc	µg/L	7	<0.5	1	1	0
Radionuclides						
Lead-210	Bq/L	22	0.02	1	1	0
Polonium-210	Bq/L	13.5	0.005	1	1	0
Radium-226	Bq/L	0.11	0.007	1	0	0
Thorium-230	Bq/L	95	0.01	1	1	0

Note:

Shaded & Bold	indicates that the value is greater than the most stringent applicable SEQG or CCME Guideline.
Yellow Shaded	indicates that guideline is hardness dependant.

a) No project threshold for pH; CCME guideline range presented (CCME 1996).

b) Fraction of unionized ammonia calculated based on total ammonia (as N), pH and temperature.

c) Computed with surface temperature and pH of Patterson Lake on same day due to site specific data not available.

d) Threshold was calculated for cadmium, copper, lead, nickel, and sulphate based on the maximum hardness observed within the RSA (21 mg/L $CaCO_3$).

e) Threshold for cobalt was calculated using the following formula: exp(0.414(ln(hardness))-1.887), where hardness is in mg/L $CaCO_3$ and the resulting cobalt threshold is in µg/L. Hardness value used in calculation is the 95th percentile hardness value for each lake.

MDL = method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; Bq/L = becquerel per litre; µS/cm = microsiemens per centimeter; NTU = nephelometric turbidity unit.

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Table 10A-1a-10 : Forrest Lake- North Basin

Area		Project Threshold	Fall 2015	Winter 2016			Spring 2018	Summer 2018	Fall 2018	Winter 2019	Spring 2019	Summer 2019	Fall 2019	Winter 2020	Spring 2020	Summer 2020	Fall 2020
Sampling Date			11-Nov-15	13-Mar-16	13-Mar-16	13-Mar-16	23-May-18	03-Aug-18	10-Oct-18	20-Feb-19	25-May-19	30-Jul-19	26-Sep-19	21-Mar-20	07-Jun-20	25-Jul-20	25-Sep-20
Sampling Location			Forrest Lake Area 1	Forrest Lake Area 1	Forrest Lake Area 1	Forrest Lake Area 1	Forrest Lake Area 1	Forrest Lake Area 1	Forrest Lake Area 1	Forrest Lake Area 1	Forrest Lake Area 1	Forrest Lake Area 1	Forrest Lake Area 1	Forrest Lake Area 1	Forrest Lake Area 1	Forrest Lake Area 1	Forrest Lake Area 1
Depth				Surface	Mid	Bottom											
Depth (m)				1.50	37.00	71.80											
Field Parameters																	
pH (Field)	-	6.5 - 9.0[a]	7.47	7.06	6.82	**6.45**	7.40	7.70	8.20	6.60	7.37	7.60	6.88	7.19	7.24	7.24	7.01
Temperature (Field)	°C		0.0	0.8	3.0	3.6	15.0	22.4	3.2	0.2	10.1	18.9	8.2	0.2	7.3	19.1	10.4
Specific Conductivity (Field)	µS/cm		51.2	82.8	78.1	160.2	41.8	39.3	43.1	48.5	39.9	40.0	39.2	45.2	40.4	38.5	37.7
Turbidity	NTU		-	3.3	3.4	18.5	0.4	0.3	0.4	0.3	0.6	0.5	0.3	0.4	1.4	0.9	0.7
General Parameters																	
pH	-	6.5 - 9.0[a]	6.86	7.27	7.32	7.11	7.53	7.26	7.40	7.17	7.40	7.44	7.48	7.11	7.48	7.31	7.27
Specific Conductivity (Lab)	µS/cm		48	52	49	48	33	33	37	38	35	33	33	38	35	32	30
Total Solids, Dissolved	mg/L		-	40	37	39	45	37	31	46	57	38	34	49	22	31	30
Total Solids, Suspended	mg/L	8.3	<6	<1	<1	<1	1	2	<1	<1	<1	<1	1	<1	4	<1	<1
Hardness	mg/L $CaCO_3$		19.4	18.5	18	18	14	14	15	18	16	15	16	17	15	15	15
Alkalinity	mg/L $CaCO_3$		23	22	-	-	26	18	23	24	23	22	24	21	21	17	16
Nutrients																	
Total Ammonia as N	mg/L		-	0.03	0.01	0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia as N (un-ionized)[b]	µg/L	16	-	0.030	0.007	0.003	<0.07	<0.2	<0.2	0.007	<0.04	<0.1	<0.01	<0.01	<0.03	<0.06	<0.02
Dissolved Organic Carbon	mg/L		-	-	-	-	2.4	2.6	2.3	2.6	2.7	2.6	2.3	2.5	1.9	2.7	2.0
Nitrate (as N)	mg/L	2.90	<0.5[c]	-	-	-	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphorus	mg/L	0.02	<0.05[c]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Major Ions																	
Bicarbonate	mg/L		28.0	26.8	-	-	31.7	21.9	28.0	29.3	28.0	26.8	29.3	25.6	25.6	20.7	19.5
Calcium	mg/L		4.38	4.7	4.3	4.5	3.7	3.7	3.8	4.4	4.1	3.9	4	4.3	3.8	3.8	3.5
Chloride	mg/L	120	<1[c]	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.5	0.6	0.7	0.6	0.6	0.6
Fluoride	mg/L		<0.01[c]	0.08	0.08	0.08	0.06	0.05	0.05	0.06	0.04	0.08	0.05	0.06	0.04	0.04	0.04
Magnesium	mg/L		1.73	1.8	1.7	1.7	1.3	1.3	1.4	1.6	1.4	1.4	1.4	1.6	1.4	1.4	1.5
Sodium	mg/L		2.03	2	1.9	1.9	1.6	1.5	1.4	1.6	1.5	1.5	1.5	1.6	1.5	1.4	1.4
Sulphate	mg/L	128[e]	-	1.8	1.6	1.7	1.6	1.5	1.6	1.7	1.6	1.6	1.6	1.7	1.5	1.5	1.4
Total Metals																	
Aluminum	µg/L	100	6.1	-	-	-	12.0	6	4.8	3.9	7.9	5.3	11	3.1	6.5	8.4	2.5
Arsenic	µg/L	5	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	<0.1
Barium	µg/L		8.8	8.5	7.6	8.6	8.8	8.3	9.9	12	9.4	7.7	8.7	11	9.9	8.7	9
Beryllium	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Boron	µg/L		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cadmium	µg/L	0.017[e]	0.01	0.01	0.01	0.01	0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Cesium	µg/L		0.01	-	-	-	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	µg/L	1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cobalt	µg/L	0.5[f]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Copper	µg/L	2[e]	<0.5	<0.2	<0.2	1.4	<0.2	<0.2	<0.2	1.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Iron	µg/L	300	112	1.6	3.8	33	54	39	27	60	46	33	50	18	79	56	31
Lead	µg/L	1[e]	0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	µg/L	260	6.5	0.8	1.8	22.0	8.6	8.2	8.0	3.5	15.0	7.2	6.9	2.0	30.0	12.0	8.2
Mercury	µg/L	0.026	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	0.002	<0.001	0.001	0.001	<0.001	<0.001
Molybdenum	µg/L	31,000	0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	µg/L	25[e]	<0.5	<0.1	<0.1	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium	µg/L	1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Strontium	µg/L		32	33	31	33	30	30	32	34	30	30	30	36	32	31	30
Tin	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Titanium	µg/L		<0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2
Uranium	µg/L	15	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	µg/L	120	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	µg/L	7	<3	0.6	<0.5	<0.5	<0.5	<0.5	1.10	1.8	1.7	0.7	0.7	1.0	<0.5	1.0	<0.5
Radionuclides																	
Lead-210	Bq/L	22	0.037	0.02	0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Polonium-210	Bq/L	13.5	0.019	0.005	0.005	0.005	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Radium-226	Bq/L	0.11	0.01	0.005	0.005	0.005	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	0.006
Thorium-230	Bq/L	95	<0.0074	0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Parameter	# of Samples	# < MDL	# Above Threshold	SD	Minimum	25th Percentile	Average[d]	95th Percentile	Maximum
Field Parameters									
pH (Field)	15	0	1	0.43	**6.45**	6.94	7.22	7.85	8.20
Temperature (Field)	14	0	N/A	7.3	0.2	3.1	8.7	20.3	22.4
Specific Conductivity (Field)	15	0	N/A	31.2	37.7	39.6	55.1	106.0	160.2
Turbidity	14	0	N/A	4.6	0.3	0.4	2.2	8.7	18.5
General Parameters									
pH	15	0	0	0.17	6.86	7.22	7.29	7.50	7.53
Specific Conductivity (Lab)	15	0	N/A	7	30	33	38	50	52
Total Solids, Dissolved	14	0	N/A	9	22	32	38	52	57
Total Solids, Suspended	15	7	0	1	1	1	1	5	6
Hardness	15	0	N/A	2	14	15	16	19	19
Alkalinity	13	0	N/A	3	16	21	21	25	26
Nutrients									
Total Ammonia as N	14	10	N/A	0.006	0.01	0.01	0.009	0.02	0.03
Ammonia as N (un-ionized)[b]	14	10	0	0.06	0.003	0.01	0.03	0.20	0.20
Dissolved Organic Carbon	11	0	N/A	0.3	1.9	2.3	2.4	2.7	2.7
Nitrate (as N)	11	11	0	0.003	0.01	0.01	0.006	0.02	0.02
Phosphorus	14	14	0	0.00	0.01	0.01	0.005	0.01	0.01
Major Ions									
Bicarbonate	13	0	N/A	3.69	19.5	23.8	26.0	30.5	31.7
Calcium	15	0	N/A	0.341	3.5	3.8	4.1	4.6	4.7
Chloride	14	1	0	0.06	0.5	0.6	0.6	0.7	0.7
Fluoride	14	1	N/A	0.02	0.04	0.04	0.06	0.08	0.08
Magnesium	15	0	N/A	0.2	1.3	1.4	1.5	1.8	1.8
Sodium	15	0	N/A	0.2	1.4	1.5	1.6	2.0	2.0
Sulphate	14	0	0	0.1	1.4	1.5	1.6	1.7	1.8
Total Metals									
Aluminum	12	0	0	2.8	2.5	4.6	6.5	11.5	12.0
Arsenic	15	1	0	0.05	0.1	0.1	0.1	0.2	0.2
Barium	15	0	N/A	1.1	7.6	8.6	9.1	11.3	12.0
Beryllium	15	15	N/A	0.0	0.1	0.1	0.05	0.1	0.1
Boron	15	15	N/A	0	10	10	5	10	10
Cadmium	15	7	0	0.001	0.01	0.01	0.007	0.01	0.01
Cesium	9	8	N/A	0.03	0.01	0.1	0.05	0.1	0.1
Chromium	15	15	0	0.1	0.1	0.5	0.2	0.5	0.5
Cobalt	15	15	0	0.0	0.1	0.1	0.05	0.1	0.1
Copper	15	13	0	0.4	0.2	0.2	0.3	1.4	1.4
Iron	15	0	0	27	2	29	43	89	112
Lead	15	11	0	0.01	0.1	0.1	0.06	0.1	0.1
Manganese	15	0	0	7.6	0.8	5.0	9.4	24.4	30.0
Mercury	14	9	0	0.0004	0.001	0.001	0.0009	0.002	0.002
Molybdenum	15	8	0	0.008	0.1	0.1	0.07	0.1	0.1
Nickel	15	11	0	0.1	0.1	0.1	0.1	0.4	0.5
Selenium	15	11	0	0.01	0.1	0.1	0.06	0.1	0.1
Strontium	15	0	N/A	2	30	30	32	35	36
Tin	15	15	N/A	0.0	0.1	0.1	0.05	0.1	0.1
Titanium	15	13	N/A	0.02	0.2	0.2	0.1	0.2	0.3
Uranium	15	12	0	0.0	0.1	0.1	0.06	0.1	0.1
Vanadium	15	15	0	0.1	0.1	0.1	0.06	0.2	0.5
Zinc	15	7	0	0.7	0.5	0.5	0.8	2.2	3.0
Radionuclides									
Lead-210	15	11	0	0.004	0.02	0.02	0.01	0.03	0.04
Polonium-210	15	10	0	0.003	0.005	0.005	0.004	0.010	0.019
Radium-226	15	8	0	0.001	0.005	0.005	0.004	0.007	0.010
Thorium-230	15	11	0	0.0006	0.01	0.01	0.006	0.01	0.01

Note:

Shaded & Bold indicates that the value is greater than the most stringent applicable SEQG or CCME Guideline.

Yellow Shaded indicates that guideline is hardness dependant.

a) No project threshold for pH; CCME guideline range presented (CCME 1996).

b) Fraction of unionized ammonia calculated based on total ammonia (as N), pH and temperature.

c) Not considered in statistics as MDL is an order of magnitudes larger than remaining samples value or MDL.

d) Computed with half of MDL value.

e) Threshold was calculated for cadmium, copper, lead, nickel, and sulphate based on the maximum hardness observed within the RSA (21 mg/L $CaCO_3$).

f) Threshold for cobalt was calculated using the following formula: exp(0.414(ln(hardness))-1.887), where hardness is in mg/L $CaCO_3$ and the resulting cobalt threshold is in µg/L. Hardness value used in calculation is the 95th percentile hardness value for each lake.

MDL = method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; Bq/L = becquerel per litre; µS/cm = microsiemens per centimeter; NTU = nephelometric turbidity unit.

Table 10A-1a-11 : Forrest Lake- South Basin

Area		Project Threshold	Winter 2015	Spring 2016			Spring 2018	Summer 2018	Fall 2018	Winter 2019	Spring 2019		Summer 2019		Fall 2019	Winter 2020	Spring 2020	Summer 2020		Fall 2020	# of Samples	# < MDL	# Above Threshold	SD	Minimum	25th Percentile	Average[d]	95th Percentile	Maximum
Sampling Date			11-Nov-15	13-Mar-16			23-May-18	03-Aug-18	01-Oct-18	20-Feb-19	29-May-19	29-May-19	29-Jul-19	29-Jul-19	02-Oct-19	22-Mar-20	08-Jun-20	25-Jul-20	25-Jul-20	23-Sep-20									
Sampling Location			Forrest Lake Area 2	Forrest Lake Area 2	Forrest Lake Area 2	Forrest Lake Area 2	Forrest Lake Area 2	Forrest Lake Area 2	Forrest Lake Area 2	Forrest Lake Area 2	Forrest Lake Area 2	Forrest Lake Area 2	Forrest Lake Area 2	Forrest Lake Area 2	Forrest Lake Area 2	Forrest Lake Area 2	Forrest Lake Area 2	Forrest Lake Area 2	Forrest Lake Area 2	Forrest Lake Area 2									
Depth				Surface	Mid	Bottom					Top	Bottom	Top	Bottom				Top	Bottom										
Depth (m)				1.20	26.00	53.25					1	10	6	18				5	18										
Field Parameters																													
pH (Field)	-	6.5 - 9.0[a]	7.26	**5.83**	6.66	**6.35**	7.20	7.90	7.50	6.90	7.60	7.50	7.53	7.31	7.60	6.71	7.36	7.69	7.18	7.36	18	0	2	0.51	**5.83**	6.97	7.19	7.72	7.90
Temperature (Field)	°C		2.1	0.2	2.8	3.5	5.6	14.5	6.6	1.4	8.2	4.7	17.0	7.5	9.6	1.3	4.8	16.2	6.7	10.5	18	0	N/A	4.9	0.2	3.0	6.8	16.3	17.0
Specific Conductivity (Field)	µS/cm		49.3	96.3	90.6	91.8	48.9	47.8	47.1	50.2	46.7	47.3	49.0	48.4	47.2	50.8	49.0	47.2	47.4	46.7	18	0	N/A	16.7	46.7	47.2	55.6	92.5	96.3
Turbidity	NTU		-	3.3	3.3	6.0	0.2	0.2	0.4	0.2	0.4	0.3	0.2	0.3	0.3	0.2	0.3	1.3	0.4	0.4	17	0	N/A	1.6	0.2	0.2	1.0	3.8	6.0
General Parameters																													
pH	-	6.5 - 9.0[a]	6.83	7.39	7.26	7.34	7.66	7.37	7.40	7.35	7.52	7.50	7.5	7.48	7.46	7.19	7.49	7.55	7.61	7.45	18	0	0	0.10	7.19	7.44	7.46	7.58	7.61
Specific Conductivity (Lab)	µS/cm		47	56	47	56	40	40	37	43	41	42	42	42	43	45	42	40	42	39	18	0	N/A	5	37	40	44	56	56
Total Solids, Dissolved	mg/L		-	41	39	44	43	44	31	52	58	55	46	50	40	62	50	33	30	35	17	0	N/A	9	30	39	44	59	62
Total Solids, Suspended	mg/L	8.3	<6	<1	<1	<1	<1	2	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	18	13	0	1	1	1	1	3	6
Hardness	mg/L $CaCO_3$		18.5	19	18	21	17	18	15	18	18	18	19	18	18	19	18	18	18	18	18	0	N/A	1	15	18	18	19	21
Alkalinity	mg/L $CaCO_3$		23	22	-	-	28	23	23	26	24	27	22	22	24	31	23	23	23	30	16	0	N/A	3	22	23	25	30	31
Nutrients																													
Total Ammonia as N	mg/L		-	0.020	0.010	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	17	13	N/A	0.003	0.01	0.01	0.007	0.02	0.02
Ammonia as N (un-ionized)[b]	µg/L	16	-	-[e]	0.0047	0.0025	0.0207	0.2045	0.0446	0.0074	0.0637	0.0383	0.1064	0.0310	0.0711	0.0047	0.0280	0.1443	0.0432	0.0441	16	0	0	0.05	0.002	0.02	0.06	0.16	0.20
Dissolved Organic Carbon	mg/L		-	-	-	-	1.4	1.5	2.3	1.5	1.2	1.4	2.0	1.9	1.4	1.5	1.8	1.3	1.3	1.3	14	0	N/A	0.3	1.2	1.3	1.6	2.1	2.3
Nitrate (as N)	mg/L	2.90	<0.5[c]	-	-	-	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	14	13	0	0.003	0.01	0.01	0.006	0.01	0.02
Phosphorus	mg/L	0.02	<0.05[c]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	17	17	0	0	0.01	0.01	0.005	0.01	0.01
Major Ions																													
Bicarbonate	mg/L		28.0	26.8	-	-	34.1	28.0	28.0	31.7	29.3	32.9	26.8	26.8	29.3	37.8	28.0	28.0	28.0	36.6	16	0	N/A	3.55	26.8	28.0	30.3	37.1	37.8
Calcium	mg/L		4.18	4.8	4.3	5.1	4.1	4.4	3.8	4.5	4.6	4.6	4.5	4.5	4.4	4.7	4.4	4.4	4.5	4.4	18	0	N/A	0.21	3.8	4.4	4.5	4.8	5.1
Chloride	mg/L	120	<1[c]	0.8	0.8	0.9	0.9	0.7	0.6	0.8	0.7	0.8	0.7	0.7	0.8	0.9	0.7	0.8	0.8	0.8	17	1	0	0.08	0.6	0.7	0.8	0.9	0.9
Fluoride	mg/L		<0.1[c]	0.085	0.08	0.09	0.07	0.07	0.05	0.07	0.06	0.06	0.10	0.10	0.07	0.08	0.05	0.04	0.04	0.06	17	1	N/A	0.02	0.04	0.06	0.07	0.10	0.10
Magnesium	mg/L		1.68	1.8	1.7	2	1.6	1.6	1.4	1.7	1.7	1.7	1.8	1.7	1.7	1.8	1.6	1.7	1.7	1.6	18	0	N/A	0.1	1.4	1.6	1.7	1.8	2.0
Sodium	mg/L		1.9	2.1	1.9	2.2	2.0	2.0	1.4	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.9	2.0	1.9	18	0	N/A	0.2	1.4	1.9	2.0	2.1	2.2
Sulphate	mg/L	128[f]	-	1.9	1.7	2.3	<2	1.7	1.6	1.7	1.8	1.8	1.8	1.8	1.6	1.7	1.6	1.6	1.6	1.7	17	0	0	0.2	1.6	1.6	1.7	2.0	2.3
Total Metals																													
Aluminum	µg/L	100	3.4	-	-	-	3.7	3.0	4.8	1.1	<0.5	1.5	1.0	1.0	1.7	1.0	1.0	1.7	1.3	4.0	15	1	0	1.3	0.5	1.0	2.0	4.2	4.8
Arsenic	µg/L	5	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.1	0.1	18	0	0	0.04	0.1	0.1	0.17	0.2	0.2
Barium	µg/L		7.7	9.3	7.6	9.3	7.5	7.7	9.9	8.5	7.5	7.9	7.6	7.8	7.5	8.9	8.2	7.4	8.0	7.4	18	0	N/A	0.7	7.4	7.5	8.1	9.4	9.9
Beryllium	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	18	18	N/A	0.0	0.1	0.1	0.05	0.1	0.1
Boron	µg/L		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	18	18	N/A	0	10	10	5	10	10
Cadmium	µg/L	0.017[f]	0.01	0.01	0.01	0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	18	12	0	0.001	0.01	0.01	0.006	0.01	0.01
Cesium	µg/L		0.01	-	-	-	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	11	N/A	0.02	0.01	0.1	0.05	0.1	0.1
Chromium	µg/L	1	<0.1	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	17	14	0	0.09	0.1	0.5	0.27	0.5	0.5
Cobalt	µg/L	0.5[g]	0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	18	14	0	0.09	0.1	0.1	0.08	0.2	0.5
Copper	µg/L	2[f]	<0.5	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	18	13	0	0.07	0.1	0.2	0.1	0.2	0.5
Iron	µg/L	300	261	0.2	3	1	18	12	27	5	11	10	10	13	12	14	15	8	1	10	18	0	0	58	0.2	6	24	62	261
Lead	µg/L	1[f]	0.1	**4.0**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	18	14	1	0.9	0.1	0.1	0.3	0.7	**4.0**
Manganese	µg/L	260	13.1	0.9	1.4	0.8	7.8	4.1	8.0	0.9	4.0	5.7	2.4	4.0	2.7	1.3	8.7	2.3	<0.5	2.1	18	1	0	3.4	0.5	1.3	3.9	9.4	13.1
Mercury	µg/L	0.026	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	0.002	0.004	0.003	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	17	11	0	0.0008	0.001	0.001	0.001	0.003	0.004
Molybdenum	µg/L	31,000	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	18	17	0	0.007	0.1	0.1	0.05	0.1	0.1
Nickel	µg/L	25[f]	<0.5	<0.1	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	18	17	0	0.1	0.1	0.1	0.08	0.3	0.5
Selenium	µg/L	1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	18	14	0	0.01	0.1	0.1	0.06	0.1	0.1
Strontium	µg/L		31	38	30	37	31	31	32	31	30	31	31	31	31	34	32	32	32	31	18	0	N/A	2	30	31	32	37	38
Tin	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.8	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	18	16	N/A	0.2	0.1	0.1	0.1	0.3	0.8
Titanium	µg/L		0.3	0.25	0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	18	14	N/A	0.02	0.2	0.2	0.1	0.3	0.3
Uranium	µg/L	15	0.01	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	18	13	0	0.02	0.01	0.1	0.06	0.1	0.1
Vanadium	µg/L	120	<0.5	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	17	17	0	0.09	0.1	0.1	0.06	0.2	0.5
Zinc	µg/L	7	3	3.2	<0.5	<0.5	<0.5	<0.5	1.1	0.9	2.6	1.6	1.0	0.8	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	18	7	0	0.9	0.5	0.5	1.0	3.0	3.2
Radionuclides																													
Lead-210	Bq/L	22	0.04	0.02	0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	18	13	0	0.004	0.02	0.02	0.01	0.02	0.04
Polonium-210	Bq/L	13.5	0.019	0.005	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	18	14	0	0.003	0.005	0.005	0.004	0.007	0.019
Radium-226	Bq/L	0.11	0.010	<0.0050	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	0.007	<0.005	<0.005	0.009	<0.005	<0.005	<0.005	18	11	0	0.001	0.005	0.005	0.004	0.009	0.010
Thorium-230	Bq/L	95	<0.0074	0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	18	14	0	0.0006	0.01	0.01	0.006	0.01	0.01

Note:

Shaded & Bold indicates that the value is greater than the most stringent applicable SEQG or CCME Guideline.

Yellow Shaded indicates that guideline is hardness dependant.

a) No project threshold for pH; CCME guideline range presented (CCME 1996).

b) Fraction of unionized ammonia calculated based on total ammonia (as N), pH and temperature.

c) Not considered in statistics as MDL is an order of magnitudes larger than remaining samples value or MDL.

d) Computed with half of MDL value.

e) Unionized ammonia fraction could not be calculated due to pH being out of range.

f) Threshold was calculated for cadmium, copper, lead, nickel, and sulphate based on the maximum hardness observed within the RSA (21 mg/L $CaCO_3$).

g) Threshold for cobalt was calculated using the following formula: exp(0.414(ln(hardness))-1.887), where hardness is in mg/L $CaCO_3$ and the resulting cobalt threshold is in µg/L. Hardness value used in calculation is the 95th percentile hardness value for each lake.

MDL = method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; Bq/L = becquerel per litre; µS/cm = microsiemens per centimeter; NTU = nephelometric turbidity unit.

NexGen Energy Ltd.

Table 10A-1a-12 : Beet Lake

Date		Project Threshold	Winter 2015	Spring 2016			Spring 2018	Summer 2018	Fall 2018	Winter 2019	Spring 2019	Summer 2019		Fall 2019	Winter 2020	Spring 2020	Summer 2020		Fall 2020	# of Samples	# < MDL	# Above Threshold	SD	Minimum	25th Percentile	Average[e]	95th Percentile	Maximum
Sampling Date			11-Nov-15	14-Mar-16	14-Mar-16	14-Mar-16	23-May-18	03-Aug-18	02-Oct-18	23-Feb-19	26-May-19	29-Jul-19	29-Jul-19	01-Oct-19	22-Mar-20	08-Jun-20	26-Jul-20	26-Jul-20	23-Sep-20									
Sampling Location			Beet Lake Area 1	Beet Lake Area 1	Beet Lake Area 1	Beet Lake Area 1	Beet Lake Area 1	Beet Lake Area 1	Beet Lake Area 1	Beet Lake Area 1	Beet Lake Area 1	Beet Lake Area 1	Beet Lake Area 1	Beet Lake Area 1	Beet Lake Area 1	Beet Lake Area 1	Beet Lake Area 1	Beet Lake Area 1	Beet Lake Area 1									
Depth				Top	Mid	Bottom						Top	Bottom				Top	Bottom										
Depth (m)				1.20	12.00	22.70						4	22				3	23										
Field Parameters																												
pH (Field)	-	6.5 - 9.0[a]	7.41	**6.38**	**6.25**	**5.94**	7.20	7.60	7.40	6.60	7.28	7.64	**6.28**	7.30	6.61	7.22	7.75	**6.48**	7.09	17	0	5	0.55	**5.94**	**6.46**	6.97	7.67	7.75
Temperature (Field)	°C		2.3	1.0	1.6	1.9	6.6	11.1	5.7	1.7	6.4	18.7	7.1	9.6	1.6	6.4	18.2	6.5	10.4	17	0	N/A	5.3	1.0	1.9	6.9	18.3	18.7
Specific Conductivity (Field)	µS/cm		45.9	84.7	82.0	79.2	44.5	44.6	43.7	48.7	43.5	45.3	45.4	43.7	47.7	44.2	42.7	43.4	42.5	17	0	N/A	14.3	42.5	43.6	51.3	82.7	84.7
Turbidity	NTU		-	3.0	3.0	12.4	0.7	0.4	0.6	0.2	0.8	0.4	0.8	1.1	3.3	1.0	1.4	0.8	0.9	16	0	N/A	2.9	0.2	0.7	1.9	5.6	12.4
General Parameters																												
pH	-	6.5 - 9.0[a]	6.84	7.20	7.16	7.07	7.53	7.32	7.68	7.17	7.39	7.46	7.20	7.54	6.97	7.46	7.53	7.31	7.35	17	0	0	0.18	6.97	7.28	7.37	7.60	7.68
Specific Conductivity (Lab)	µS/cm		43	45	45	45	36	37	37	39	38	38	38	38	44	37	36	38	36	17	0	N/A	3	36	37	39	45	45
Total Solids, Dissolved	mg/L			36	34	38	42	44	54	50	46	40	42	39	50	40	22	26	40	16	0	N/A	8	22	38	40	51	54
Total Solids, Suspended	mg/L	8.3	<6	<1	<1	<1	2	2	<1	<1	<1	<1	2	<1	2	1	<1	<1	<1	17	12	0	1	1	1	1	2	2
Hardness	mg/L $CaCO_3$		18	17	17	18	15	16	17	18	18	17	18	17	18	16	16	17	16	17	0	N/A	1	15	16	17	18	18
Alkalinity	mg/L $CaCO_3$		21	-	-	-	24	21	21	22	26	20	24	25	28	22	20	21	28	14	0	N/A	3	20	21	23	28	28
Nutrients																												
Total Ammonia as N	mg/L		-	0.03	0.02	0.02	<0.01	<0.01	0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.30	<0.01	<0.01	0.04	<0.01	16	9	N/A	0.07	0.01	0.01	0.03	0.11	0.30
Ammonia as N (un-ionized)[b]	µg/L	16	-	0.006	0.003	-[d]	<0.02	<0.08	0.03	0.008	<0.03	<0.2	<0.003	<0.04	0.12	<0.02	<0.2	0.020	<0.02	15	9	0	0.06	0.003	0.01	0.03	0.20	0.20
Dissolved Organic Carbon	mg/L		-	-	-	-	1.9	2.1	2.1	2.1	2	2.8	2.4	2.0	2.0	2.4	2.2	2.0	2.0	13	0	N/A	1.0	1.9	2.0	2.2	2.6	2.8
Nitrate (as N)	mg/L	2.90	<0.5[c]	-	-	-	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	14	12	0	0.010	0.01	0.01	0.010	0.03	0.03
Phosphorus	mg/L	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	17	17	0	0.00	0.01	0.01	0.010	0.01	0.01
Major Ions																												
Bicarbonate	mg/L		25.6	-	-	-	29.3	25.6	25.6	26.8	31.7	24.4	29.3	30.5	34.1	26.8	24.4	25.6	34.1	14	0	N/A	3.44	24.4	25.6	28.2	34.1	34.1
Calcium	mg/L		3.89	4.3	4.3	4.4	3.8	4	4.3	4.4	4.4	4.3	4.4	4.2	4.6	4	4.1	4.2	4.1	17	0	N/A	0.18	4.0	4.1	4.3	4.5	4.6
Chloride	mg/L	120	<1[c]	0.6	0.6	0.6	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.6	0.6	0.6	0.7	17	1	0	0.04	0.6	0.6	0.6	0.7	0.7
Fluoride	mg/L		<0.1[c]	0.07	0.07	0.07	0.06	0.06	0.08	0.07	0.06	0.09	0.08	0.06	0.06	0.04	0.04	0.04	0.05	17	1	N/A	0.01	0.04	0.06	0.06	0.08	0.09
Magnesium	mg/L		1.51	1.6	1.6	1.6	1.4	1.6	1.6	1.6	1.6	1.6	1.7	1.5	1.6	1.5	1.5	1.5	1.5	17	0	N/A	0.06	1.5	1.5	1.6	1.6	1.7
Sodium	mg/L		1.64	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.8	1.7	1.7	1.7	1.6	1.7	1.7	1.7	17	0	N/A	0.04	1.6	1.7	1.7	1.7	1.8
Sulphate	mg/L	128[f]	-	1.8	1.6	1.6	1.6	1.7	1.6	1.5	1.6	1.7	1.7	1.6	1.5	1.5	1.4	1.5	1.5	16	0	0	0.1	1.4	1.5	1.6	1.7	1.8
Total Metals																												
Aluminum	µg/L	100	<3[c]	-	-	-	4.4	3.6	1.6	1.2	2.2	1.6	1.5	3.9	0.9	2.4	1.8	1.2	1.5	14	1	0	1.1	0.9	1.5	2.1	4.1	4.4
Arsenic	µg/L	5	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	<0.1	0.2	0.1	0.1	<0.1	<0.1	17	3	0	0.04	0.1	0.1	0.10	0.2	0.2
Barium	µg/L		8.4	8.6	9.3	10.0	10.0	9.7	9.1	9.5	9.7	7.7	10.0	8.9	22.0	9.7	7.9	9.7	8.6	17	0	N/A	3.1	7.7	8.6	9.9	12.4	22.0
Beryllium	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	17	13	N/A	0.0	0.1	0.1	0.10	0.1	0.1
Boron	µg/L		<10	<10	<10	<10	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	17	12	N/A	0	10	10	6	10	10
Cadmium	µg/L	0.017[f]	<0.005	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	17	16	0	0.001	0.01	0.01	0.010	0.01	0.01
Cesium	µg/L		<0.1	-	-	-	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11	11	N/A	0.0	0.1	0.1	0.10	0.1	0.1
Chromium	µg/L	1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	17	17	0	0.1	0.1	0.5	0.2	0.5	0.5
Cobalt	µg/L	0.5[g]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	17	17	0	0.0	0.1	0.1	0.10	0.1	0.1
Copper	µg/L	2[f]	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.40	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	17	16	0	0.3	0.2	0.2	0.2	0.7	1.4
Iron	µg/L	300	61	4	18	64	95	54	87	13	120	11	100	100	**850**	92	20	65	67	17	0	1	189	4	20	107	266	**850**
Lead	µg/L	1[f]	0.1	1.0	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**1.3**	<0.1	<0.1	<0.1	<0.1	17	12	1	0.3	0.1	0.1	0.2	1.1	**1.3**
Manganese	µg/L	260	16.5	1.7	5.7	24.0	25.0	22.0	22.0	2.2	29.0	5.7	46.0	36.0	**1100**	16.0	6.3	32.0	24.0	17	0	1	254.5	1.7	6.3	83.2	257.0	**1100**
Mercury	µg/L	0.026	-	0.001	0.001	0.001	0.002	<0.001	<0.001	0.002	0.002	0.003	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	16	8	0	0.0010	0.001	0.001	0.001	0.003	0.003
Molybdenum	µg/L	31,000	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	17	16	0	0.0	0.1	0.1	0.05	0.1	0.1
Nickel	µg/L	25[f]	<0.5	1.2	<0.1	<0.1	<0.1	<0.1	<0.1	0.20	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	17	15	0	0.3	0.1	0.1	0.14	0.6	1.2
Selenium	µg/L	1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	17	16	0	0.0	0.1	0.1	0.05	0.1	0.1
Strontium	µg/L		32	32	33	32	31	31	31	31	31	30	32	31	36	32	31	32	31	17	0	N/A	1	30	31	32	34	36
Tin	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.2	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	17	10	N/A	0.03	0.1	0.1	0.08	0.2	0.2
Titanium	µg/L		<0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	17	13	N/A	0.02	0.2	0.2	0.13	0.2	0.3
Uranium	µg/L	15	0.01	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	17	16	0	0.02	0.01	0.1	0.05	0.1	0.1
Vanadium	µg/L	120	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	17	17	0	0.1	0.1	0.1	0.06	0.2	0.5
Zinc	µg/L	7	<3[c]	0.8	0.6	<0.5	<0.5	<0.5	<0.5	1.4	1.5	1.1	0.9	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	17	10	0	0.3	0.5	0.5	0.6	1.4	1.5
Radionuclides																												
Lead-210	Bq/L	22	0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	17	16	0	0.004	0.02	0.02	0.01	0.02	0.04
Polonium-210	Bq/L	13.5	0.019	0.005	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	17	13	0	0.003	0.005	0.005	0.004	0.008	0.019
Radium-226	Bq/L	0.11	0.010	0.006	0.005	0.005	<0.005	0.01	0.01	<0.005	<0.005	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	17	10	0	0.002	0.005	0.005	0.004	0.010	0.010
Thorium-230	Bq/L	95	0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	16	15	0	0.001	0.01	0.01	0.010	0.01	0.01

Note:

Shaded & Bold	indicates that the value is greater than the most stringent applicable SEQG or CCME Guideline.
Yellow Shaded	indicates that guideline is hardness dependant.

a) No project threshold for pH; CCME guideline range presented (CCME 1996).

b) Fraction of unionized ammonia calculated based on total ammonia (as N), pH and temperature.

c) Not considered in statistics as MDL is an order of magnitudes larger than remaining samples value or MDL.

d) Unionized ammonia fraction could not be calculated due to pH being out of range.

e) Computed with half of MDL value.

f) Threshold was calculated for cadmium, copper, lead, nickel, and sulphate based on the maximum hardness observed within the RSA (21 mg/L $CaCO_3$).

g) Threshold for cobalt was calculated using the following formula: exp(0.414(ln(hardness))-1.887), where hardness is in mg/L $CaCO_3$ and the resulting cobalt threshold is in µg/L. Hardness value used in calculation is the 95th percentile hardness value for each lake.

MDL = method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; Bq/L = becquerel per litre; µS/cm = microsiemens per centimeter; NTU = nephelometric turbidity unit.

Table 10A-1a-13 : Clearwater River below Beet Lake

Date		Project Threshold	Spring 2018	Summer 2018	Fall 2018	Winter 2019	Spring 2019	Summer 2019	Fall 2019	Winter 2020	Spring 2020	Summer 2020	Fall 2020	# of Samples	# < MDL	# Above Threshold	SD	Minimum	25th Percentile	Average[c]	95th Percentile	Maximum
Sampling Date			21-May-18	03-Aug-18	29-Sep-18	23-Feb-19	26-May-19	28-Jul-19	01-Oct-19	21-Mar-20	08-Jun-20	26-Jul-20	23-Sep-20									
Sampling Location			Beet Creek	Beet Creek	Beet Creek	Beet Creek	Beet Creek	Beet Creek	Beet Creek	Beet Creek	Beet Creek	Beet Creek	Beet Creek									
Depth																						
Depth (m)																						
Field Parameters																						
pH (Field)	-	6.5 - 9.0[a]	7.20	7.20	6.90	6.80	6.80	7.20	6.80	6.93	7.23	7.11	7.06	11	0	0	0.17	6.80	6.85	7.02	7.21	7.23
Temperature (Field)	°C		15.8	24.3	1.3	0.2	10.4	17.9	6.8	0.3	7.0	18.9	11.2	11	0	N/A	7.8	0.2	4.1	10.4	21.6	24.3
Specific Conductivity (Field)	µS/cm		41.8	44.9	45.5	50.9	42.8	43.6	42.9	50.3	39.8	40.9	41.7	11	0	N/A	3.4	39.8	41.8	44.1	50.6	50.9
Turbidity	NTU		0.6	0.3	0.6	0.2	0.6	0.6	0.9	0.3	1.3	1.3	0.8	11	0	N/A	0.4	0.2	0.5	0.7	1.3	1.3
General Parameters																						
pH	-	6.5 - 9.0[a]	7.54	7.33	7.67	7.15	7.39	7.39	7.48	7.04	7.47	7.41	7.32	11	0	0	0.17	7.04	7.33	7.38	7.61	7.67
Specific Conductivity (Lab)	µS/cm		34	36	36	42	38	36	37	42	35	33	36	11	0	N/A	3	33	36	37	42	42
Total Solids, Dissolved	mg/L		42	46	50	51	48	45	42	58	45	21	27	11	0	N/A	10	21	42	43	55	58
Total Solids, Suspended	mg/L	8.3	2	2	2	<1	<1	1	1	<1	<1	<1	<1	11	6	0	0.4	1	1	1	2	2
Hardness	mg/L $CaCO_3$		15	17	17	19	17	17	18	19	15	16	16	11	0	N/A	1	15	16	17	19	19
Alkalinity	mg/L $CaCO_3$		26	22	22	22	24	23	29	25	22	22	18	11	0	N/A	3	18	22	23	28	29
Nutrients																						
Total Ammonia as N	mg/L		0.05	<0.01	<0.01	0.040	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	11	8	N/A	0.010	0.01	0.01	0.01	0.05	0.05
Ammonia as N (un-ionized)[b]	µg/L	16	0.200	<0.08	<0.007	0.020	<0.01	<0.05	<0.009	<0.007	<0.02	0.050	<0.02	11	8	0	0.05	0.01	0.01	0.03	0.14	0.20
Dissolved Organic Carbon	mg/L		2.4	2.4	2.4	2.5	3.0	3.0	3.0	2.4	3.3	3.8	3.6	10	0	N/A	1.0	2.4	2.4	2.9	3.7	3.8
Nitrate (as N)	mg/L	2.90	<0.01	<0.01	<0.01	0.22	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	10	10	0	0.06	0.01	0.01	0.02	0.13	0.22
Phosphorus	mg/L	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	10	11	0	0.00	0.01	0.01	0.010	0.01	0.01
Major Ions																						
Bicarbonate	mg/L		31.7	26.8	26.8	26.8	29.3	28.0	35.4	30.5	26.8	26.8	21.9	11	0	N/A	3.28	21.9	26.8	28.3	33.5	35.4
Calcium	mg/L		3.7	4.2	4.2	4.8	4.3	4.2	4.4	4.8	3.9	3.9	4	11	0	N/A	0.34	3.7	4.0	4.2	4.8	4.8
Chloride	mg/L	120	0.7	0.6	0.6	0.7	0.6	0.6	0.7	0.8	0.6	0.6	0.6	11	0	0	0.07	0.60	0.60	0.65	0.75	0.80
Fluoride	mg/L		0.06	0.06	0.08	0.07	0.06	0.08	0.06	0.06	0.04	0.04	0.05	11	0	N/A	0.01	0.04	0.06	0.06	0.08	0.08
Magnesium	mg/L		1.4	1.5	1.6	1.7	1.6	1.6	1.6	1.7	1.4	1.5	1.5	11	0	N/A	0.10	1.4	1.5	1.6	1.7	1.7
Sodium	mg/L		1.7	1.7	1.7	1.9	1.7	1.7	1.7	1.8	1.6	1.7	1.7	11	0	N/A	0.07	1.6	1.7	1.7	1.9	1.9
Sulphate	mg/L	128[d]	1.6	1.6	1.7	1.8	1.6	1.6	1.5	1.8	1.4	1.4	1.5	11	0	0	0.1	1.4	1.5	1.6	1.8	1.8
Total Metals																						
Aluminum	µg/L	100	6.8	6.2	6.8	2.2	9.2	7.4	9.8	4.5	11	11	6.8	11	0	0	2.6	2.2	6.5	7.4	11.0	11.0
Arsenic	µg/L	5	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.2	<0.1	11	1	0	0.04	0.1	0.1	0.10	0.2	0.2
Barium	µg/L		9.2	8	8.9	11	8.9	8.3	8.2	11	9.9	7.5	8.2	11	0	N/A	1.1	7.5	8.2	9.0	11.0	11.0
Beryllium	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10	11	N/A	0.0	0.1	0.1	0.10	0.1	0.1
Boron	µg/L		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	11	N/A	0.0	10	10	5	10	10
Cadmium	µg/L	0.017[d]	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	10	9	0	0.00	0.01	0.01	0.010	0.01	0.01
Cesium	µg/L		-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8	8	N/A	0.0	0.1	0.1	0.10	0.1	0.1
Chromium	µg/L	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	10	11	0	0.0	0.5	0.5	0.30	0.5	0.5
Cobalt	µg/L	0.5[e]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10	11	0	0.0	0.1	0.1	0.10	0.1	0.1
Copper	µg/L	2[d]	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	10	11	0	0.0	0.2	0.2	0.1	0.2	0.2
Iron	µg/L	300	90	44	110	22	95	59	110	24	190	170	110	11	0	0	52	22	52	93	180	190
Lead	µg/L	1[d]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10	11	0	0.0	0.1	0.1	0.10	0.1	0.1
Manganese	µg/L	260	12.0	7.7	20.0	2.0	9.9	9.2	23.0	6.0	16.0	11.0	15.0	11	0	0	5.9	2.0	8.5	12.0	21.5	23.0
Mercury	µg/L	0.026	0.001	<0.001	<0.001	0.002	0.001	0.002	<0.001	<0.001	0.001	0.001	<0.001	11	5	0	0.0004	0.001	0.001	0.001	0.002	0.002
Molybdenum	µg/L	31,000	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10	10	0	0.0	0.1	0.1	0.10	0.1	0.1
Nickel	µg/L	25[d]	<0.1	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10	10	0	0.10	0.1	0.1	0.10	0.3	0.4
Selenium	µg/L	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10	11	0	0.0	0.1	0.1	0.10	0.1	0.1
Strontium	µg/L		30	31	29	34	30	30	30	37	31	30	30	11	0	N/A	2	29	30	31	36	37
Tin	µg/L		<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10	10	N/A	0.0	0.1	0.1	0.10	0.1	0.1
Titanium	µg/L		<0.2	<0.2	0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	10	10	N/A	0.10	0.2	0.2	0.1	0.3	0.4
Uranium	µg/L	15	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10	11	0	0.0	0.1	0.1	0.10	0.1	0.1
Vanadium	µg/L	120	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10	11	0	0.0	0.1	0.1	0.10	0.1	0.1
Zinc	µg/L	7	1.1	<0.5	<0.5	3	1.2	0.8	0.7	0.7	<0.5	1.0	<0.5	11	4	0	0.7	0.5	0.5	0.9	2.1	3.0
Radionuclides																						
Lead-210	Bq/L	22	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	10	10	0	0.00	0.02	0.02	0.01	0.02	0.02
Polonium-210	Bq/L	13.5	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	10	11	0	0.000	0.005	0.005	0.003	0.005	0.005
Radium-226	Bq/L	0.11	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	0.01	<0.005	<0.005	10	9	0	0.001	0.005	0.005	0.004	0.008	0.010
Thorium-230	Bq/L	95	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	10	11	0	0.00	0.01	0.01	0.01	0.01	0.01

Note:

Shaded & Bold	indicates that the value is greater than the most stringent applicable SEQG or CCME Guideline.
Yellow Shaded	indicates that guideline is hardness dependant.

a) No project threshold for pH; CCME guideline range presented (CCME 1996).

b) Fraction of unionized ammonia calculated based on total ammonia (as N), pH and temperature.

c) Computed with half of MDL value.

d) Threshold was calculated for cadmium, copper, lead, nickel, and sulphate based on the maximum hardness observed within the RSA (21 mg/L $CaCO_3$).

e) Threshold for cobalt was calculated using the following formula: exp(0.414(ln(hardness))-1.887), where hardness is in mg/L $CaCO_3$ and the resulting cobalt threshold is in µg/L. Hardness value used in calculation is the 95th percentile hardness value for each lake.

MDL = method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; Bq/L = becquerel per litre; µS/cm = microsiemens per centimeter; NTU = nephelometric turbidity unit.

Table 10A-1a-14 : Naomi Lake

Date		Project Threshold	Spring 2018	Summer 2018	Fall 2018	Winter 2019	Spring 2019	Summer 2019	Fall 2019	Winter 2020	Spring 2020	Summer 2020		Fall 2020	# of Samples	# < MDL	# Above Threshold	SD	Minimum	25th Percentile	Average[e]	95th Percentile	Maximum
Sampling Date			21-May-18	03-Aug-18	25-Sep-18	22-Feb-19	26-May-19	28-Jul-19	01-Oct-19	21-Mar-20	07-Jun-20	26-Jul-20	26-Jul-20	23-Sep-20									
Sampling Location			Naomi Lake	Naomi Lake	Naomi Lake	Naomi Lake	Naomi Lake	Naomi Lake	Naomi Lake	Naomi Lake	Naomi Lake	Naomi Lake	Naomi Lake	Naomi Lake									
Depth												Top	Bottom										
Depth (m)												2	5										
Field Parameters																							
pH (Field)	-	6.5 - 9.0[a]	7.00	7.51	7.26	6.69	7.22	6.71	7.05	**5.93**	6.76	6.75	**6.31**	**6.25**	12	0	3	0.44	**5.93**	6.60	6.79	7.37	7.51
Temperature (Field)	°C		14.2	20.5	5.1	2.7	12.7	29.2	5.4	1.7	12.0	18.7	16.3	9.8	12	0	N/A	7.8	1.7	5.3	12.4	24.4	29.2
Specific Conductivity (Field)	µS/cm		23.2	27.3	25.9	33.9	23.6	18.6	22.1	26.1	18.2	20.1	21.1	18.3	12	0	N/A	4.4	18.2	19.7	23.2	30.3	33.9
Turbidity	NTU		2.4	0.8	1.9	1.1	1.8	2.9	3.1	1.4	2.0	2.5	4.6	2.6	12	0	N/A	1.0	0.8	1.7	2.3	3.8	4.6
General Parameters																							
pH	-	6.5 - 9.0[a]	7.21	7.03	7.38	6.60	7.15	7.13	7.09	**6.32**	**6.47**	**5.44**	**5.41**	7	12	0	4	0.63	**5.41**	**6.43**	6.66	7.29	7.38
Specific Conductivity (Lab)	µS/cm		16	20	18	24	18	22	16	20	17	14	15	12	12	0	N/A	3	12	16	18	23	24
Total Solids, Dissolved	mg/L		32	41	45	43	24	39	40	58	29	30	37	40	12	0	N/A	9	24	32	38	51	58
Total Solids, Suspended	mg/L	8.3	3	4	1	3	3	2	2	1	1	<1	2	<1	12	2	0	1	1	1	2	3	4
Hardness	mg/L $CaCO_3$		8	10	10	11	9	12	9	10	7	8	8	7	12	0	N/A	1	7	8	9	11	12
Alkalinity	mg/L $CaCO_3$		12	12	13	12	21	14	7	10	8	63	79	2	12	0	N/A	23	2	10	21	70	79
Nutrients																							
Total Ammonia as N	mg/L		<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	0.02	12	9	N/A	0.010	0.01	0.01	0.01	0.03	0.04
Ammonia as N (un-ionized)[b]	µg/L	16	<0.03	<0.1	0.05	<0.005	<0.04	<0.04	<0.01	-[c]	<0.01	<0.02	0.02	0.007	11	8	0	0.03	0.005	0.01	0.02	0.08	0.1
Dissolved Organic Carbon	mg/L		6.0	6.9	6.2	7.2	5.7	6.1	7.4	8.8	8.4	9.5	9.2	11.0	11	0	N/A	1.0	5.7	6.6	7.7	10.3	11.0
Nitrate (as N)	mg/L	2.90	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01	0.09	<0.01	<0.01	<0.01	<0.01	12	10	0	0.03	0.01	0.01	0.02	0.10	0.11
Phosphorus	mg/L	0.02	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	12	11	0	0.00	0.01	0.01	0.010	0.01	0.01
Major Ions																							
Bicarbonate	mg/L		14.6	14.6	15.9	14.6	25.6	17.1	8.5	12.2	9.8	76.8	96.3	2.4	12	0	N/A	28.01	2.4	11.6	25.7	85.6	96.3
Calcium	mg/L		2.2	2.8	2.7	3	2.6	3.2	2.5	2.7	1.9	2.3	2.4	2	12	0	N/A	0.37	1.9	2.3	2.5	3.1	3.2
Chloride	mg/L	120	0.6	0.5	0.6	0.6	0.5	0.5	0.6	0.6	0.3	0.4	0.4	0.4	12	0	0	0.1	0.3	0.4	0.5	0.6	0.6
Fluoride	mg/L		0.03	0.03	0.04	0.04	0.02	0.06	0.03	0.03	0.02	0.02	0.02	0.02	12	0	N/A	0.01	0.02	0.02	0.03	0.05	0.06
Magnesium	mg/L		0.6	0.8	0.8	0.8	0.7	0.9	0.6	0.7	0.5	0.6	0.6	0.5	12	0	N/A	0.12	0.5	0.6	0.7	0.8	0.9
Sodium	mg/L		1.0	1.1	1.1	1.1	1.0	1.2	0.9	1.0	0.8	0.8	0.8	0.8	12	0	N/A	0.14	0.8	0.8	1.0	1.1	1.2
Sulphate	mg/L	128[f]	0.7	0.7	0.8	0.8	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.7	12	0	0	0.1	0.5	0.6	0.6	0.8	0.8
Total Metals																							
Aluminum	µg/L	100	29.0	14.0	13.0	34.0	25.0	9.3	28.0	54.0	44.0	42.0	38.0	52.0	12	0	0	14.3	9.3	22.3	31.9	52.9	54.0
Arsenic	µg/L	5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	12	0	0	0.03	0.1	0.2	0.2	0.2	0.2
Barium	µg/L		8.5	6.6	6.1	10.0	7.0	7.6	7.8	10.0	7.3	8.0	8.9	8.2	12	0	N/A	1.2	6.1	7.2	8.0	10.0	10.0
Beryllium	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	12	N/A	0.0	0.1	0.1	0.10	0.1	0.1
Boron	µg/L		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	12	12	N/A	0	10	10	5	10	10
Cadmium	µg/L	0.017[f]	0.01	<0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	12	8	0	0.00	0.01	0.01	0.010	0.01	0.01
Cesium	µg/L		-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	9	9	N/A	0.00	0.1	0.1	0.10	0.1	0.1
Chromium	µg/L	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	12	12	0	0.0	0.5	0.5	0.3	0.5	0.5
Cobalt	µg/L	0.4[g]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	12	0	0.0	0.1	0.1	0.10	0.1	0.1
Copper	µg/L	2[f]	<0.2	<0.2	<0.2	0.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	12	11	0	0.2	0.2	0.2	0.2	0.5	0.8
Iron	µg/L	300	**1260**	**640**	**350**	**840**	**960**	**630**	**660**	**870**	**940**	**750**	**990**	**1020**	12	0	12	227	**350**	**655**	**826**	**1128**	**1260**
Lead	µg/L	1[f]	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	11	0	0.1	0.1	0.1	0.10	0.2	0.3
Manganese	µg/L	260	68	32	18	99	21	74	28	79	32	29	68	32	12	0	0	26	18	29	48	88	99
Mercury	µg/L	0.026	0.006	0.002	0.003	0.002	0.002	0.004	<0.001	<0.001	0.001	0.002	0.001	0.001	12	2	0	0.0010	0.001	0.001	0.002	0.005	0.006
Molybdenum	µg/L	31,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	12	0	0.0	0.1	0.1	0.10	0.1	0.1
Nickel	µg/L	25[f]	0.2	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	12	7	0	0.0	0.1	0.1	0.10	0.1	0.2
Selenium	µg/L	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	12	0	0.0	0.1	0.1	0.10	0.1	0.1
Strontium	µg/L		22	27	22	27	24	30	24	27	19	23	23	20	12	0	N/A	3	19	22	24	28	30
Tin	µg/L		<0.1	<0.1	1.7	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	10	N/A	0.4	0.1	0.1	0.2	1.0	1.7
Titanium	µg/L		0.5	0.2	0.2	0.7	0.5	0.3	0.3	0.8	0.6	0.6	0.5	0.5	12	0	N/A	0.2	0.2	0.3	0.5	0.7	0.8
Uranium	µg/L	15	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	12	0	0.0	0.1	0.1	0.10	0.1	0.1
Vanadium	µg/L	120	<0.3	<0.2	<0.2	<0.3	<0.3	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	12	5	0	0.10	0.1	0.1	0.2	0.3	0.3
Zinc	µg/L	7	3.7	<0.5	<0.5	0.9	1.4	0.8	0.7	0.7	0.6	0.7	<0.5	0.8	12	3	0	0.9	0.5	0.6	0.9	2.4	3.7
Radionuclides																							
Lead-210	Bq/L	22	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	<0.02	12	11	0	0.010	0.02	0.02	0.01	0.03	0.05
Polonium-210	Bq/L	13.5	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	12	10	0	0.0010	0.005	0.005	0.003	0.006	0.007
Radium-226	Bq/L	0.11	<0.005	<0.005	0.006	<0.005	<0.005	0.007	0.008	<0.005	<0.005	<0.005	<0.005	0.008	12	8	0	0.001	0.005	0.005	0.004	0.008	0.008
Thorium-230	Bq/L	95	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	12	12	0	0.00	0.01	0.01	0.010	0.01	0.01

Note:

Shaded & Bold indicates that the value is greater than the most stringent applicable SEQG or CCME Guideline.

Yellow Shaded indicates that guideline is hardness dependant.

a) No project threshold for pH; CCME guideline range presented (CCME 1996).

b) Fraction of unionized ammonia calculated based on total ammonia (as N), pH and temperature.

d) Unionized ammonia fraction could not be calculated due to pH being out of range.

e) Computed with half of MDL value.

f) Threshold was calculated for cadmium, copper, lead, nickel, and sulphate based on the maximum hardness observed within the RSA (21 mg/L $CaCO_3$).

g) Threshold for cobalt was calculated using the following formula: exp(0.414(ln(hardness))-1.887), where hardness is in mg/L $CaCO_3$ and the resulting cobalt threshold is in µg/L. Hardness value used in calculation is the 95th percentile hardness value for each lake.

MDL = method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; Bq/L = becquerel per litre; µS/cm = microsiemens per centimeter; NTU = nephelometric turbidity unit.

Table 10A-1a-15 : Clearwater River below Naomi Lake

Date		Project Threshold	Winter 2016		Spring 2018	Summer 2018	Fall 2018	Winter 2019	Spring 2019	Summer 2019	Fall 2019	Winter 2020	Spring 2020	Summer 2020	Fall 2020	# of Samples	# < MDL	# Above Threshold	SD	Minimum	25th Percentile	Average[d]	95th Percentile	Maximum
Sampling Date			17-Mar-16		21-May-18	03-Aug-18	29-Sep-18	23-Feb-19	26-May-19	28-Jul-19	01-Oct-19	21-Mar-20	08-Jun-20	26-Jul-20	23-Sep-20									
Sampling Location			STM-08 (Area 1)	STM-09	Clearwater River Area 1	Clearwater River Area 1	Clearwater River Area 1	Clearwater River Area 1	Clearwater River Area 1	Clearwater River Area 1	Clearwater River Area 1	Clearwater River Area 1	Clearwater River Area 1	Clearwater River Area 1	Clearwater River Area 1									
Depth																								
Depth (m)																								
Field Parameters																								
pH (Field)	-	6.5 - 9.0[a]	**6.38**	**6.38**	7.30	7.70	7.20	**6.40**	6.90	7.24	6.90	**5.70**	7.13	6.99	6.98	12	0	4	0.50	**5.70**	**6.78**	6.86	7.48	7.70
Temperature (Field)	°C		1.0	1.0	18.0	24.1	1.3	0.5	12.2	17.1	3.8	0.2	8.5	19.2	11.4	12	0	N/A	8.1	0.2	1.2	9.1	21.4	24.1
Specific Conductivity (Field)	µS/cm		84.7	84.7	37.6	39.0	36.7	42.6	38.3	39.2	34.2	28.2	33.6	32.4	32.3	12	0	N/A	14.0	28.2	33.3	43.3	61.5	84.7
Turbidity	NTU		-	-	1.1	0.3	1.7	0.8	1.3	1.1	2.7	1.7	2.5	2.8	3.4	11	0	N/A	0.9	0.3	1.1	1.8	3.1	3.4
General Parameters																								
pH	-	6.5 - 9.0[a]	7.12	7.06	7.52	7.28	7.34	6.69	7.39	7.30	7.40	**6.31**	7.32	7.20	7.16	12	0	1	0.33	**6.31**	7.14	7.16	7.45	7.52
Specific Conductivity (Lab)	µS/cm		38	37	31	31	28	33	33	32	28	22	26	25	25	12	0	N/A	4	22	26	30	35	37
Total Solids, Dissolved	mg/L		36	32	45	40	47	58	58	41	32	55	35	26	39	12	0	N/A	10	26	34	42	58	58
Total Solids, Suspended	mg/L	8.3	2	2	2	2	4	<1	3	1	5	1	4	3	1	12	1	0	1	1	1	2	4	5
Hardness	mg/L $CaCO_3$		14	13	13	14	13	15	15	15	14	10	12	12	12	12	0	N/A	1	10	12	13	15	15
Alkalinity	mg/L $CaCO_3$		-	-	18	24	25	17	26	15	21	11	23	13	16	11	0	N/A	5	11	16	19	26	26
Nutrients																								
Total Ammonia as N	mg/L		0.02	0.02	<0.01	<0.01	0.01	0.06	<0.01	<0.01	<0.01	0.05	0.01	<0.01	<0.01	12	7	N/A	0.02	0.01	0.01	0.02	0.05	0.06
Ammonia as N (un-ionized)[b]	µg/L	16	0.004	0.004	<0.07	<0.3	0.010	0.010	<0.02	<0.06	<0.009	-[c]	0.02	<0.04	<0.02	11	7	0	0.08	0.004	0.01	0.03	0.19	0.3
Dissolved Organic Carbon	mg/L		-	-	3.2	3.5	3.5	5.5	2.8	3.8	3.8	7.4	4.4	5.4	5.4	11	0	N/A	1.0	2.8	3.5	4.4	6.5	7.4
Nitrate (as N)	mg/L	2.90	-	-	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	11	9	0	0.02	0.01	0.01	0.01	0.05	0.05
Phosphorus	mg/L	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	12	13	0	0.00	0.01	0.01	0.005	0.01	0.01
Major Ions																								
Bicarbonate	mg/L		-	-	21.9	29.3	30.5	20.7	31.7	18.3	25.6	13.4	28.0	15.9	19.5	12	0	N/A	5.93	13.4	18.9	23.2	31.1	31.7
Calcium	mg/L		3.6	3.3	3.4	3.6	3.4	4.1	3.8	3.8	3.5	3.0	3.1	3.2	3.2	12	0	N/A	0.31	3.0	3.2	3.5	3.9	4.1
Chloride	mg/L	120	0.6	0.6	0.7	0.6	0.6	0.7	0.6	0.5	0.6	0.6	0.5	0.5	0.6	12	0	0	0.1	0.5	0.6	0.6	0.7	0.7
Fluoride	mg/L		-	-	0.06	0.06	0.06	0.04	0.05	0.08	0.04	0.03	0.03	0.03	0.04	11	0	N/A	0.02	0.03	0.04	0.05	0.07	0.08
Magnesium	mg/L		1.2	1.1	1.2	1.3	1.2	1.2	1.4	1.4	1.2	7	1.1	1.1	1.1	12	0	N/A	0.2	0.7	1.1	1.2	1.4	1.4
Sodium	mg/L		1.4	1.4	1.5	1.5	1.5	1.5	1.6	1.6	1.4	1	1.3	1.3	1.3	12	0	N/A	0.2	1.0	1.3	1.4	1.6	1.6
Sulphate	mg/L	128[e]	1.4	1.3	1.3	1.3	1.3	1.2	1.4	1.2	1.2	0.8	1.2	1.1	1.1	12	0	0	0.1	0.8	1.2	1.2	1.3	1.4
Total Metals																								
Aluminum	µg/L	100	-	-	14	10.0	26.0	20.0	14.0	12.0	27.0	53.0	31.0	27.0	34.0	11	0	0	11.9	10.0	14.0	24.4	43.5	53.0
Arsenic	µg/L	5	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0.2	0.1	0.2	<0.1	12	1	0	0.05	0.1	0.1	0.1	0.2	0.2
Barium	µg/L		9.0	9.2	8.2	6.8	8.1	12	7.8	8	8	13	8.5	7.8	8.4	12	0	N/A	1.7	6.8	8.0	8.8	12.5	13.0
Beryllium	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	13	N/A	0.0	0.1	0.1	0.05	0.1	0.1
Boron	µg/L		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	12	13	N/A	0.0	10	10	5	10	10
Cadmium	µg/L	0.017[e]	0.01	0.017	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	12	9	0	0.002	0.01	0.01	0.007	0.01	0.02
Cesium	µg/L		-	-	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8	8	N/A	0.0	0.1	0.1	0.05	0.1	0.1
Chromium	µg/L	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	12	11	0	0.0	0.5	0.5	0.3	0.5	0.5
Cobalt	µg/L	0.5[f]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	11	0	0.0	0.1	0.1	0.06	0.1	0.1
Copper	µg/L	2[e]	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	12	10	0	0.0	0.2	0.2	0.1	0.2	0.2
Iron	µg/L	300	270	**340**	250	180	**420**	**560**	200	200	**390**	**1200**	**440**	**420**	**480**	12	0	8	262	180	238	**412**	**848**	**1200**
Lead	µg/L	1[e]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	9	0	0.0	0.1	0.1	0.07	0.1	0.1
Manganese	µg/L	260	15.0	16.0	16.0	14.0	20.0	53.0	10.0	18.0	24.0	74.0	22.0	32.0	40.0	12	0	0	18.1	10.0	16.0	27.2	62.5	74.0
Mercury	µg/L	0.026	0.001	0.001	0.001	<0.001	<0.001	0.002	0.002	0.002	<0.001	<0.001	0.002	0.001	<0.001	12	5	0	0.0005	0.001	0.001	0.001	0.002	0.002
Molybdenum	µg/L	31,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	11	0	0.0	0.1	0.1	0.06	0.1	0.1
Nickel	µg/L	25[e]	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	9	0	0.03	0.1	0.1	0.07	0.1	0.2
Selenium	µg/L	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	11	0	0.0	0.1	0.1	0.06	0.1	0.1
Strontium	µg/L		31	30	28	29	27	31	29	30	28	29	27	28	27	12	0	N/A	1	27	28	29	30	31
Tin	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	13	N/A	0.0	0.1	0.1	0.05	0.1	0.1
Titanium	µg/L		0.2	0.4	0	<0.2	0.7	0.5	0.3	0.4	0.7	0.6	0.6	0.4	0.6	12	1	N/A	0.2	0.2	0.4	0.45	0.7	0.7
Uranium	µg/L	15	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	12	11	0	0.0	0.1	0.1	0.06	0.1	0.1
Vanadium	µg/L	120	0.1	0.2	0.1	<0.1	<0.2	0.2	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	12	4	0	0.05	0.1	0.1	0.1	0.2	0.2
Zinc	µg/L	7	<0.5	<0.5	<0.5	<0.5	<0.5	0.7	1.3	0.6	<0.5	<1.3	<0.8	<0.5	<0.5	12	5	0	0.3	0.5	0.5	0.6	1.3	1.3
Radionuclides																								
Lead-210	Bq/L	22	0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	12	11	0	0.00	0.02	0.02	0.01	0.02	0.02
Polonium-210	Bq/L	13.5	0.005	0.005	<0.005	<0.005	0.009	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	12	10	0	0.001	0.005	0.005	0.003	0.007	0.009
Radium-226	Bq/L	0.11	0.005	0.005	<0.005	0.008	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	12	9	0	0.0008	0.005	0.005	0.004	0.007	0.008
Thorium-230	Bq/L	95	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	12	11	0	0.00	0.01	0.01	0.006	0.01	0.01

Note:

Shaded & Bold	indicates that the value is greater than the most stringent applicable SEQG or CCME Guideline.
Yellow Shaded	indicates that guideline is hardness dependant.

a) No project threshold for pH; CCME guideline range presented (CCME 1996).

b) Fraction of unionized ammonia calculated based on total ammonia (as N), pH and temperature.

c) Unionized ammonia fraction could not be calculated due to pH being out of range.

d) Computed with half of MDL value.

e) Threshold was calculated for cadmium, copper, lead, nickel, and sulphate based on the maximum hardness observed within the RSA (21 mg/L $CaCO_3$).

f) Threshold for cobalt was calculated using the following formula: exp(0.414(ln(hardness))-1.887), where hardness is in mg/L $CaCO_3$ and the resulting cobalt threshold is in µg/L. Hardness value used in calculation is the 95th percentile hardness value for each lake.

MDL = method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; Bq/L = becquerel per litre; µS/cm = microsiemens per centimeter; NTU = nephelometric turbidity unit.

Table 10A-1a-16: Reference Lakes

Date		Project Threshold	Winter 2016			Summer 2018	Fall 2018	Winter 2019			Spring 2019		
Sampling Date			16-Mar-16	16-Mar-16	16-Mar-16	11-Aug-18	21-Sep-18	23-Feb-19	24-Feb-19	25-Feb-19	24-May-19	25-May-19	25-May-19
Sampling Location			Harbo Lake			Hodge Lake	Hodge Lake Area 1	Hodge Lake Area 1	Lake D	Lake J	Hodge Lake Area 1	Lake D	Lake J
Depth			Surface	Mid	Bottom								
Depth (m)			1.00	14.50	28.30								
Field Parameters													
pH (Field)	-	6.5 - 9.0[a]	6.56	6.51	**6.44**	6.96	6.79	6.92	6.70	**5.80**	6.79	7.80	**6.30**
Temperature (Field)	°C		1.1	2.4	2.7	10.2	7.2	2.1	2.9	3.8	4.6	15.0	14.5
Specific Conductivity (Field)	µS/cm		25.7	21.6	20.5	27.4	27.4	28.9	58.9	17.1	27.2	41.0	7.0
Turbidity	NTU		3.3	3.3	1.4	-	0.4	0.3	5.0	0.7	0.4	1.0	1.5
General Parameters													
Specific Conductivity (Lab)	µS/cm		20	18	18	20	20	22	57	6	22	35	1
Total Solids, Dissolved	mg/L		32	30	30	28	38	38	72	29	37	40	<5
Total Solids, Suspended	mg/L	8.3	<1	<1	<1	2	<1	<1	3	3	1	2	3
Hardness	mg/L $CaCO_3$		6	5	5.5	10	10	10	25	2	10	18	1
Alkalinity	mg/L $CaCO_3$		8	7	7	-	13	12	32	4	12	26	4
Nutrients													
Total Ammonia as N	mg/L		<0.01	<0.01	<0.01	0.01	0.03	0.01	0.57	0.13	<0.01	<0.01	<0.01
Ammonia as N (un-ionized)[b]	µg/L	16	<0.003	<0.003	<0.003	0.020	0.030	0.008	0.300	-c	<0.007	<0.2	<0.005
Dissolved Organic Carbon	mg/L		-	-	-	1.0	2.2	2.3	7.1	7.0	2.1	6.7	6.8
Nitrate (as N)	mg/L	2.90	-	-	-	0.01	<0.01	0.04	0.02	0.02	<0.01	<0.01	<0.01
Phosphorus	mg/L	0.02	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Major Ions													
Bicarbonate	mg/L		9.8	8.5	8.5	-	15.9	14.6	39.0	4.9	14.6	31.7	4.9
Calcium	mg/L		1.6	1.3	1.4	2.7	2.9	3.0	7.4	0.7	3.0	5.0	0.4
Chloride	mg/L	120	0.1	0.1	0.1	2.0	2.0	2.1	<0.1	0.1	2.0	0.3	<0.1
Fluoride	mg/L		0.03	0.03	0.03	-	0.04	0.03	0.04	0.02	0.02	0.03	0.01
Magnesium	mg/L		0.5	0.5	0.5	0.7	0.7	0.7	1.7	0.2	0.7	1.3	0.1
Sodium	mg/L		1	0.9	0.9	1	1	1	1.7	0.8	1	1.4	0.6
Sulphate	mg/L	128[e]	0.8	0.7	0.7	1.1	1.0	1.1	0.8	0.7	1.1	1.0	0.6
Total Metals													
Aluminum	µg/L	100	-	-	-	-	2.2	1.2	1.6	9.5	4	3.7	9.3
Arsenic	µg/L	5	0.1	0.1	0.1	0.1	0.2	<0.1	0.1	0.2	0.1	0.1	0.2
Barium	µg/L		5.4	4.7	4.8	-	7.3	7.1	11	6.9	6.8	4.3	3.1
Beryllium	µg/L		<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Boron	µg/L		<10	<10	<10	-	10	10	<10	<10	10	<10	<10
Cadmium	µg/L	0.017[e]	0.01	0.01	0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Cesium	µg/L		-	-	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	µg/L	1	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cobalt	µg/L	0.5[f]	<0.1	<0.1	<0.1	0.1	<0.0001	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Copper	µg/L	2[e]	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	0.2	0.5	<0.2	<0.2	<0.2
Iron	µg/L	300	5	9	17	12	30	14	**1580**	170	24	170	59
Lead	µg/L	1[e]	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	µg/L	260	1.2	2.1	3.4	-	15.0	10.0	200.0	18.0	8.8	10.0	3.9
Mercury	µg/L	0.026	0.001	0.001	0.001	0.002	<0.001	0.003	0.002	0.002	0.002	0.002	0.002
Molybdenum	µg/L	31,000	0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	µg/L	25[e]	0.1	0.1	0.1	0.1	<0.1	<0.1	0.3	<0.1	<0.1	<0.1	<0.1
Selenium	µg/L	1	0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Strontium	µg/L		20	17	18	-	60	61	19	6	61	15	4
Tin	µg/L		0.1	0.1	0.1	-	<0.1	0.9	<0.1	<0.1	6	<0.1	<0.1
Titanium	µg/L		0.2	0.2	0.2	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Uranium	µg/L	15	0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	µg/L	120	0.1	0.1	0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1
Zinc	µg/L	7	0.5	0.5	0.6	0.5	2.8	<0.5	0.6	1.7	1.2	1.6	1.7
Radionuclides													
Lead-210	Bq/L	22	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Polonium-210	Bq/L	13.5	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	0.008
Radium-226	Bq/L	0.11	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Thorium-230	Bq/L	95	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Date	Summer 2019				Fall 2019				Winter 2020		
Sampling Date	19-Jul-19	19-Jul-19	23-Jul-19	23-Jul-19	24-Sep-19	24-Sep-19	25-Sep-19	24-Sep-19	17-Mar-20	24-Mar-20	17-Mar-20
Sampling Location	Hodge Lake Area 1		Lake D	Lake J	Hodge Lake Area 1		Lake D	Lake J	Hodge Lake Area 1	Lake D	Lake J
Depth	Top	Bottom			Top	Bottom					
Depth (m)	5	14			8	27					
Field Parameters											
pH (Field)	6.74	6.67	7.80	**5.94**	7.12	**6.20**	7.50	6.60	**5.84**	**6.49**	6.95
Temperature (Field)	17.4	8.2	23.0	23.0	12.5	6.6	11.4	10.9	2.5	2.9	1.6
Specific Conductivity (Field)	28.7	28.0	41.9	5.1	27.1	28.3	45.0	6.4	28.6	66.5	11.4
Turbidity	0.3	0.4	1.2	1.0	0.4	0.4	1.1	1.5	0.4	1.6	1.1
General Parameters											
Specific Conductivity (Lab)	21	21	39	<1	21	22	39	<1	22	57	5
Total Solids, Dissolved	36	32	60	20	27	27	54	14	37	66	19
Total Solids, Suspended	<1	<1	3	2	1	1	2	4	<1	4	2
Hardness	10	10	20	2	10	10	19	<1	10	24	2
Alkalinity	9	10	25	3	11	12	28	4	10	31	6
Nutrients											
Total Ammonia as N	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.19	<0.01	<0.01	0.84	0.14
Ammonia as N (un-ionized)[b]	<0.02	<0.008	0.300	-c	<0.03	<0.002	1.200	<0.008	-c	0.280	0.120
Dissolved Organic Carbon	2.8	2.4	7.7	8.4	2.3	2.3	6.3	5.6	2.3	7.4	7.1
Nitrate (as N)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	0.02	<0.01
Phosphorus	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Major Ions											
Bicarbonate	11.0	12.2	30.5	3.7	13.4	14.6	34.1	4.9	12.2	37.8	7.3
Calcium	3.0	3.0	5.7	0.3	2.9	3.0	5.4	0.3	2.9	7.0	0.6
Chloride	1.8	1.8	0.1	0.1	2.0	2.0	<0.1	0.1	2.0	0.2	0.2
Fluoride	0.05	0.05	0.06	0.04	0.02	0.02	0.03	0.02	0.03	0.04	0.02
Magnesium	0.7	0.7	1.5	0.2	0.6	0.7	1.4	<.0.100	7	1.6	0.2
Sodium	1	1	1.5	0.7	1	1	1.4	0.6	1	1.6	0.7
Sulphate	1.0	1.0	1.0	0.7	1.0	1.1	1.0	0.6	1.0	1.0	0.9
Total Metals											
Aluminum	3.7	1.2	4.0	20.0	3.3	3.6	6.4	15.0	1.9	2.3	8.7
Arsenic	0.1	<0.1	0.1	0.2	0.1	0.1	0.1	0.2	<0.1	0.1	0.2
Barium	6.6	7	5.4	2.9	6.4	7.3	6.3	3.0	7.8	15.0	4.4
Beryllium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Boron	10	10	<10	<10	10	10	<10	<10	10	<10	<10
Cadmium	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cesium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cobalt	<0.0001	<0.0001	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Copper	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.4
Iron	4.6	8	59	33	9	28	47	38	31	**1090**	28
Lead	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	<0.1	0.6
Manganese	2.2	3.8	19	3.3	2.6	16	10.0	4.7	37.0	200.0	5.0
Mercury	0.002	0.002	0.005	0.007	<0.001	<0.001	<0.001	0.001	0.002	<0.001	0.003
Molybdenum	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	0.4
Selenium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Strontium	62	61	18	4	61	63	17	4	64	24	6
Tin	<0.1	<0.1	0.3	0.6	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	1.4
Titanium	<0.2	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Uranium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	<0.1	<0.1	0.2	0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1
Zinc	2.1	1.5	1	1	<0.5	2.4	1	1.1	0.7	1	1.3
Radionuclides											
Lead-210	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	0.03	<0.02
Polonium-210	<0.005	<0.005	0.005	0.008	<0.005	<0.005	0.007	0.010	<0.005	0.005	<0.005
Radium-226	0.006	0.008	0.005	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	<0.005
Thorium-230	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Date	Spring 2020			Summer 2020				Fall 2020				# of Samples	# < MDL	# Above Threshold	SD	Minimum	25th Percentile	Average[d]	95th Percentile	Maximum
Sampling Date	03-Jun-20	05-Jun-20	03-Jun-20	24-Jul-20	24-Jul-20	25-Jul-20	24-Jul-20	20-Sep-20	20-Sep-20	22-Sep-20	20-Sep-20									
Sampling Location	Hodge Lake Area 1	Lake D	Lake J	Hodge Lake Area 1	Hodge Lake Area 1	Lake D	Lake J	Hodge Lake Area 1	Hodge Lake Area 1	Lake D	Lake J									
Depth				Top	Bottom			Top	Bottom											
Depth (m)				3	25			9	27											
Field Parameters																				
pH (Field)	6.91	8.13	6.66	7.21	**6.33**	7.56	**6.45**	7.08	**6.35**	7.42	**6.24**	33	0	11	0.56	**5.80**	**6.44**	6.78	7.80	8.13
Temperature (Field)	5.2	14.0	14.0	17.6	6.4	19.0	19.4	10.4	6.4	10.0	9.6	33	0	N/A	6.3	1.1	3.8	9.7	20.8	23.0
Specific Conductivity (Field)	29.3	42.3	6.4	26.4	27.3	41.8	6.7	25.8	27.7	39.5	10.7	33	0	N/A	14.3	5.1	20.5	27.4	50.6	66.5
Turbidity	0.5	1.2	1.3	0.4	0.6	1.8	1.7	0.5	0.6	1.3	2.0	32	0	N/A	1.0	0.3	0.4	1.2	3.3	5.0
General Parameters																				
Specific Conductivity (Lab)	21	36	<1	20	21	35	<1	19	19	32	4	33	4	N/A	14	1	18	21	46	57
Total Solids, Dissolved	30	51	5	14	18	32	21	22	25	37	16	33	1	N/A	15	5	21	32	62	72
Total Solids, Suspended	<1	1	1	<1	<1	<1	<1	<1	<1	2	<1	33	16	0.00	1	1	1	1	3	4
Hardness	9	17	1	9	10	18	1	10	9	17	2	33	1	N/A	7	1	5	10	22	25
Alkalinity	12	27	2	12	14	31	9	8	9	24	3	32	0	N/A	9	2	7	13	31	32
Nutrients																				
Total Ammonia as N	<0.01	0.02	0.01	0.02	0.01	0.02	<0.01	<0.01	<0.01	0.03	0.41	33	17	N/A	0.2	0.01	0.01	0.08	0.47	0.84
Ammonia as N (un-ionized)[b]	<0.01	0.700	0.010	0.100	0.003	0.300	<0.01	<0.02	<0.003	0.100	0.130	30	15	0	0.2	0.002	0.007	0.1	0.5	1.2
Dissolved Organic Carbon	2.5	6.4	4.4	2.8	2.2	6.2	5.8	2.3	2.3	6.3	5.6	30	0	1	2.3	1.0	2.3	4.6	7.6	8.4
Nitrate (as N)	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	30	23	0	0.007	0.01	0.01	0.009	0.03	0.04
Phosphorus	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	33	30	0	0.002	0.01	0.01	0.006	0.01	0.02
Major Ions																				
Bicarbonate	14.6	32.9	2.4	14.6	17.1	37.8	11.0	9.8	11.0	29.3	3.7	32	0	N/A	10.97	2.4	9.1	16.0	35.1	37.8
Calcium	2.8	5.0	0.4	2.8	2.9	5.1	0.4	2.7	2.7	4.8	0.4	33	0	N/A	1.72	0.4	0.6	2.6	5.0	5.1
Chloride	1.9	<0.1	<0.1	1.9	2.0	<0.1	<0.1	1.8	1.9	<0.1	<0.1	33	9	0	0.9	0.1	0.1	0.9	2.0	2.1
Fluoride	0.02	0.02	0.01	0.02	0.02	0.03	0.01	0.02	0.02	0.03	0.02	32	0	N/A	0.01	0.01	0.02	0.03	0.05	0.06
Magnesium	0.6	1.2	0.1	0.6	0.7	1.3	0.1	0.7	0.6	1.2	0.2	33	1	N/A	0.5	0.1	0.5	0.7	1.5	1.7
Sodium	0.9	1.3	0.6	0.9	1	1.3	0.6	0.9	0.9	1.3	0.5	33	0	N/A	0.3	0.5	0.9	1	1.5	1.7
Sulphate	1.0	1.0	0.6	1.0	1.0	1.0	0.7	1.0	1.0	1.0	0.9	33	0	0	0.2	0.6	0.8	0.9	1.1	1.1
Total Metals																				
Aluminum	3.3	4.0	9.9	7.9	2.3	3.2	16.0	7.0	5.3	4.9	25.0	29	0	0	5.7	1.2	3.2	6.6	18.4	25.0
Arsenic	<0.1	0.1	0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	0.2	33	10	0	0.04	0.1	0.1	0.1	0.2	0.2
Barium	7.3	6.1	2.5	6.5	7.1	5.0	2.7	6.7	6.8	5.5	4.4	32	0	N/A	2.4	2.5	4.6	6.1	9.2	15.0
Beryllium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	32	32	N/A	0.0	0.1	0.1	0.05	0.1	0.1
Boron	<10	<10	<10	10	<10	<10	<10	<10	<10	<10	<10	32	23	N/A	0	10	10	6	10	10
Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	33	26	0	0.00	0.01	0.01	0.006	0.01	0.01
Cesium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	28	28	N/A	0.0	0.1	0.1	0.05	0.1	0.1
Chromium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	32	32	0	0.0	0.5	0.5	0.3	0.5	0.5
Cobalt	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	33	32	0	0.03	0.0	0.1	0.05	0.1	0.1
Copper	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	33	29	0	0.06	0.2	0.2	0.13	0.3	0.5
Iron	39	**320**	61	8	15	56	35	18	17	40	26	33	0	3	319	5	15	124	628	1580
Lead	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	33	30	0	0.1	0.1	0.1	0.08	0.2	0.6
Manganese	15.0	8.3	2.8	3.1	6.2	15.0	3.5	2.6	3.3	6.0	3.5	32	0	0	47.0	1.2	3.3	20.2	110.4	200.0
Mercury	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	33	14	0	0.001	0.001	0.001	0.001	0.004	0.007
Molybdenum	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	33	29	0	0.0	0.1	0.1	0.06	0.1	0.1
Nickel	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	33	26	0	0.07	0.1	0.1	0.08	0.3	0.4
Selenium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	33	29	0	0.0	0.1	0.1	0.06	0.1	0.1
Strontium	64	16	4	60	62	16	4	59	60	16	5	32	0	N/A	25	4	13	32	63	64
Tin	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	32	23	N/A	1.0	0.1	0.1	0.3	1.1	6.0
Titanium	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	32	27	N/A	0.02	0.2	0.2	0.1	0.2	0.3
Uranium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	33	29	0	0.0	0.1	0.1	0.06	0.1	0.1
Vanadium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	32	24	0	0.02	0.1	0.1	0.07	0.1	0.2
Zinc	0.6	<0.5	0.6	<0.5	1	<0.5	0.9	<0.5	0.7	<0.5	0.9	33	7	0	0.6	0.5	0.5	0.9	2.2	2.8
Radionuclides																				
Lead-210	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	33	29	0	0.00	0.02	0.02	0.01	0.03	0.03
Polonium-210	<0.005	0.007	0.008	<0.005	<0.005	<0.005	0.010	<0.005	<0.006	<0.005	0.010	33	21	0	0.002	0.005	0.005	0.004	0.010	0.010
Radium-226	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	33	27	0	0.001	0.005	0.005	0.003	0.007	0.010
Thorium-230	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	33	32	0	0.00	0.01	0.01	0.005	0.01	0.01

Note:

Shaded & Bold indicates that the value is greater than the most stringent applicable SEQG or CCME Guideline.

Yellow Shaded indicates that guideline is hardness dependant.

a) No project threshold for pH; CCME guideline range presented (CCME 1996).

b) Fraction of unionized ammonia calculated based on total ammonia (as N), pH and temperature.

c) Unionized ammonia fraction could not be calculated due to pH being out of range.

d) Computed with half of MDL value.

e) Threshold was calculated for cadmium, copper, lead, nickel, and sulphate based on the maximum hardness observed within the RSA (21 mg/L $CaCO_3$).

f) Threshold for cobalt was calculated using the following formula: exp(0.414(ln(hardness))-1.887), where hardness is in mg/L $CaCO_3$ and the resulting cobalt threshold is in µg/L. Hardness value used in calculation is the 95th percentile hardness value for each lake.

MDL = method detection limit; mg/L = milligrams per litre; µg/L = micrograms per litre; Bq/L = becquerel per litre; µS/cm = microsiemens per centimeter; NTU = nephelometric turbidity unit.

Attachment 10A-1b Surface Water Quality Summary Statistics Plots

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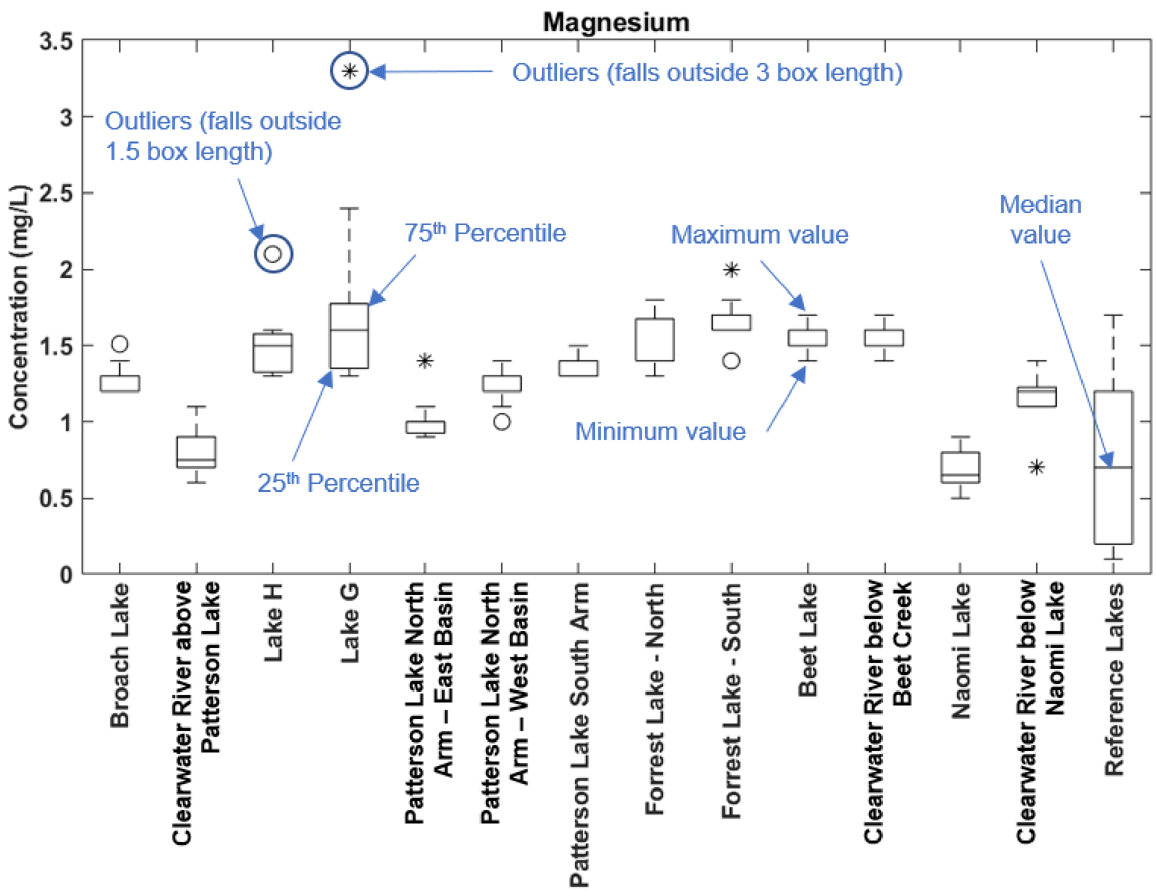
List of Figures

Figure Description

Boxplots of the water quality measurements are presented in this appendix by parameter and waterbody. The vertical length of the boxplot represents the inter-quartile range (25th to 75th inter-quartiles) with the median denoted by the dark horizontal line. The whiskers represent the minimum and maximum values of the dataset unless outliers are present, in which case the whiskers extend to a maximum of the 1.5 times the inter-quartiles range. Outliers (circles) are values that fall between 1.5 and 3 box lengths from the upper and lower edges of the box, and extreme cases (stars) are values that are more than 3 box lengths from the upper and lower edge of the box. The components of the box plots are visually shown in Figure 10A-1b-1.

Figure 10A-1b-1: Example Boxplot and Boxplot Components Visually Shown



In some cases where all or most of the samples were reported less than or at the detection limit, the boxes and whiskers are presented as a single line (e.g., Figure 10A-1b-18 for total phosphorus).

10A-1b-1 PHYSICAL PARAMETERS

Figure 10A-1b-2: Summary Statistics of pH (Field Measured) of Waterbodies and Watercourses in the Local Study Area

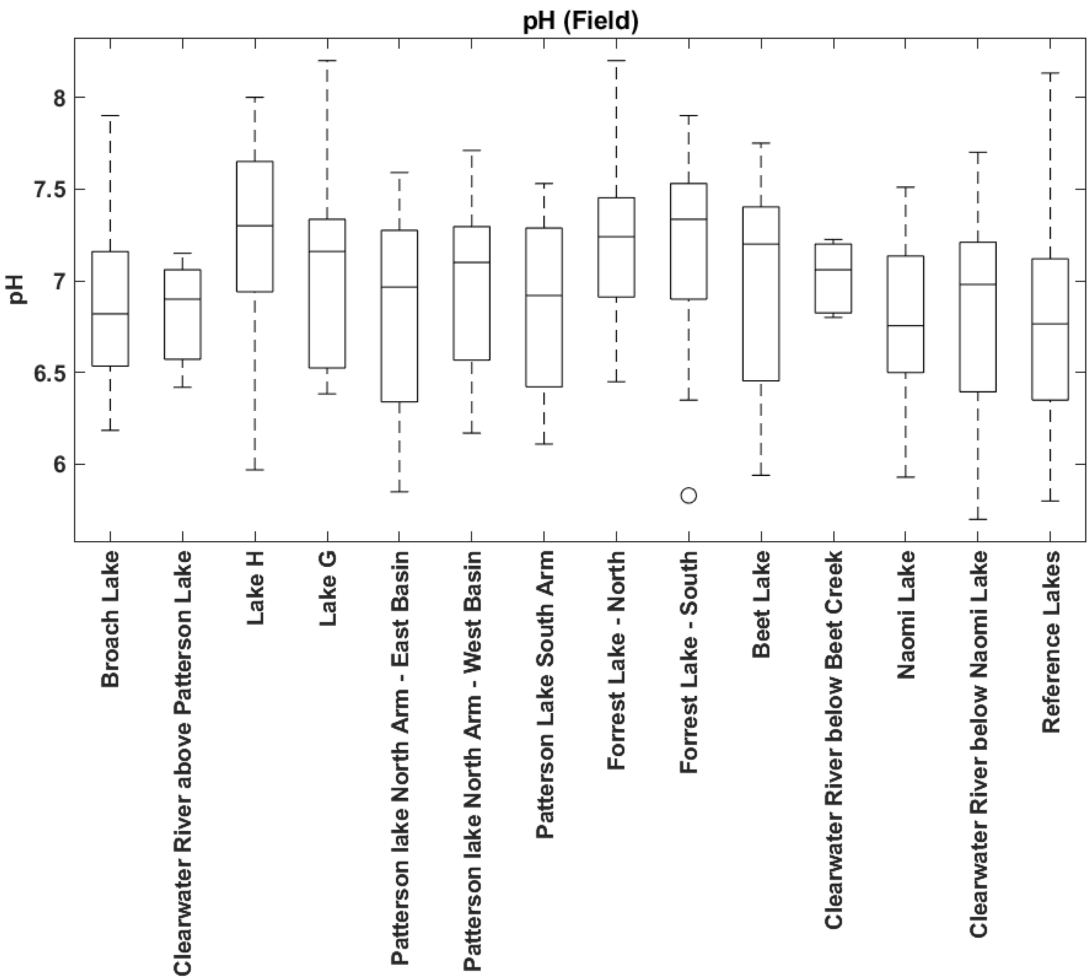


Figure 10A-1b-3: Summary Statistics of Specific Conductivity (Field) of Waterbodies and Watercourses in the Local Study Area

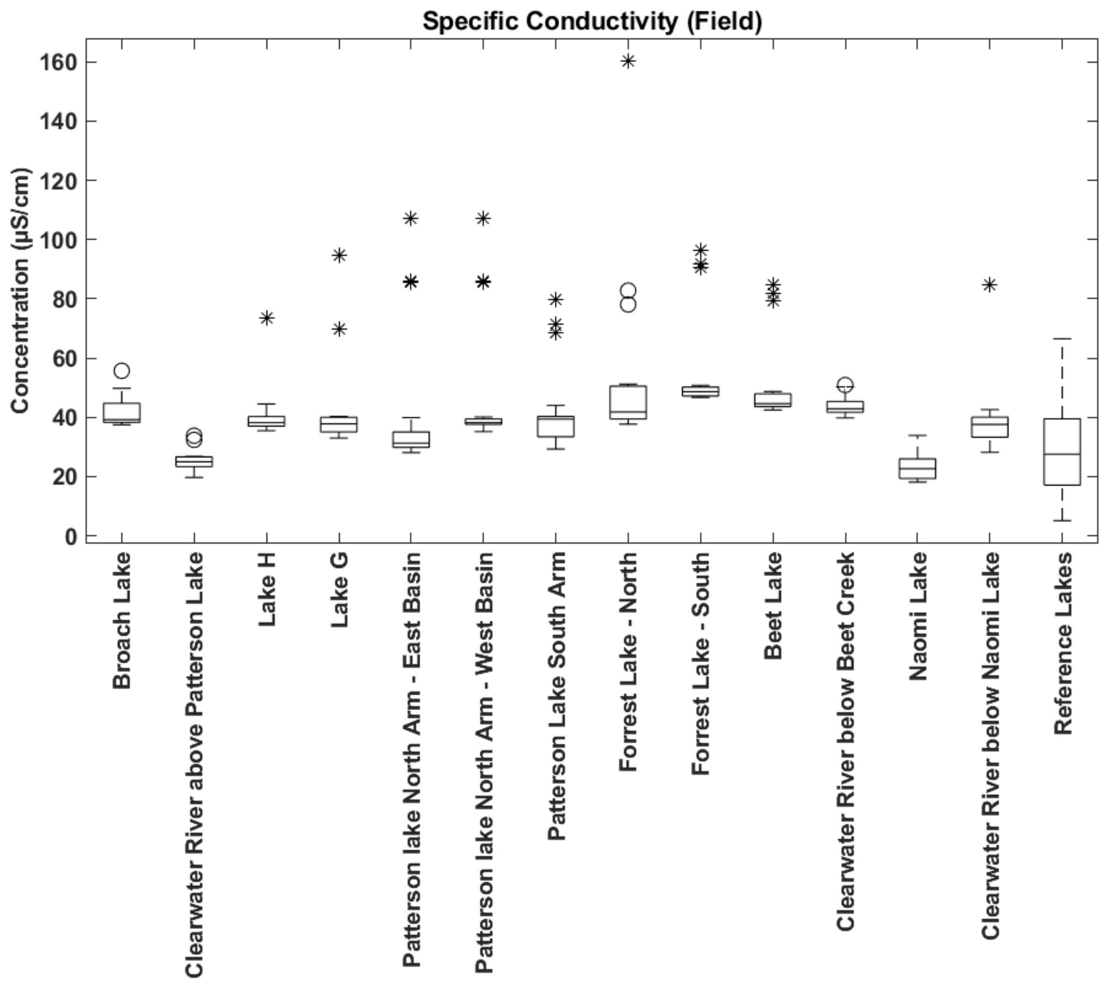
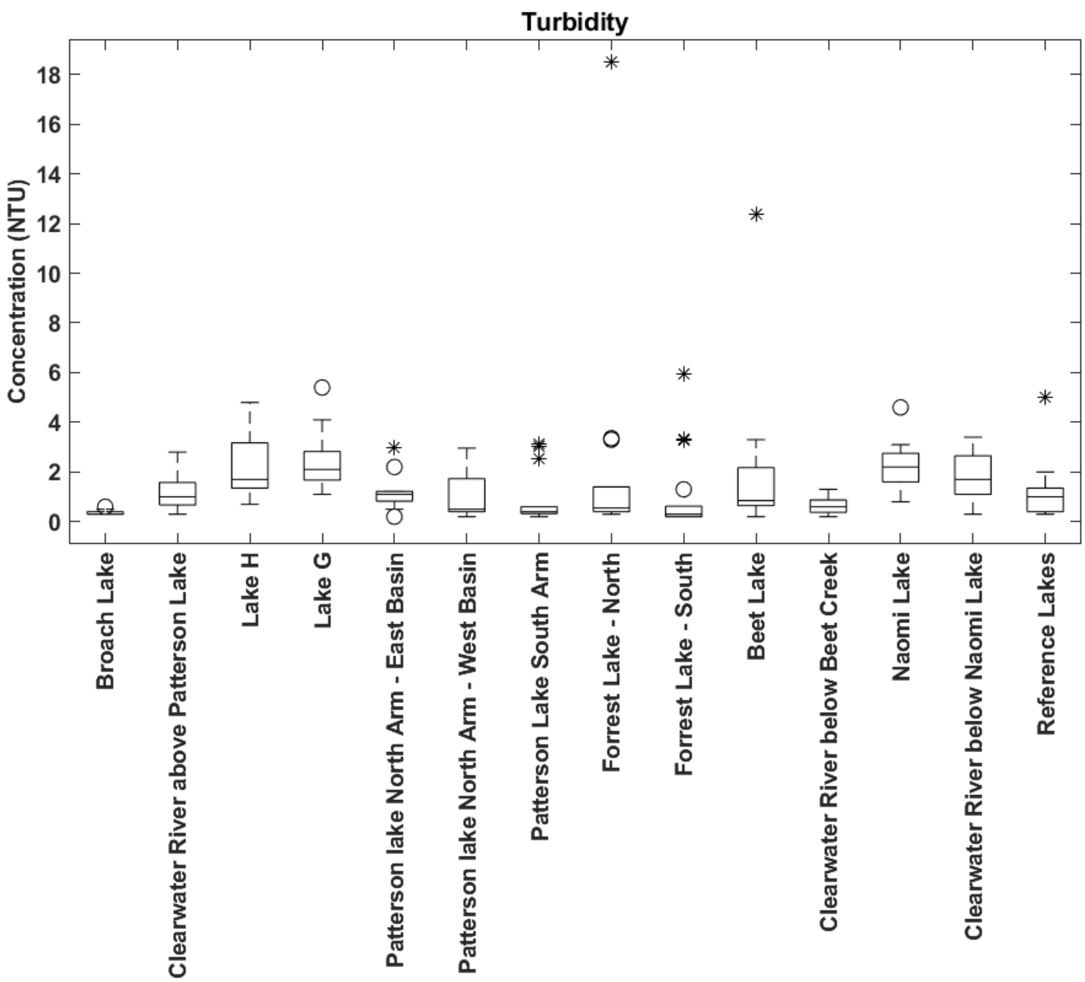


Figure 10A-1b-4: Summary Statistics of Turbidity of Waterbodies and Watercourses in the Local Study Area



10A-1b-2 GENERAL PARAMETERS

Figure 10A-1b-5: Summary Statistics of Total Dissolved Solids of Waterbodies and Watercourses in the Local Study Area

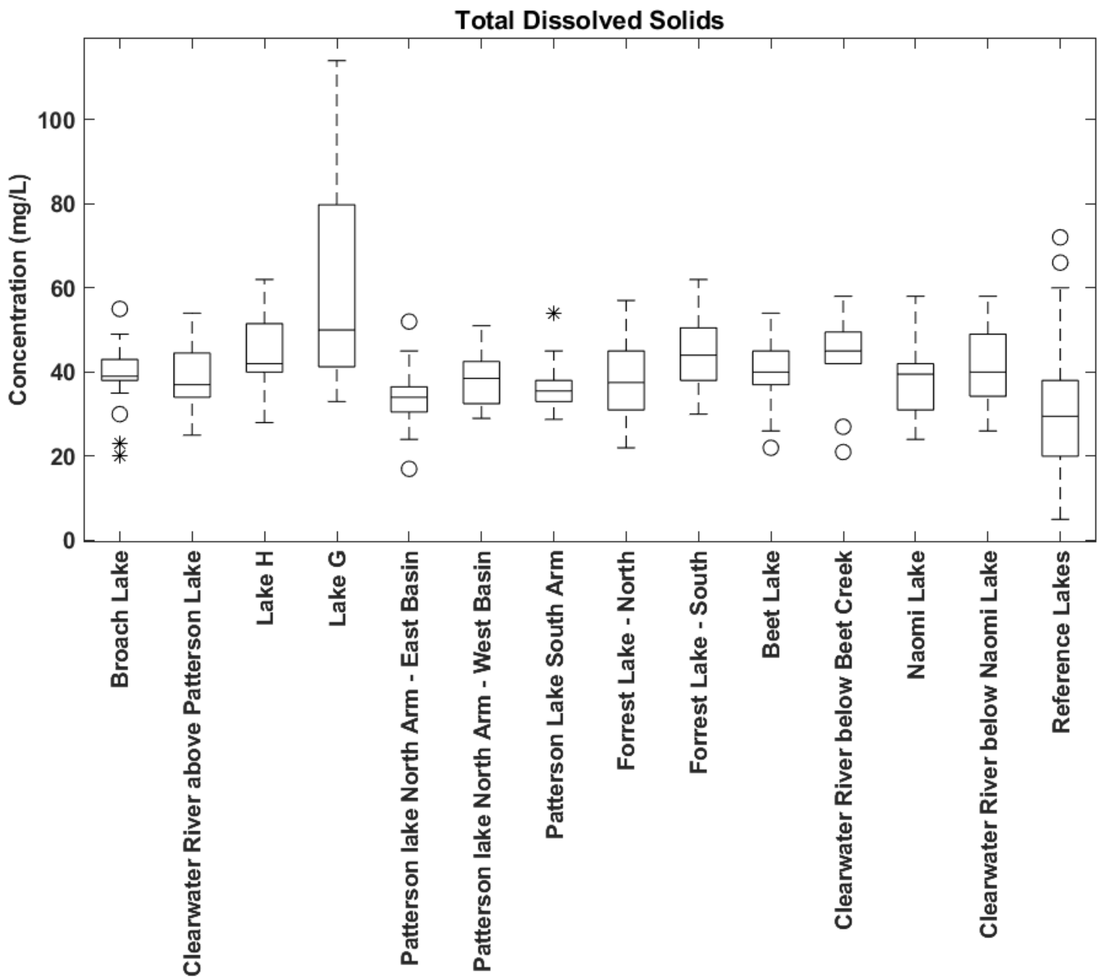


Figure 10A-1b-6: Summary Statistics of Total Suspended Solids of Waterbodies and Watercourses in the Local Study Area

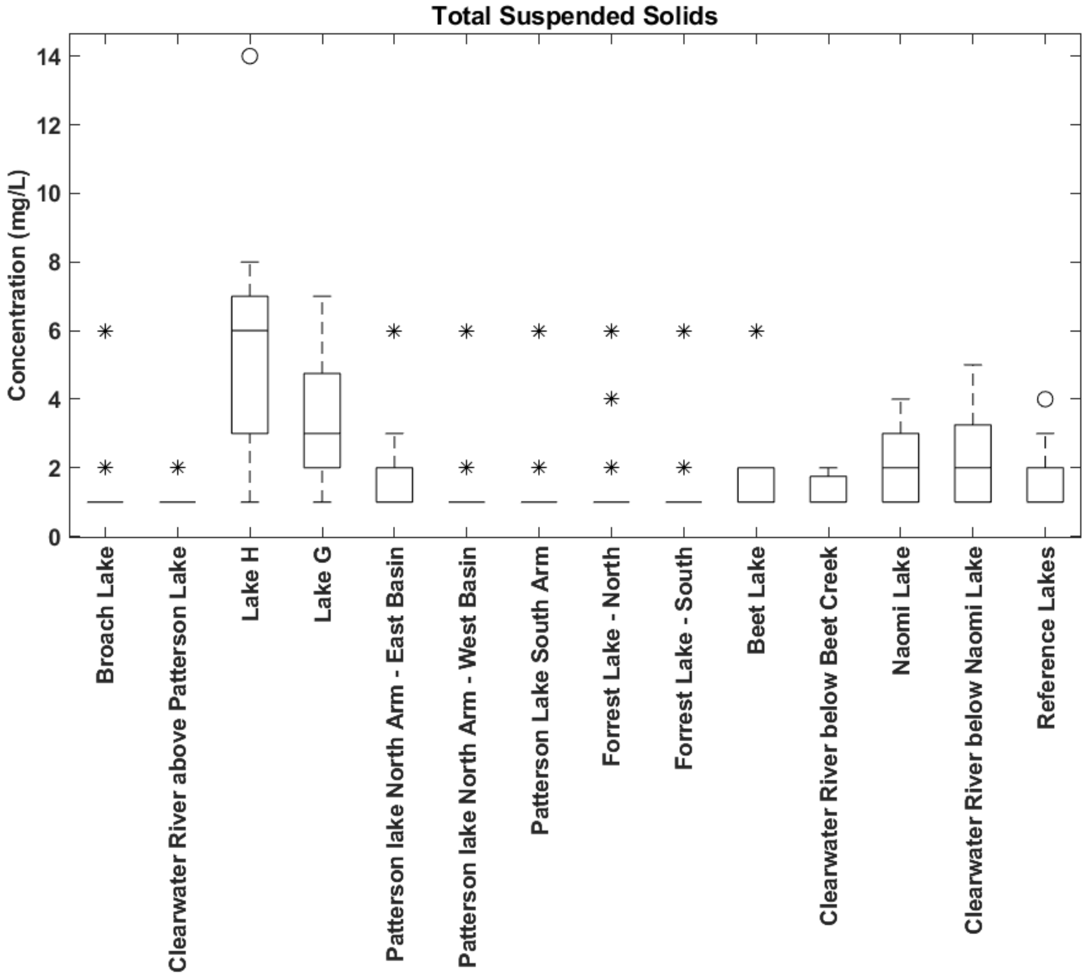


Figure 10A-1b-7: Summary Statistics of Hardness of Waterbodies and Watercourses in the Local Study Area

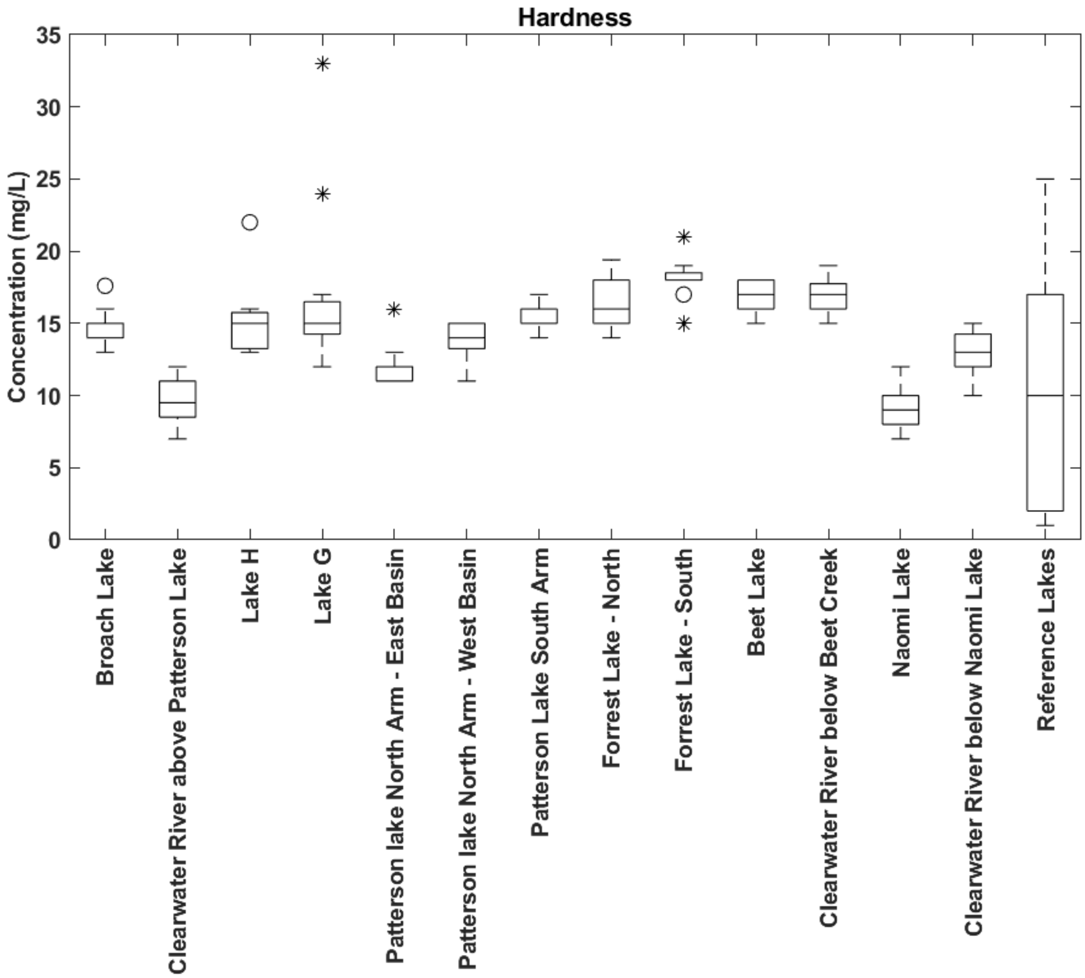
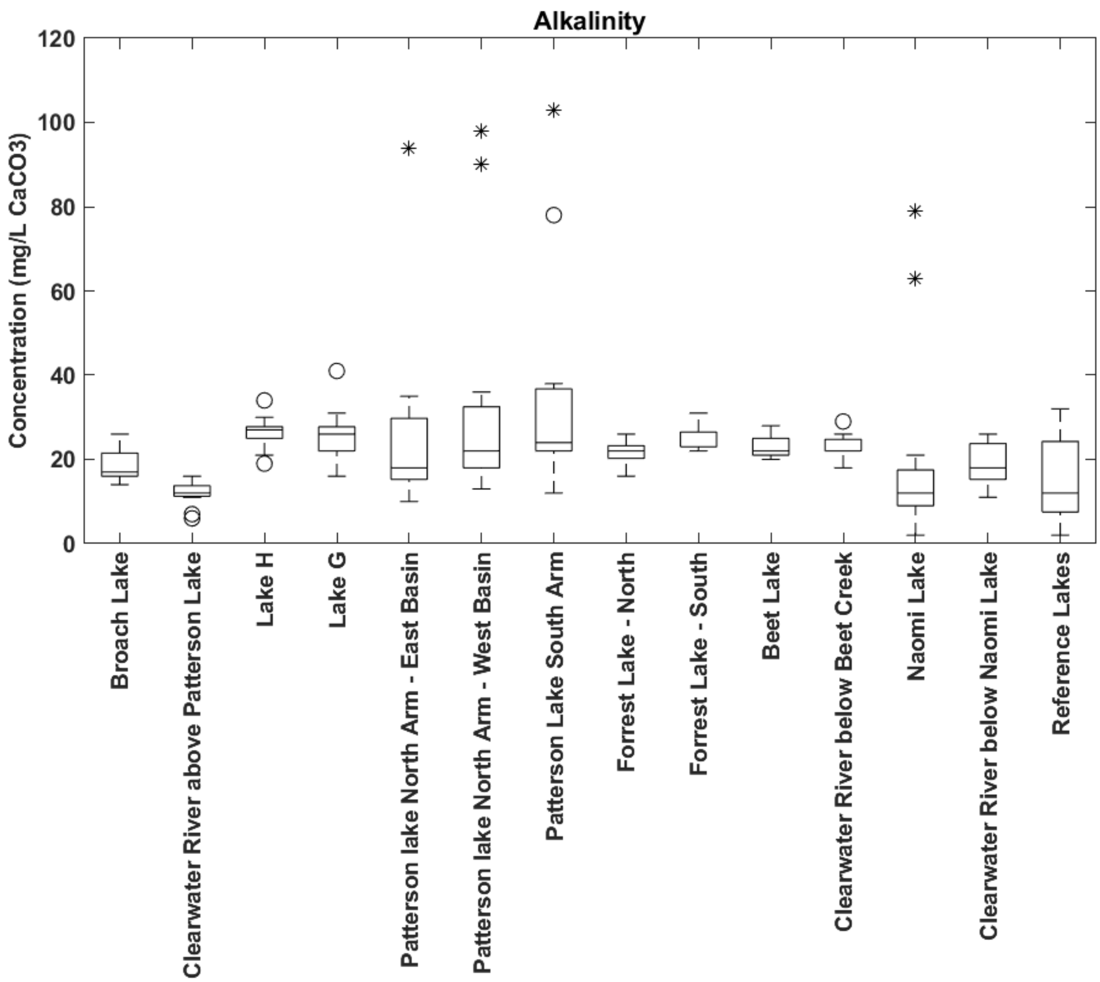


Figure 10A-1b-8: Summary Statistics of Total Alkalinity of Waterbodies and Watercourses in the Local Study Area



10A-1b-3 MAJOR IONS

Figure 10A-1b-9: Summary Statistics of Calcium of Waterbodies and Watercourses in the Local Study Area

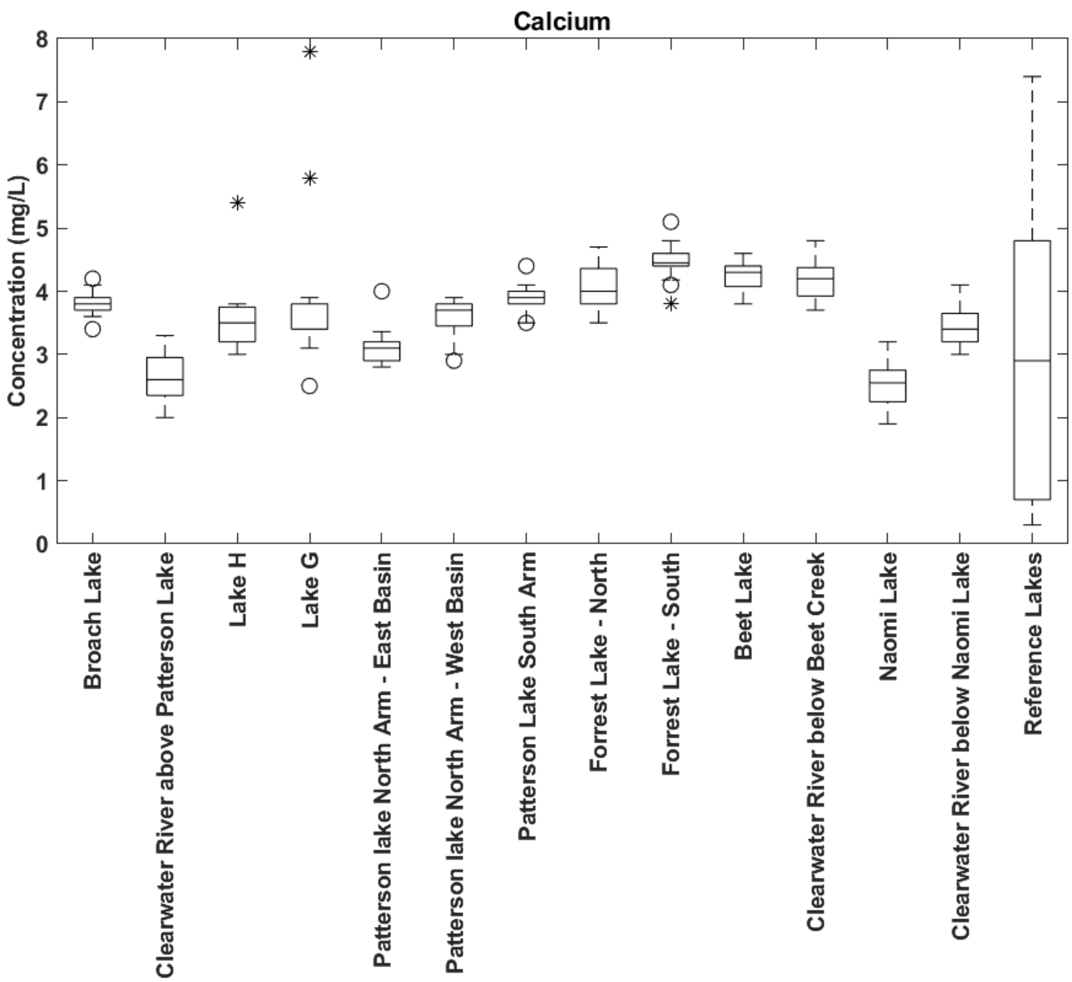
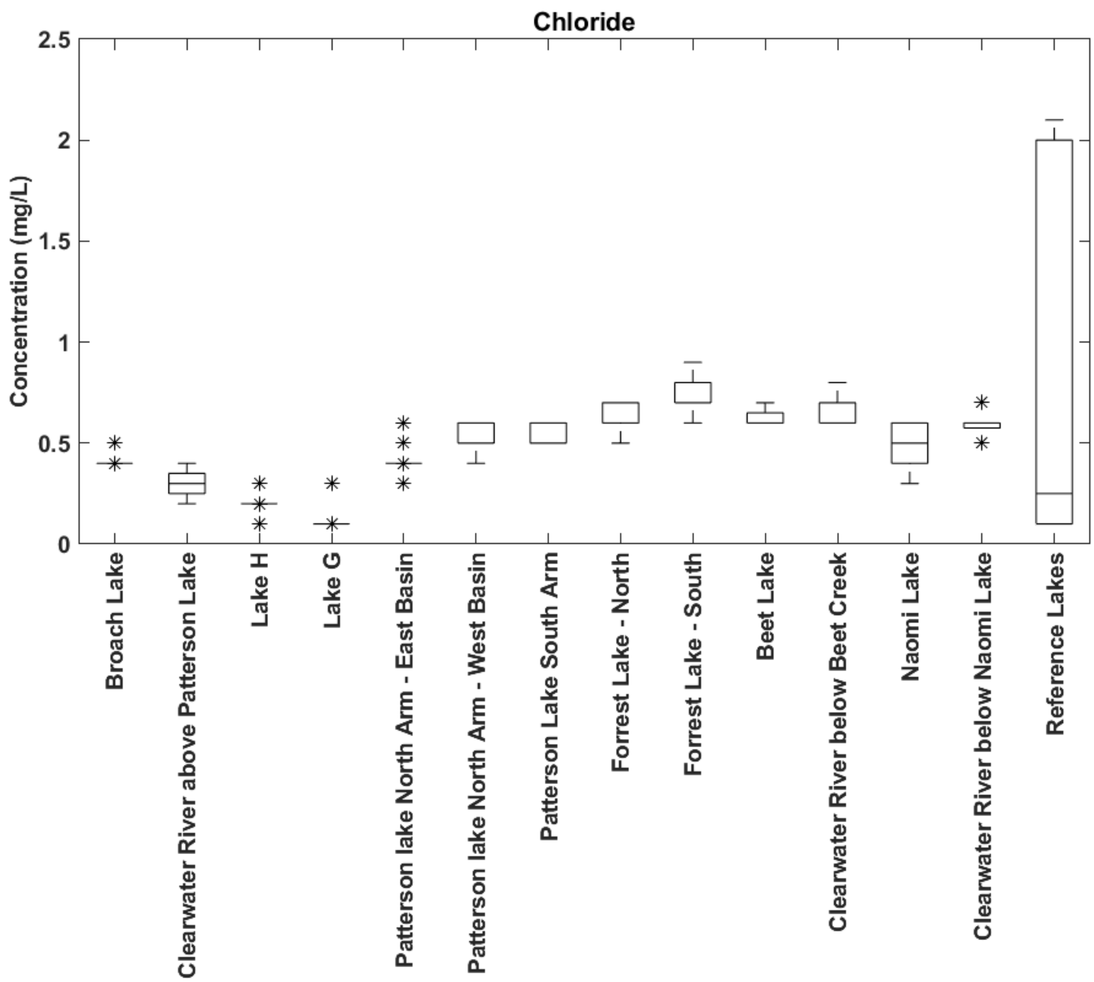


Figure 10A-1b-10: Summary Statistics of Chloride of Waterbodies and Watercourses in the Local Study Area



Note: Calcium threshold = 120 mg/L.

Figure 10A-1b-11: Summary Statistics of Fluoride of Waterbodies and Watercourses in the Local Study Area

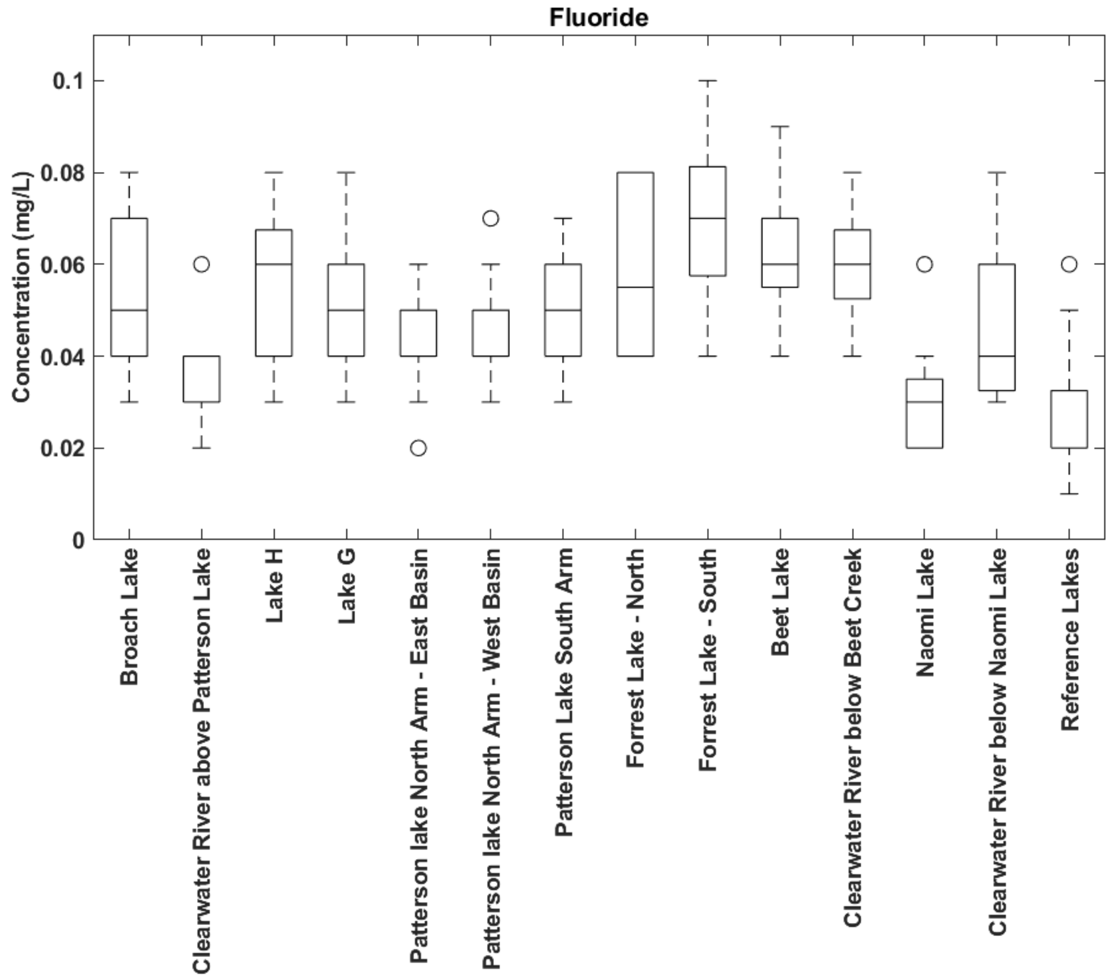


Figure 10A-1b-12: Summary Statistics of Magnesium of Waterbodies and Watercourses in the Local Study Area

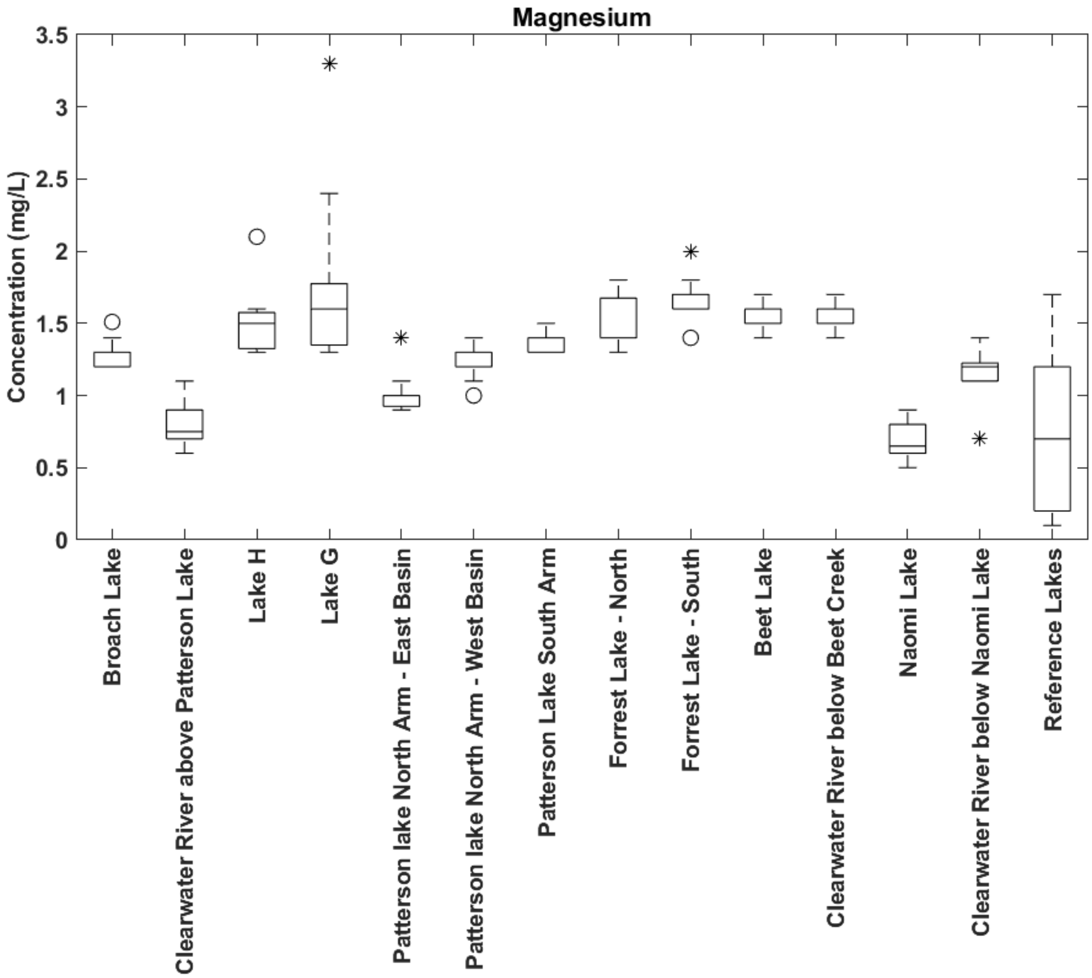


Figure 10A-1b-13: Summary Statistics of Sodium of Waterbodies and Watercourses in the Local Study Area

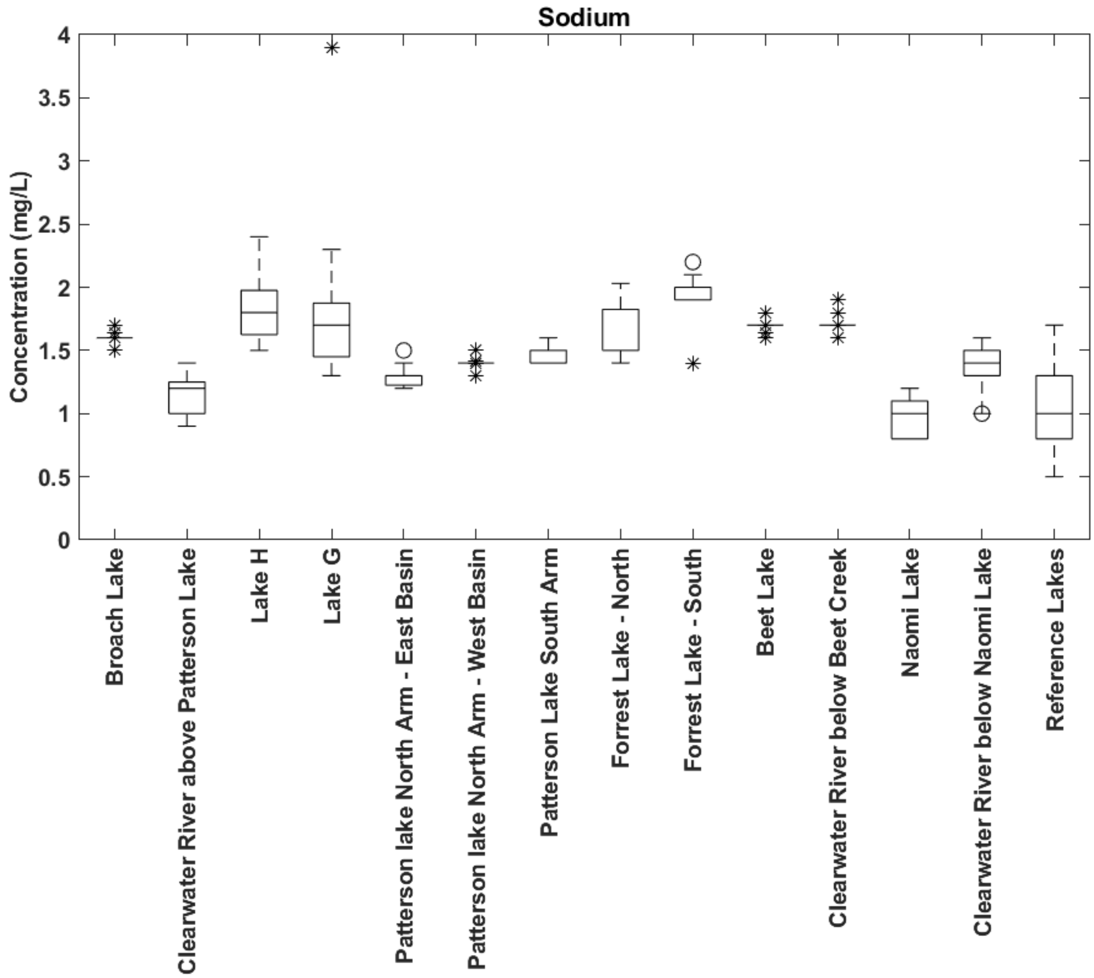
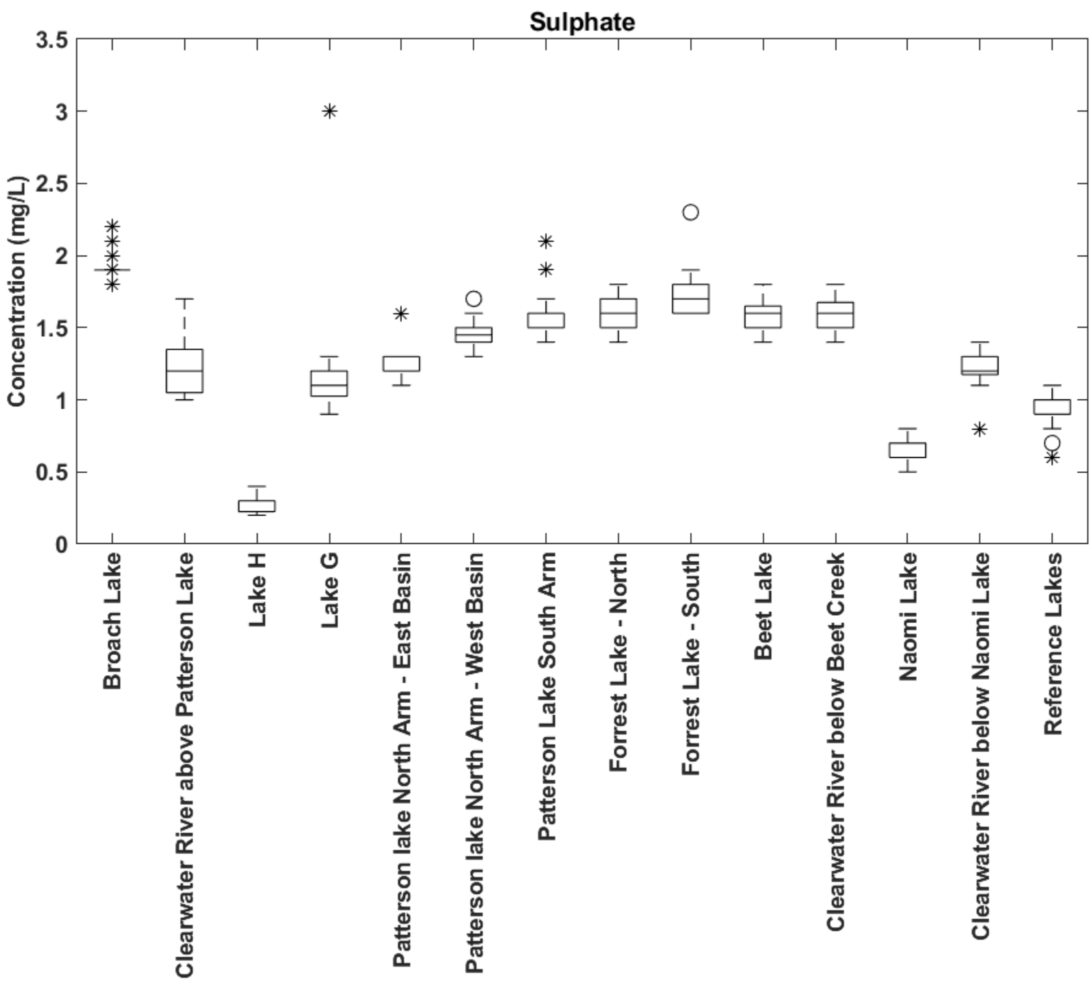


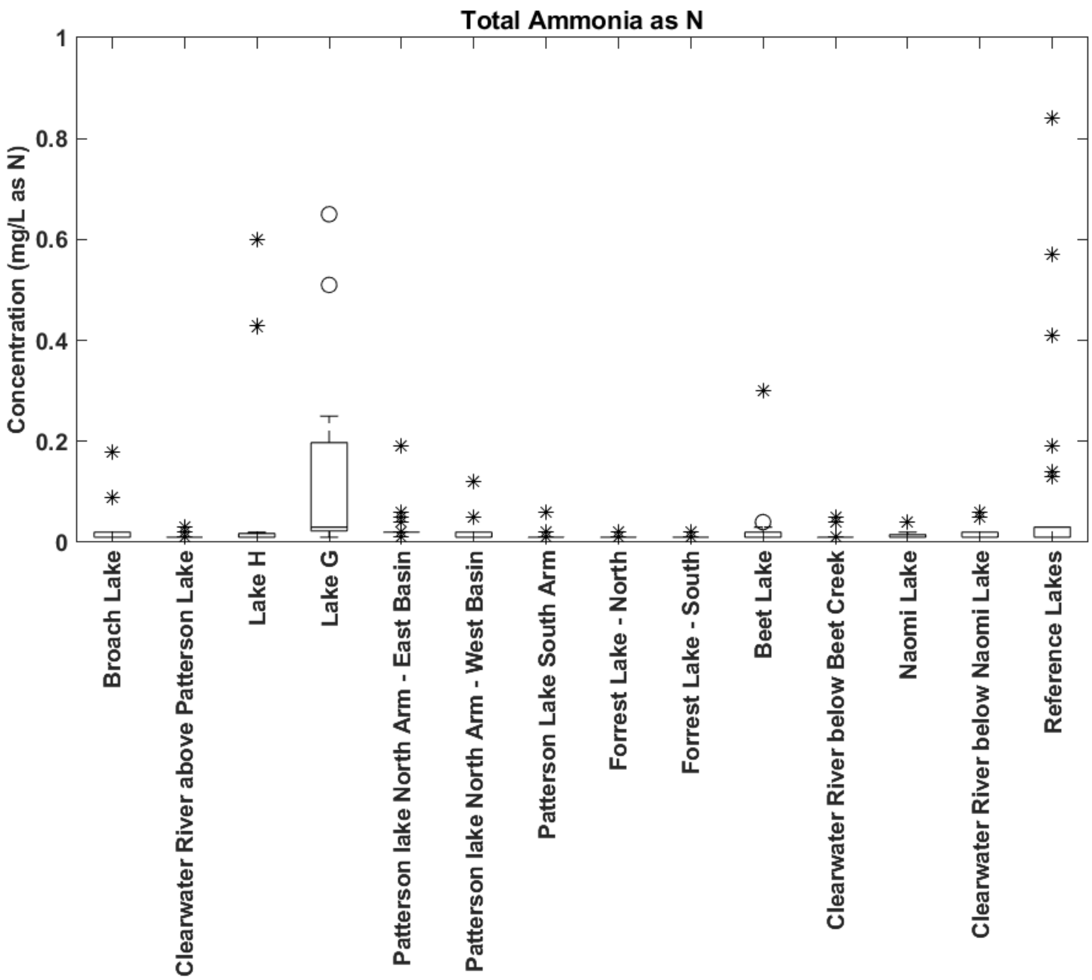
Figure 10A-1b-14: Summary Statistics of Sulphate of Waterbodies and Watercourses in the Local Study Area



Note: Sulphate threshold = 128 mg/L.

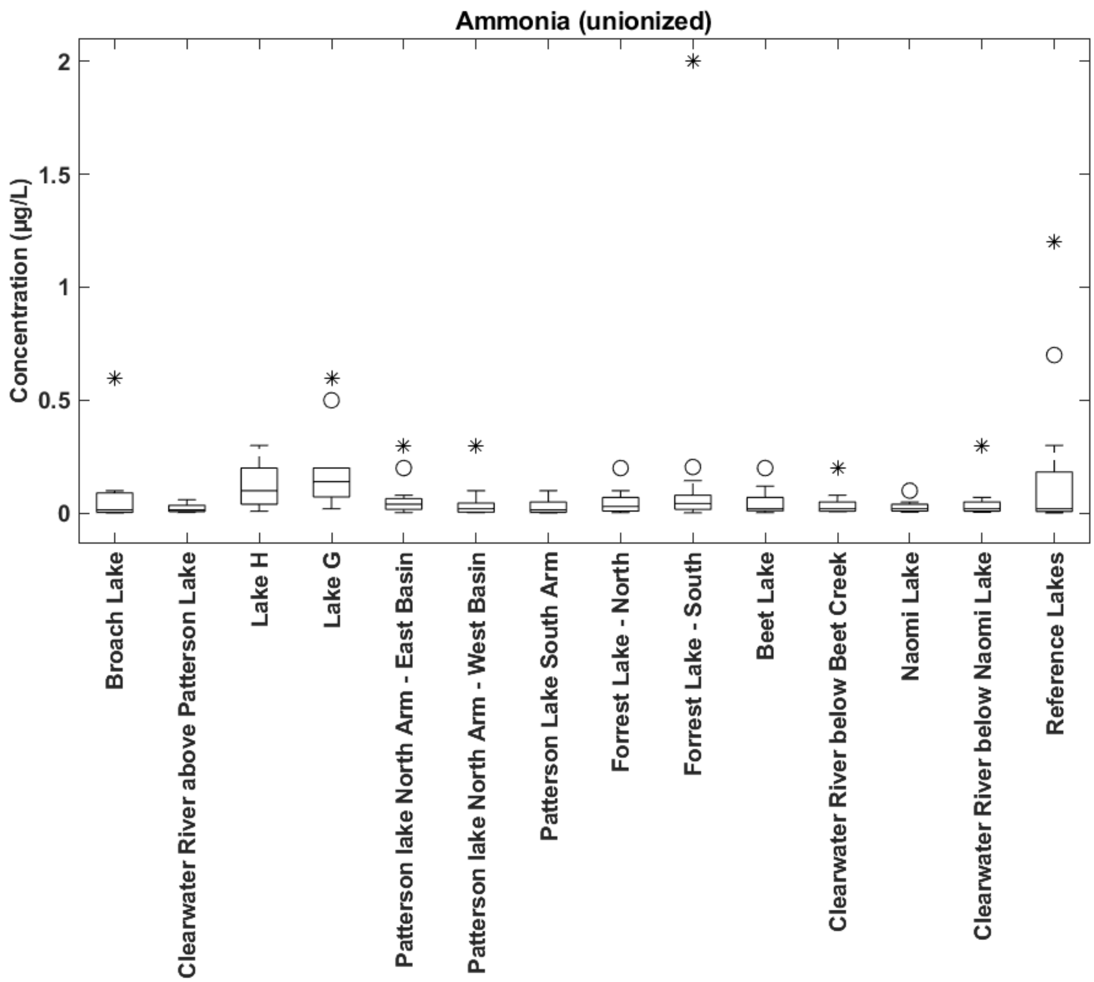
10A-1b-4 NUTRIENTS

Figure 10A-1b-15: Summary Statistics of Total Ammonia (as N) of Waterbodies and Watercourses in the Local Study Area



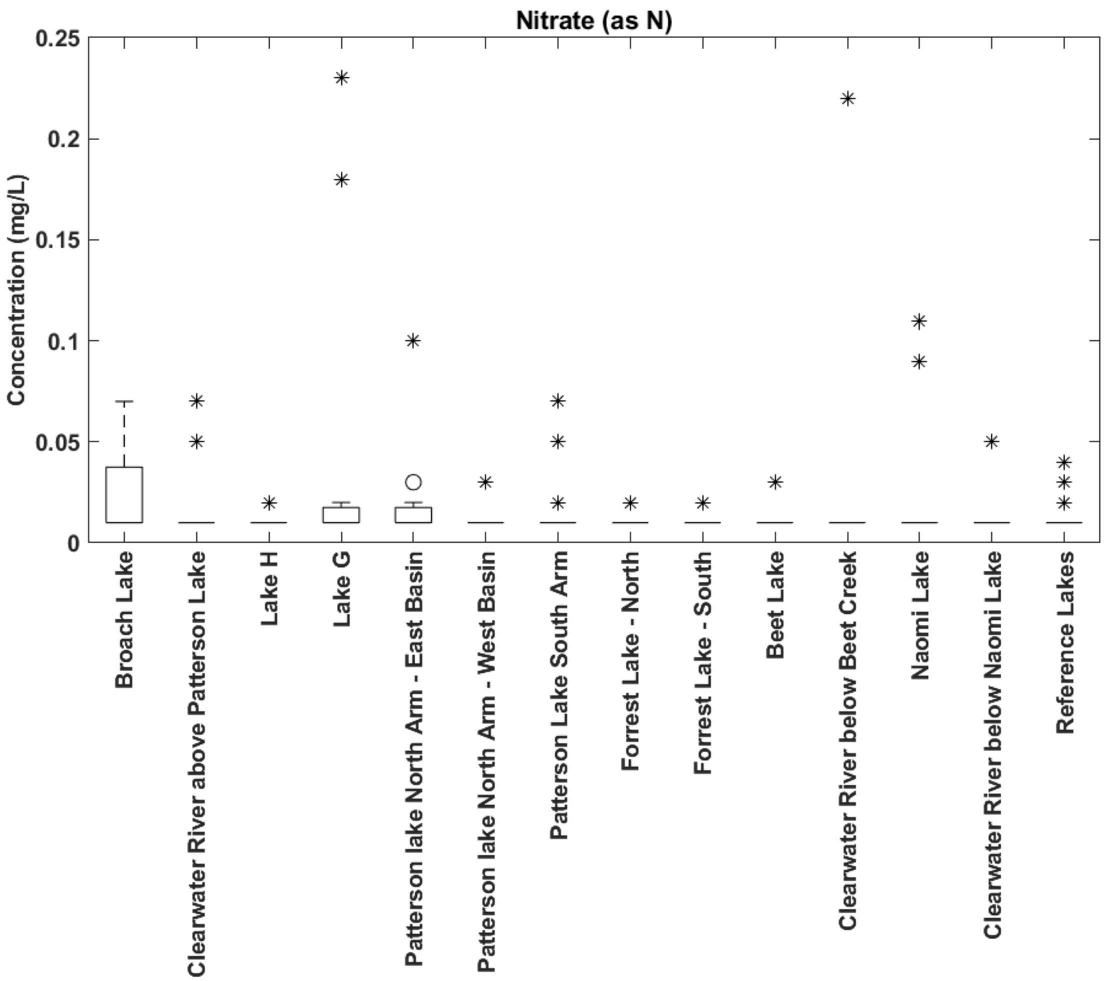
Note: Total Ammonia as N is a function of un-ionized ammonia, pH, and temperature.

Figure 10A-1b-16: Summary Statistics of Un-ionized Ammonia of Waterbodies and Watercourses in the Local Study Area



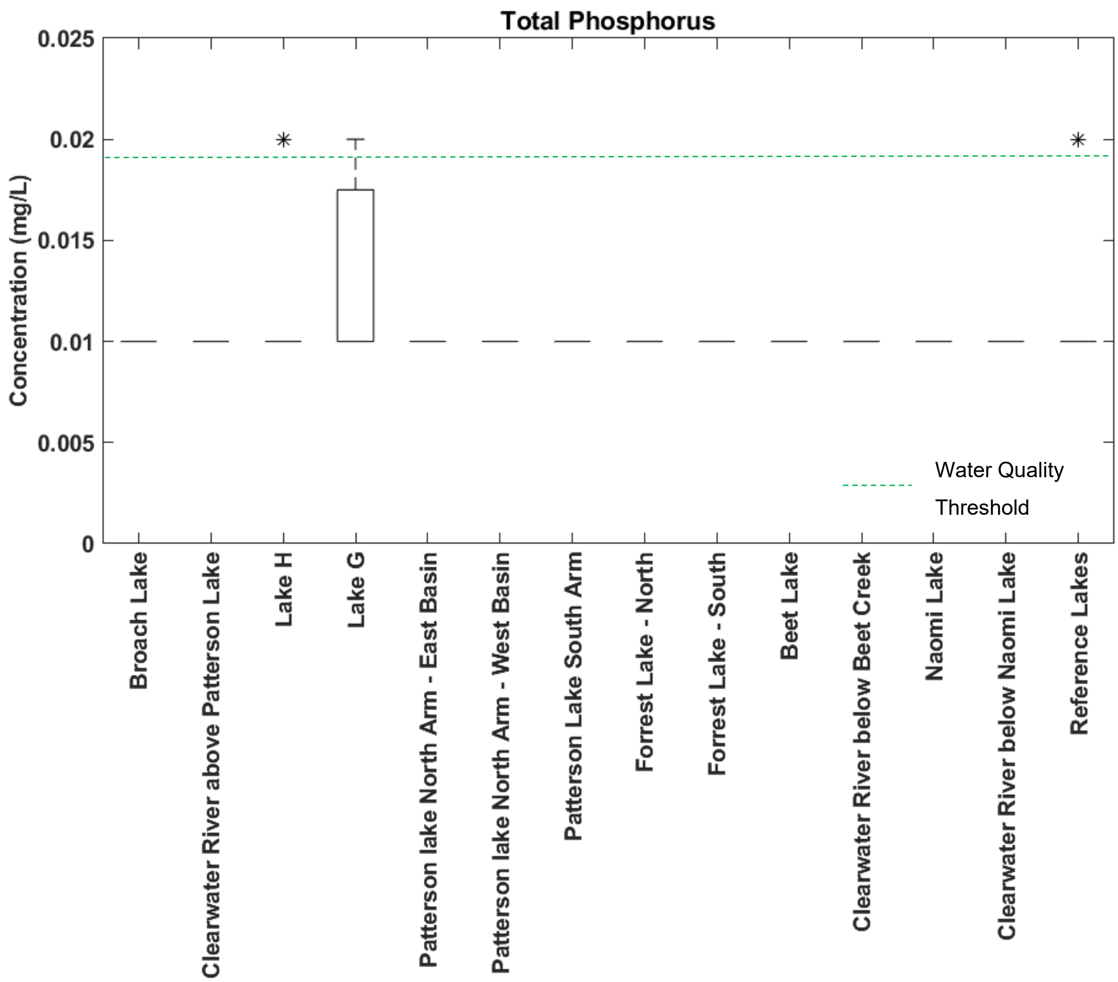
Note: Un-ionized ammonia threshold = 15.6 mg/L.

Figure 10A-1b-17: Summary Statistics of Nitrate (as N) of Waterbodies and Watercourses in the Local Study Area



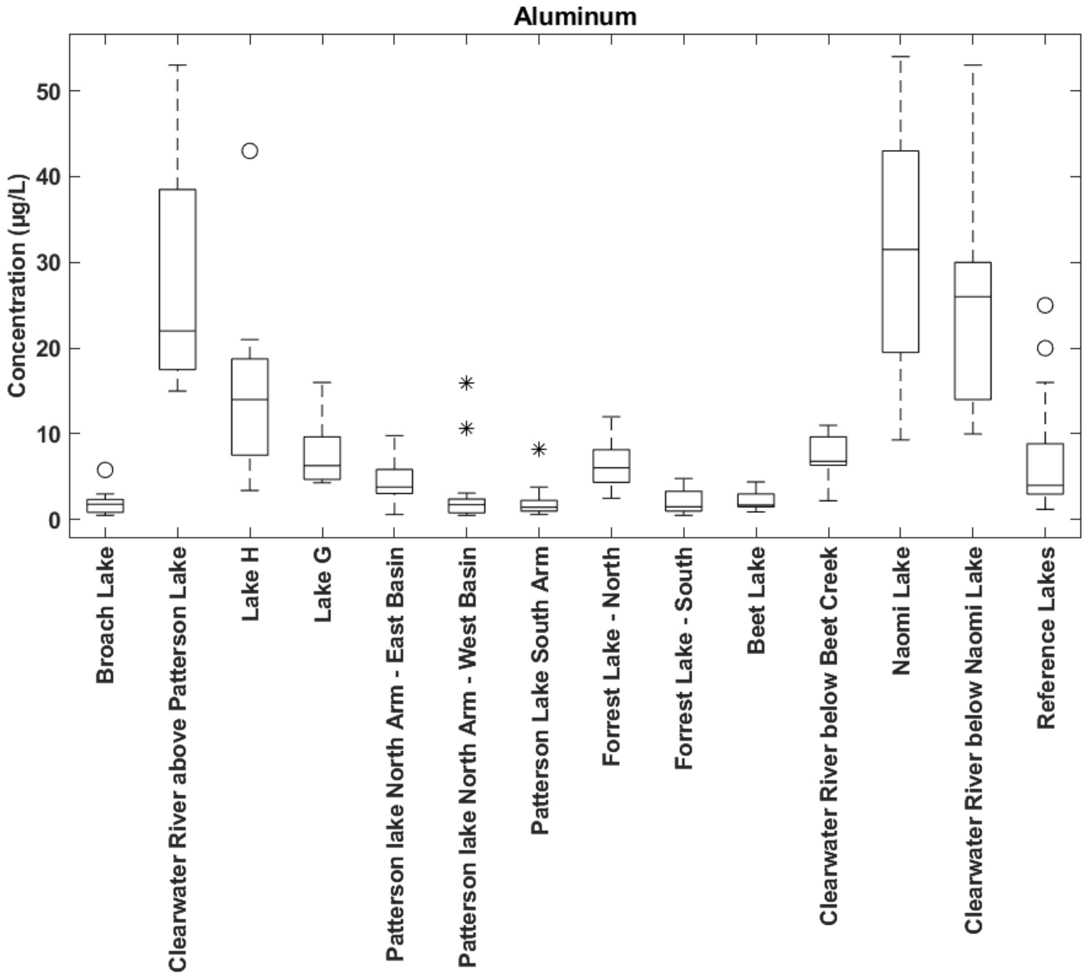
Note: Nitrate threshold = 3.0 mg/L.

Figure 10A-1b-18: Summary Statistics of Total Phosphorus of Waterbodies and Watercourses in the Local Study Area



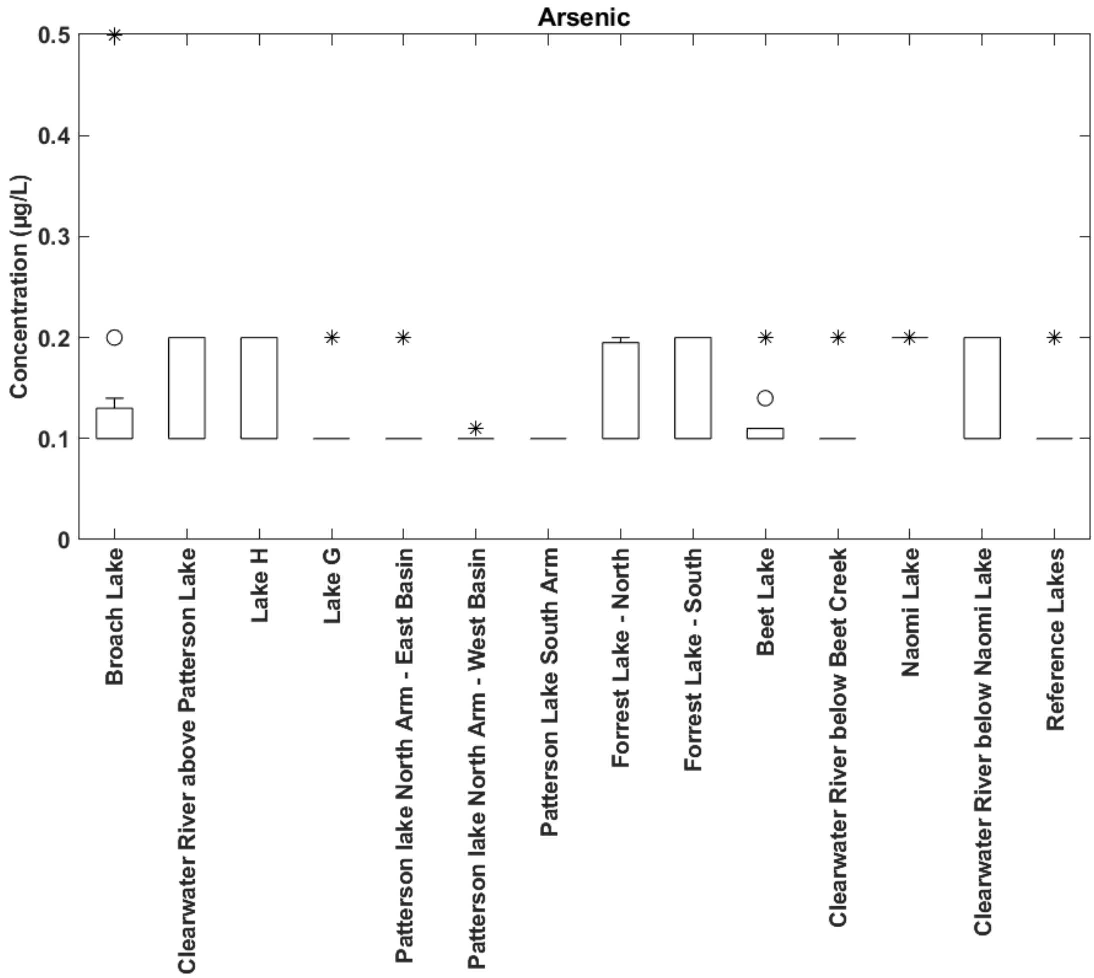
10A-1b-5 TOTAL METALS

Figure 10A-1b-19: Summary Statistics of Aluminium of Waterbodies and Watercourses in the Local Study Area



Note: Aluminium water quality threshold = 10 µg/L.

Figure 10A-1b-20: Summary Statistics of Arsenic of Waterbodies and Watercourses in the Local Study Area



Notes: One value from Patterson South Basin was removed due to its extreme value of 23.1 µg/L measured in Fall 2015.
Arsenic water quality threshold = 5 µg/L.

Figure 10A-1b-21: Summary Statistics of Barium of Waterbodies and Watercourses in the Local Study Area

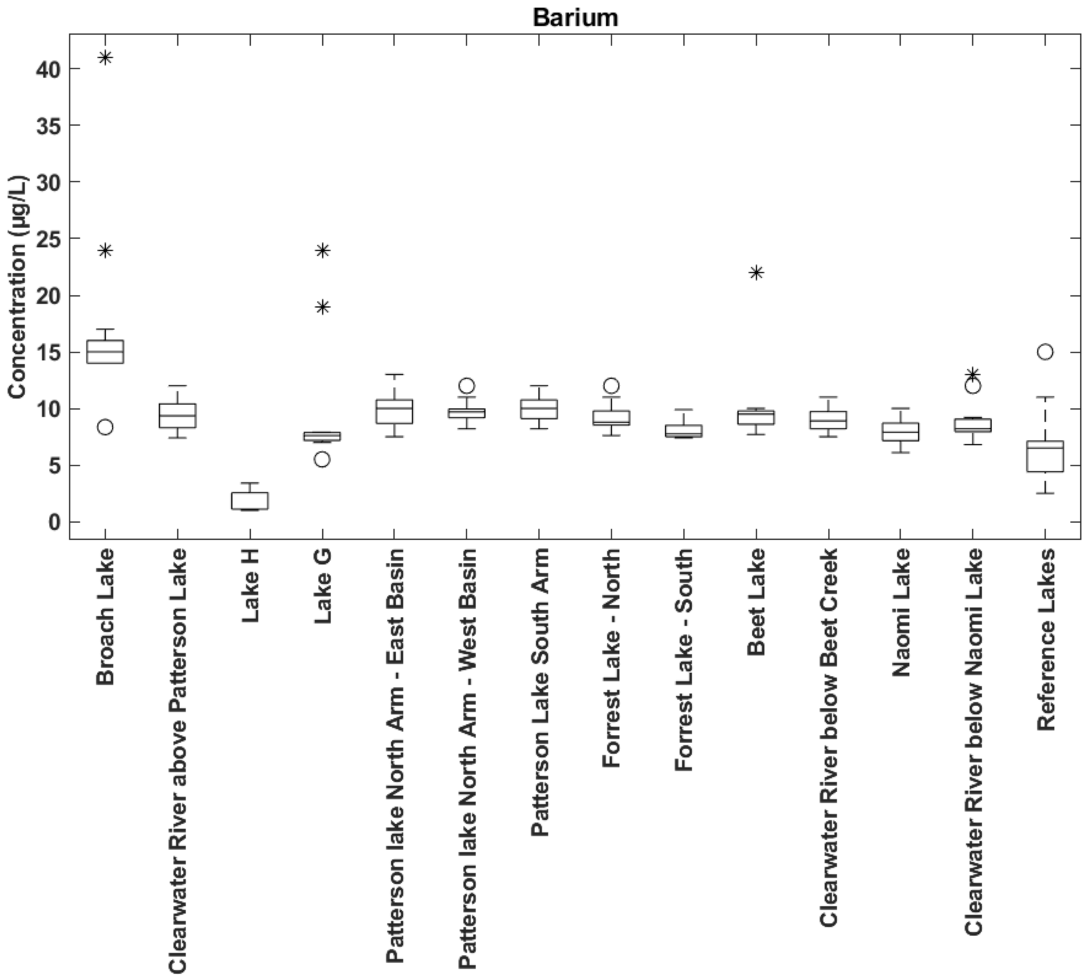
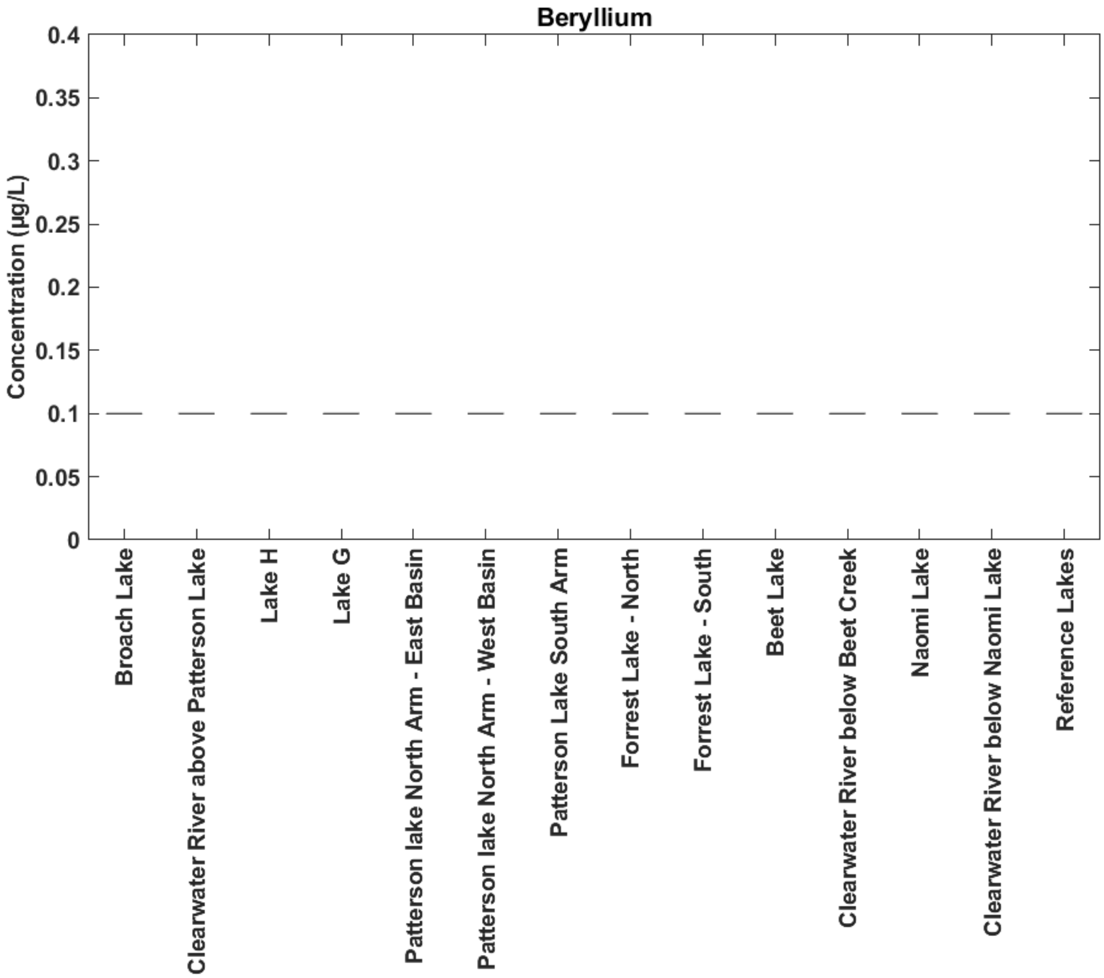


Figure 10A-1b-22: Summary Statistics of Beryllium of Waterbodies and Watercourses in the Local Study Area



Note: Beryllium water quality threshold = 11 µg/L.

Figure 10A-1b-23: Summary Statistics of Boron of Waterbodies and Watercourses in the Local Study Area

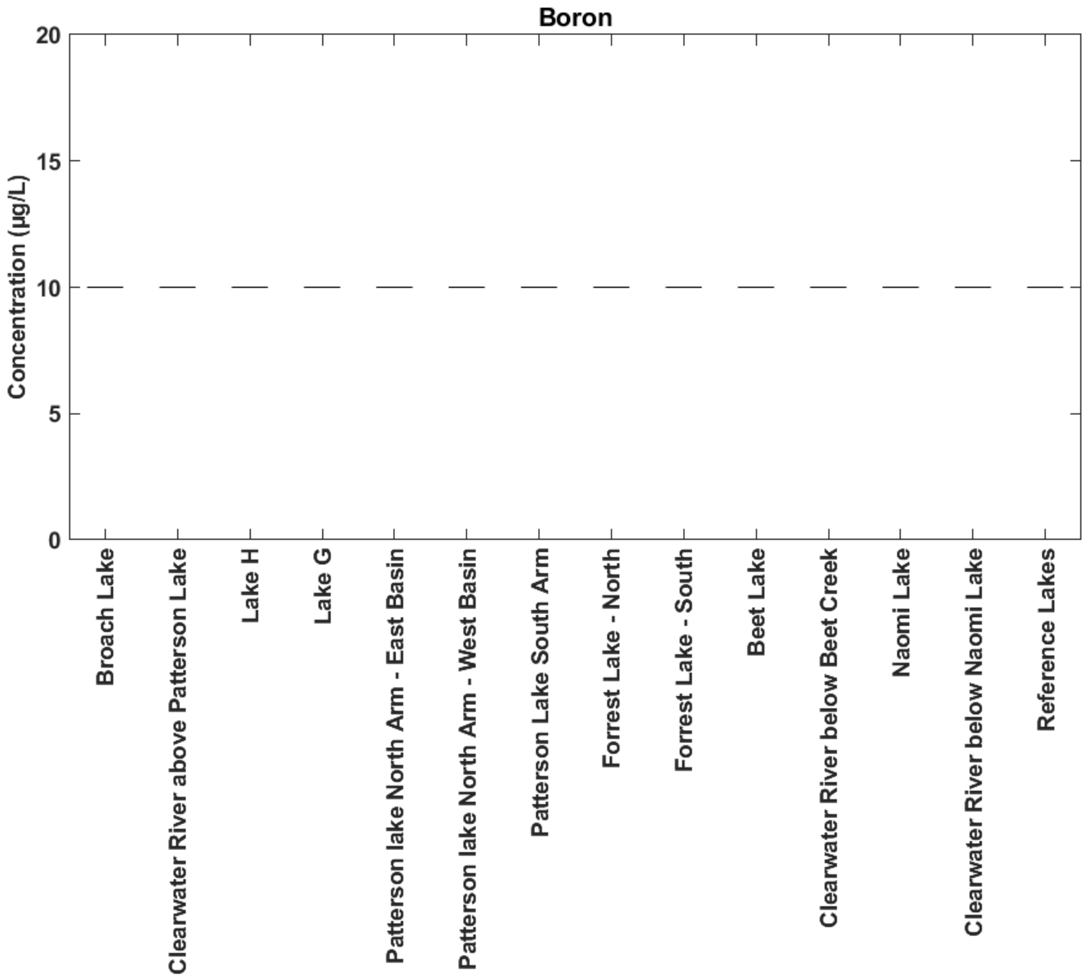


Figure 10A-1b-24: Summary Statistics of Cadmium of Waterbodies and Watercourses in the Local Study Area

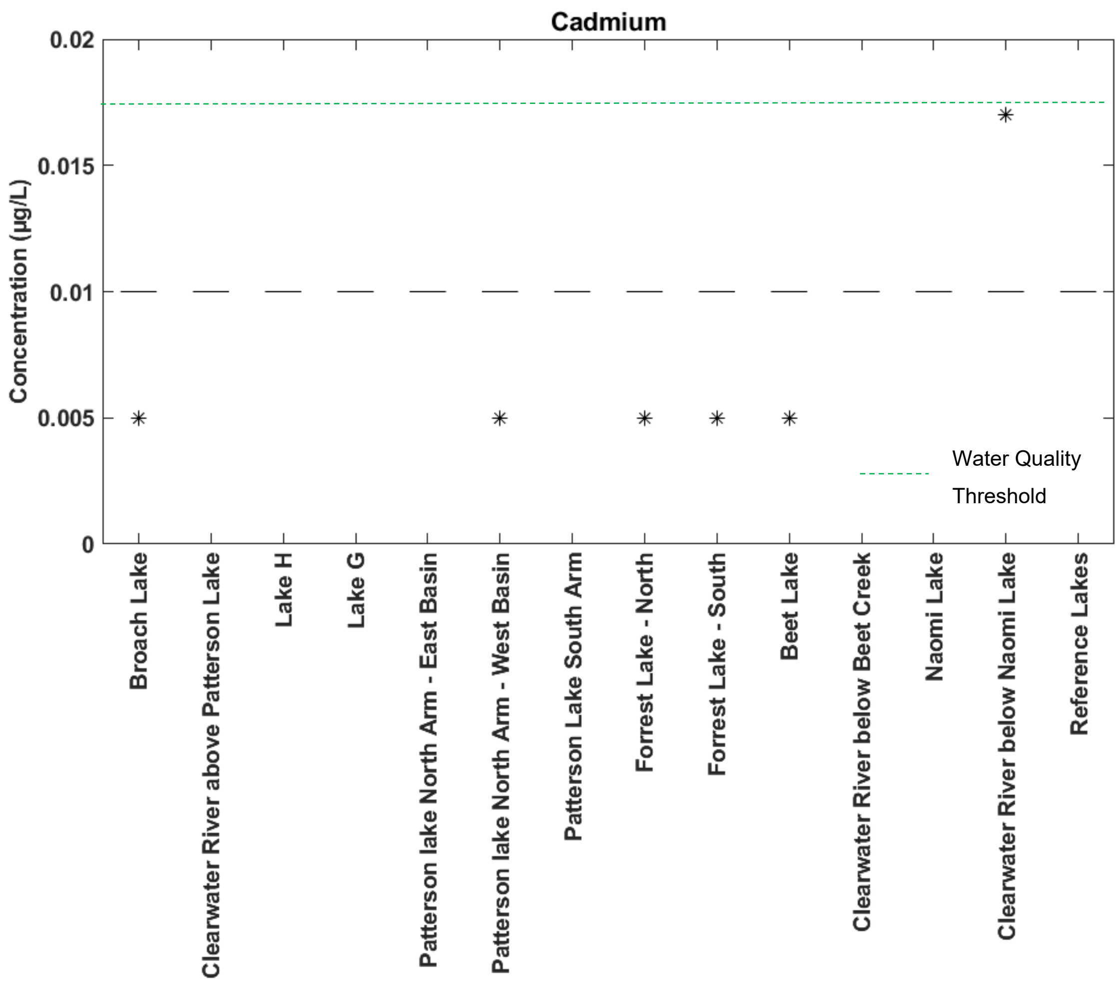


Figure 10A-1b-25: Summary Statistics of Cesium of Waterbodies and Watercourses in the Local Study Area

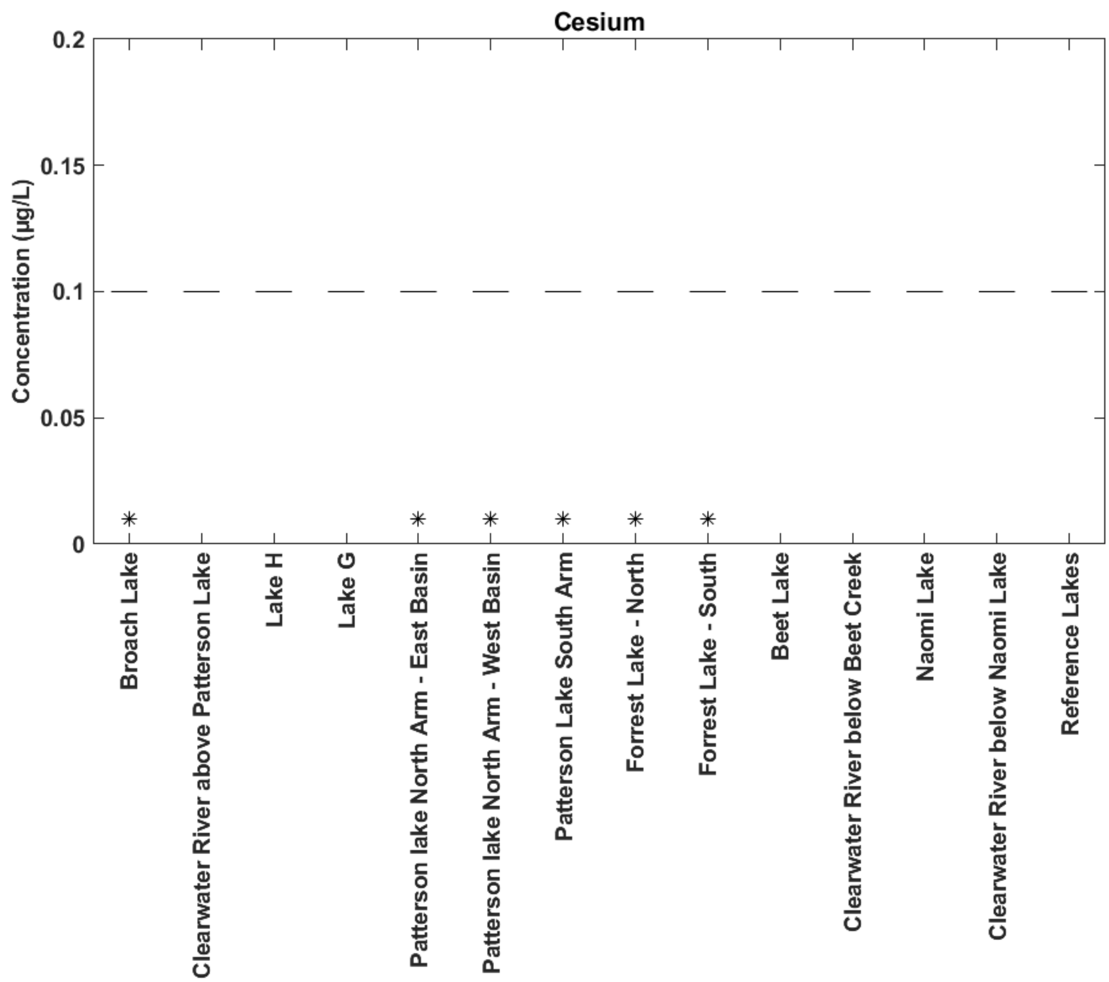
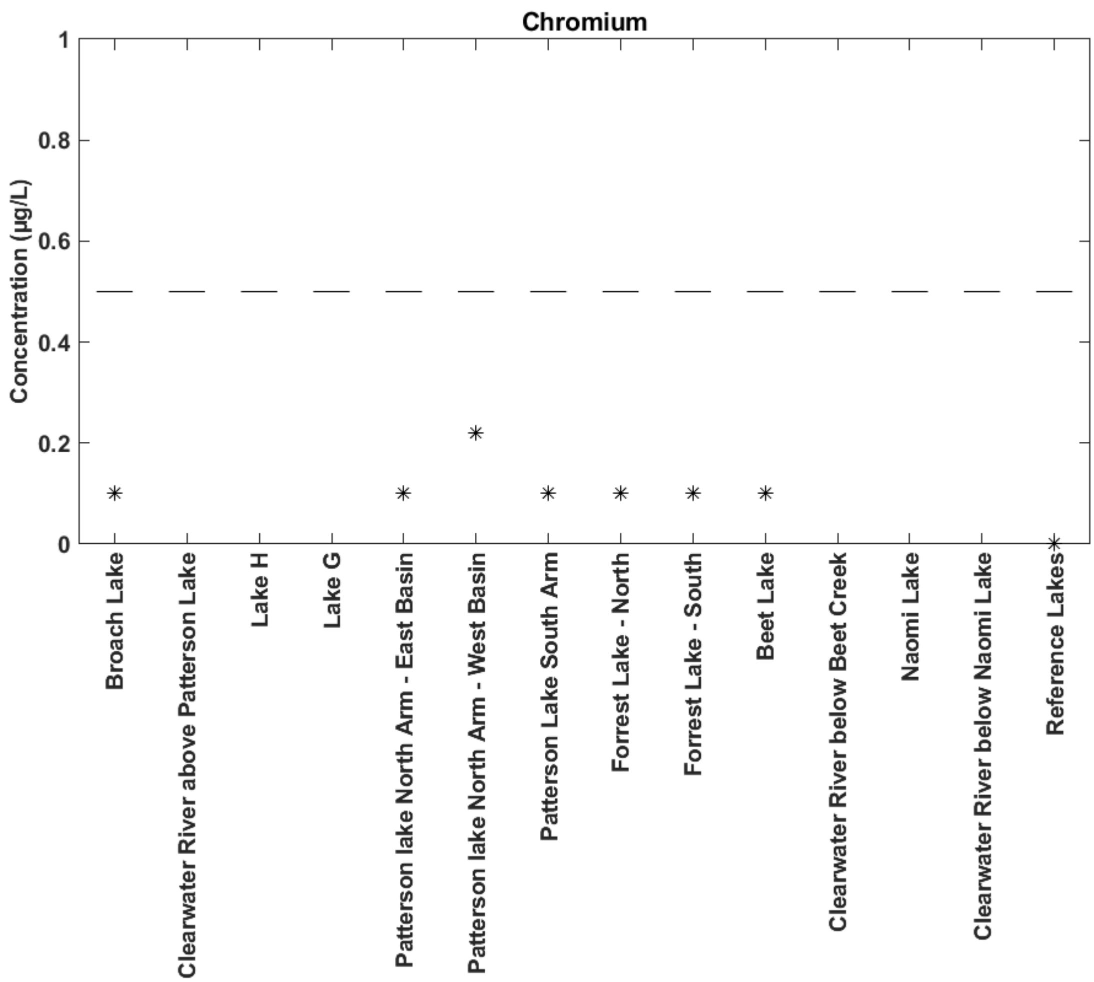
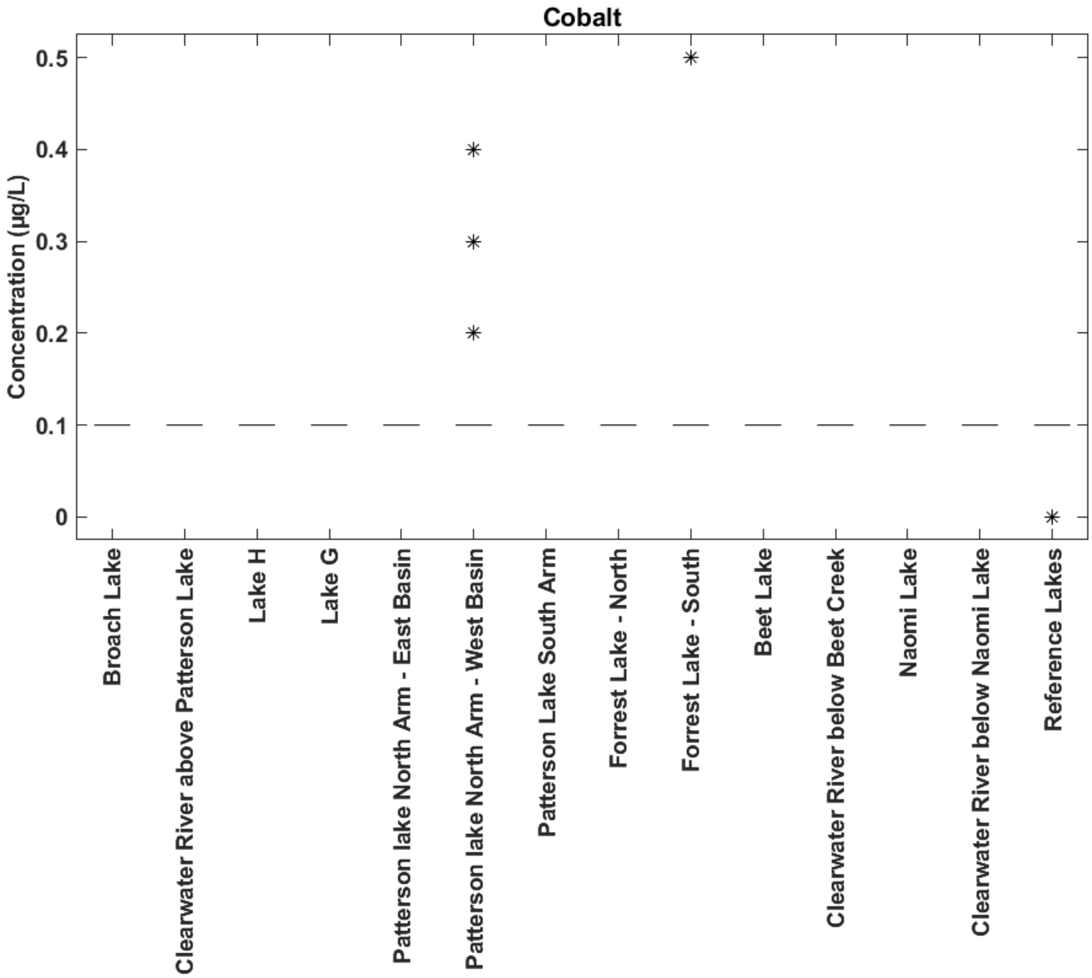


Figure 10A-1b-26: Summary Statistics of Chromium of Waterbodies and Watercourses in the Local Study Area



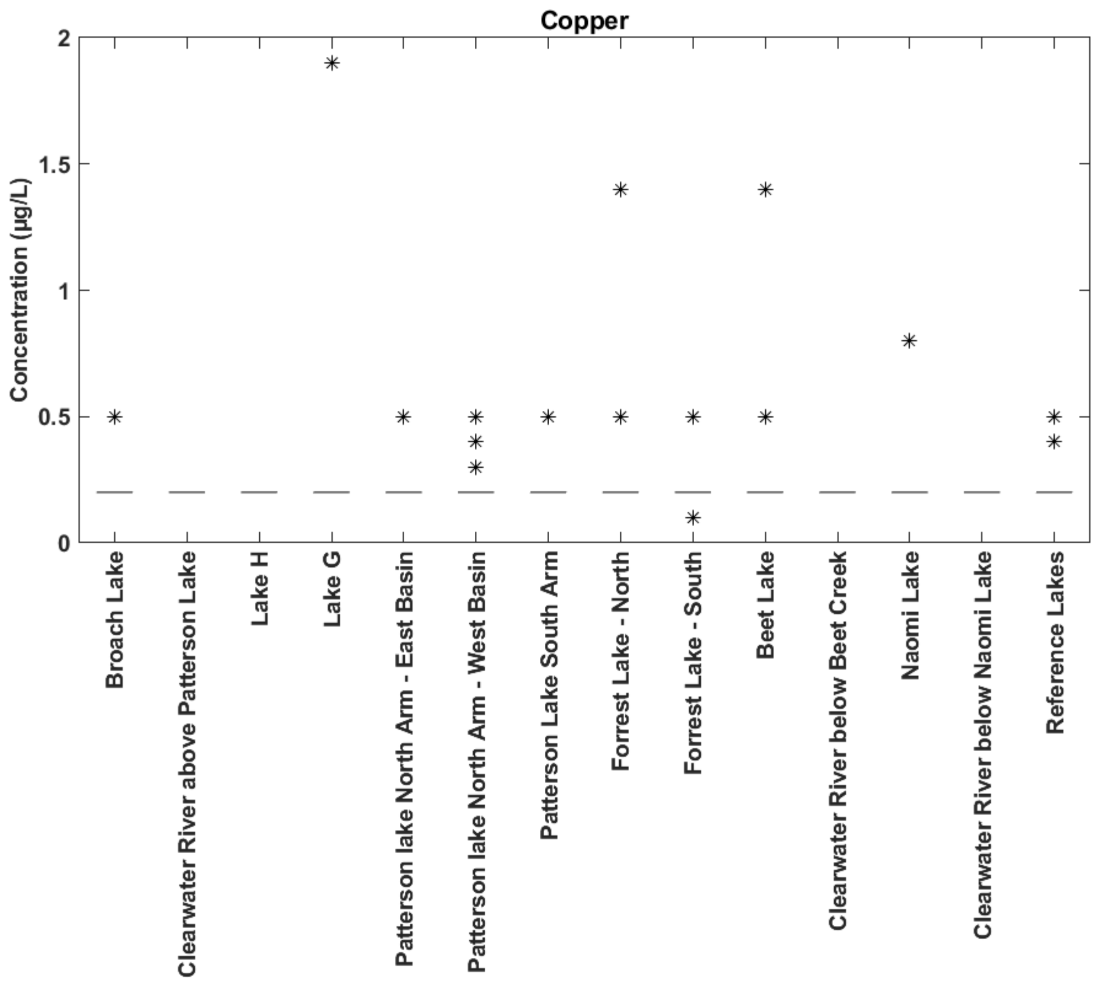
Note: Chromium water quality threshold = 1 µg/L.

Figure 10A-1b-27: Summary Statistics of Cobalt of Waterbodies and Watercourses in the Local Study Area



Note: Cobalt water quality threshold is a function of hardness.

Figure 10A-1b-28: Summary Statistics of Copper of Waterbodies and Watercourses in the Local Study Area



Note: Copper water quality threshold = 2 µg/L.

Figure 10A-1b-29: Summary Statistics of Iron of Waterbodies and Watercourses in the Local Study Area

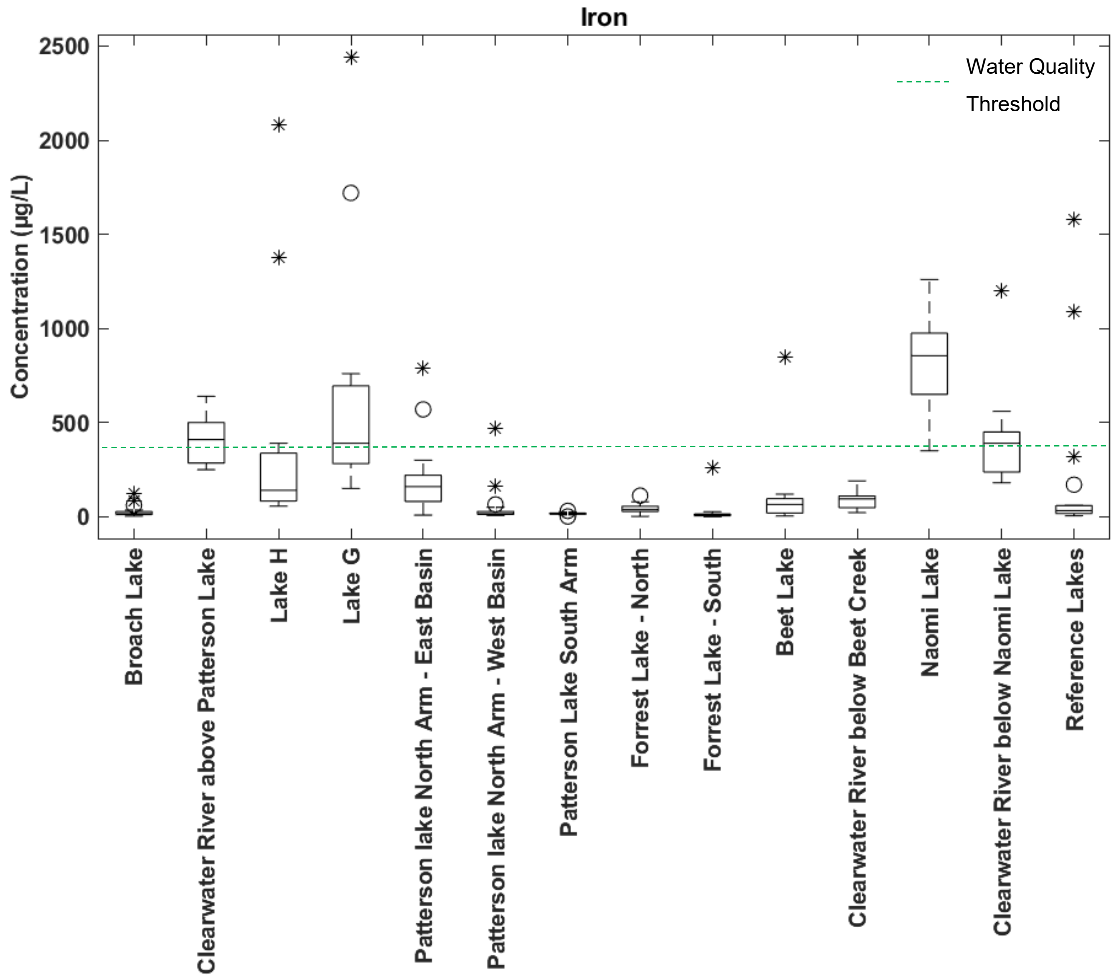
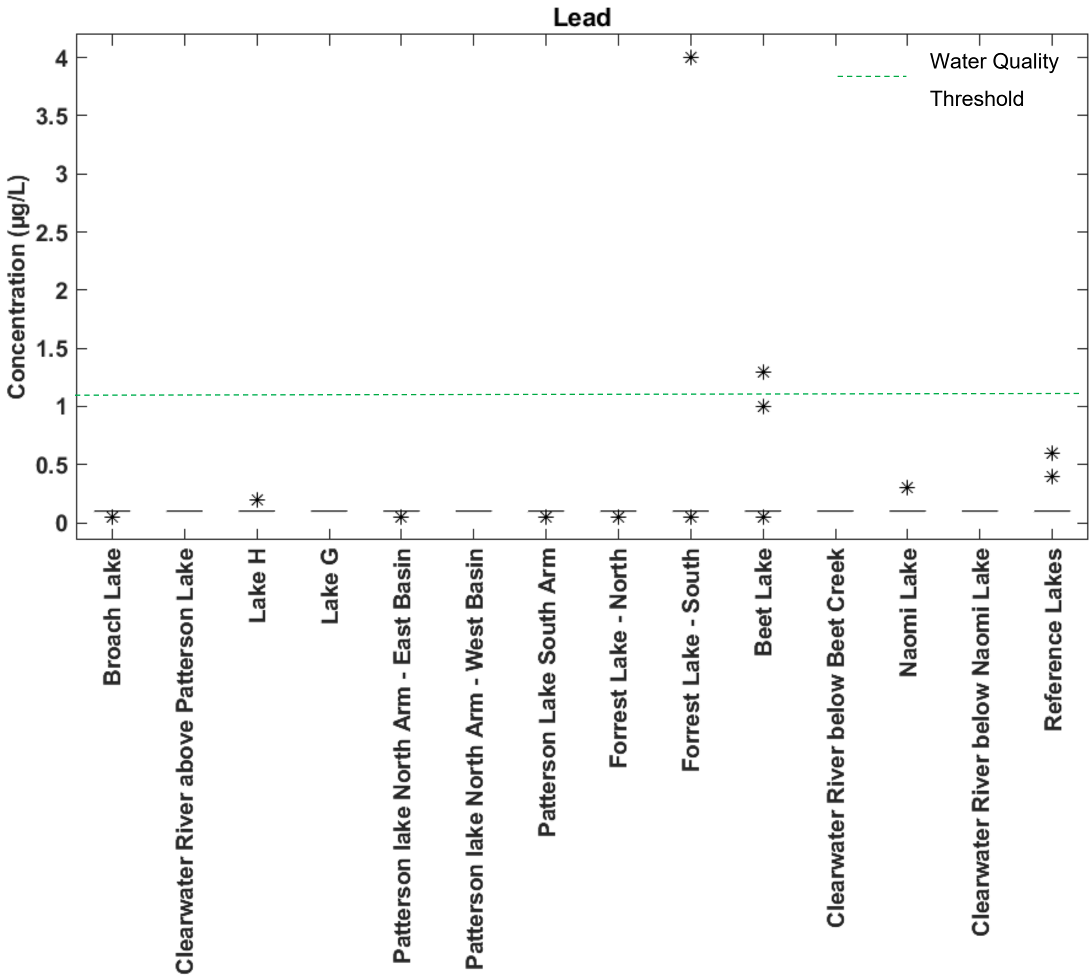
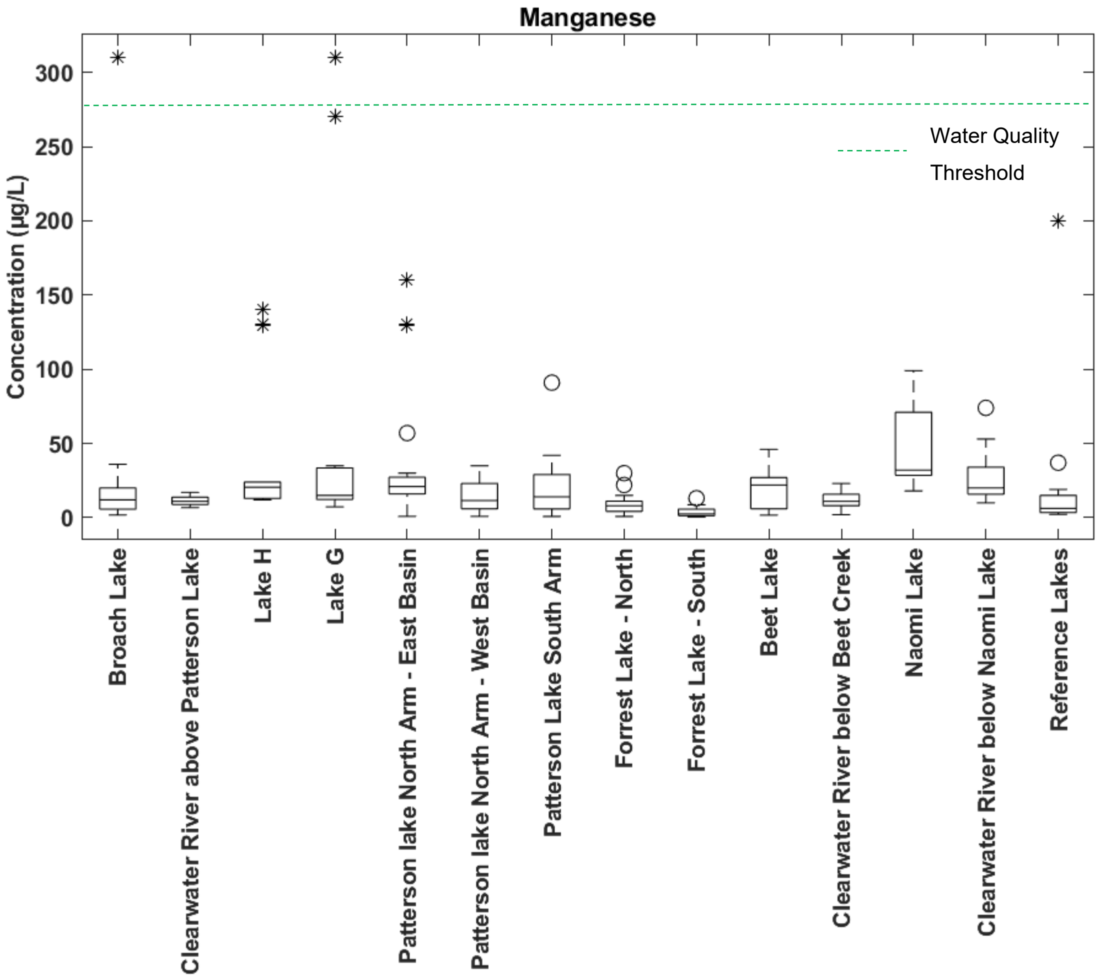


Figure 10A-1b-30: Summary Statistics of Lead of Waterbodies and Watercourses in the Local Study Area



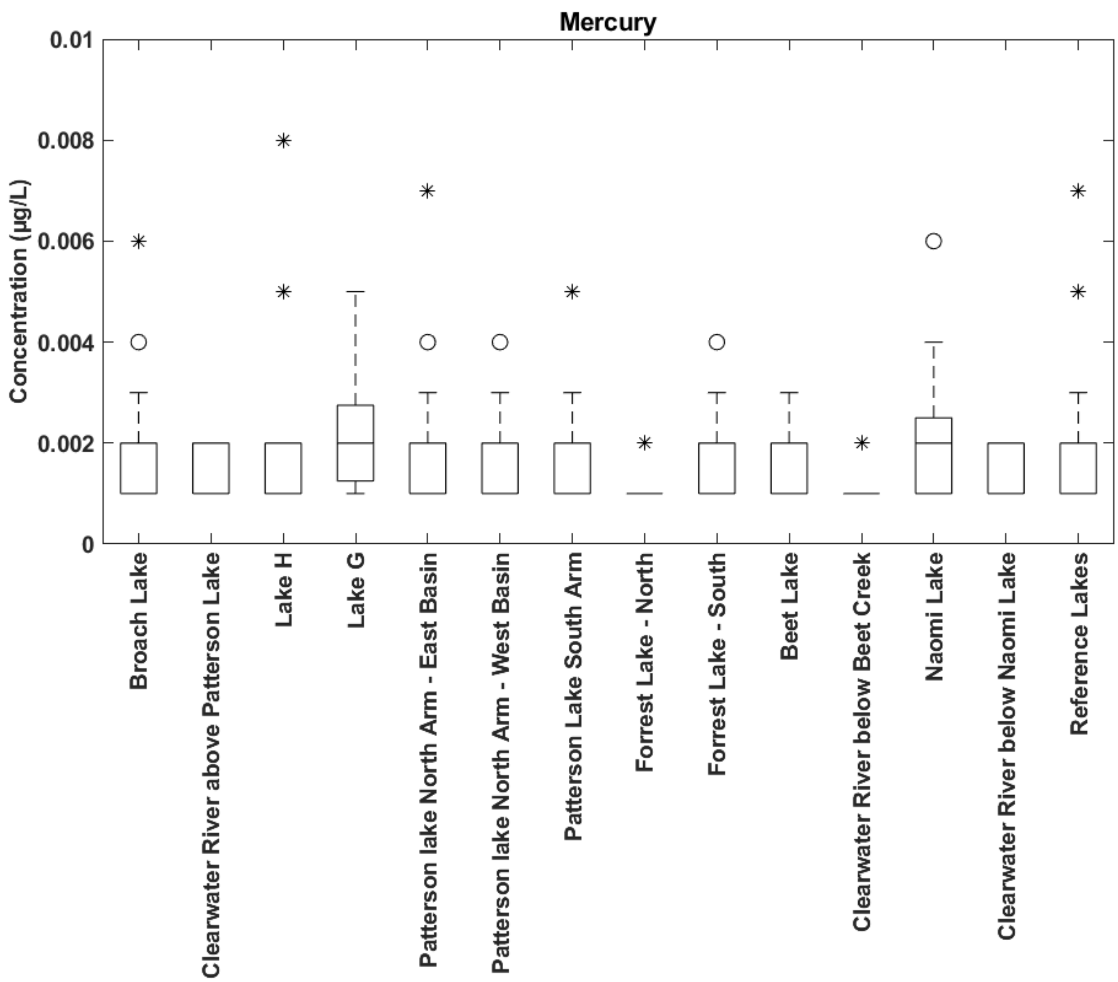
Note: Water Quality Threshold assumes as hardness of less than 23 mg/L $CaCO_3$.

Figure 10A-1b-31: Summary Statistics of Manganese of Waterbodies and Watercourses in the Local Study Area



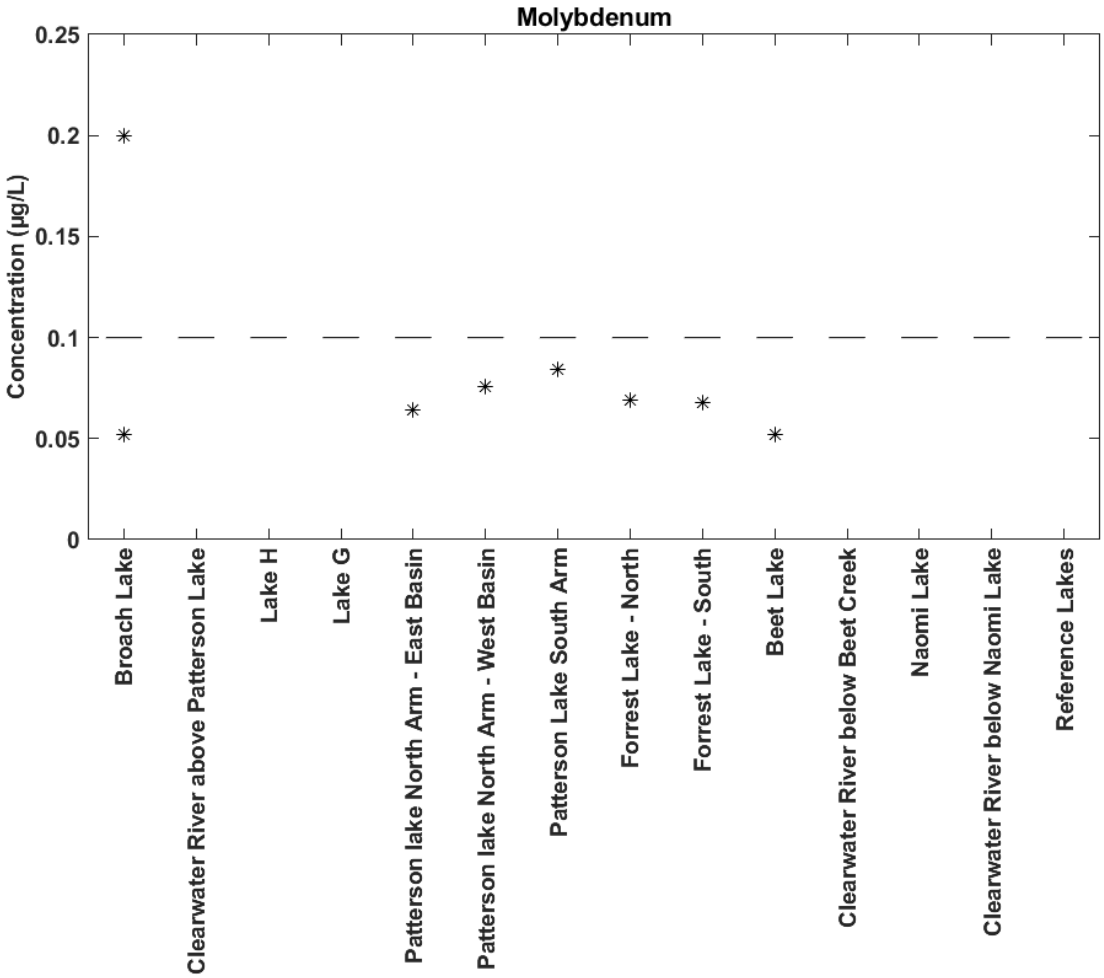
Notes: One value from Broach Lake was removed due to its extreme value of 1,440 μg/L measured in Spring 2019.
One value from Beet Lake was removed due to its extreme value of 1,100 μg/L measured in Winter 2020.

Figure 10A-1b-32: Summary Statistics of Mercury of Waterbodies and Watercourses in the Local Study Area



Note: Mercury water quality threshold = 0.026 µg/L.

Figure 10A-1b-33: Summary Statistics of Molybdenum of Waterbodies and Watercourses in the Local Study Area



Note: Molybdenum water quality threshold = 31,000 µg/L.

Figure 10A-1b-34: Summary Statistics of Nickel of Waterbodies and Watercourses in the Local Study Area

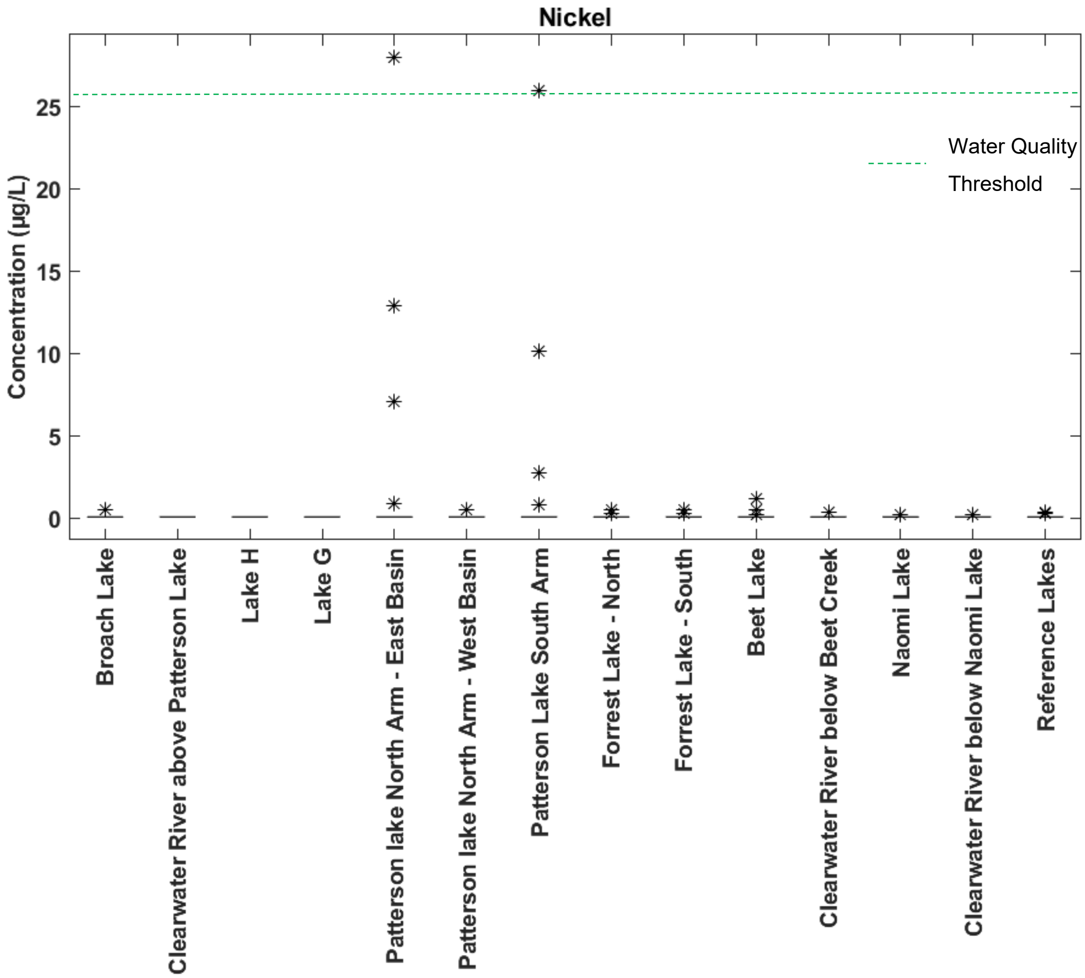
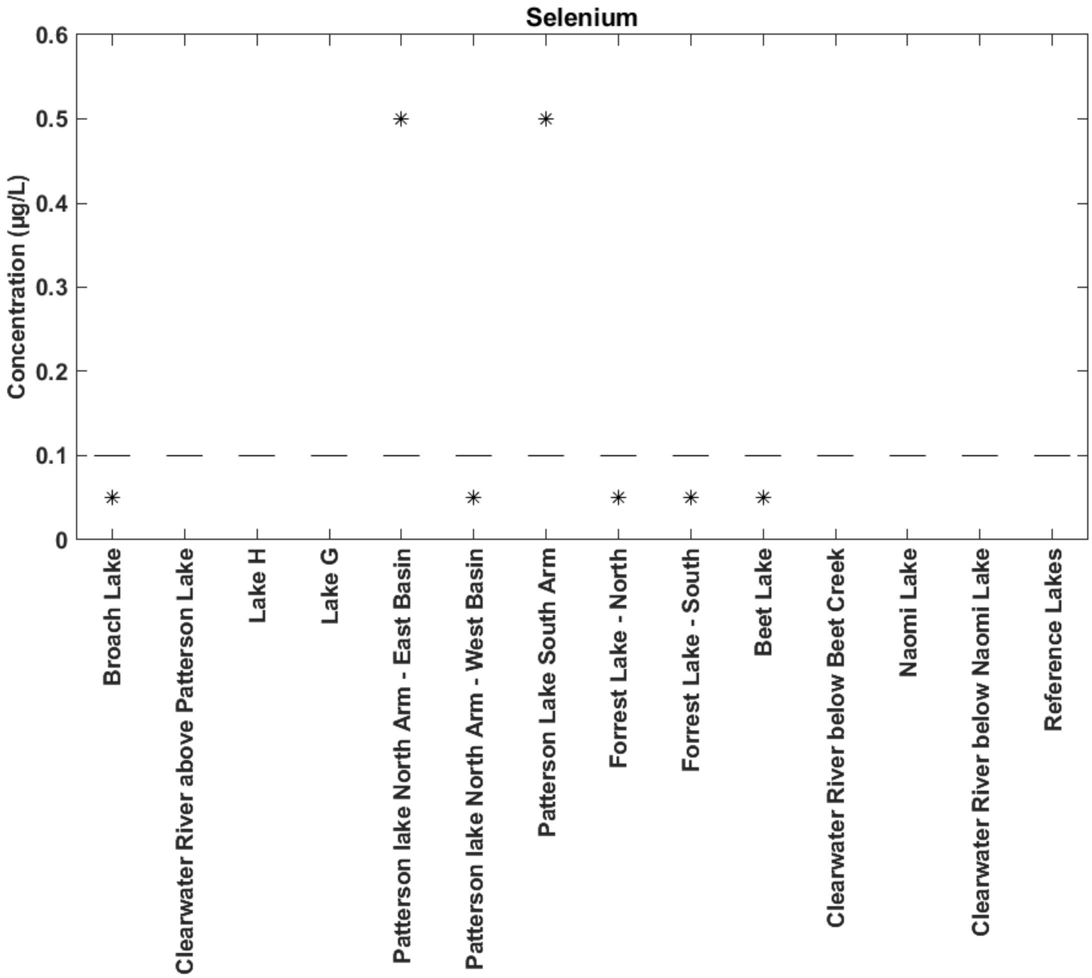
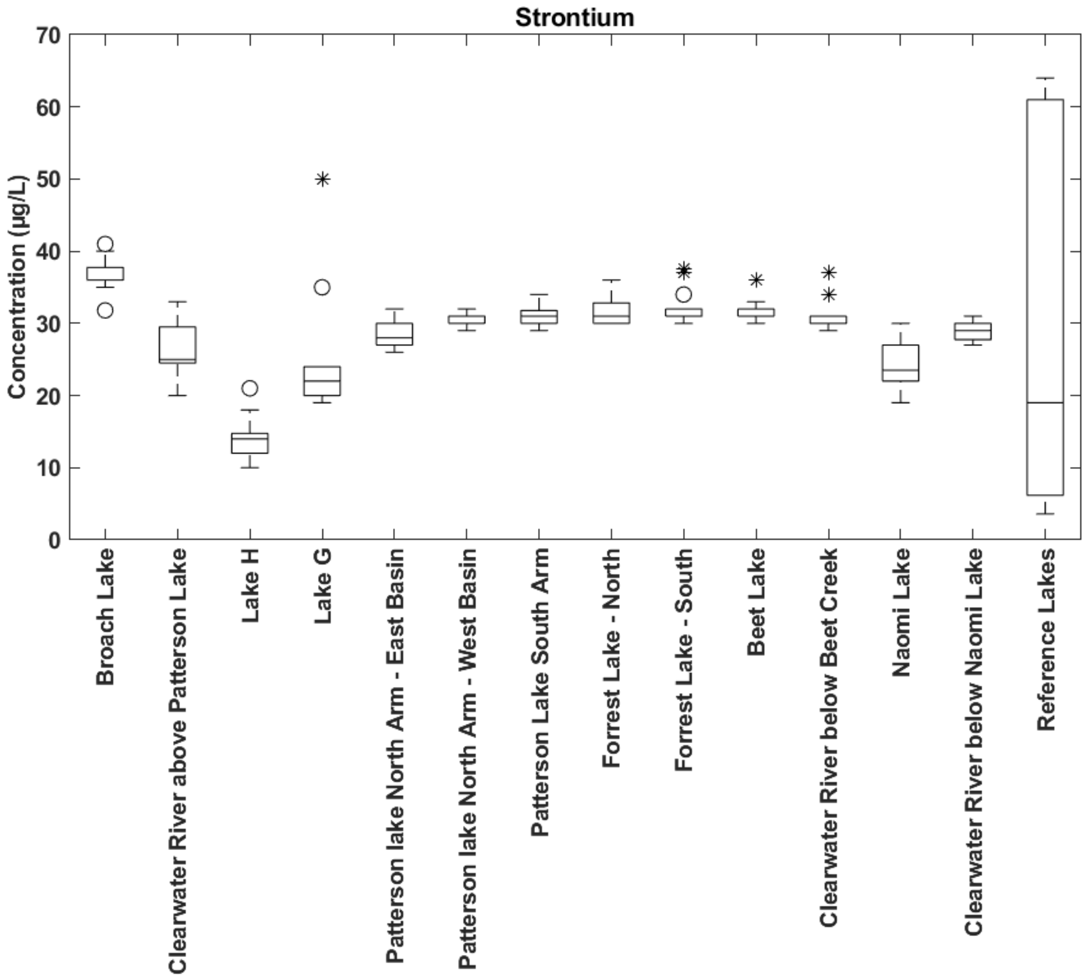


Figure 10A-1b-35: Summary Statistics of Selenium of Waterbodies and Watercourses in the Local Study Area



Note: Selenium water quality threshold = 1 µg/L.

Figure 10A-1b-36: Summary Statistics of Strontium of Waterbodies and Watercourses in the Local Study Area



Note: Strontium water quality threshold = 7,000 µg/L.

Figure 10A-1b-37: Summary Statistics of Tin of Waterbodies and Watercourses in the Local Study Area

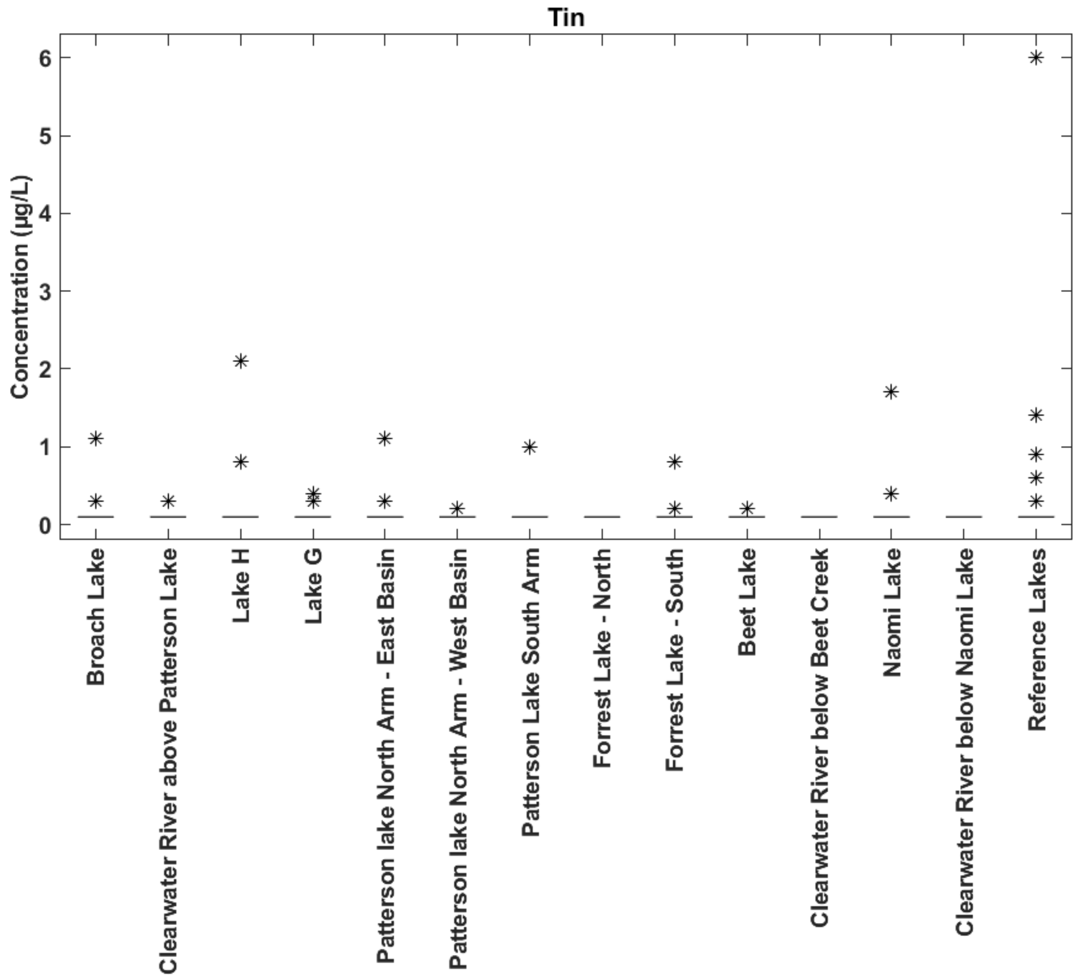


Figure 10A-1b-38: Summary Statistics of Titanium of Waterbodies and Watercourses in the Local Study Area

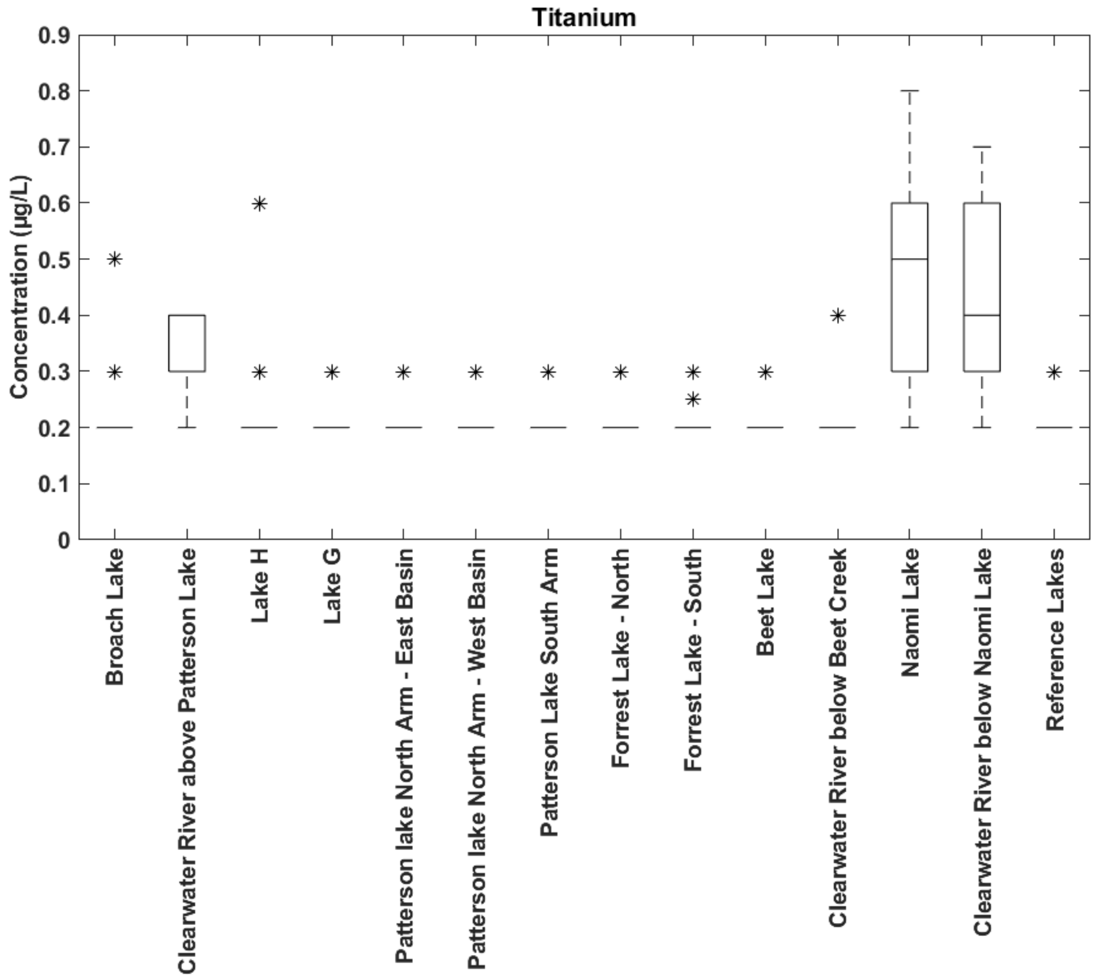
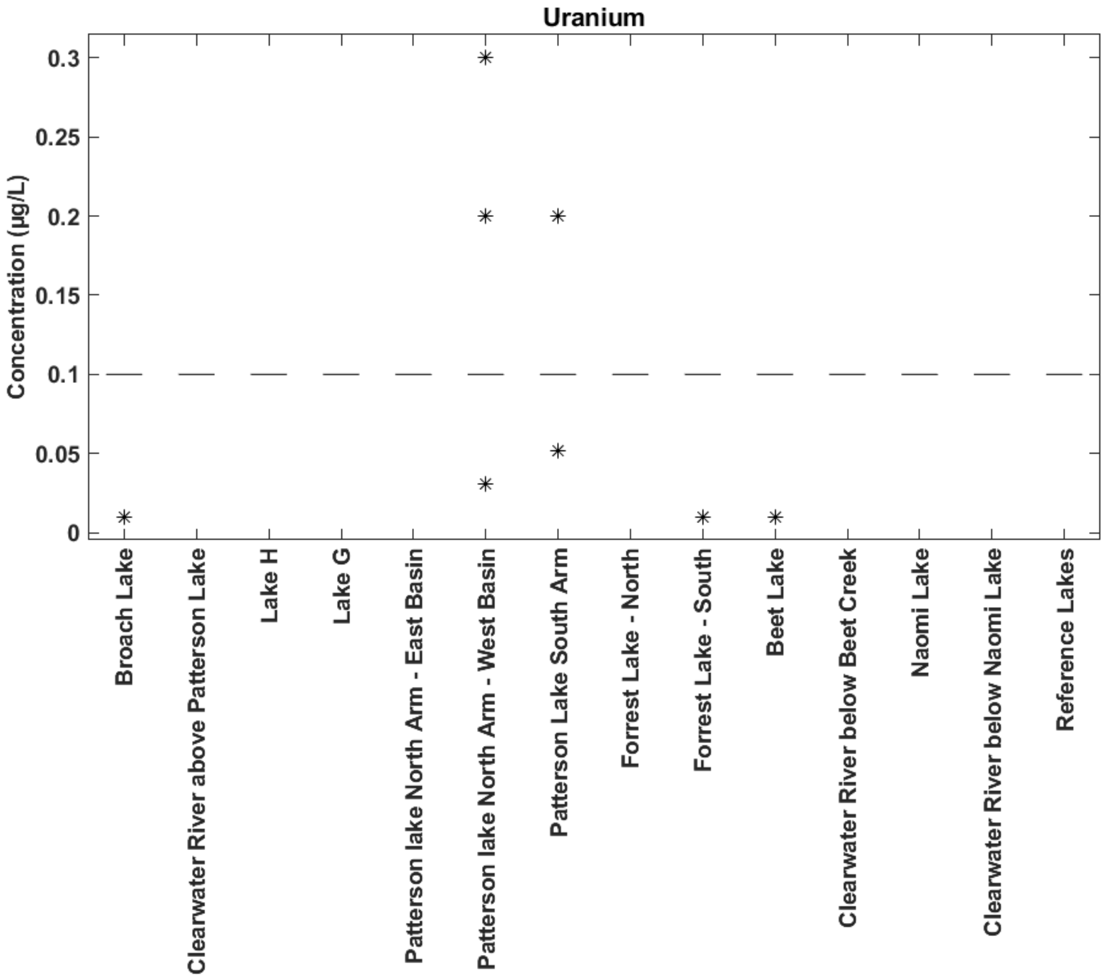


Figure 10A-1b-39: Summary Statistics of Uranium of Waterbodies and Watercourses in the Local Study Area



Note: Uranium water quality threshold = 15 µg/L.

Figure 10A-1b-40: Summary Statistics of Vanadium of Waterbodies and Watercourses in the Local Study Area

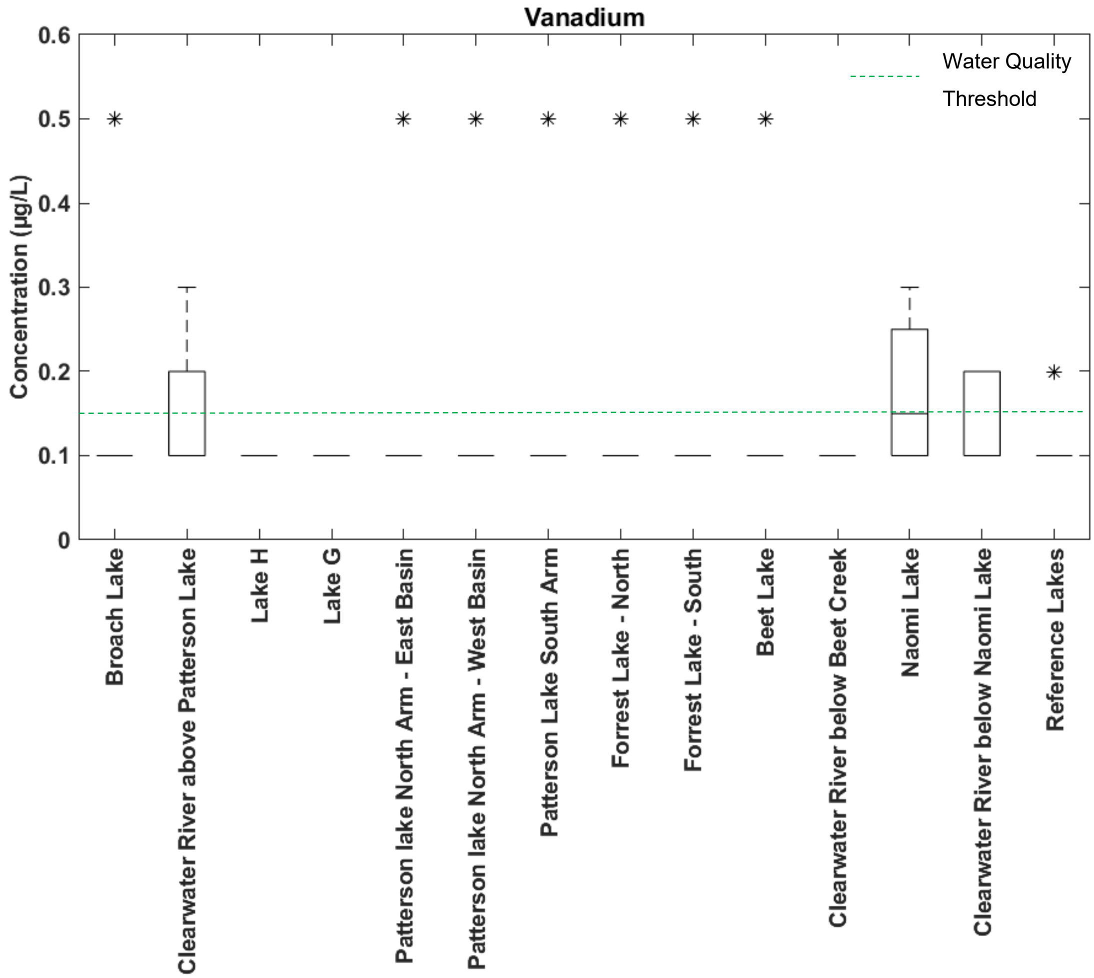
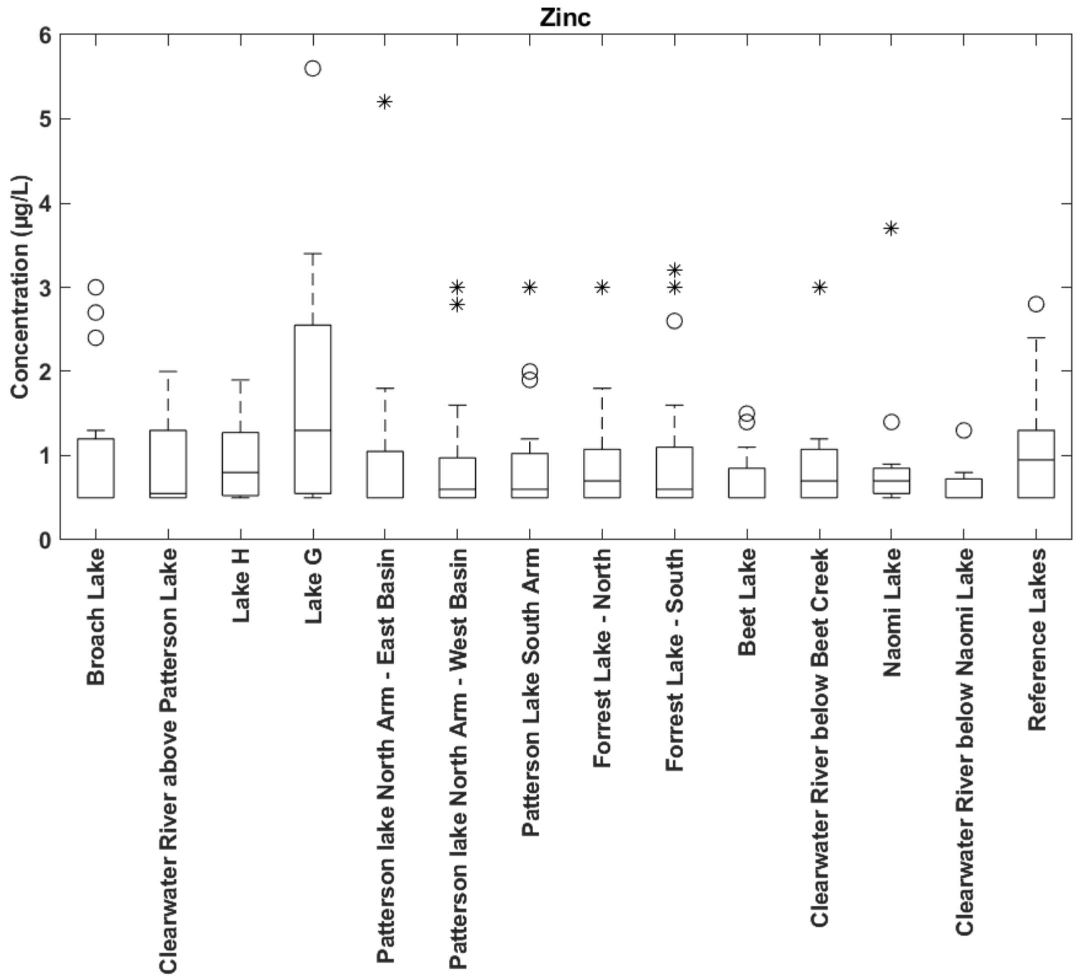


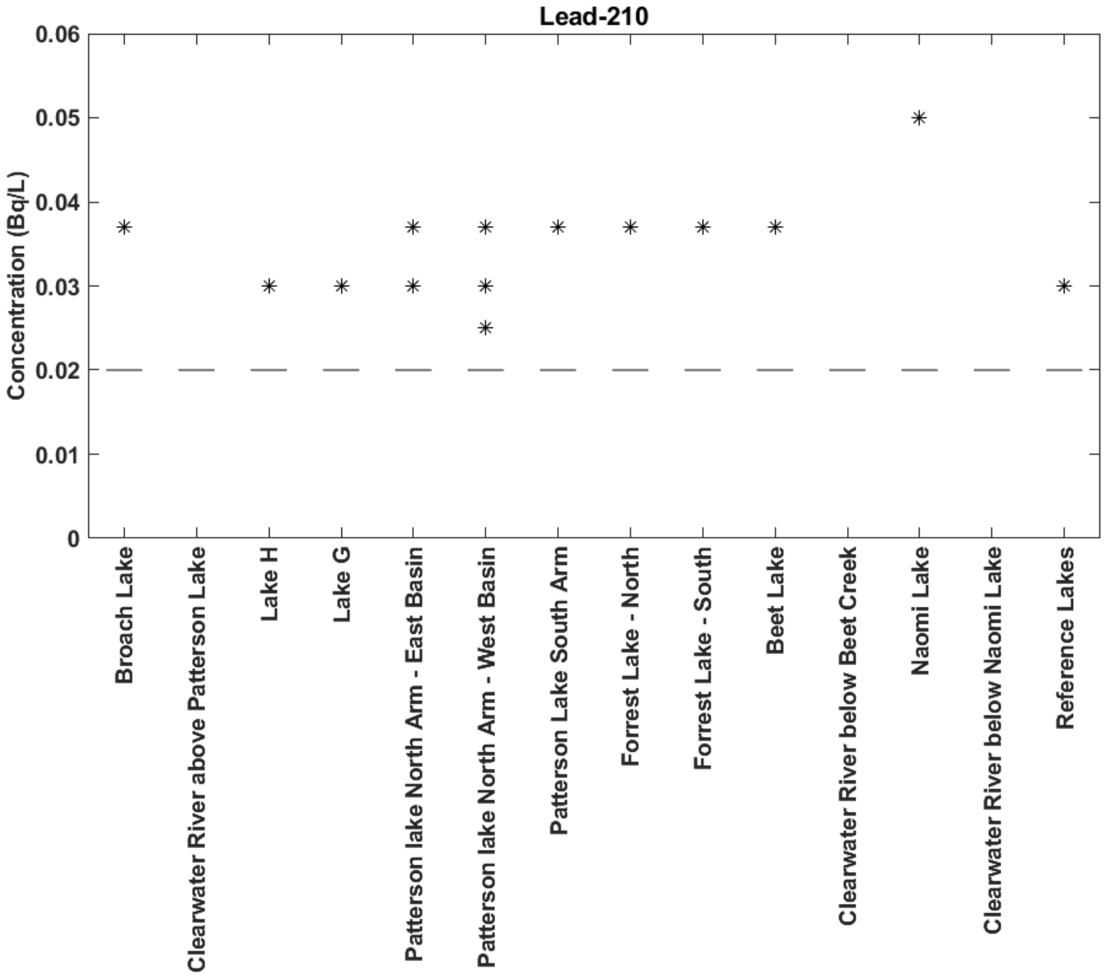
Figure 10A-1b-41: Summary Statistics of Zinc of Waterbodies and Watercourses in the Local Study Area



Note: Zinc water quality threshold = 7 µg/L.

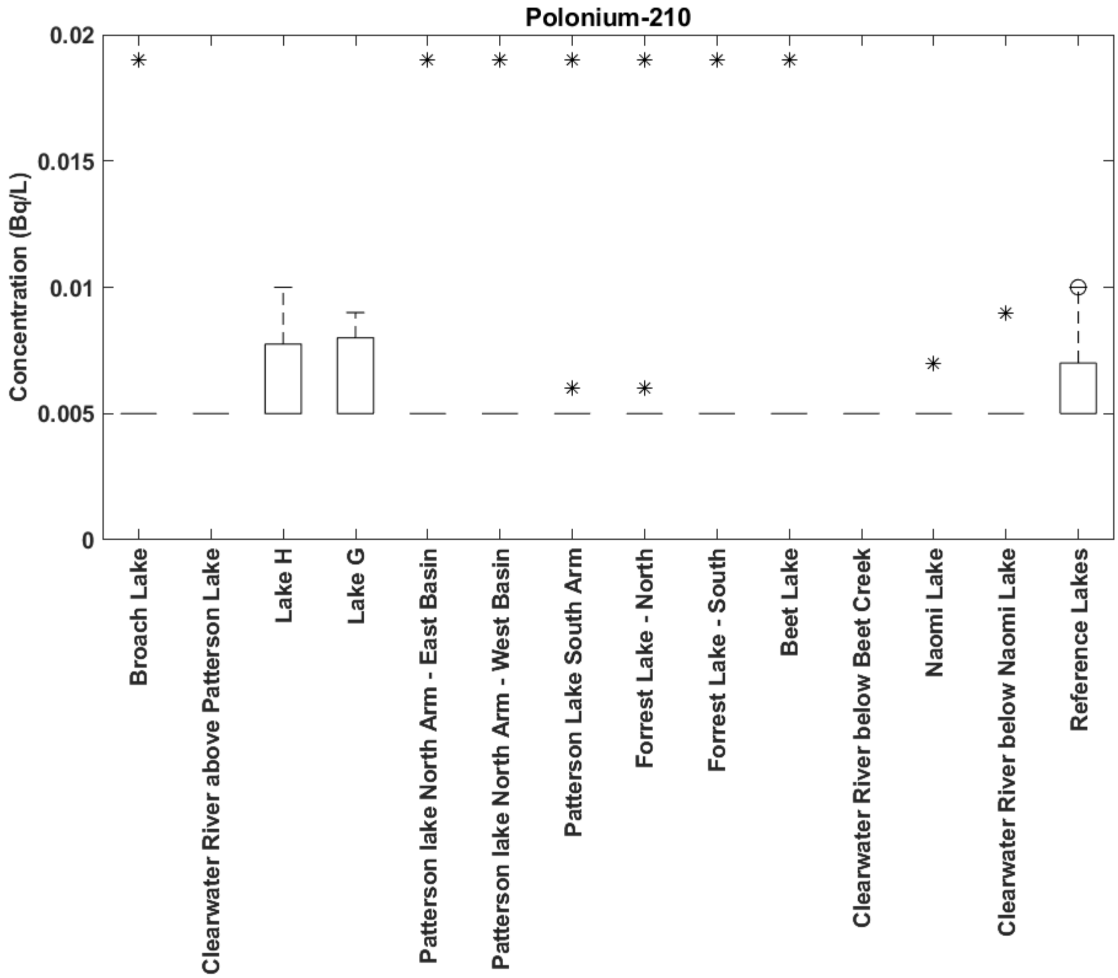
10A-1b-6 RADIONUCLIDES

Figure 10A-1b-42: Summary Statistics of Lead-210 of Waterbodies and Watercourses in the Local Study Area



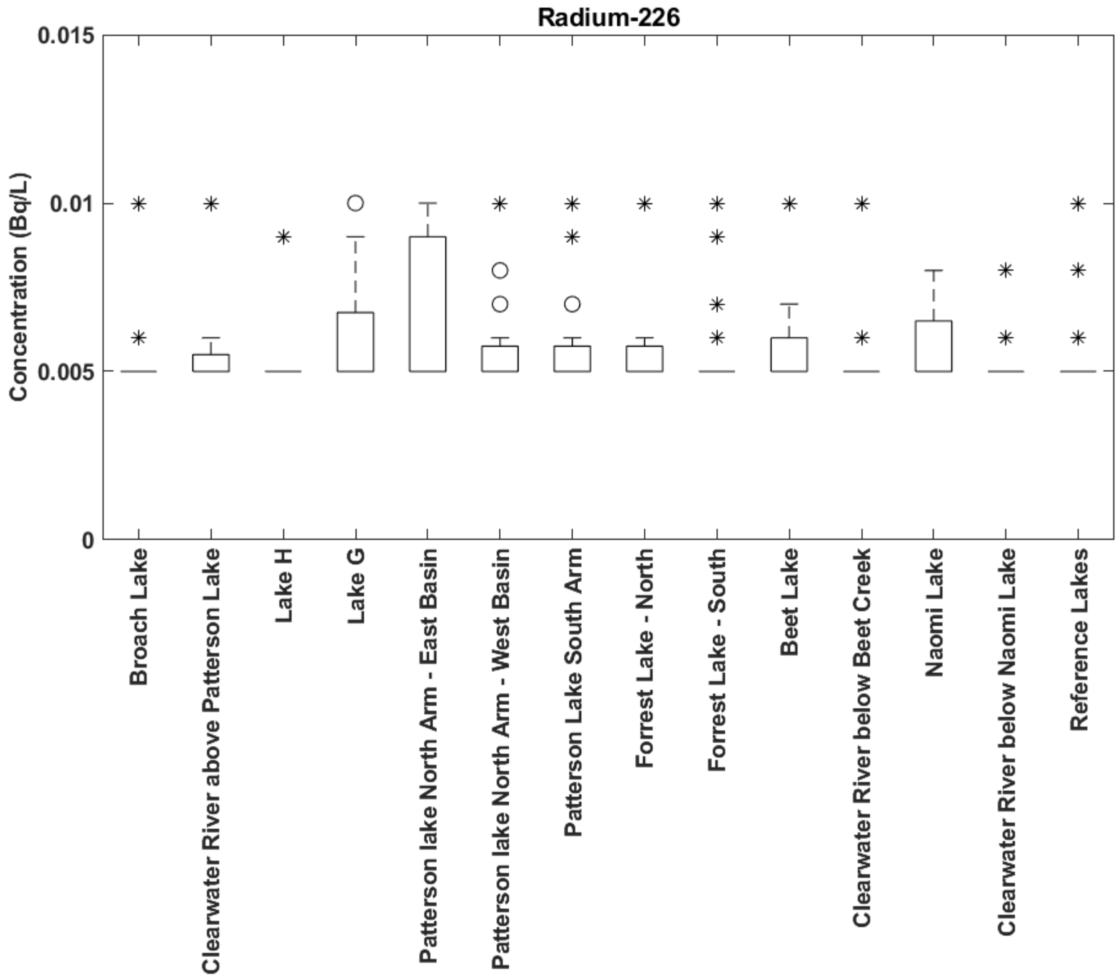
Note: Lead-210 water quality threshold = 22 Bq/L.

Figure 10A-1b-43: Summary Statistics of Polonium-210 of Waterbodies and Watercourses in the Local Study Area



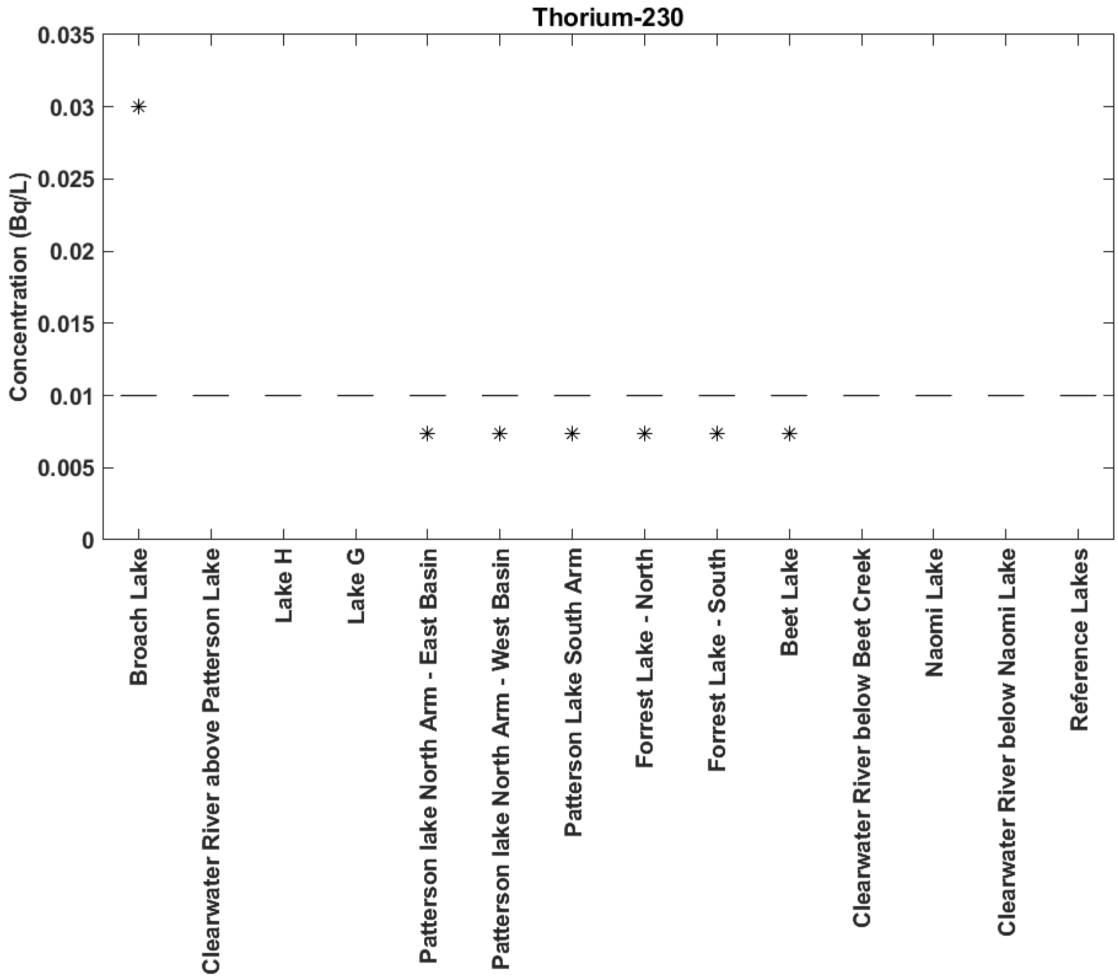
Note: Polonium-210 water quality threshold = 13.5 Bq/L.

Figure 10A-1b-44: Summary Statistics of Radium-226 of Waterbodies and Watercourses in the Local Study Area



Note: Radium-226 water quality threshold = 0.11 Bq/L.

Figure 10A-1b-45: Summary Statistics of Thorium-230 of Waterbodies and Watercourses in the Local Study Area



Note: Throrium-230 water quality threshold = 95 Bq/L.

Attachment 10A-1c Lake Physico-chemical Water Column Profile Plots

List of Figures

Figure 10A-1c-1: Broach Lake (Area 1) Profiles: (a) Dissolved Oxygen, (b) pH, (c) Specific Conductivity, (d) Temperature

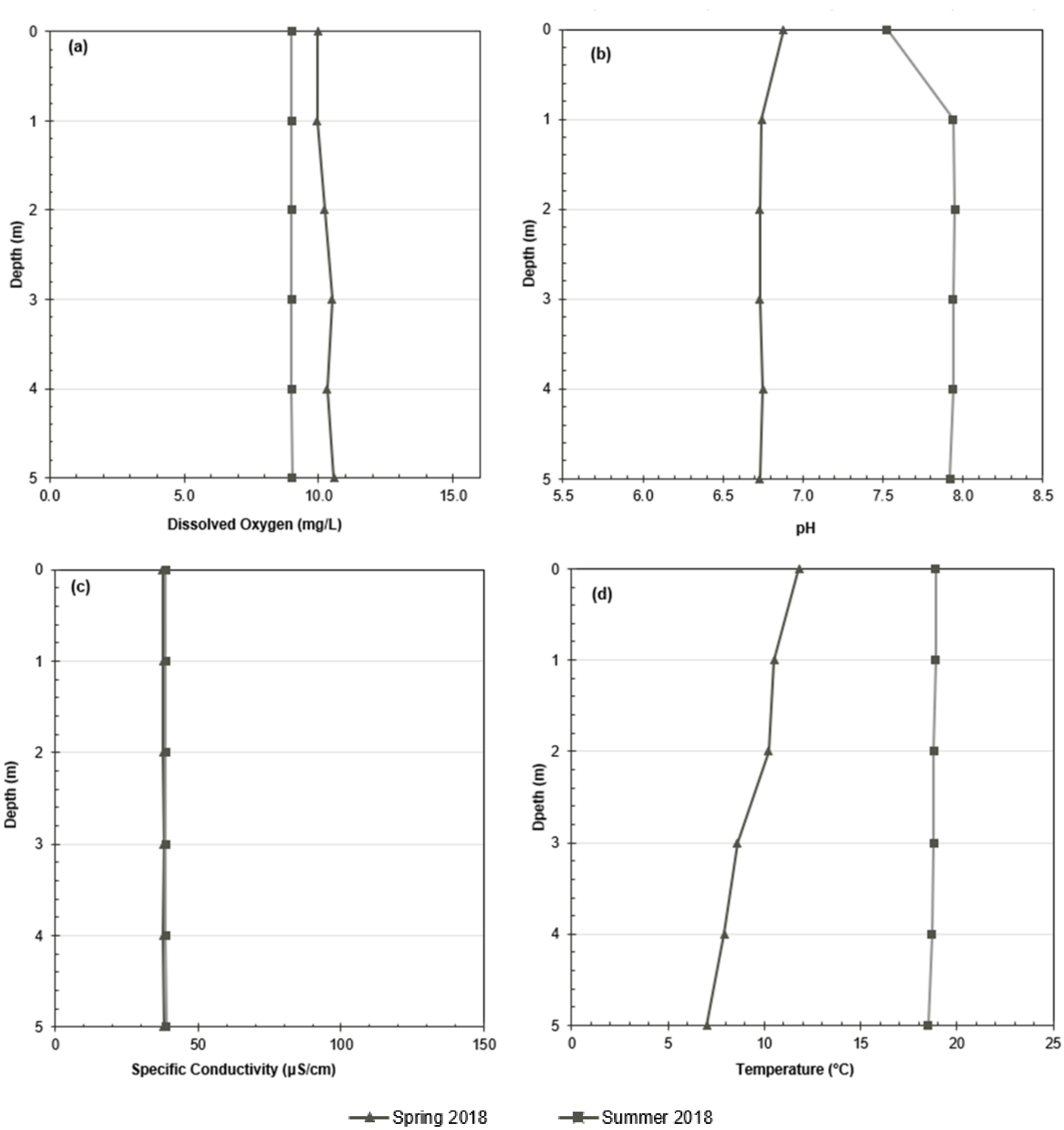


Figure 10A-1c-2: Broach Lake (Area 2) Profiles: (a) Dissolved Oxygen, (b) pH, (c) Specific Conductivity, (d) Temperature

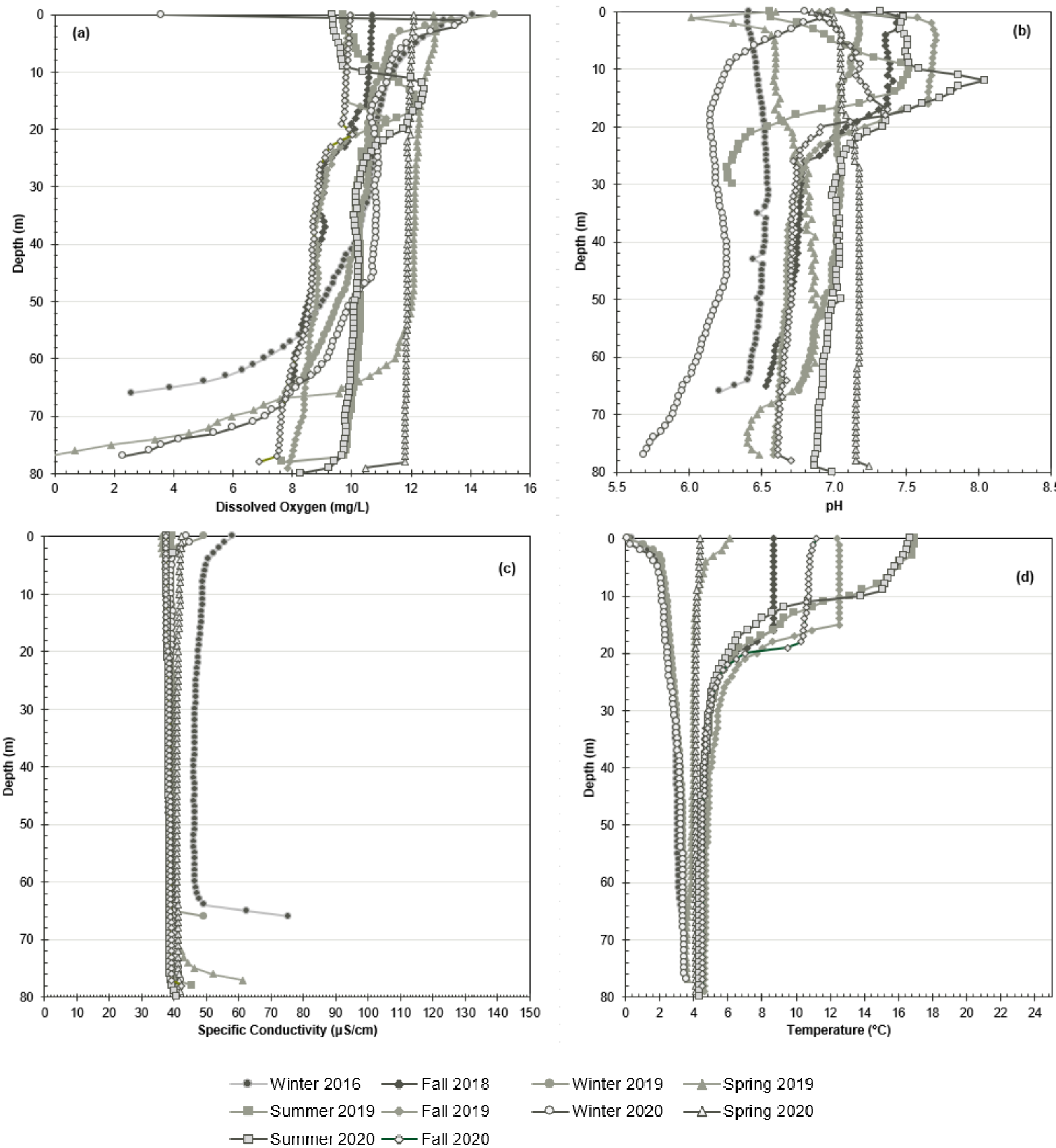
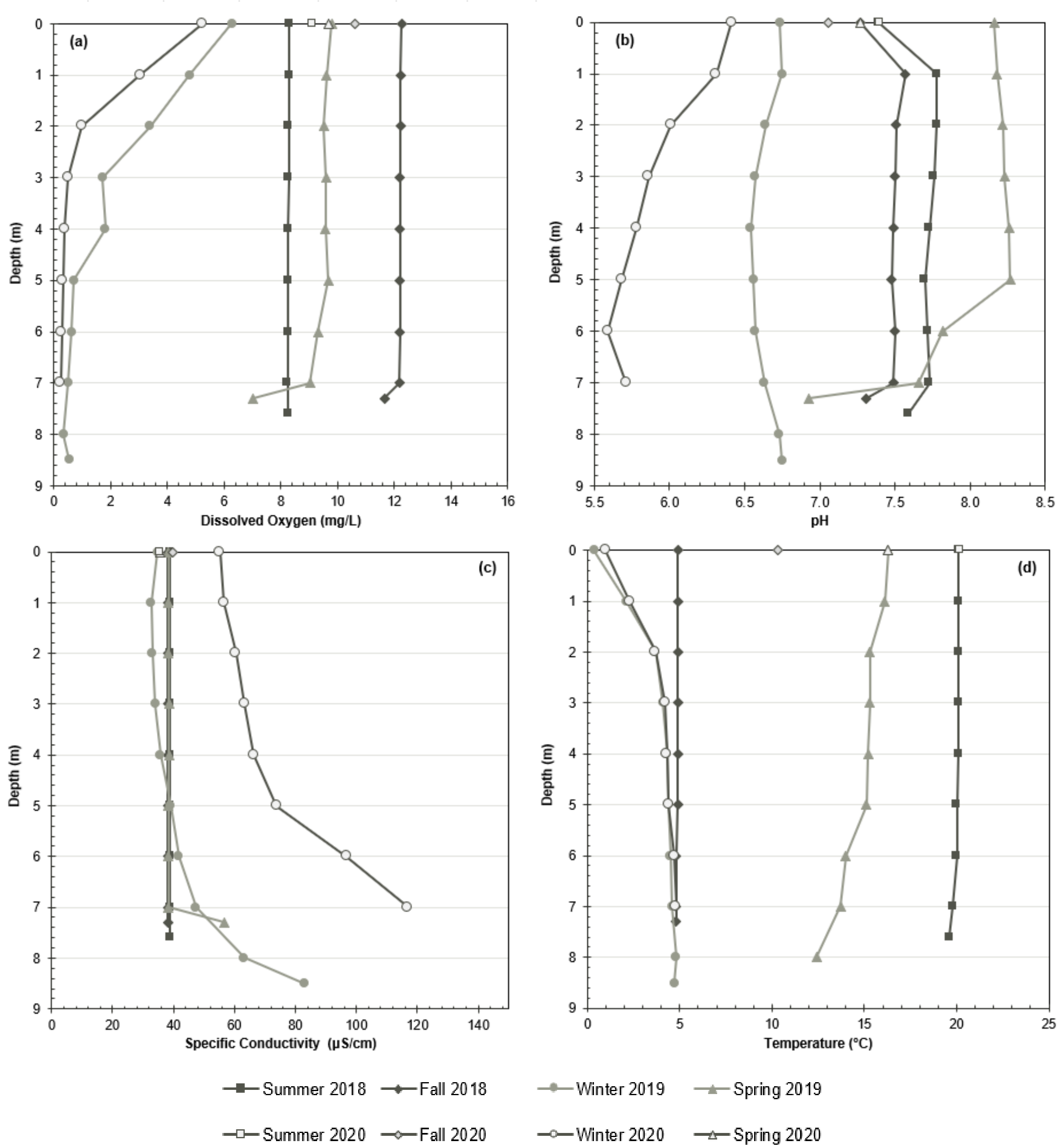


Figure 10A-1c-3: Lake H (Area 2) Profiles: (a) Dissolved Oxygen, (b) pH, (c) Specific Conductivity, (d) Temperature



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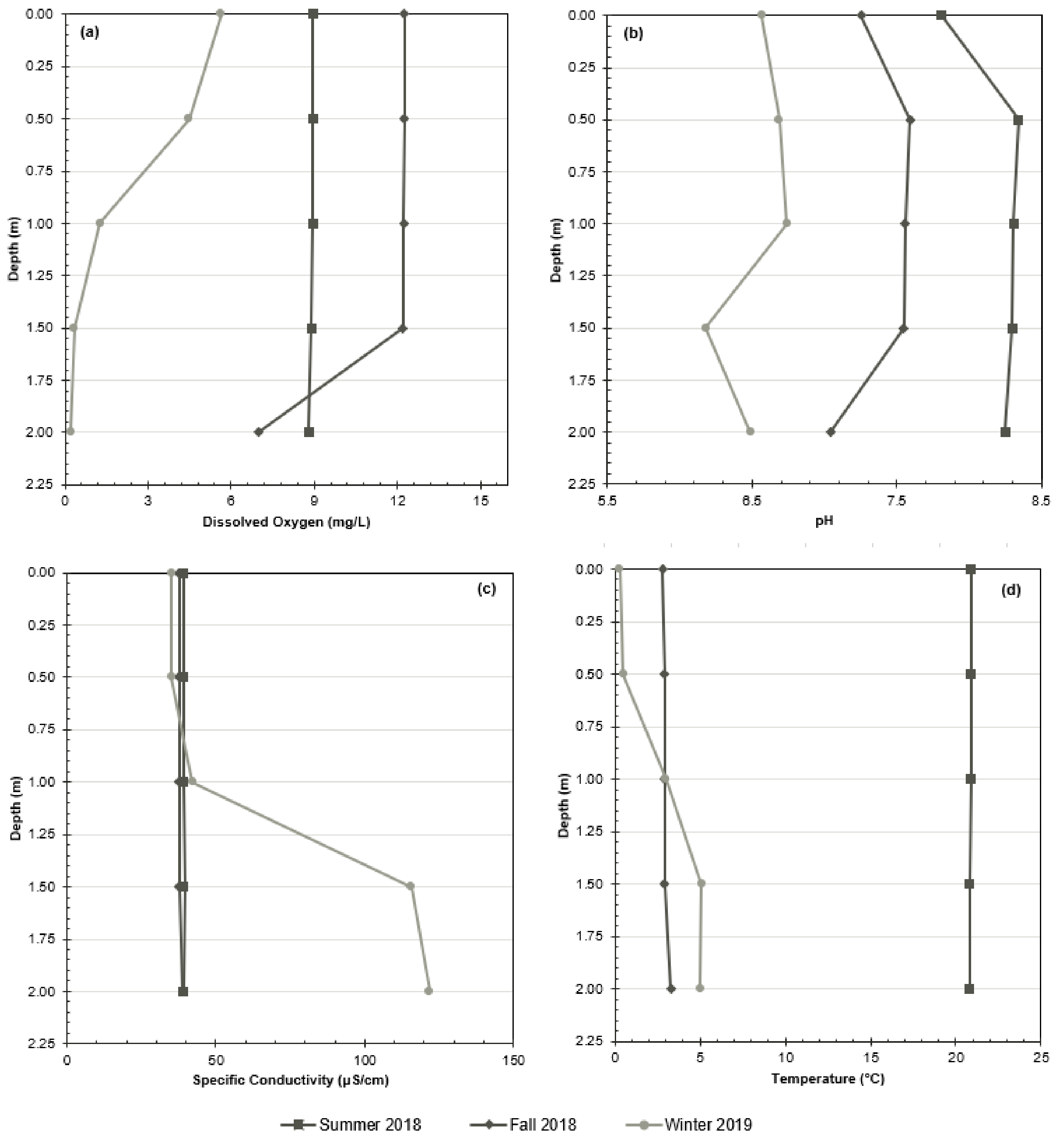


Figure 10A-1c-5: Patterson Lake North Arm – East Basin (Area 1) Profiles: (a) Dissolved Oxygen, (b) pH, (c) Specific Conductivity, (d) Temperature

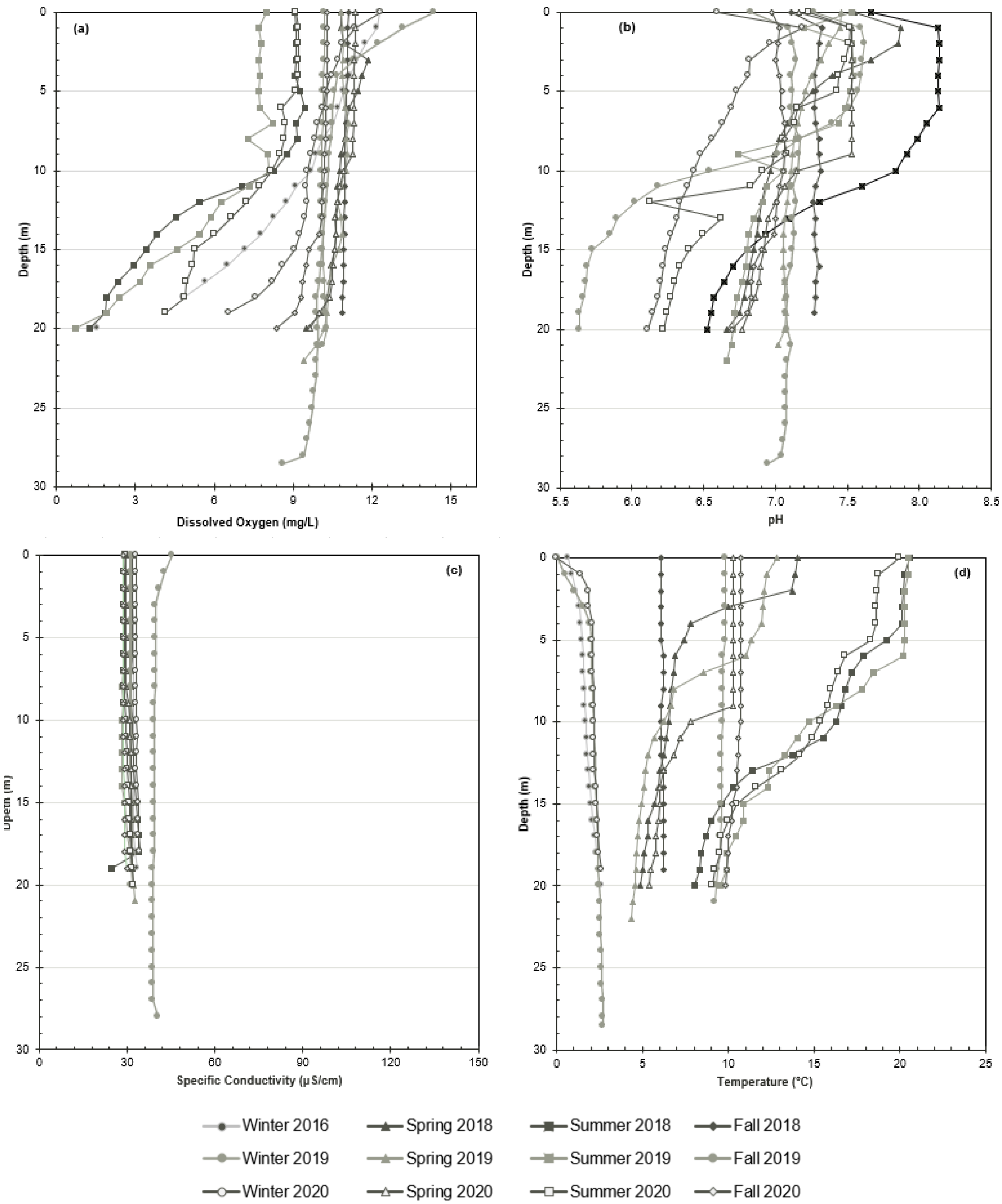


Figure 10A-1c-6: Patterson Lake North Arm – West Basin (Area 2) Profiles: (a) Dissolved Oxygen, (b) pH, (c) Specific Conductivity, (d) Temperature

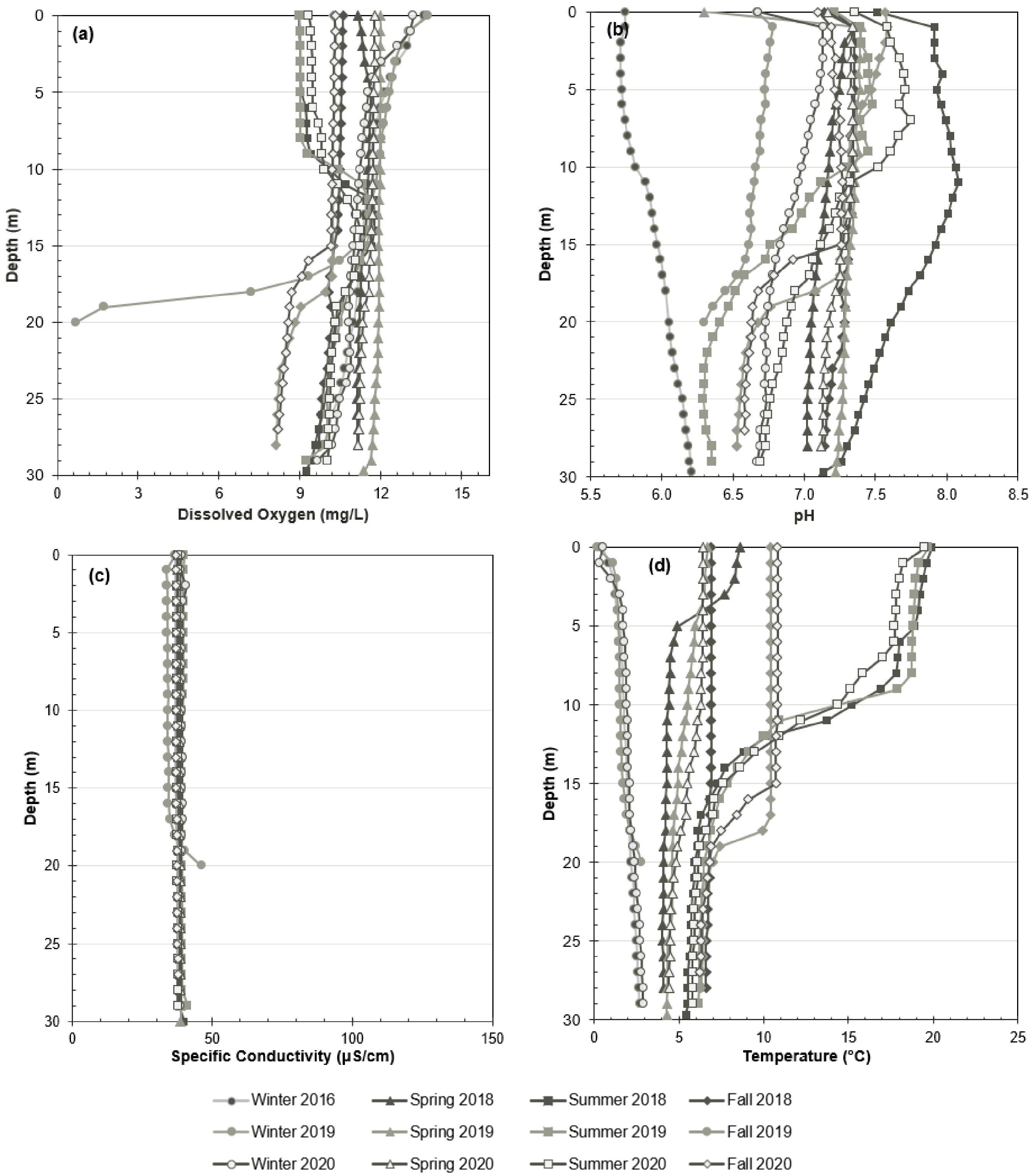


Figure 10A-1c-7: Patterson Lake South Arm (Area 3) Profiles: (a) Dissolved Oxygen, (b) pH, (c) Specific Conductivity, (d) Temperature

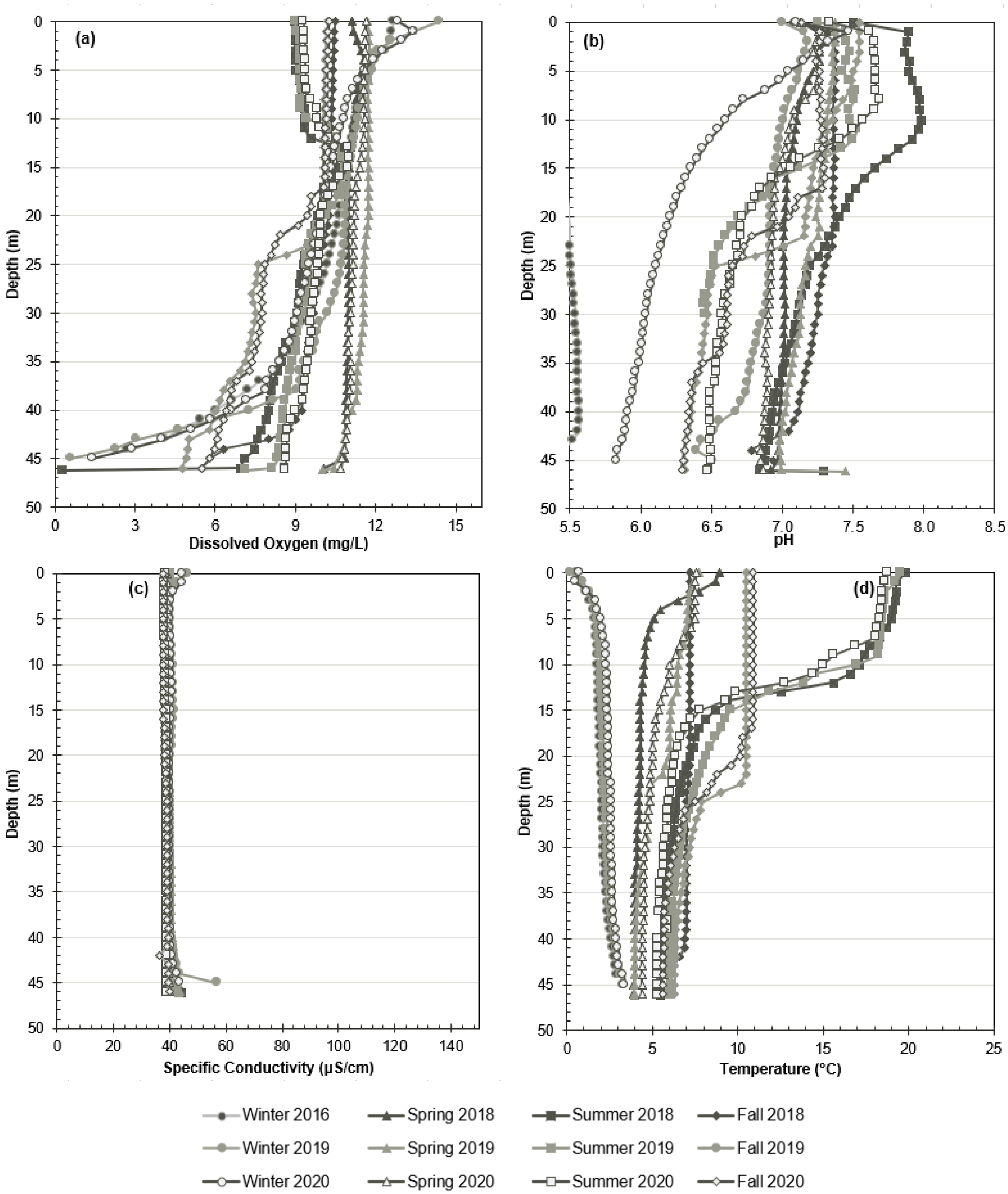


Figure 10A-1c-8: Forrest Lake North Basin (Area 1) Profiles: (a) Dissolved Oxygen, (b) pH, (c) Specific Conductivity, (d) Temperature

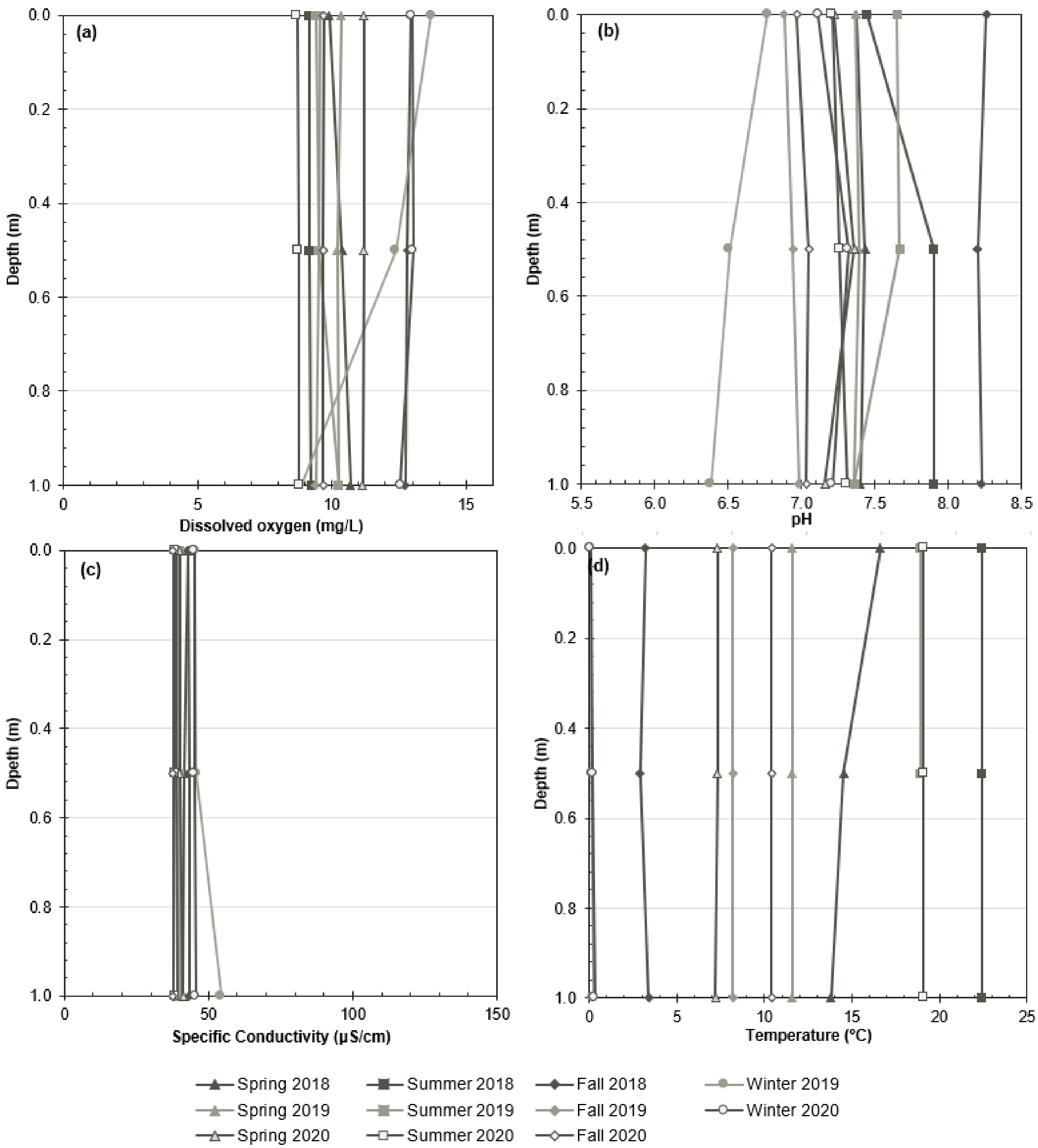


Figure 10A-1c-9: Forrest Lake South Basin (Area 2) Profiles: (a) Dissolved Oxygen, (b) pH, (c) Specific Conductivity, (d) Temperature

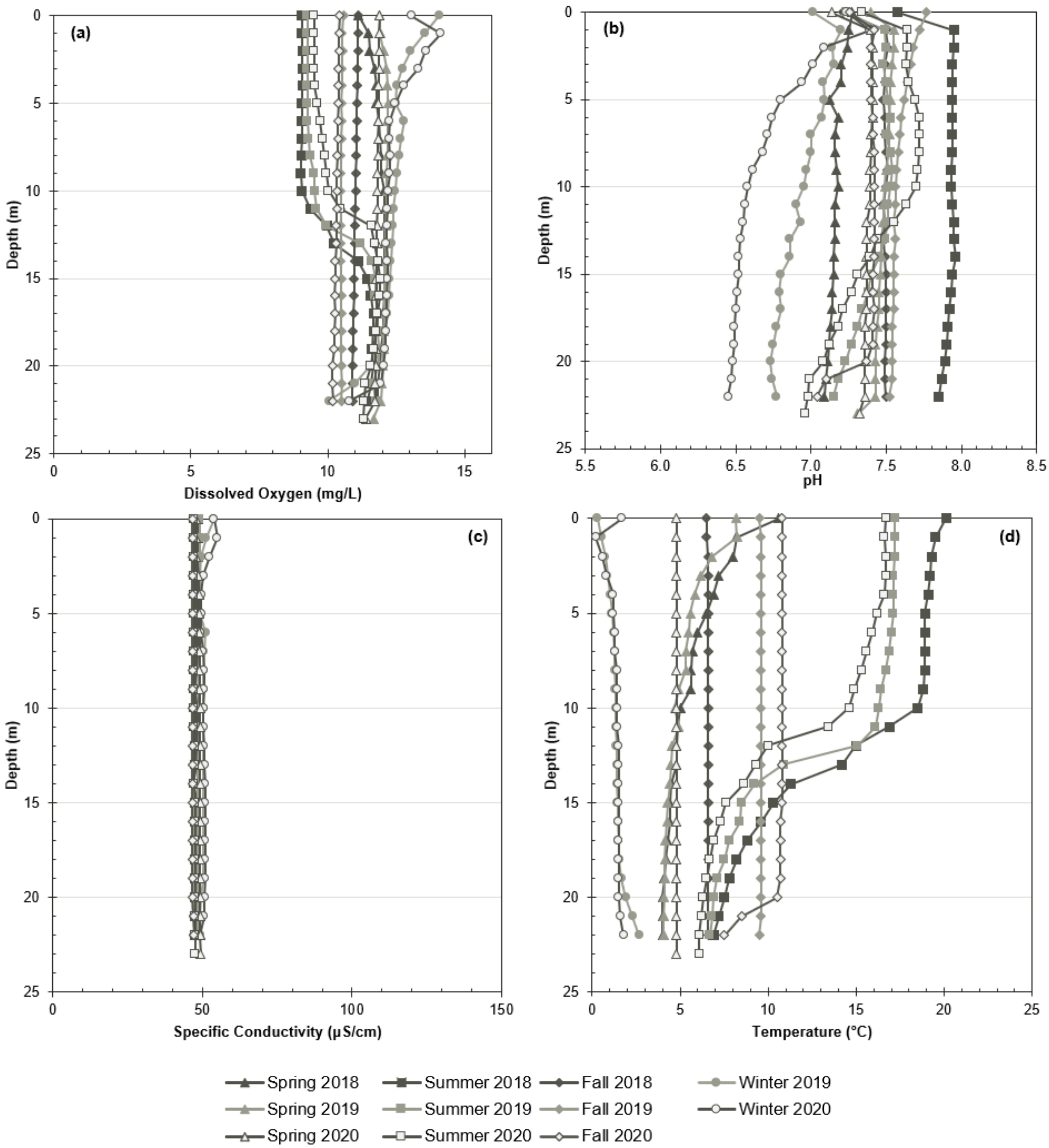


Figure 10A-1c-10: Beet Lake (Area 1) Profiles: (a) Dissolved Oxygen, (b) pH, (c) Specific Conductivity, (d) Temperature

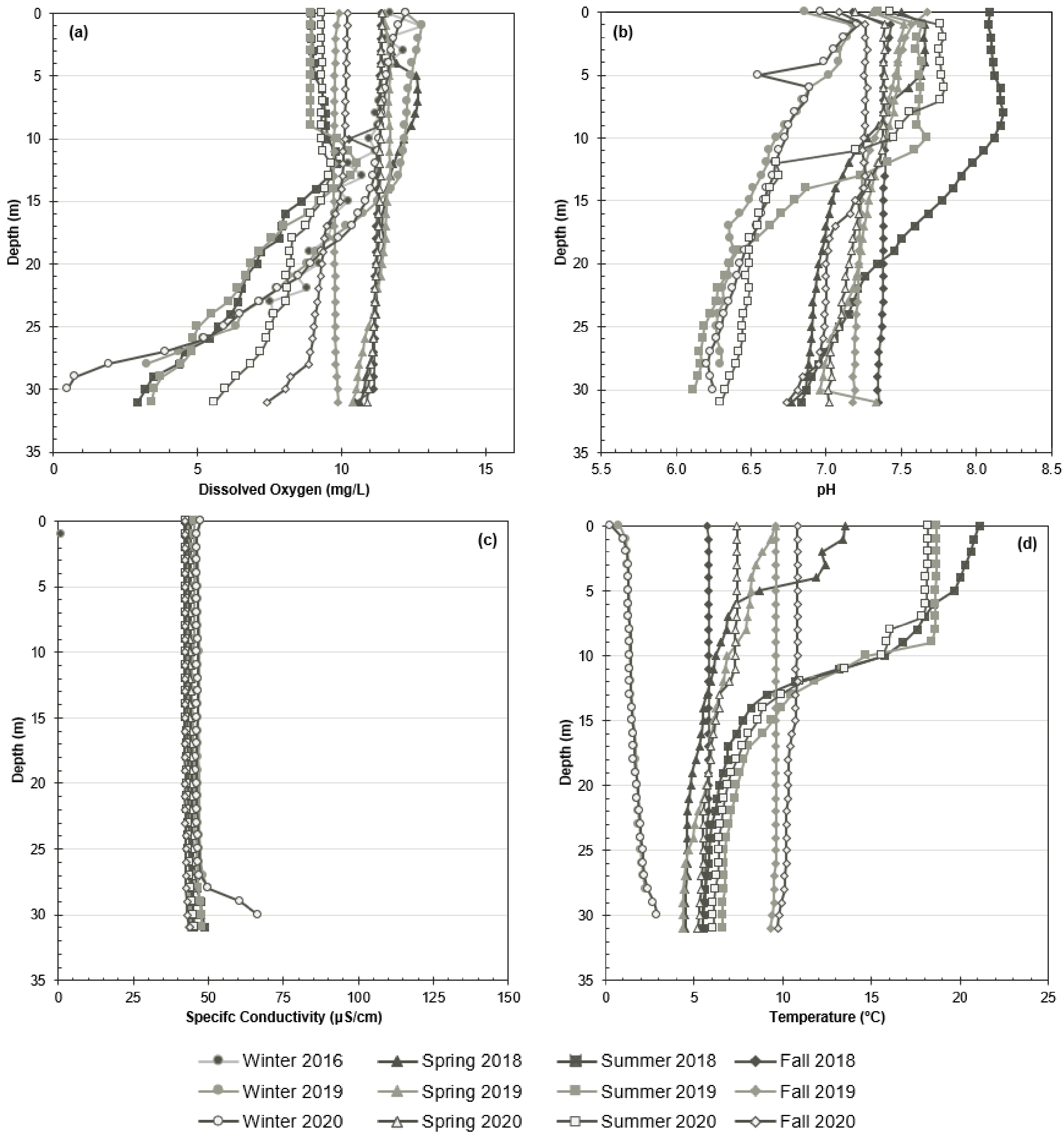


Figure 10A-1c-11: Naomi Lake Profiles: (a) Dissolved Oxygen, (b) pH, (c) Specific Conductivity, (d) Temperature

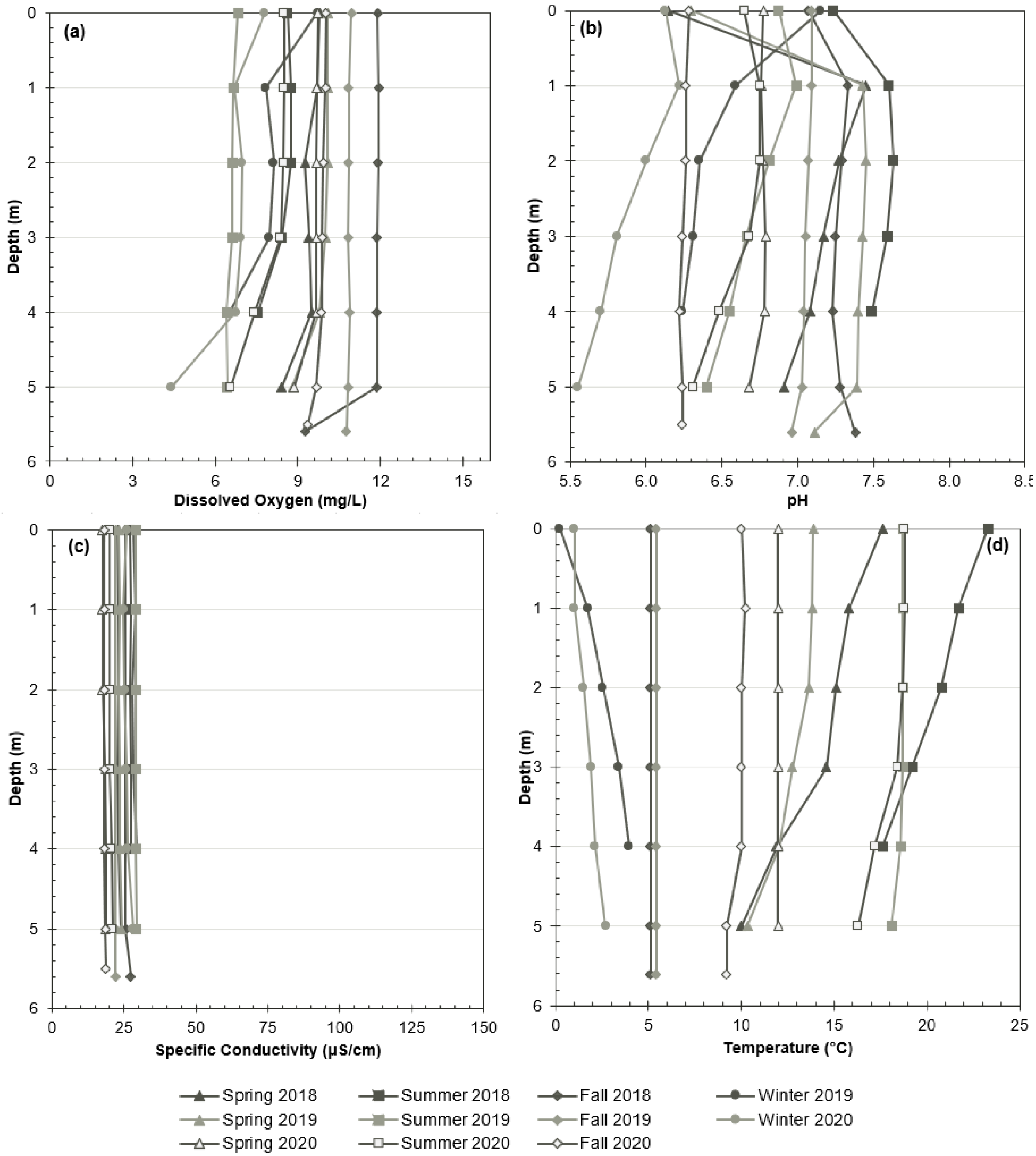


Figure 10A-1c-12: Harbo Lake (HL_WQ01) Profiles: (a) Dissolved Oxygen, (b) pH, (c) Specific Conductivity, (d) Temperature

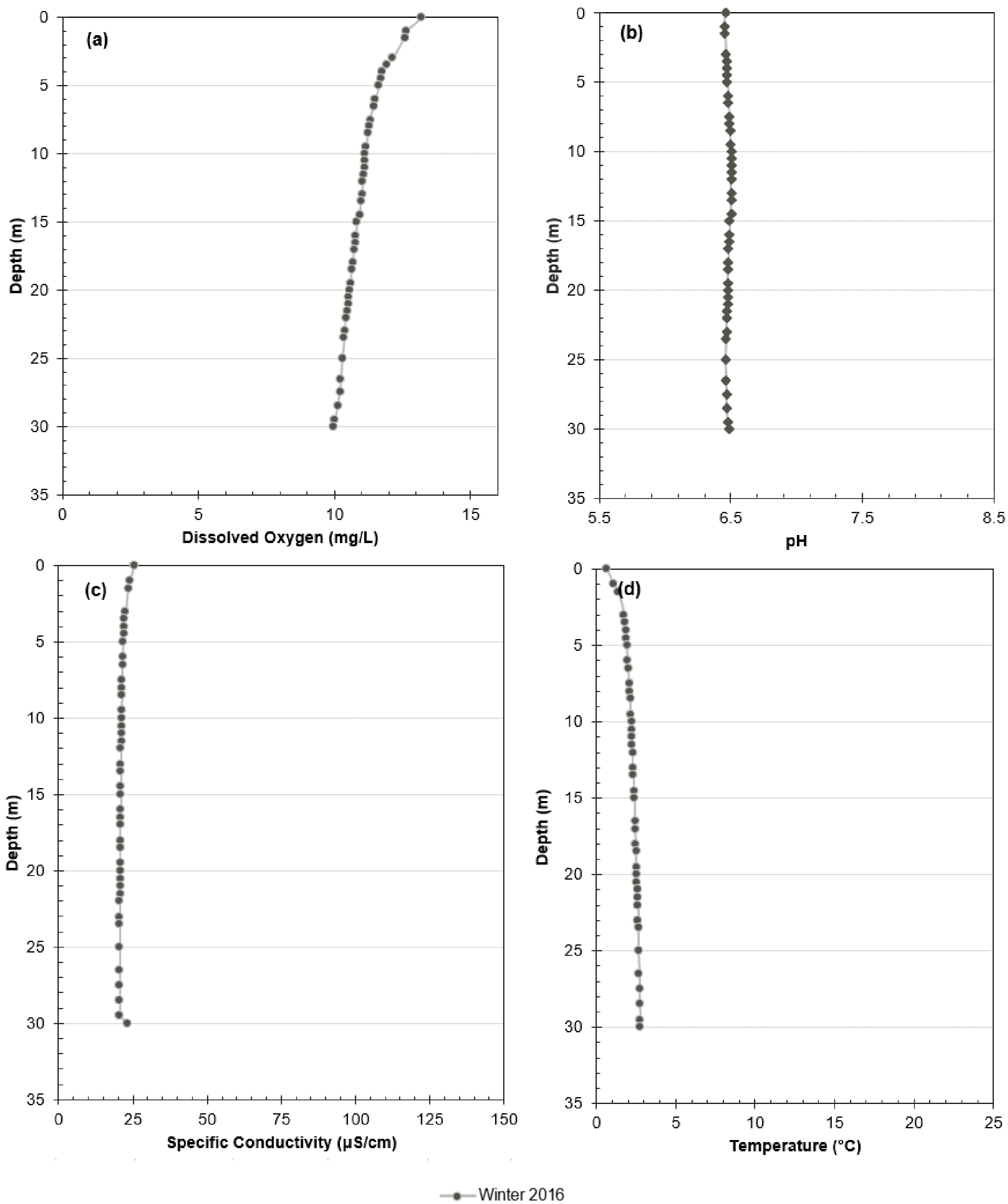


Figure 10A-1c-13: Hodge Lake (Area 1) Profiles: (a) Dissolved Oxygen, (b) pH, (c) Specific Conductivity, (d) Temperature

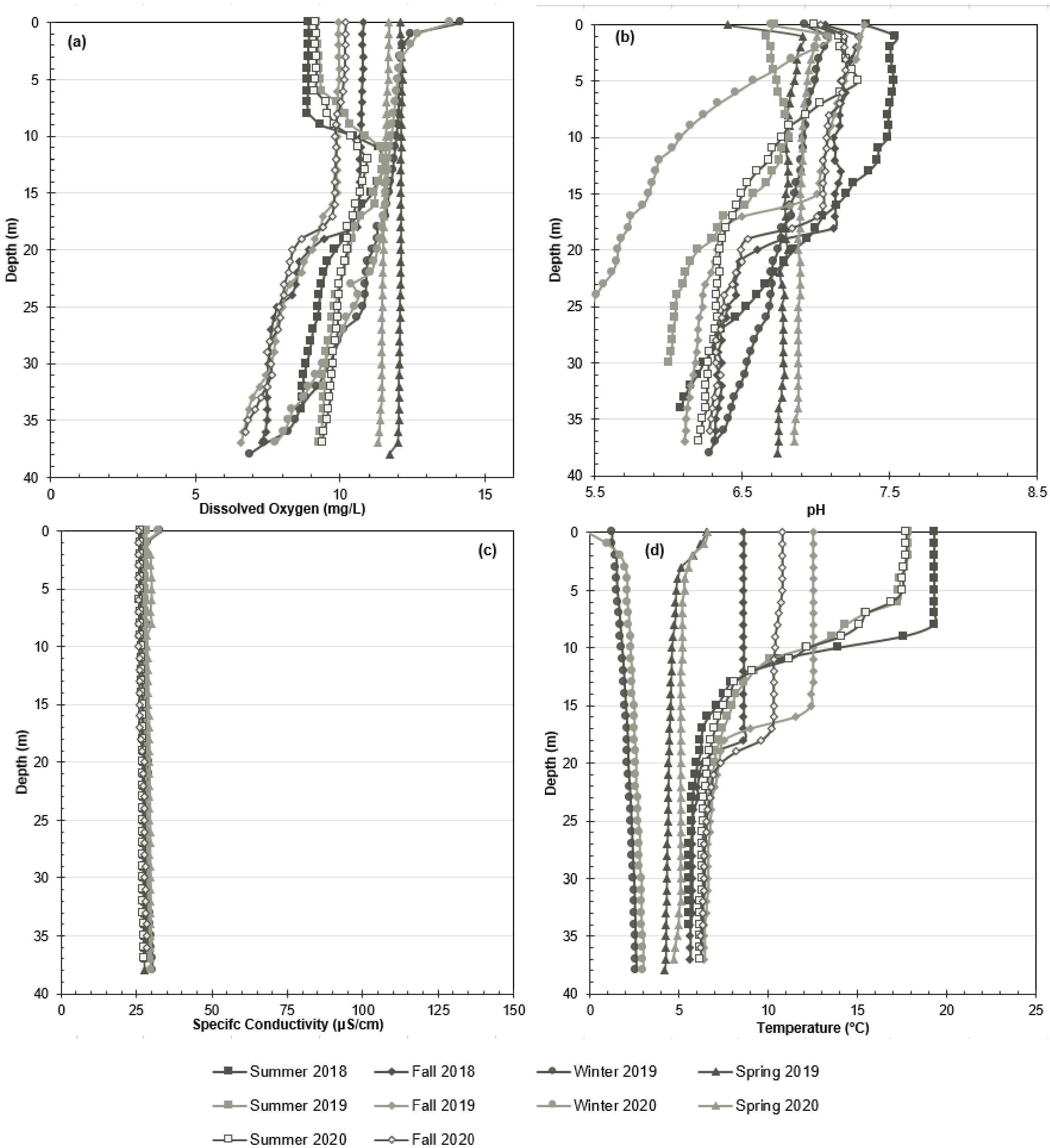


Figure 10A-1c-14: Lake D Profiles: (a) Dissolved Oxygen, (b) pH, (c) Specific Conductivity, (d) Temperature

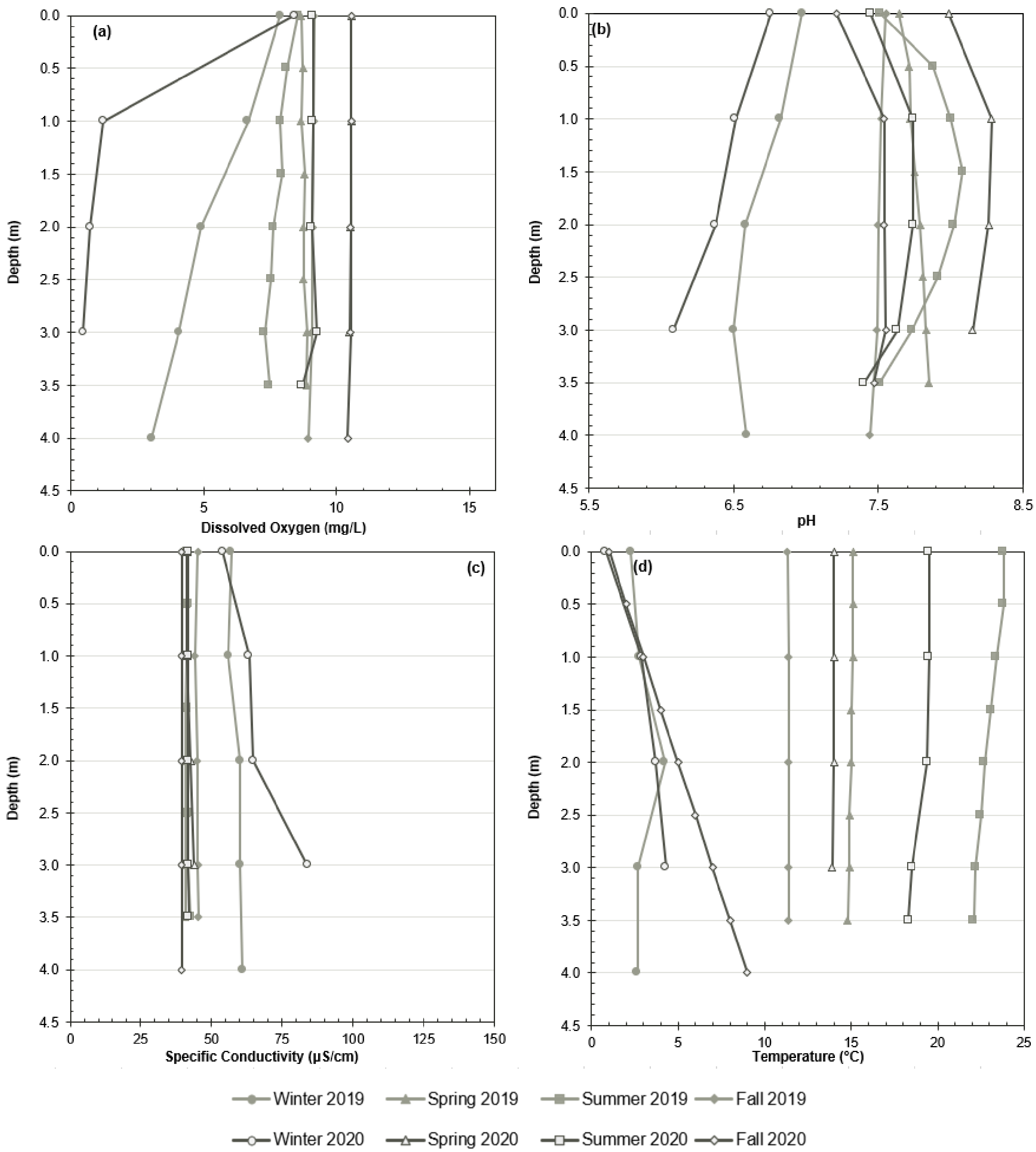
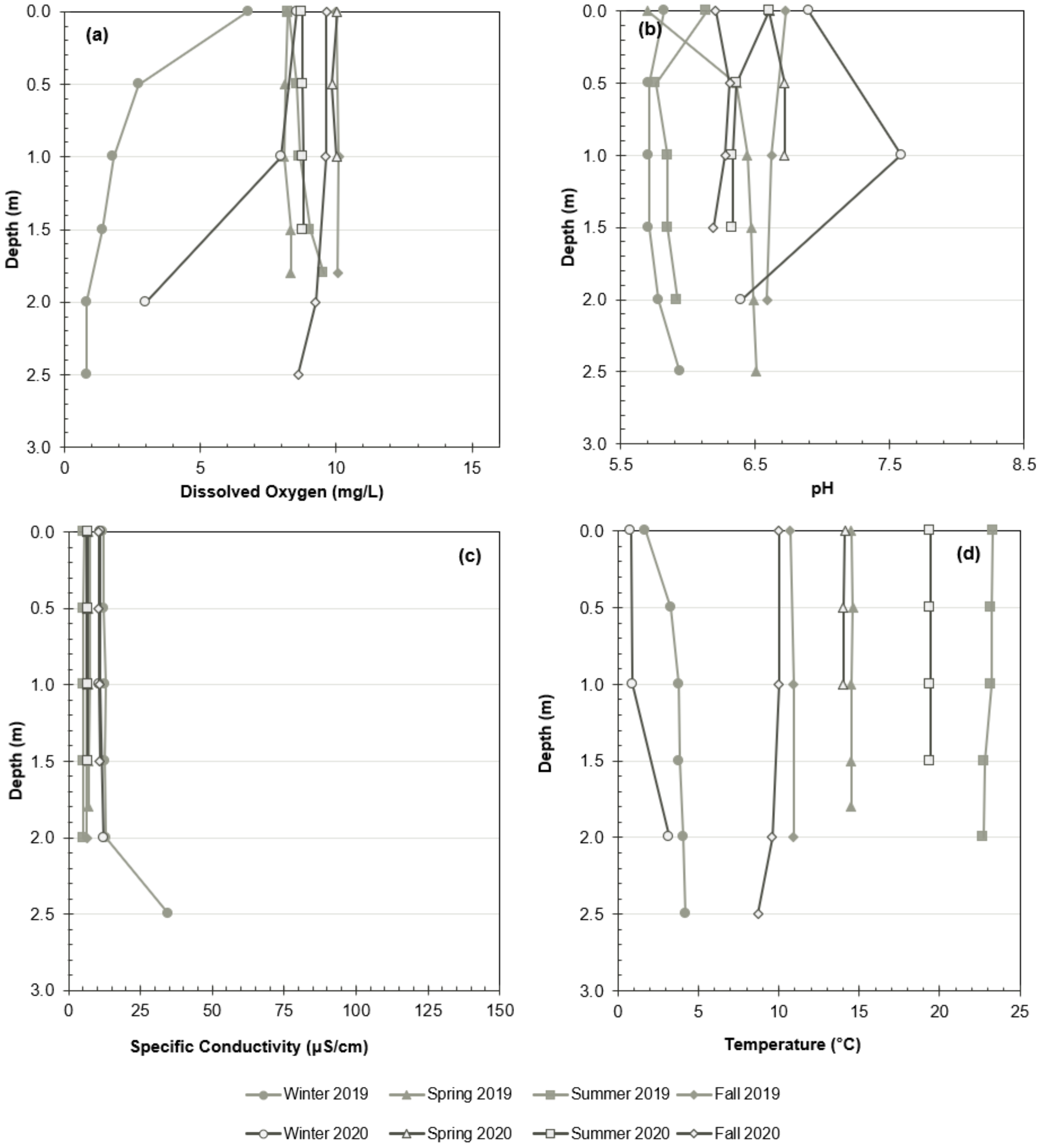
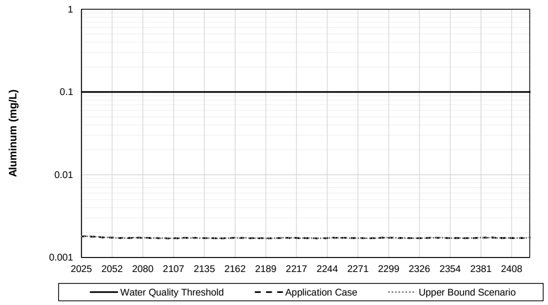


Figure 10A-1c-15: Lake J Profiles: (a) Dissolved Oxygen, (b) pH, (c) Specific Conductivity, (d) Temperature

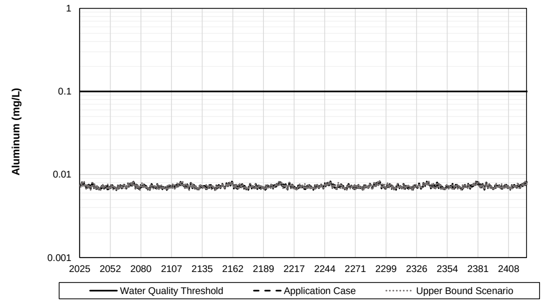


Attachment 10A-2 Regional Surface Water Quality Model Results

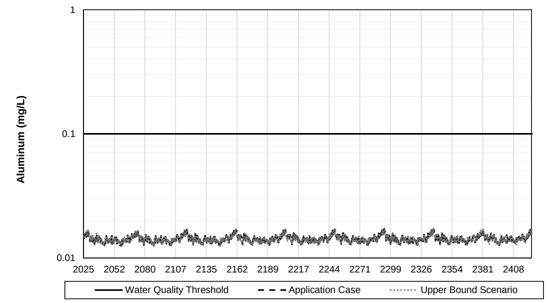
Broach Lake



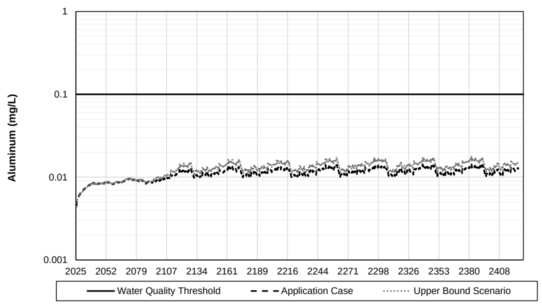
Lake G



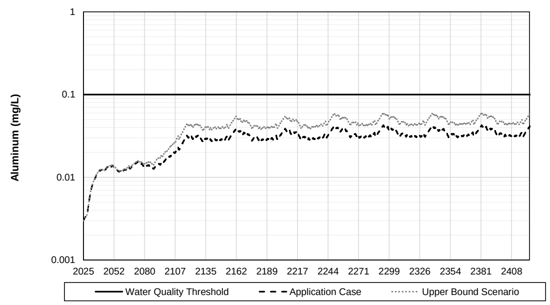
Lake H



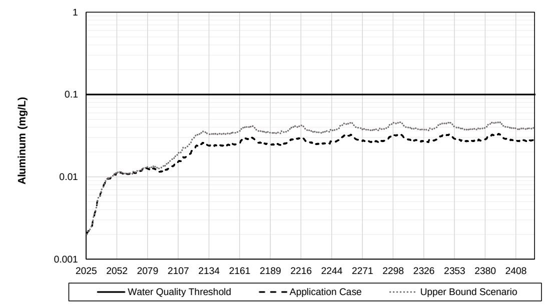
Patterson Lake North Arm – East Basin



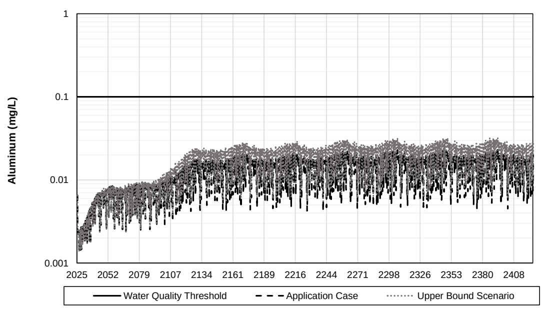
Patterson Lake North Arm – West Basin



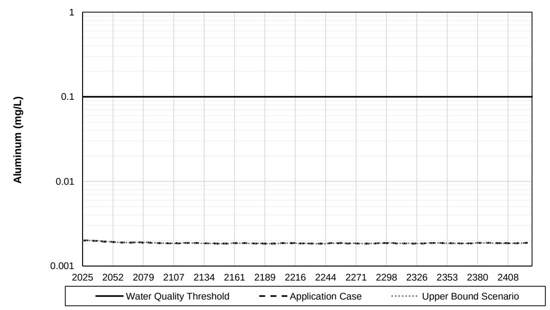
Patterson Lake South Arm



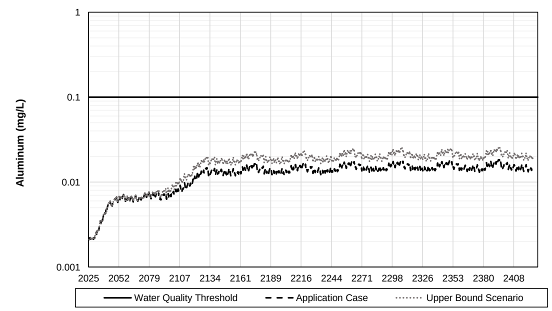
Forrest Lake North Basin



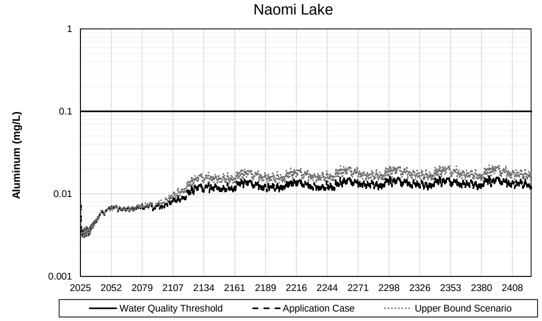
Forrest Lake South Basin

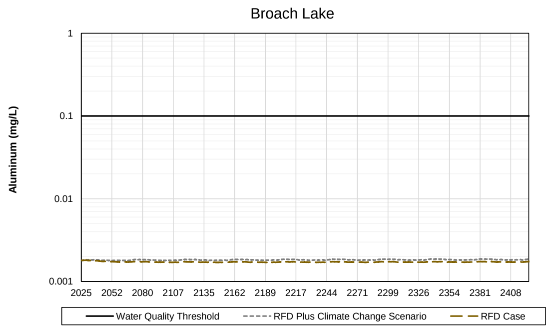


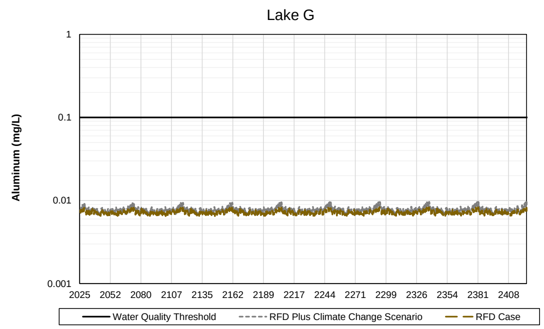
Beet Lake



Naomi Lake




Broach Lake
Aluminum (mg/L)
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Lake G
Aluminum (mg/L)
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0.1
0.01
0.001
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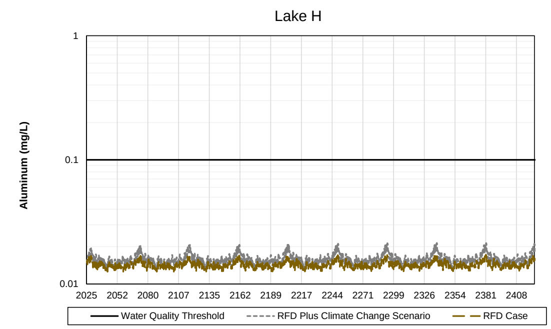
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Lake H
Aluminum (mg/L)
1
0.1
0.01
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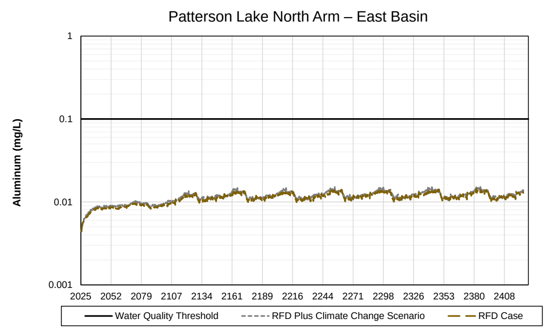
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake North Arm – East Basin
Aluminum (mg/L)
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0.1
0.01
0.001
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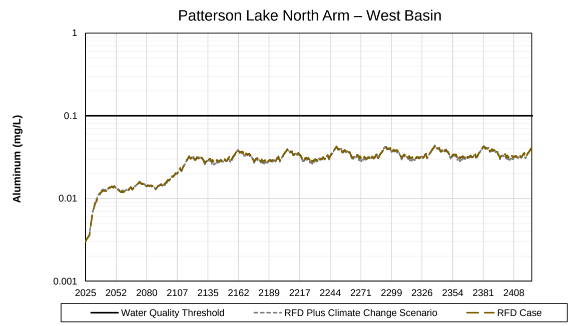
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake North Arm – West Basin
Aluminum (mg/L)
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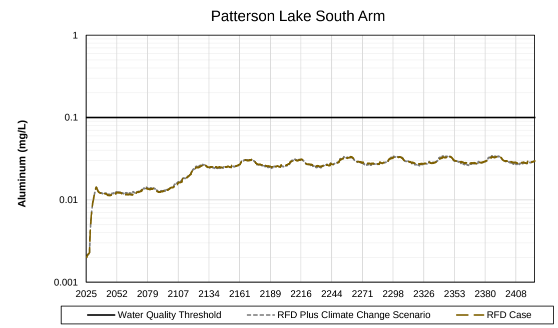
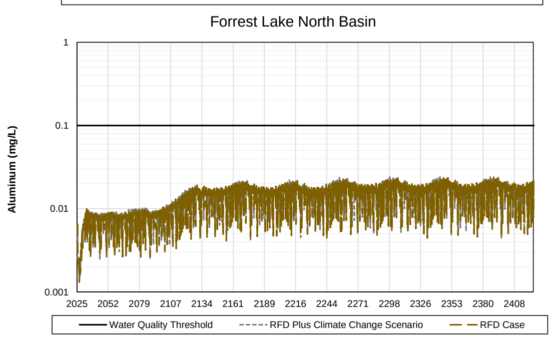
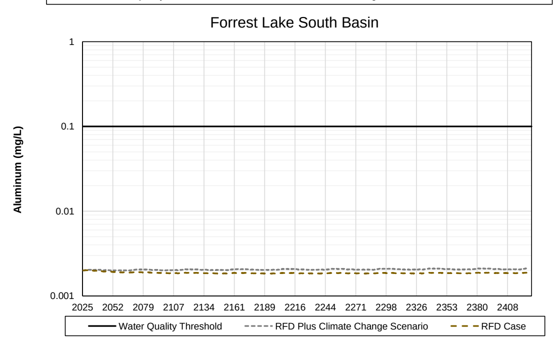
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake South Arm
Aluminum (mg/L)
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Forrest Lake North Basin
Aluminum (mg/L)
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Forrest Lake South Basin
Aluminum (mg/L)
1
0.1
0.01
0.001
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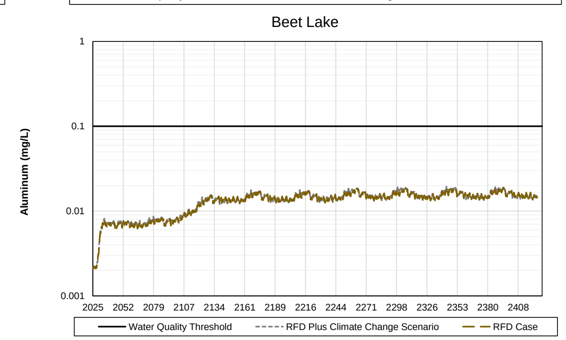
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Beet Lake
Aluminum (mg/L)
1
0.1
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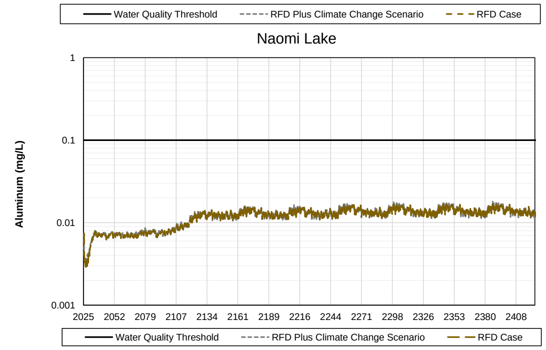
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Naomi Lake
Aluminum (mg/L)
1
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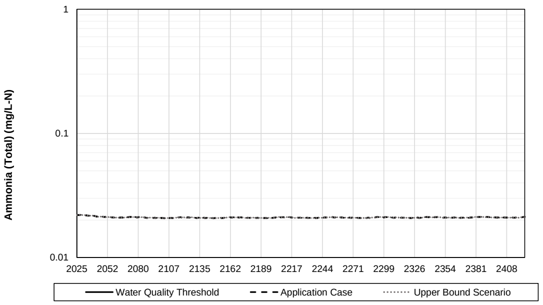
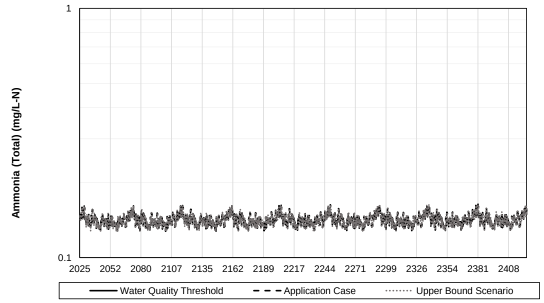
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

Broach Lake



Lake G



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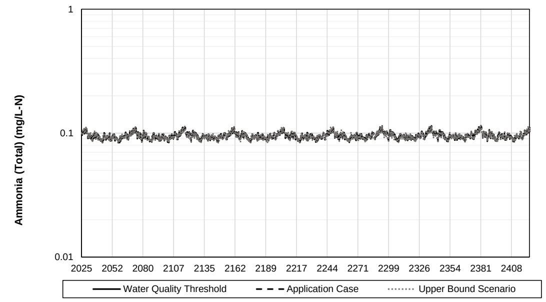
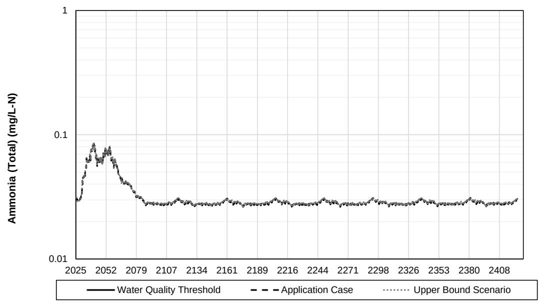
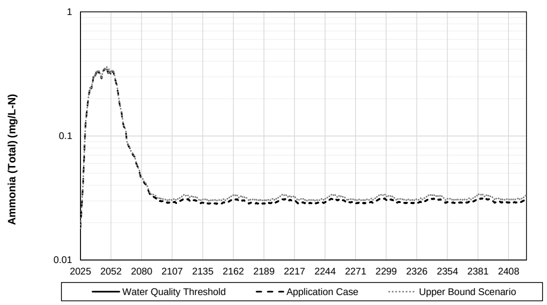


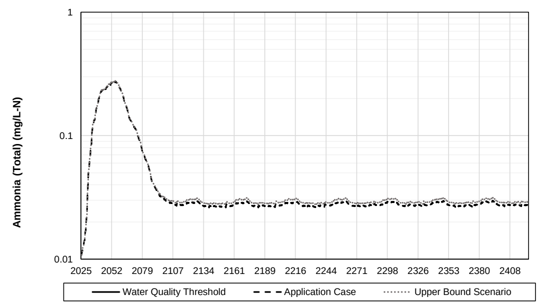
Patterson Lake North Arm – East Basin



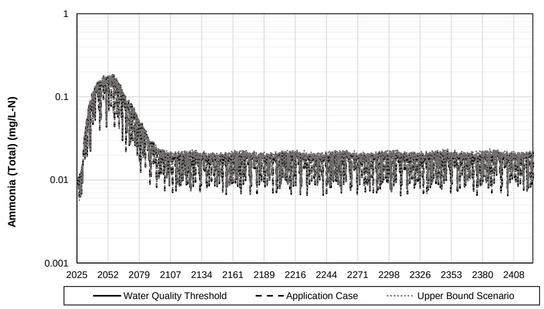
Patterson Lake North Arm – West Basin



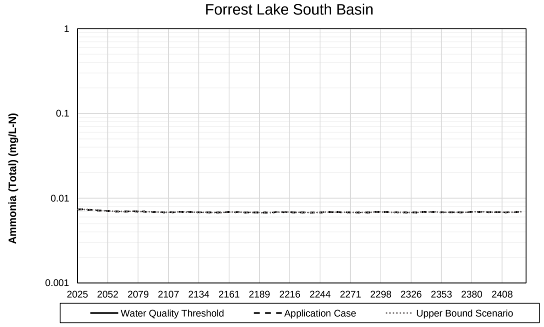
Patterson Lake South Arm



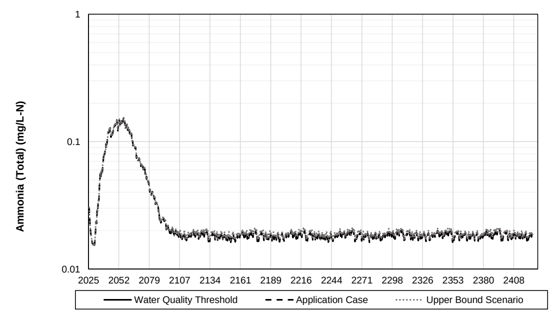
Forrest Lake North Basin



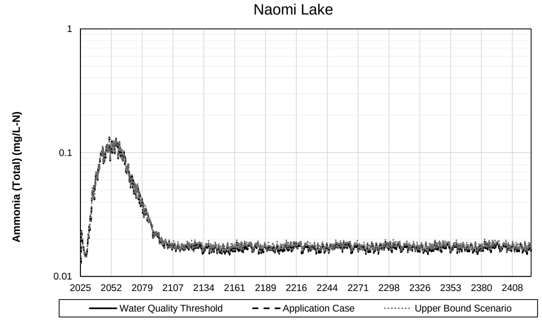
Forrest Lake South Basin

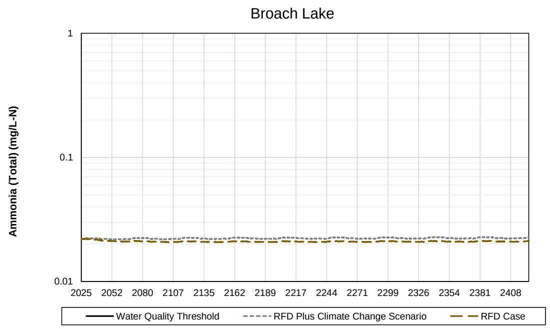


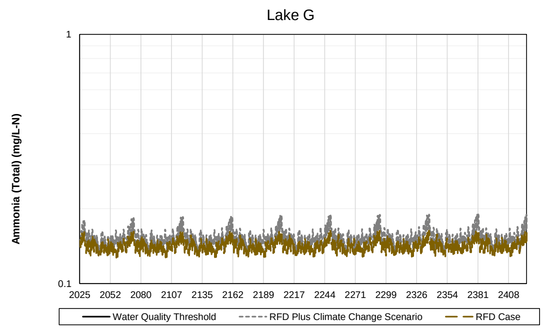
Beet Lake



Naomi Lake




Broach Lake
Ammonia (Total) (mg/L-N)
1
0.1
0.01
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Lake G
Ammonia (Total) (mg/L-N)
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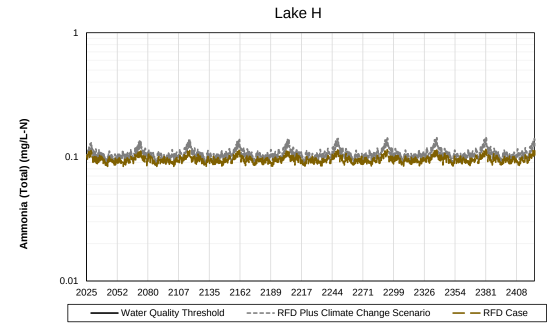
0.1
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Lake H
Ammonia (Total) (mg/L-N)
1
0.1
0.01
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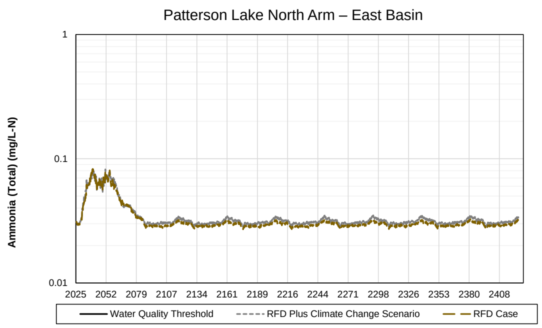
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake North Arm – East Basin
Ammonia (Total) (mg/L-N)
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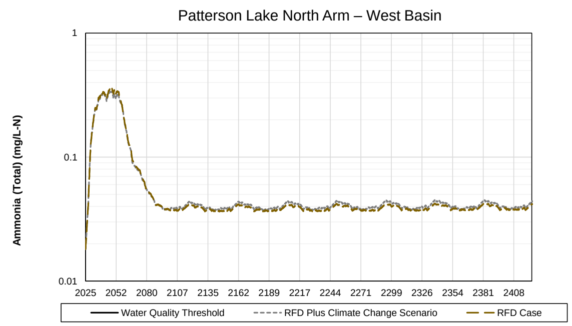
0.1
0.01
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake North Arm – West Basin
Ammonia (Total) (mg/L-N)
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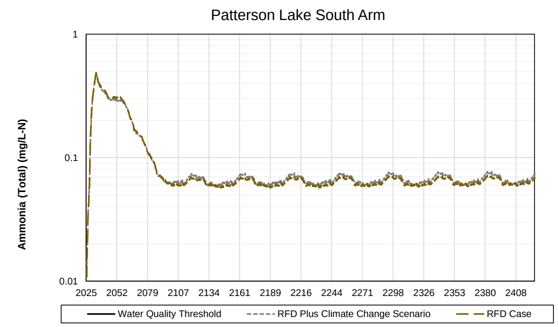
0.1
0.01
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake South Arm
Ammonia (Total) (mg/L-N)
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0.01
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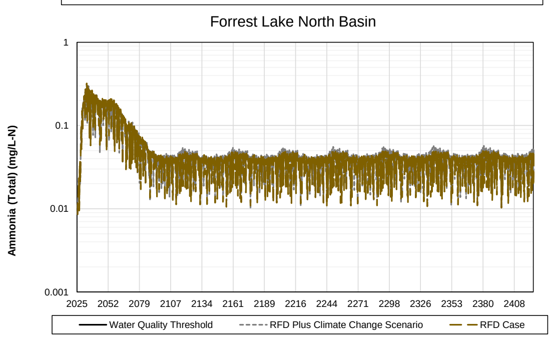
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Forrest Lake North Basin
Ammonia (Total) (mg/L-N)
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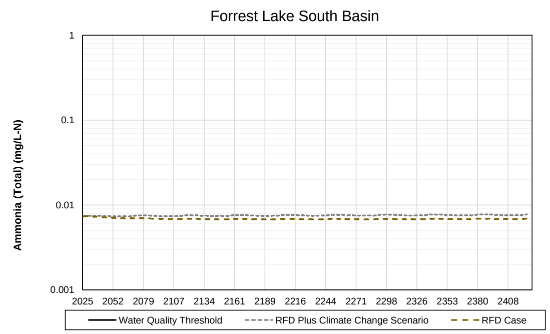
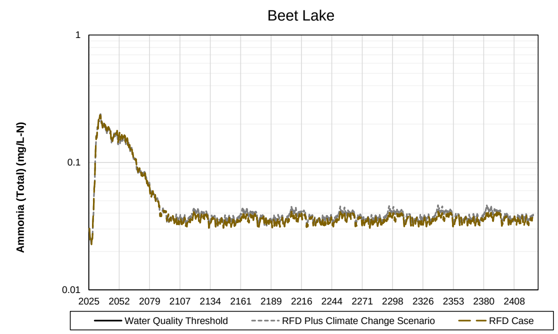
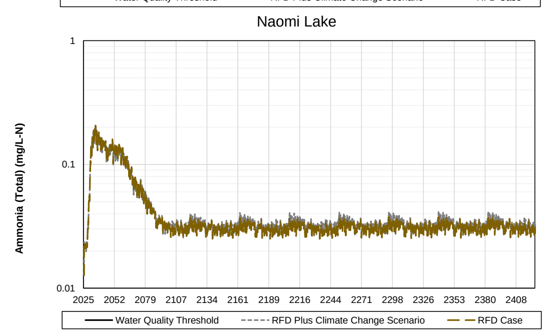
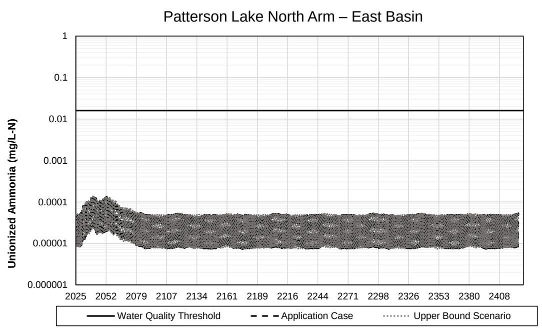
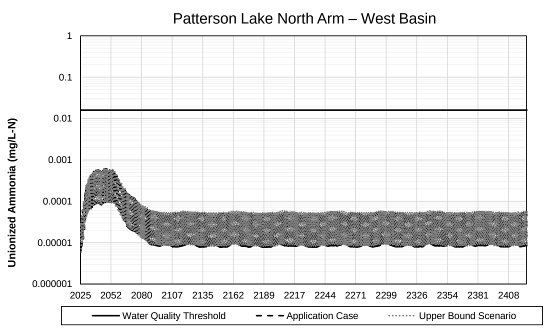
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

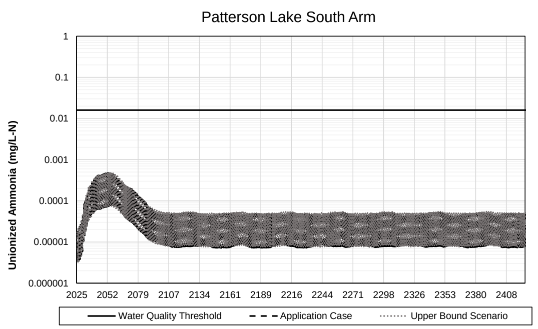

Forrest Lake South Basin
Ammonia (Total) (mg/L-N)
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

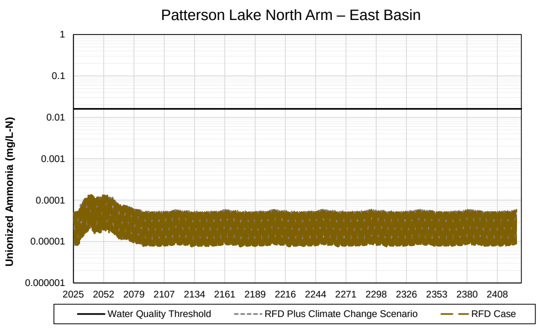

Beet Lake
Ammonia (Total) (mg/L-N)
1
0.1
0.01
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

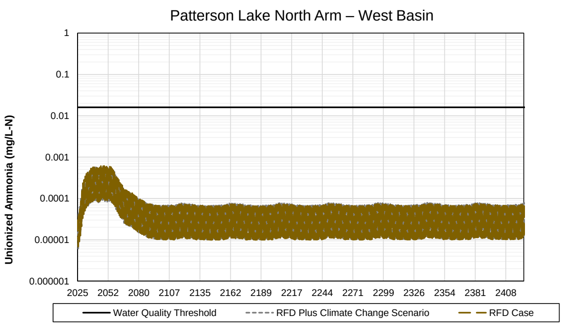

Naomi Lake
Ammonia (Total) (mg/L-N)
1
0.1
0.01
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

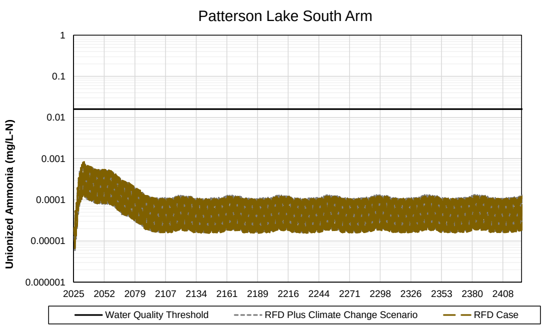

Patterson Lake North Arm – East Basin
Unionized Ammonia (mg/L-N)
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Patterson Lake North Arm – West Basin
Unionized Ammonia (mg/L-N)
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

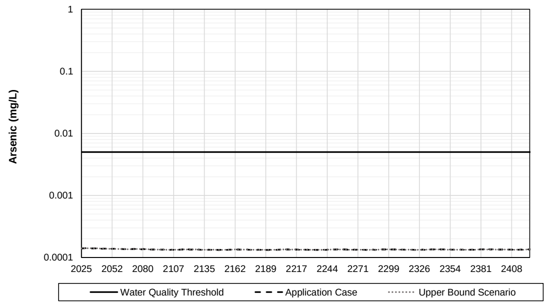

Patterson Lake South Arm
Unionized Ammonia (mg/L-N)
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Patterson Lake North Arm – East Basin
Unionized Ammonia (mg/L-N)
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

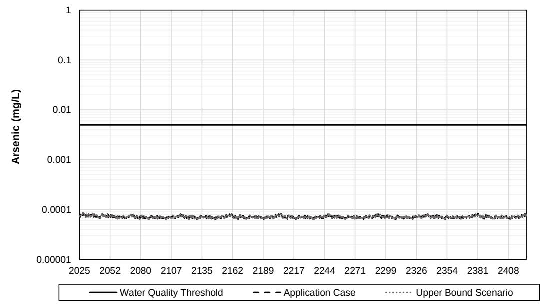

Patterson Lake North Arm – West Basin
Unionized Ammonia (mg/L-N)
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake South Arm
Unionized Ammonia (mg/L-N)
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

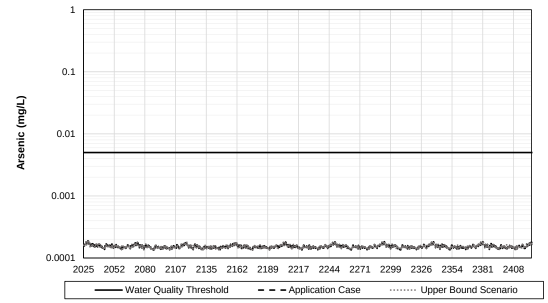
Broach Lake



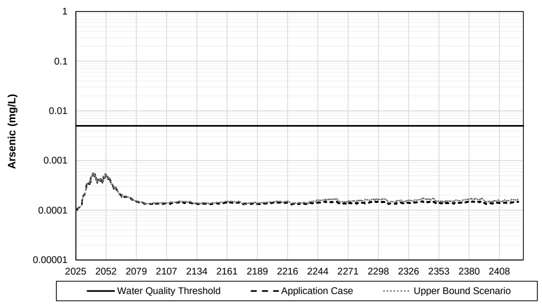
Lake G



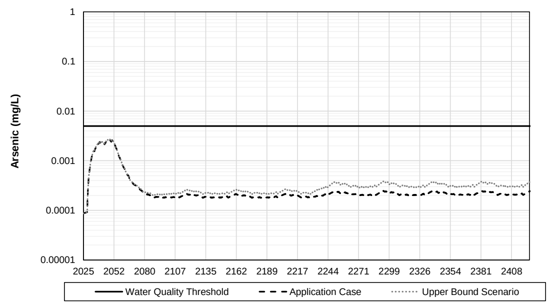
Lake H



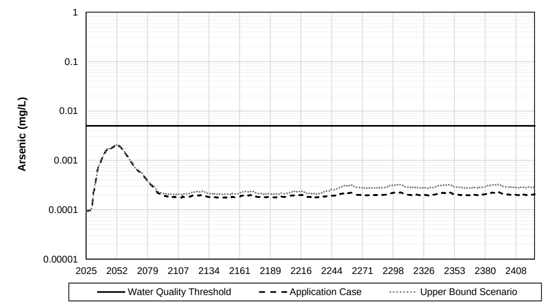
Patterson Lake North Arm – East Basin



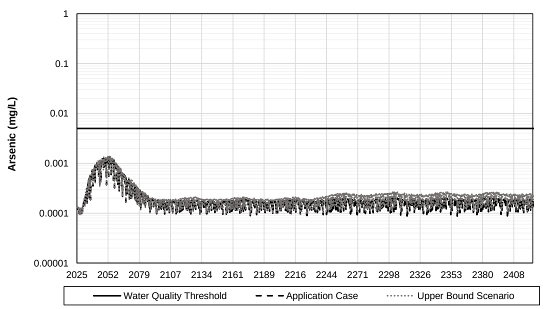
Patterson Lake North Arm – West Basin



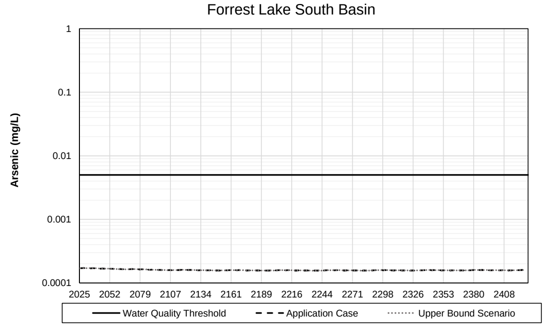
Patterson Lake South Arm



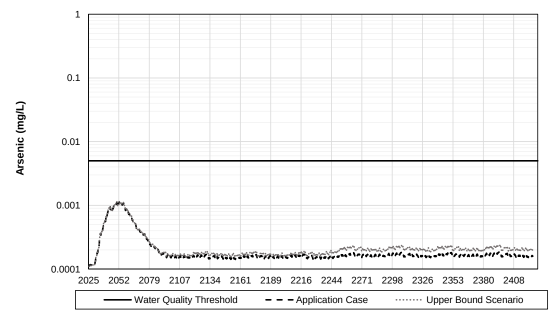
Forrest Lake North Basin



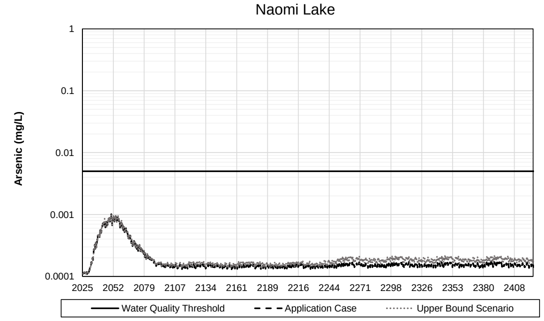
Forrest Lake South Basin



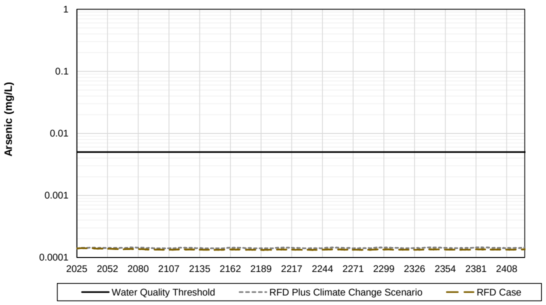
Beet Lake



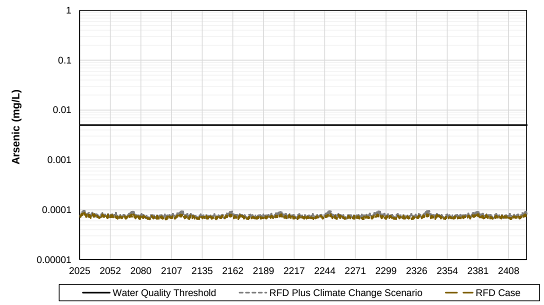
Naomi Lake



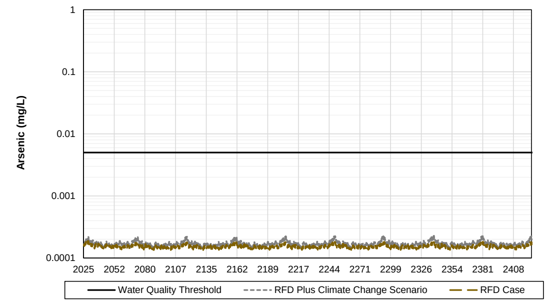
Broach Lake



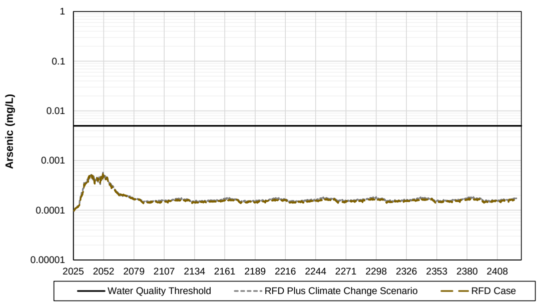
Lake G



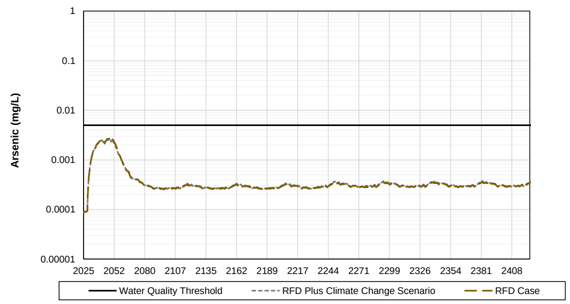
Lake H



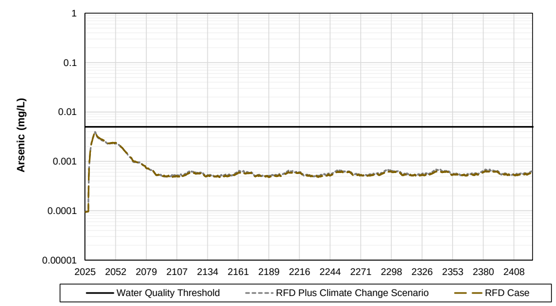
Patterson Lake North Arm – East Basin



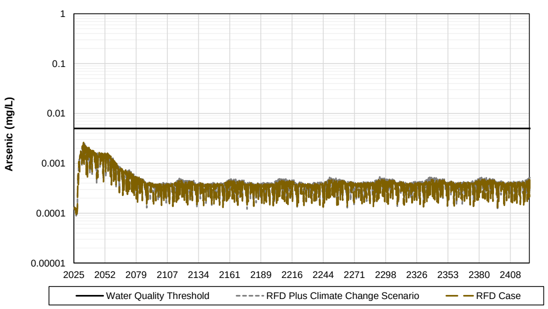
Patterson Lake North Arm – West Basin



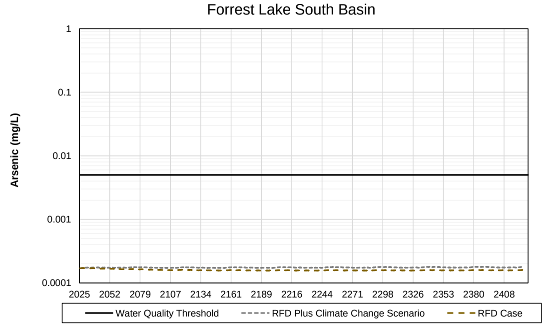
Patterson Lake South Arm



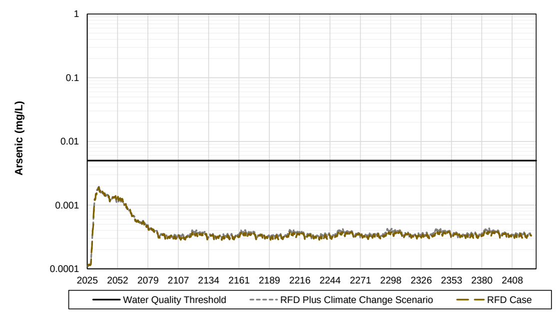
Forrest Lake North Basin



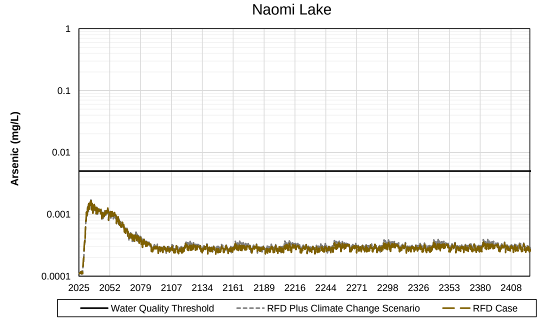
Forrest Lake South Basin



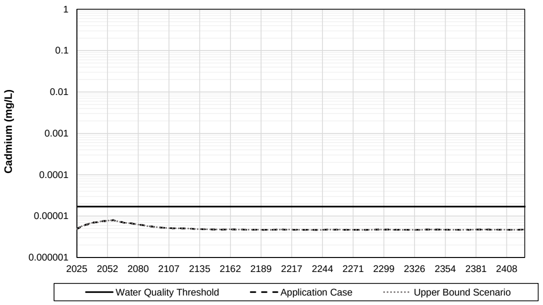
Beet Lake



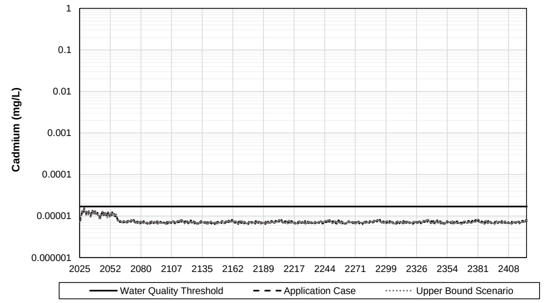
Naomi Lake



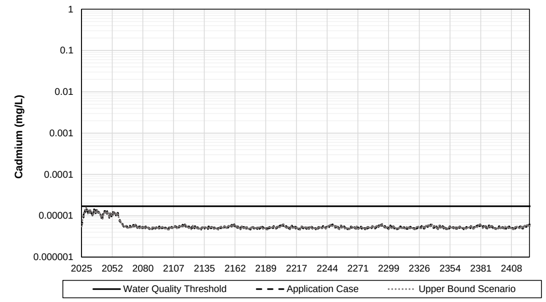
Broach Lake



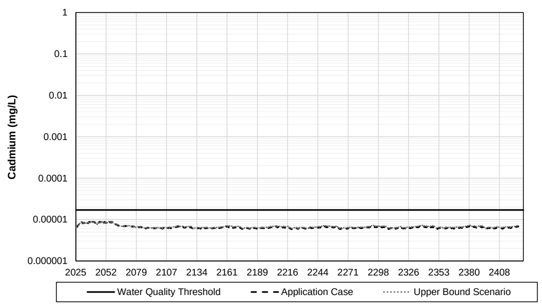
Lake G



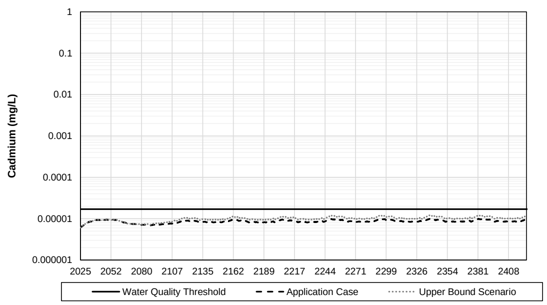
Lake H



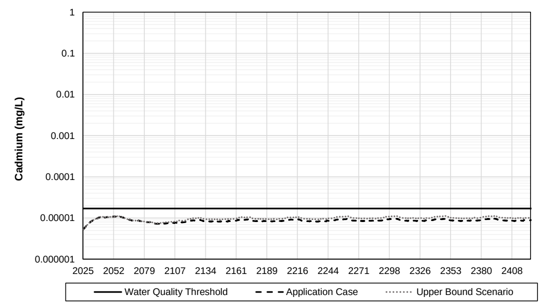
Patterson Lake North Arm – East Basin



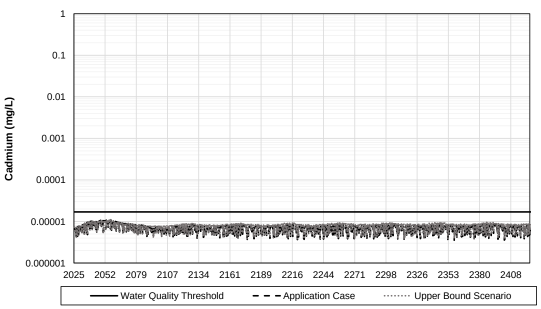
Patterson Lake North Arm – West Basin



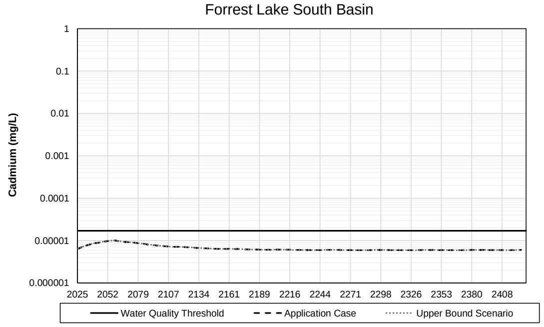
Patterson Lake South Arm



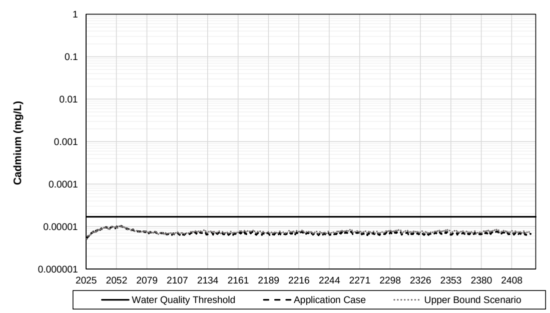
Forrest Lake North Basin



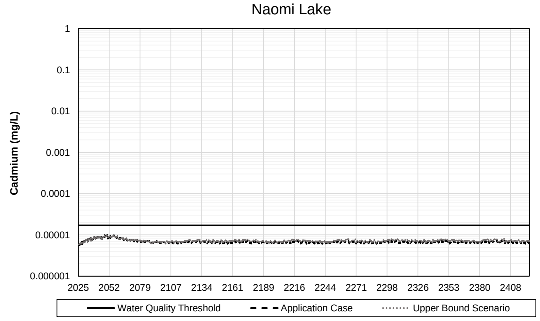
Forrest Lake South Basin

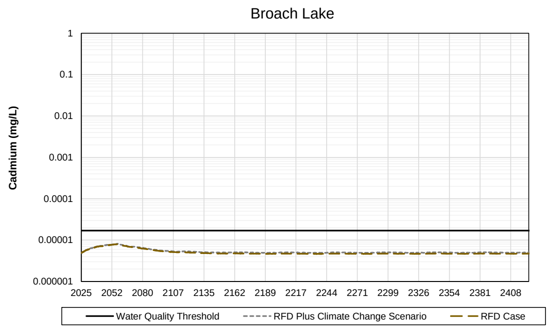


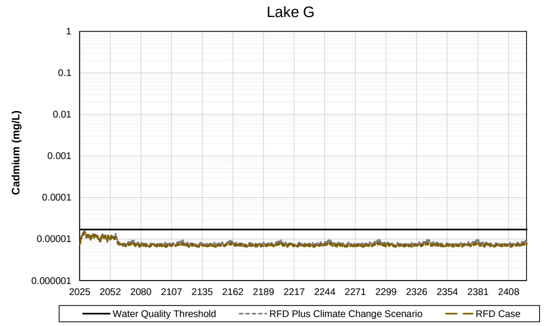
Beet Lake

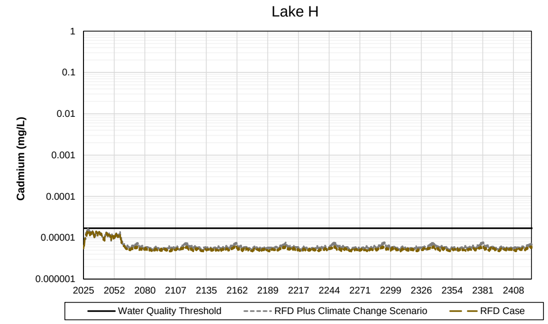


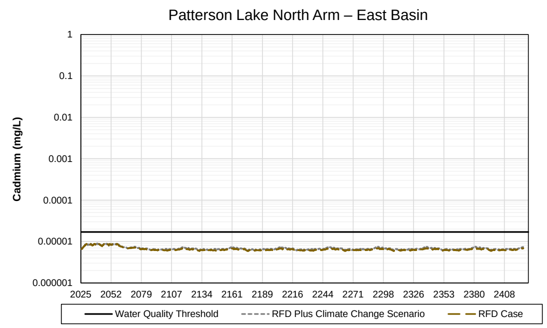
Naomi Lake

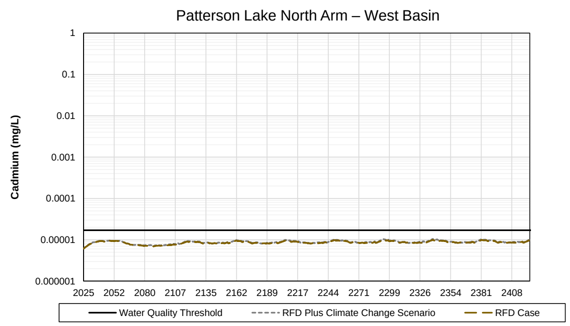


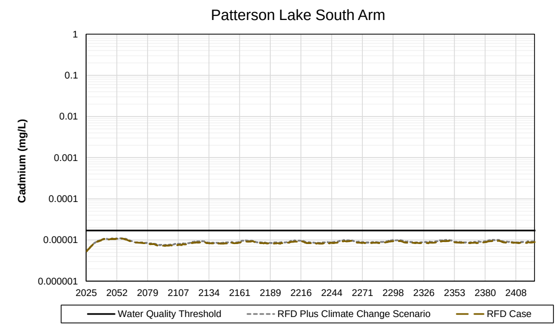

Broach Lake
Cadmium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

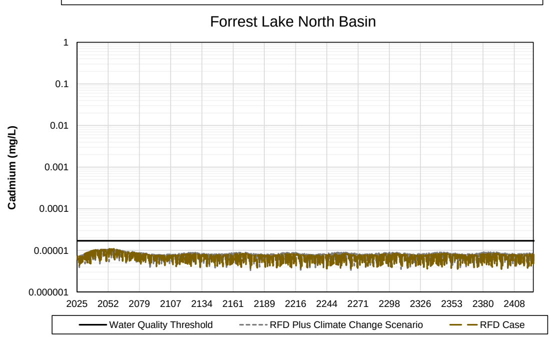

Lake G
Cadmium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

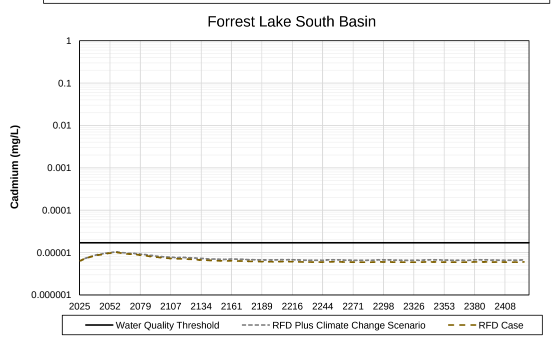

Lake H
Cadmium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

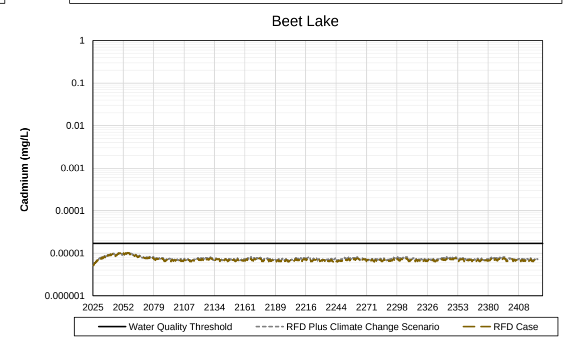

Patterson Lake North Arm – East Basin
Cadmium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

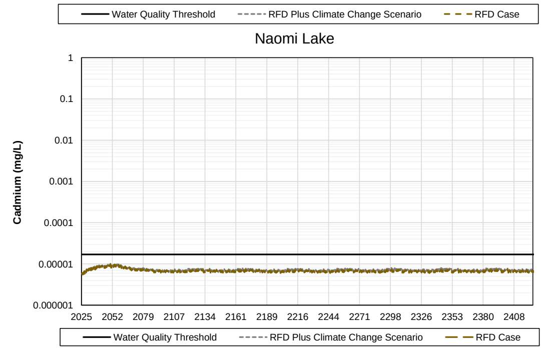

Patterson Lake North Arm – West Basin
Cadmium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

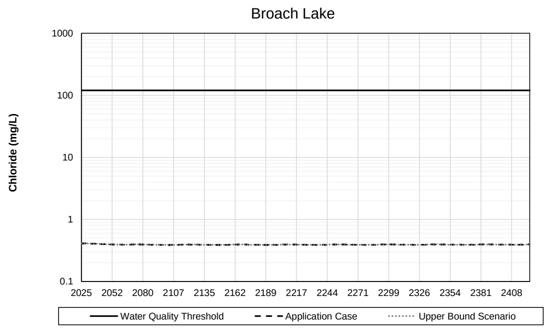

Patterson Lake South Arm
Cadmium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

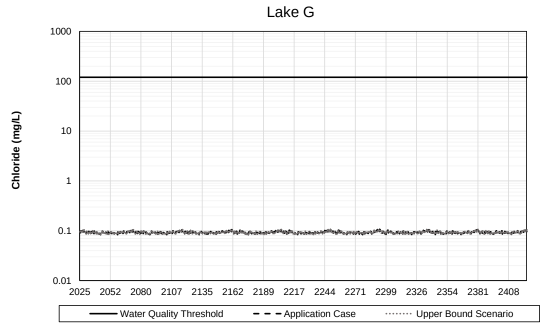

Forrest Lake North Basin
Cadmium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

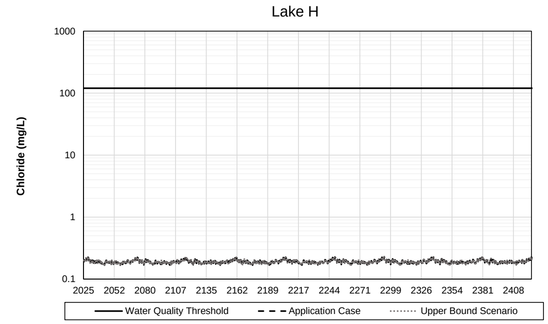

Forrest Lake South Basin
Cadmium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

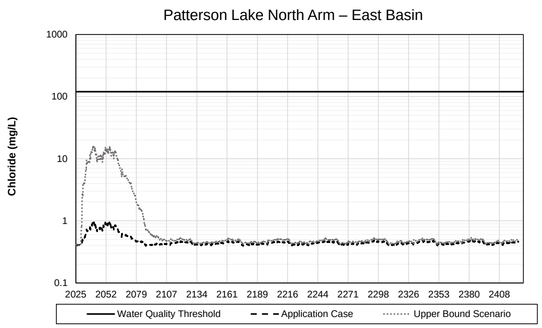

Beet Lake
Cadmium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

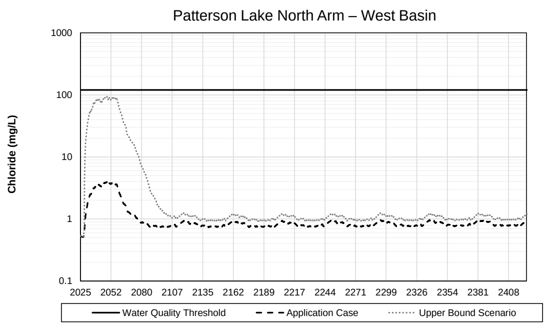

Naomi Lake
Cadmium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

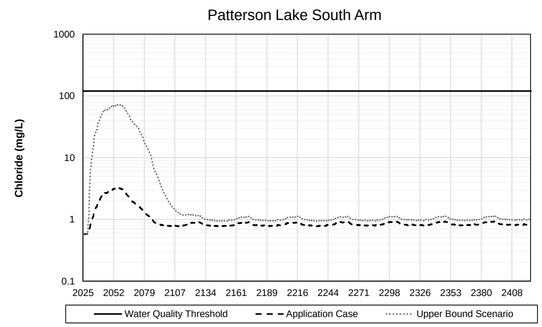

Broach Lake
Chloride (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

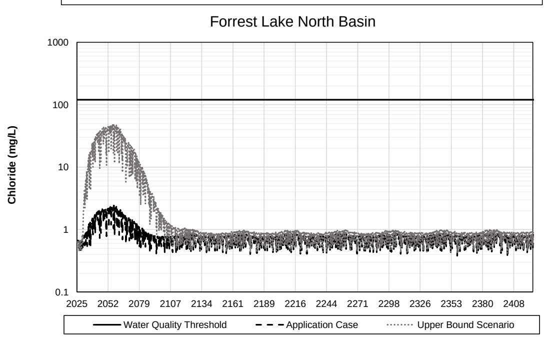

Lake G
Chloride (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

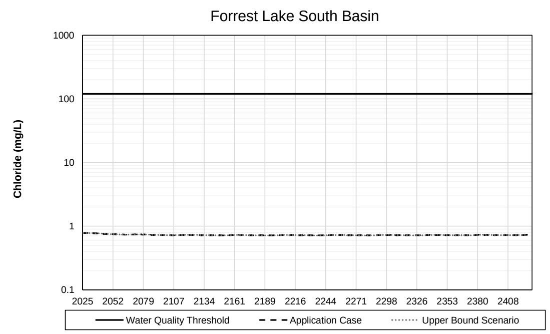

Lake H
Chloride (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

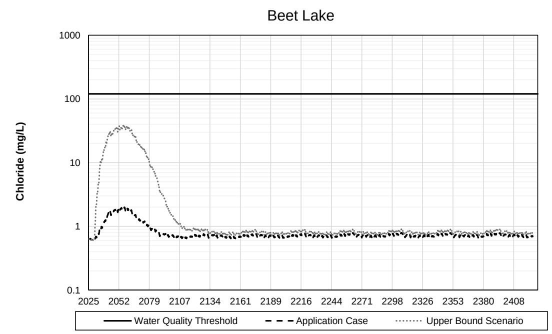

Patterson Lake North Arm – East Basin
Chloride (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

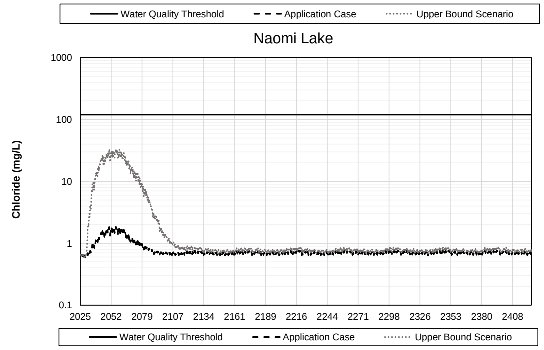

Patterson Lake North Arm – West Basin
Chloride (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

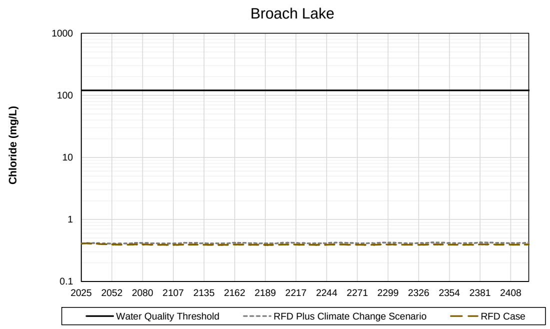

Patterson Lake South Arm
Chloride (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

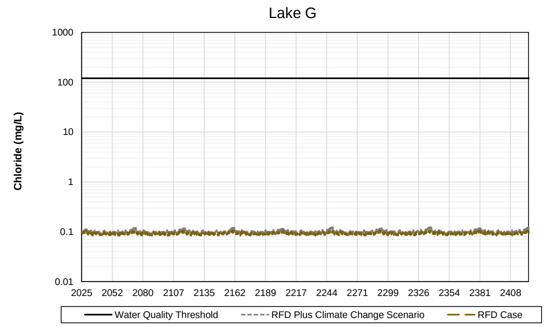

Forrest Lake North Basin
Chloride (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

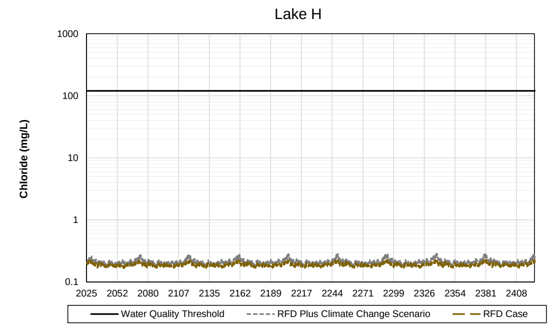

Forrest Lake South Basin
Chloride (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

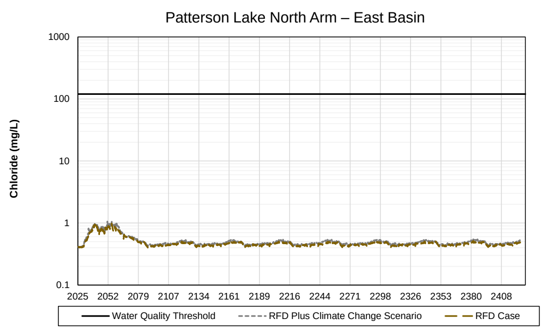

Beet Lake
Chloride (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

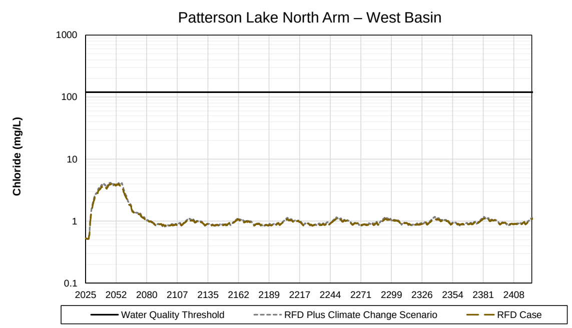

Naomi Lake
Chloride (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

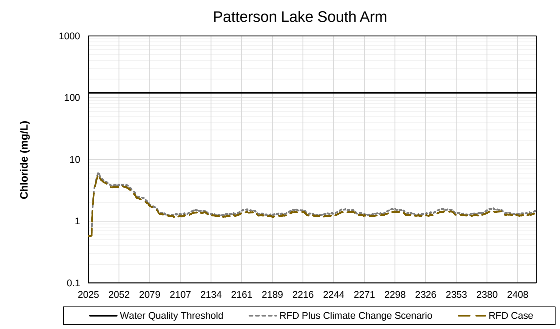

Broach Lake
Chloride (mg/L)
1000
100
10
1
0.1
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

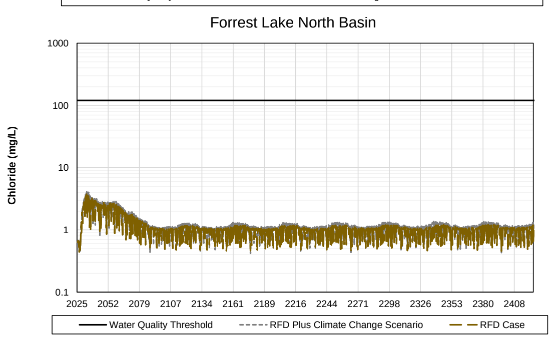

Lake G
Chloride (mg/L)
1000
100
10
1
0.1
0.01
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

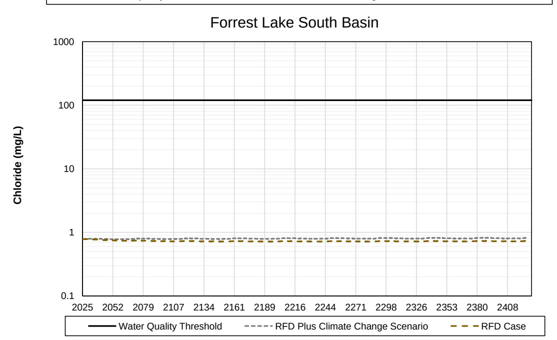

Lake H
Chloride (mg/L)
1000
100
10
1
0.1
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

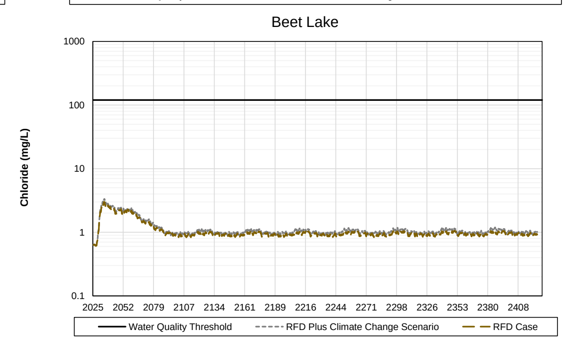

Patterson Lake North Arm – East Basin
Chloride (mg/L)
1000
100
10
1
0.1
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

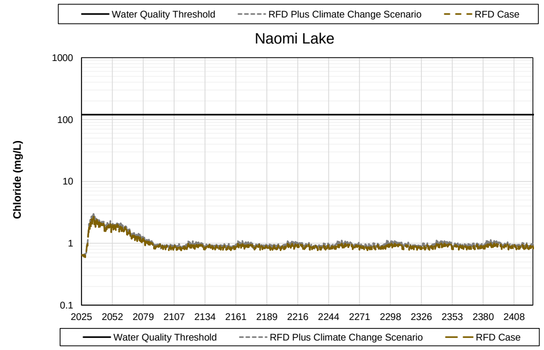

Patterson Lake North Arm – West Basin
Chloride (mg/L)
1000
100
10
1
0.1
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

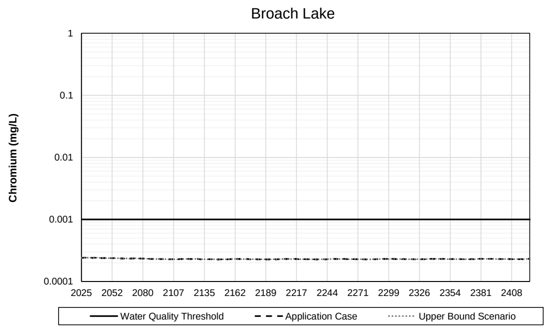

Patterson Lake South Arm
Chloride (mg/L)
1000
100
10
1
0.1
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

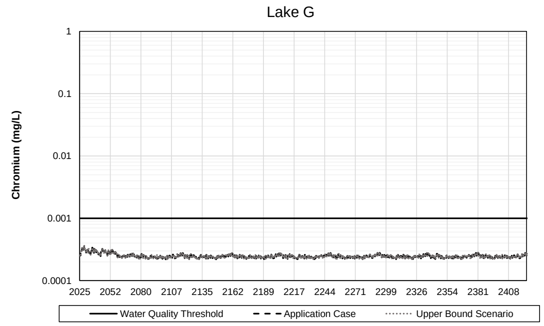

Forrest Lake North Basin
Chloride (mg/L)
1000
100
10
1
0.1
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

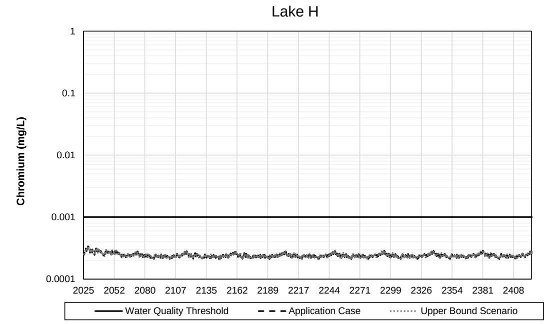

Forrest Lake South Basin
Chloride (mg/L)
1000
100
10
1
0.1
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

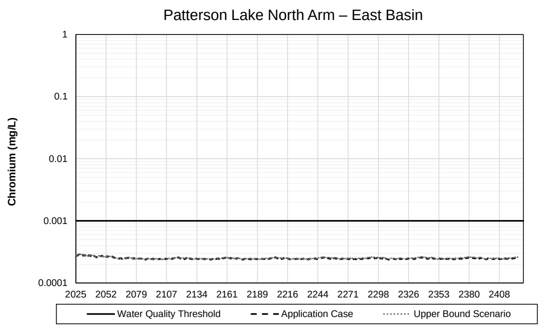

Beet Lake
Chloride (mg/L)
1000
100
10
1
0.1
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

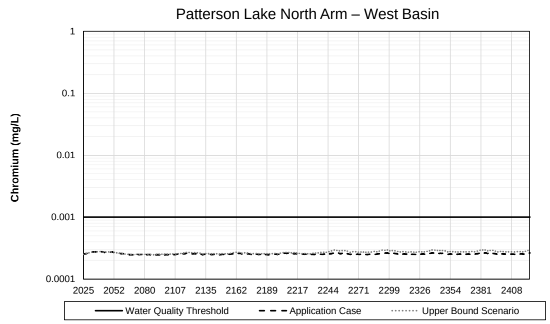

Naomi Lake
Chloride (mg/L)
1000
100
10
1
0.1
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

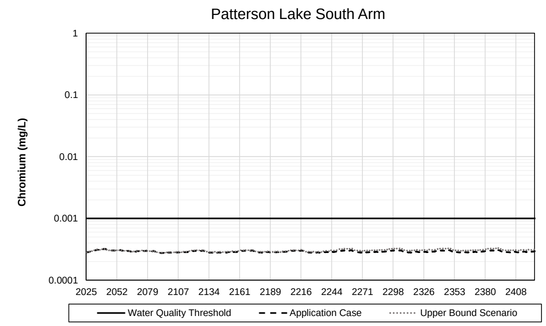

Broach Lake
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

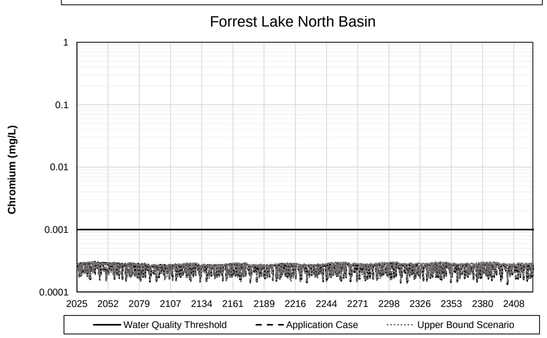

Lake G
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

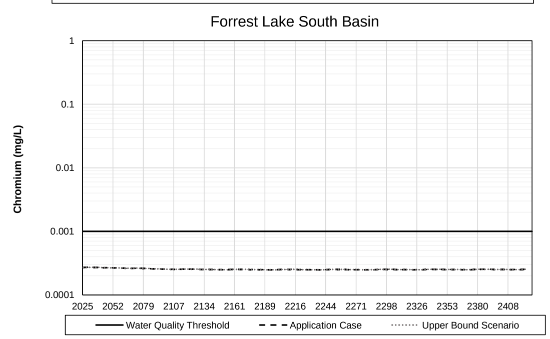

Lake H
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

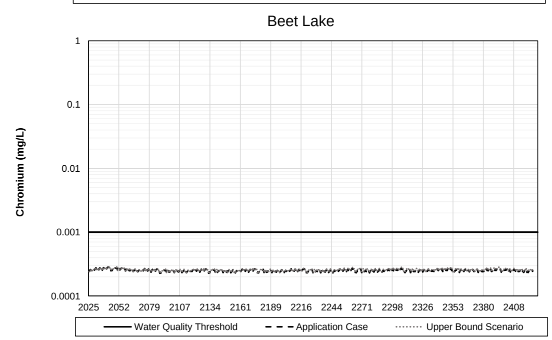

Patterson Lake North Arm – East Basin
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

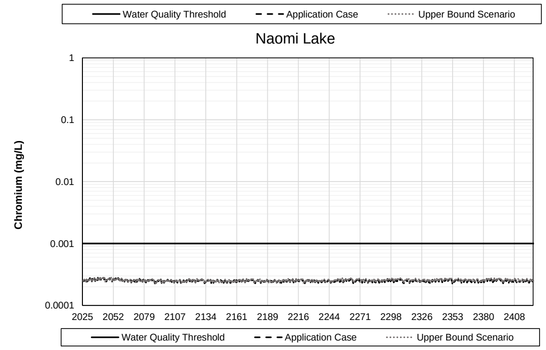

Patterson Lake North Arm – West Basin
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

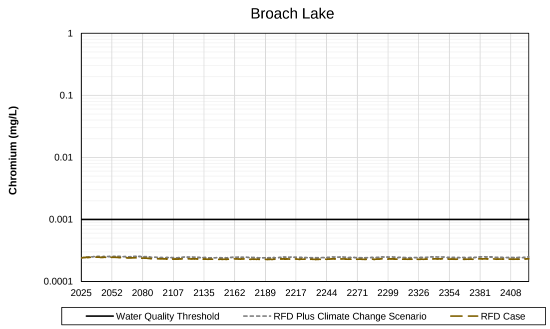

Patterson Lake South Arm
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

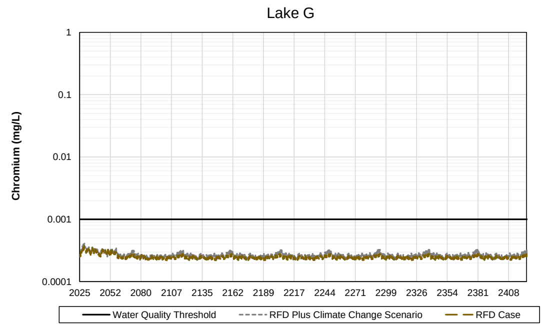

Forrest Lake North Basin
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

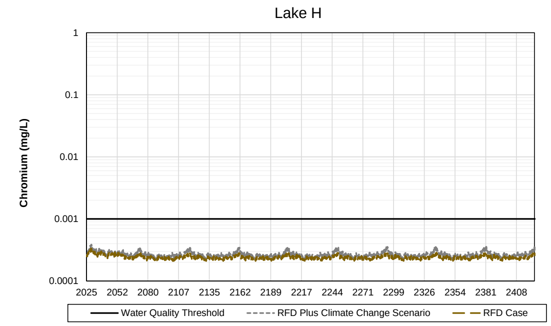

Forrest Lake South Basin
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

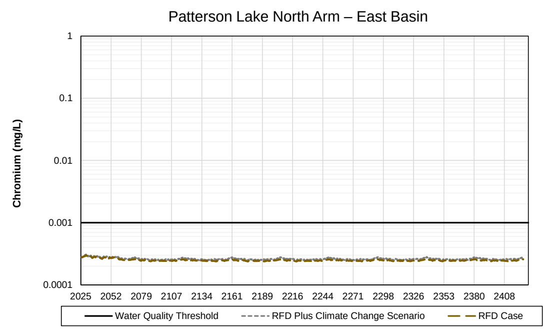

Beet Lake
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

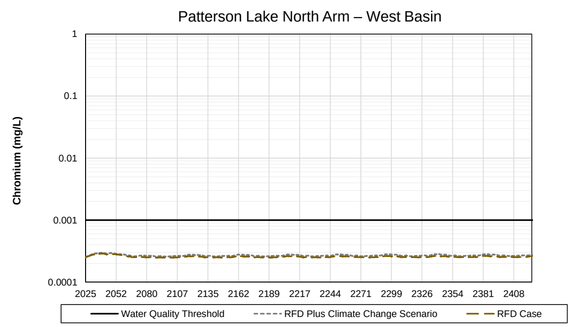

Naomi Lake
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

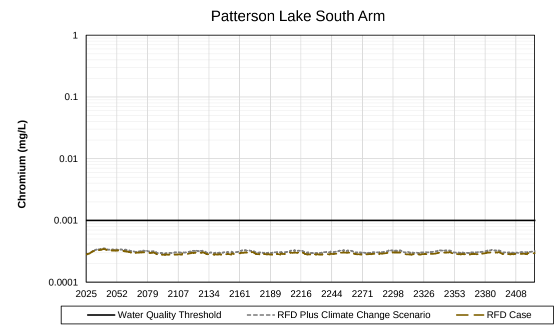

Broach Lake
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

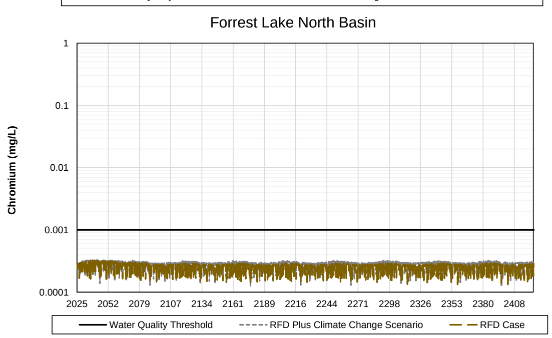

Lake G
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

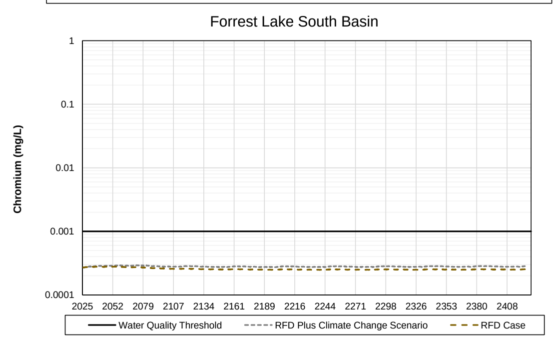

Lake H
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

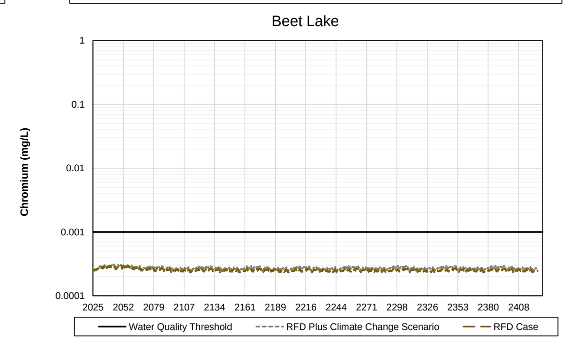

Patterson Lake North Arm – East Basin
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

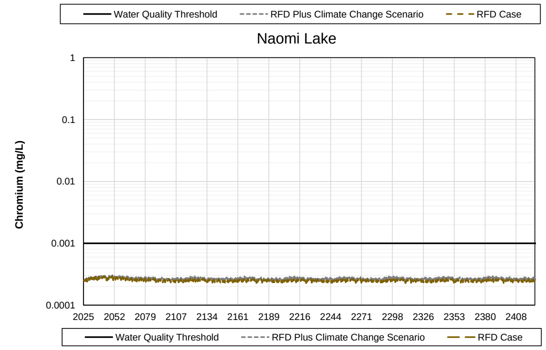

Patterson Lake North Arm – West Basin
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

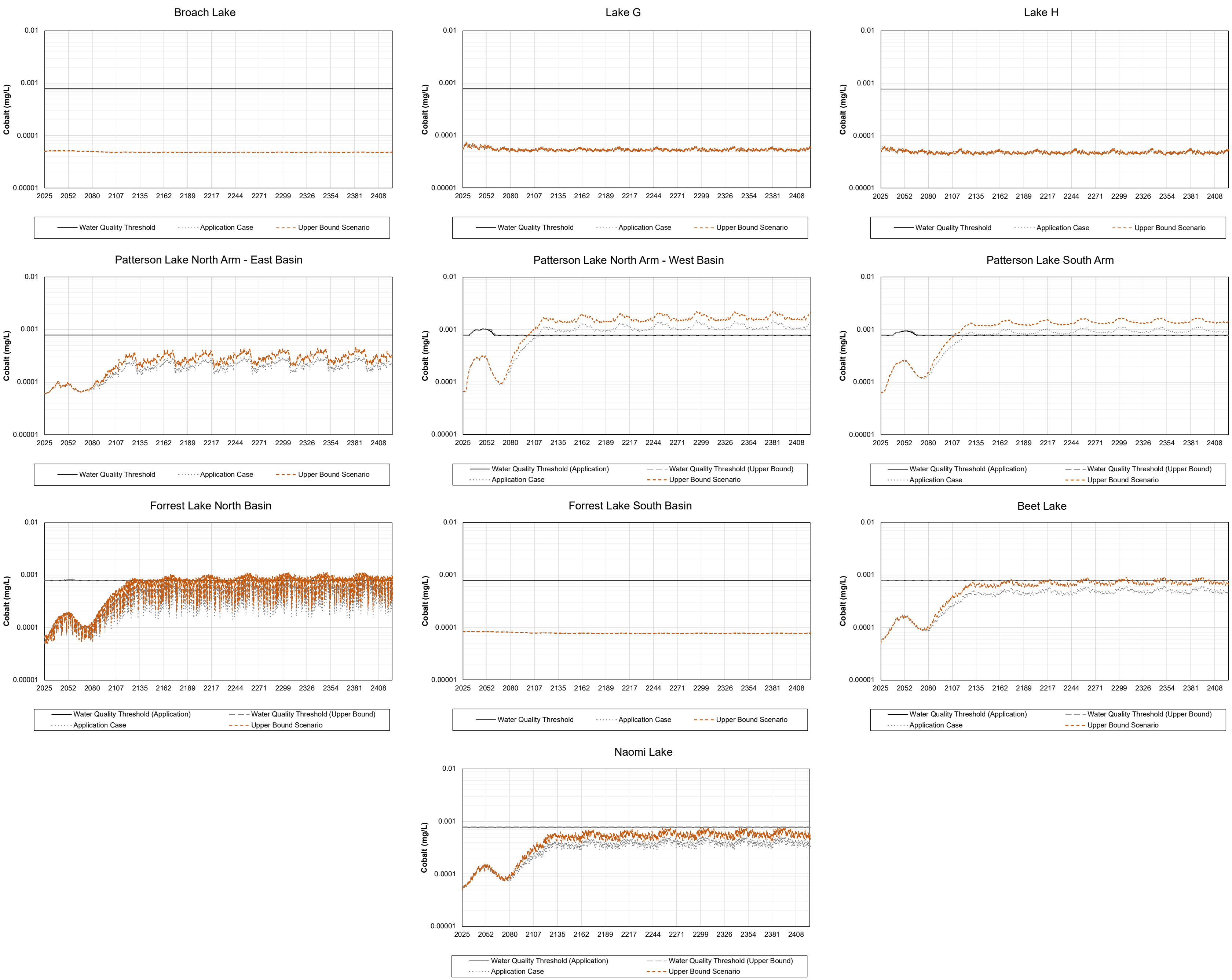

Patterson Lake South Arm
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Forrest Lake North Basin
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

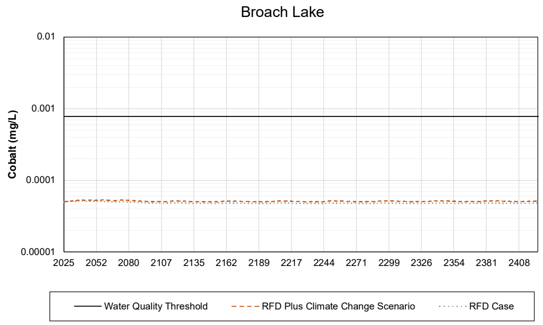

Forrest Lake South Basin
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

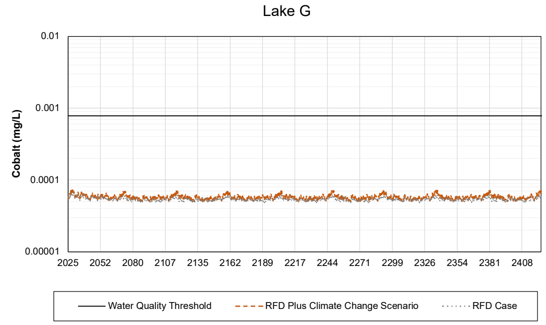

Beet Lake
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

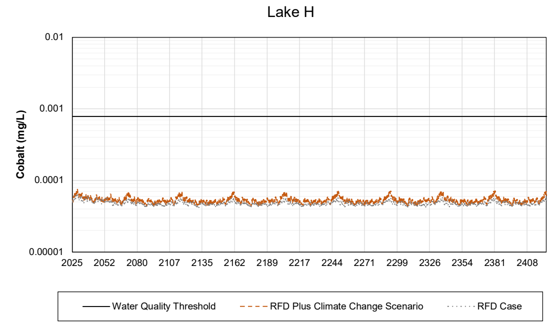

Naomi Lake
Chromium (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

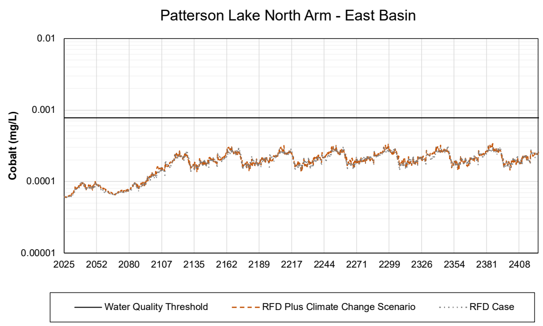

Broach Lake
Lake G
Lake H
Patterson Lake North Arm - East Basin
Patterson Lake North Arm - West Basin
Patterson Lake South Arm
Forrest Lake North Basin
Forrest Lake South Basin
Beet Lake
Naomi Lake
Cobalt (mg/L)
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario
Water Quality Threshold (Application)
Water Quality Threshold (Upper Bound)

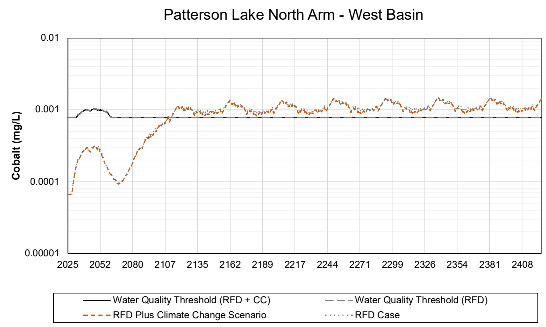
15

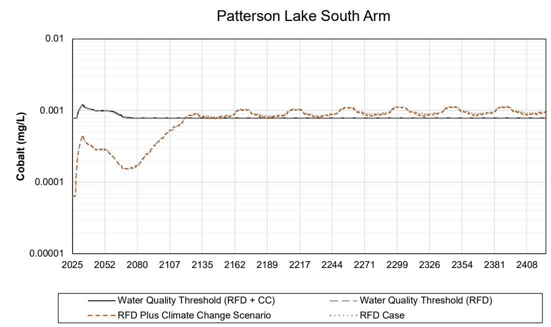

Broach Lake
Cobalt (mg/L)
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

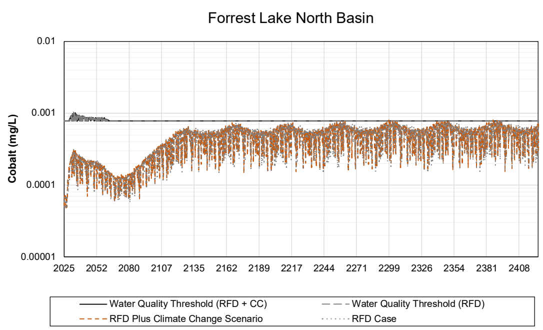

Lake G
Cobalt (mg/L)
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

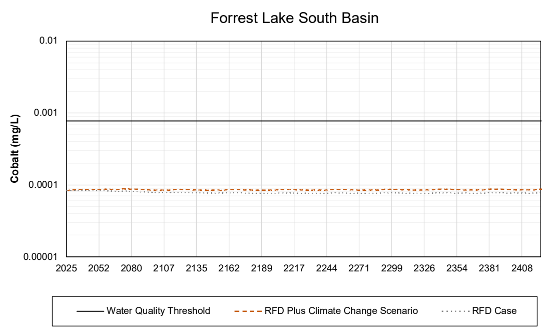

Lake H
Cobalt (mg/L)
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

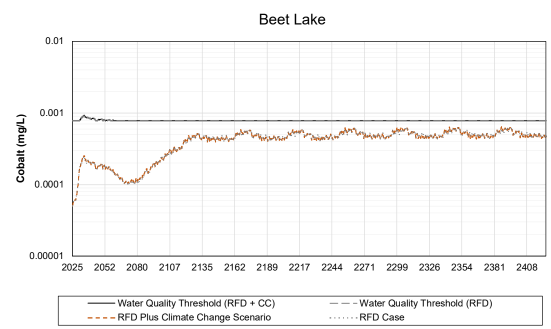

Patterson Lake North Arm - East Basin
Cobalt (mg/L)
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

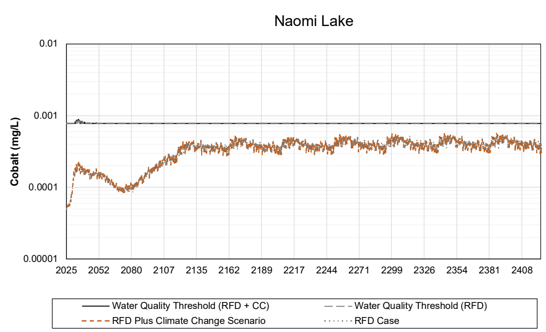

Patterson Lake North Arm - West Basin
Cobalt (mg/L)
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold (RFD + CC)
Water Quality Threshold (RFD)
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake South Arm
Cobalt (mg/L)
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold (RFD + CC)
Water Quality Threshold (RFD)
RFD Plus Climate Change Scenario
RFD Case

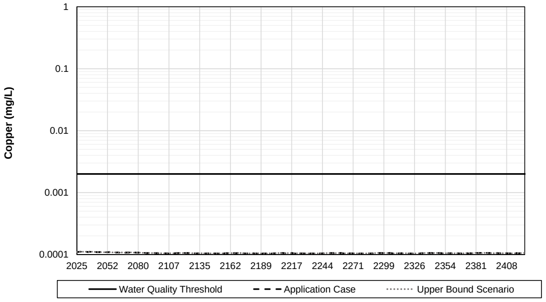

Forrest Lake North Basin
Cobalt (mg/L)
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold (RFD + CC)
Water Quality Threshold (RFD)
RFD Plus Climate Change Scenario
RFD Case


Forrest Lake South Basin
Cobalt (mg/L)
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

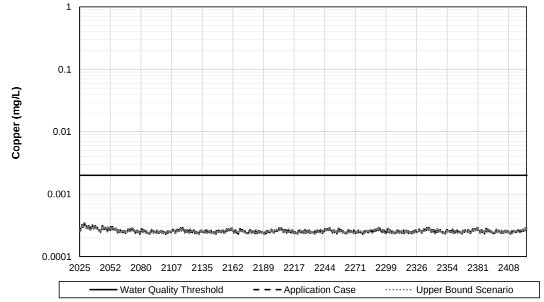

Beet Lake
Cobalt (mg/L)
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold (RFD + CC)
Water Quality Threshold (RFD)
RFD Plus Climate Change Scenario
RFD Case


Naomi Lake
Cobalt (mg/L)
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold (RFD + CC)
Water Quality Threshold (RFD)
RFD Plus Climate Change Scenario
RFD Case

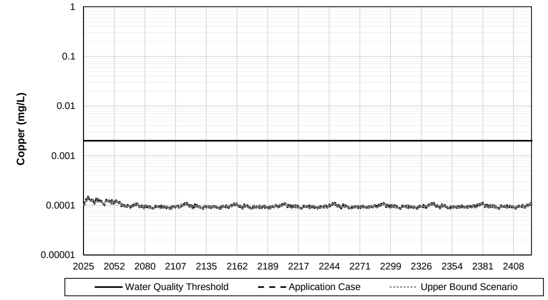
Broach Lake



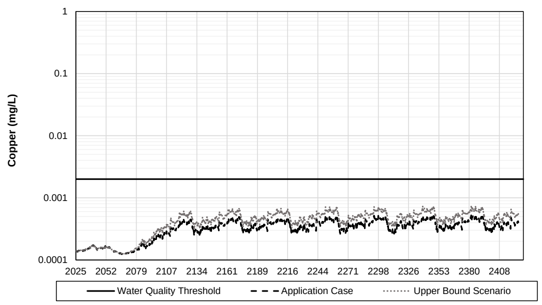
Lake G



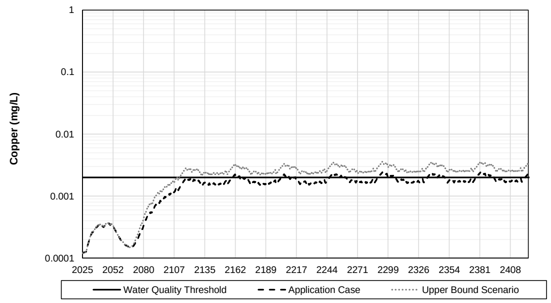
Lake H



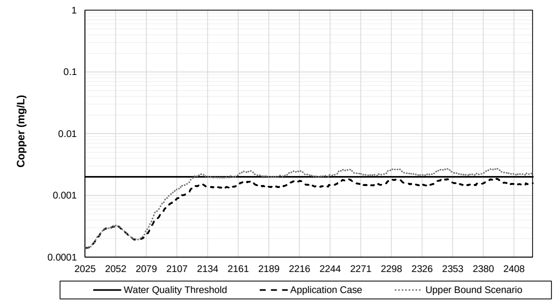
Patterson Lake North Arm – East Basin



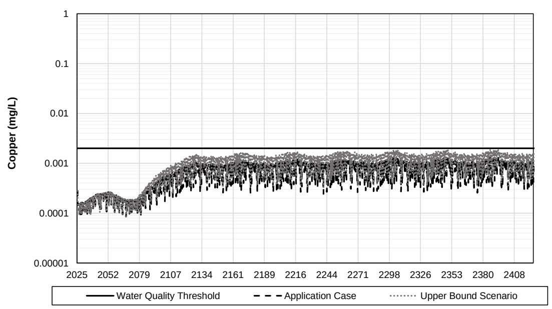
Patterson Lake North Arm – West Basin



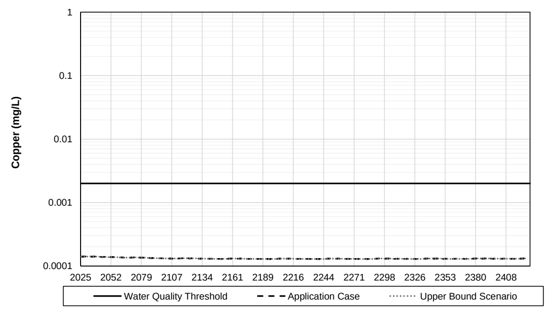
Patterson Lake South Arm



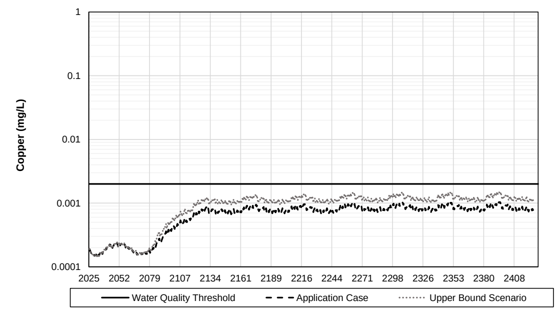
Forrest Lake North Basin



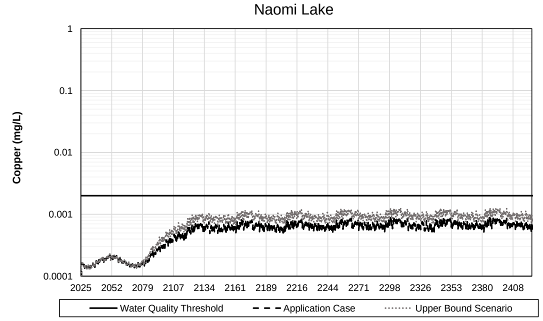
Forrest Lake South Basin

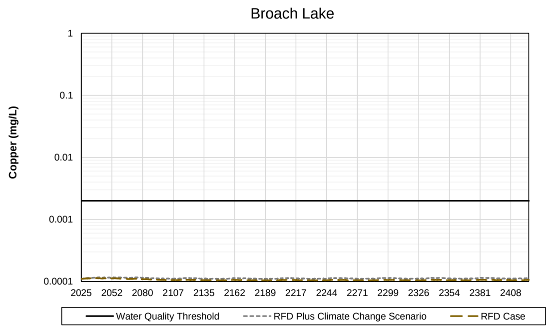


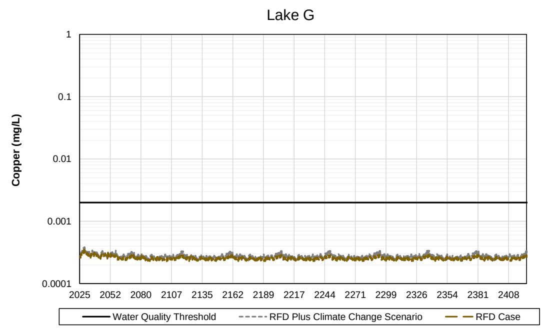
Beet Lake

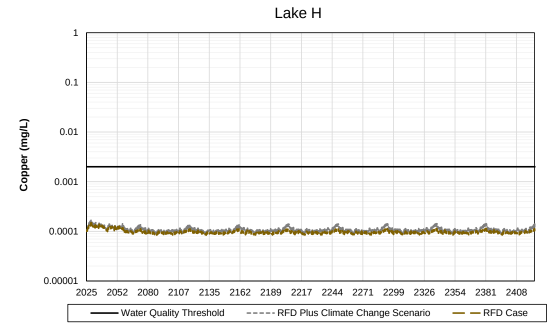


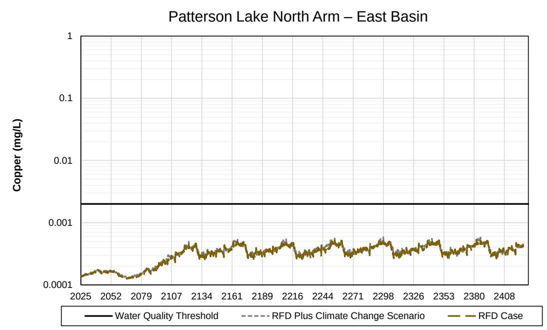
Naomi Lake

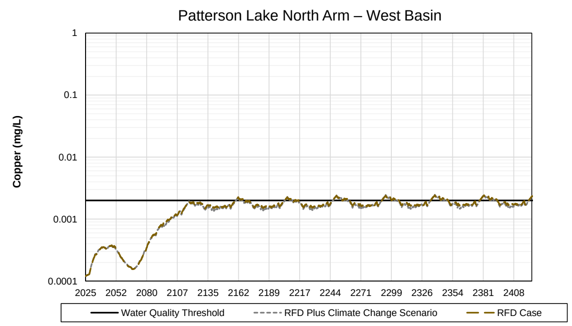


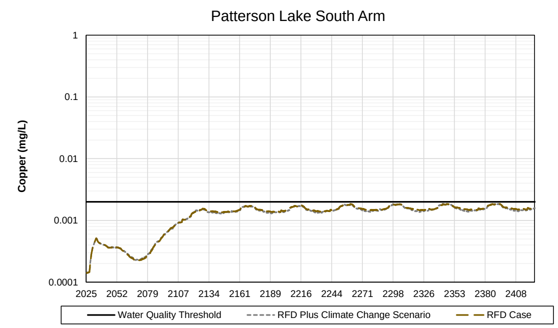

Broach Lake
Copper (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

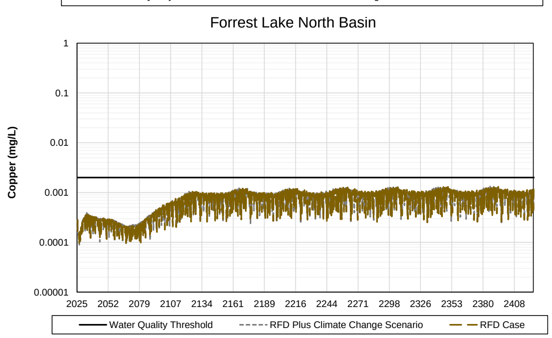

Lake G
Copper (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

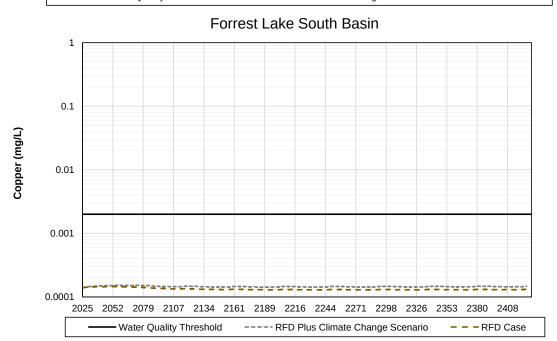

Lake H
Copper (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

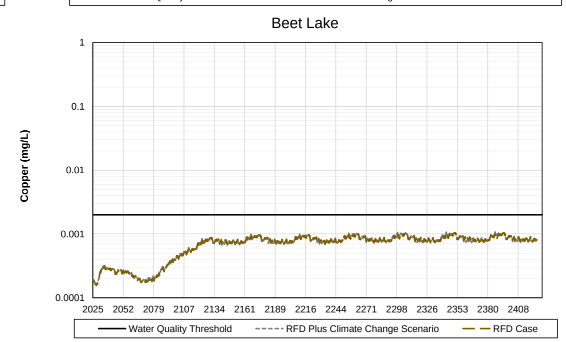

Patterson Lake North Arm – East Basin
Copper (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

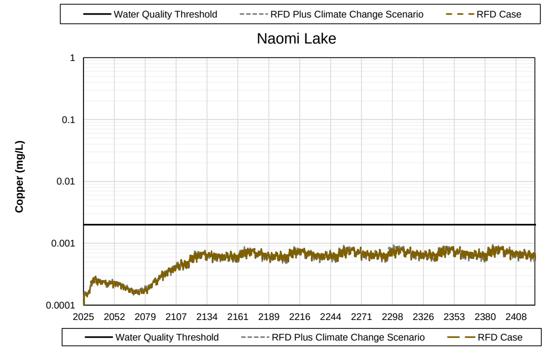

Patterson Lake North Arm – West Basin
Copper (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake South Arm
Copper (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

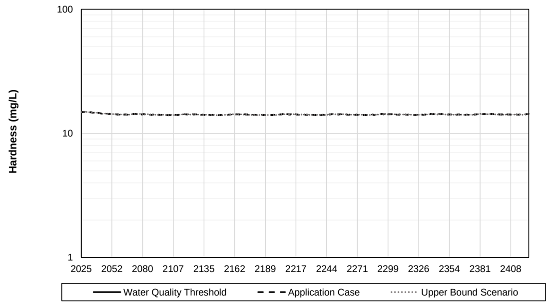

Forrest Lake North Basin
Copper (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Forrest Lake South Basin
Copper (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

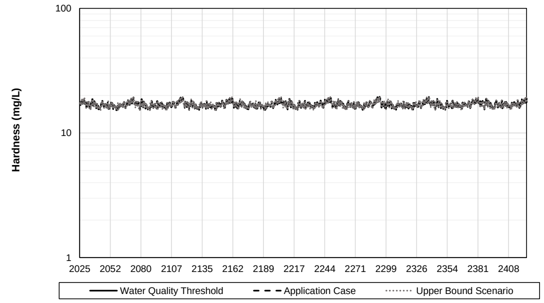

Beet Lake
Copper (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Naomi Lake
Copper (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

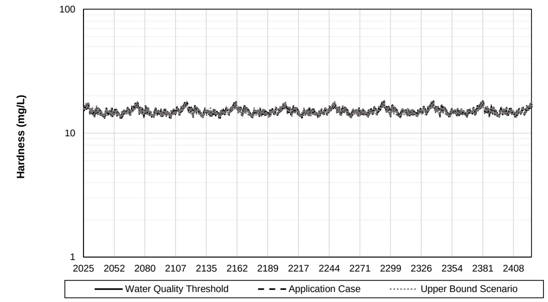
Broach Lake



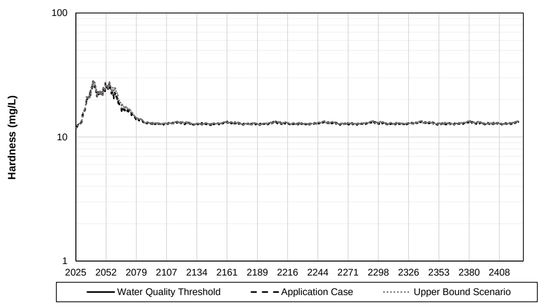
Lake G



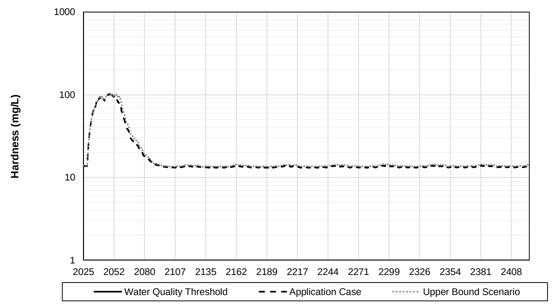
Lake H



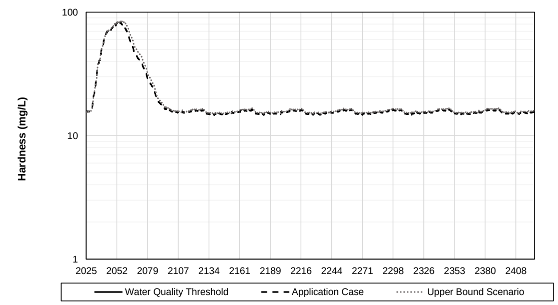
Patterson Lake North Arm – East Basin



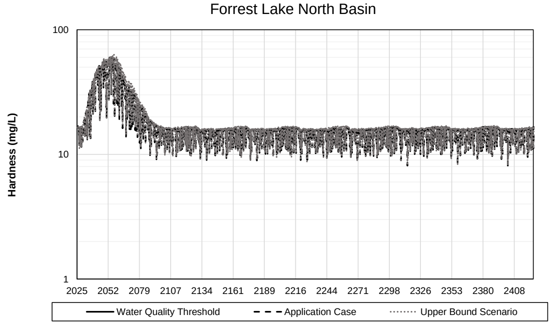
Patterson Lake North Arm – West Basin



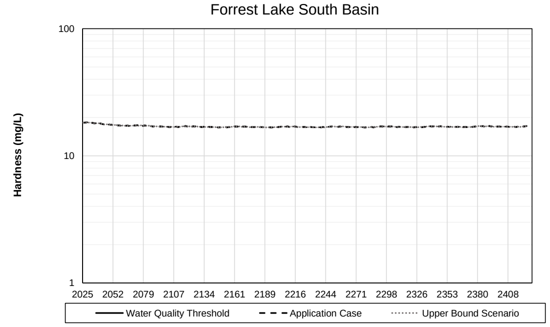
Patterson Lake South Arm



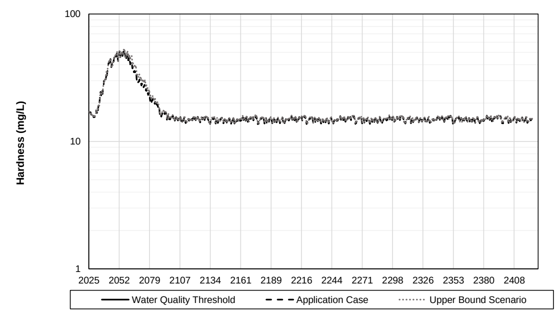
Forrest Lake North Basin



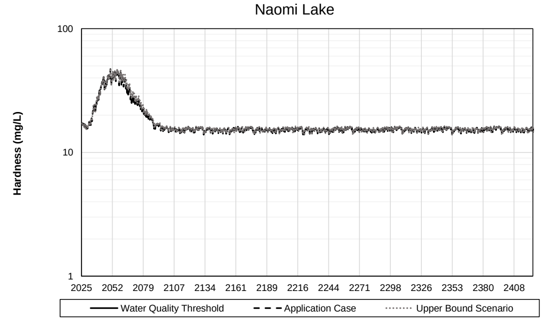
Forrest Lake South Basin

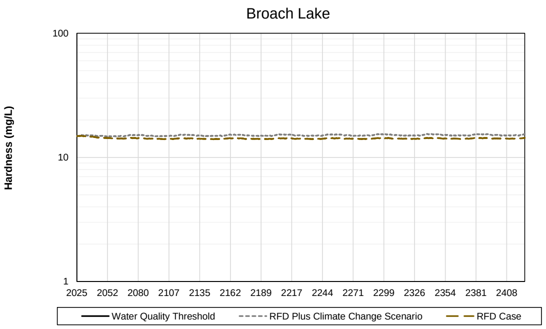


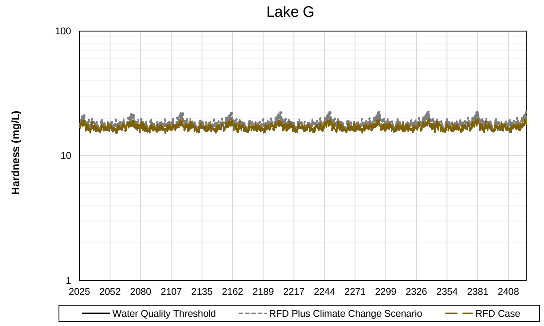
Beet Lake

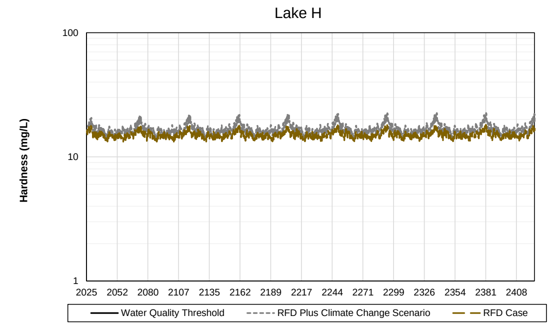


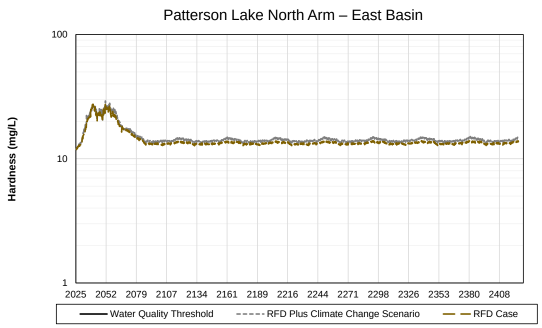
Naomi Lake

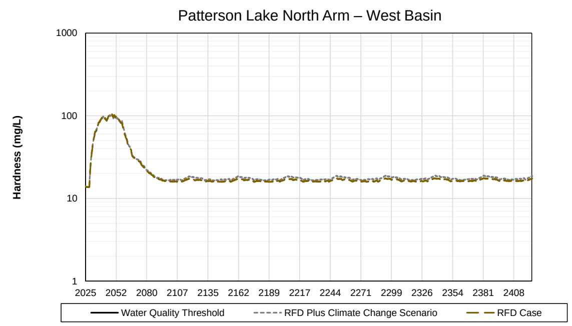


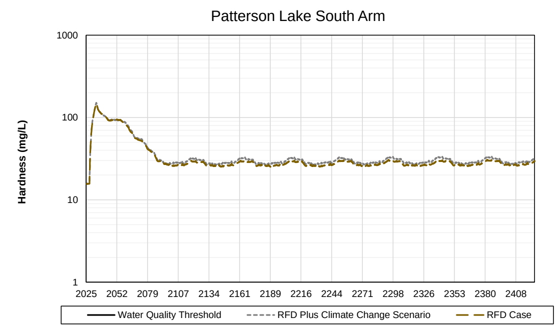

Broach Lake
Hardness (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

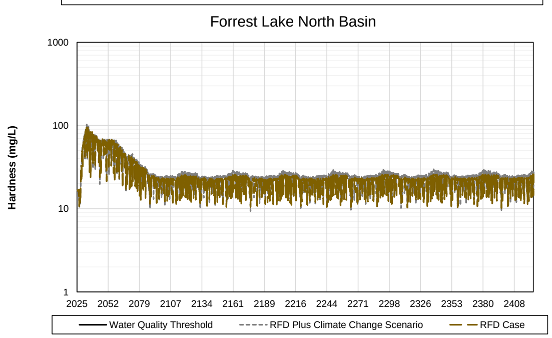

Lake G
Hardness (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

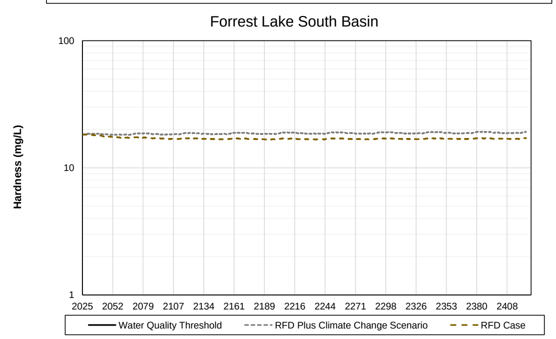

Lake H
Hardness (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

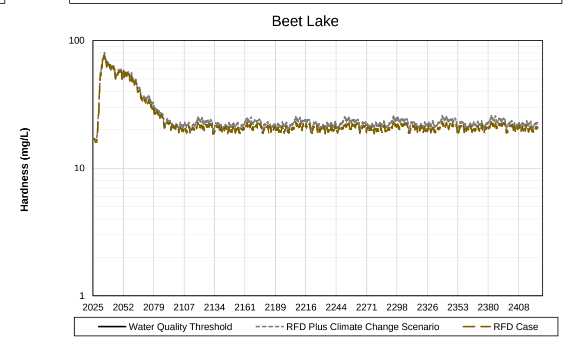

Patterson Lake North Arm – East Basin
Hardness (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

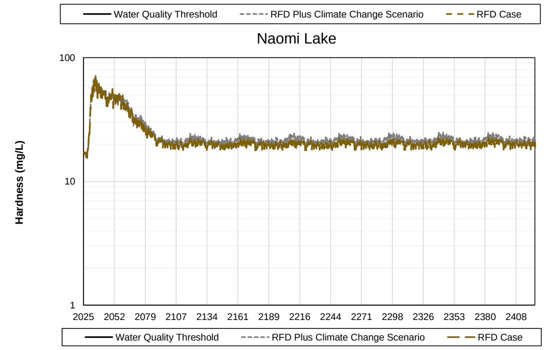

Patterson Lake North Arm – West Basin
Hardness (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake South Arm
Hardness (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

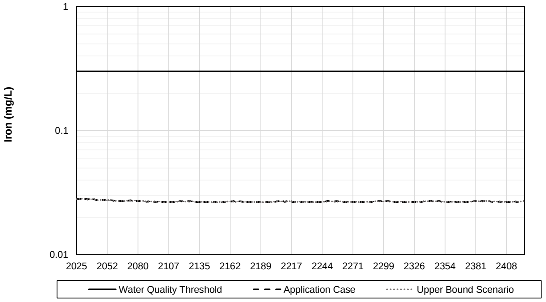

Forrest Lake North Basin
Hardness (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Forrest Lake South Basin
Hardness (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

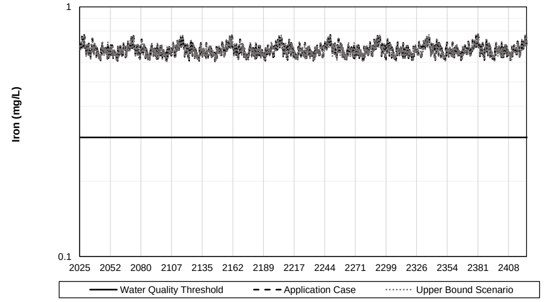

Beet Lake
Hardness (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Naomi Lake
Hardness (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

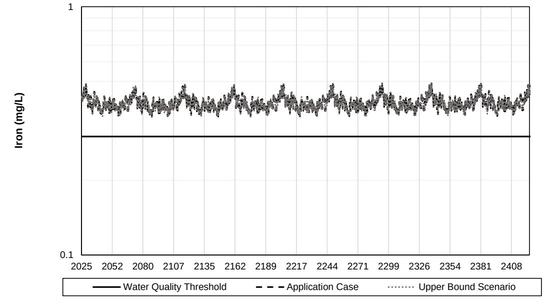
Broach Lake



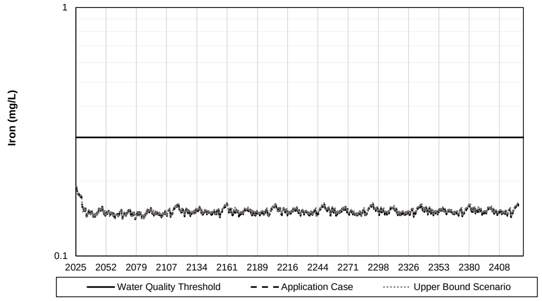
Lake G



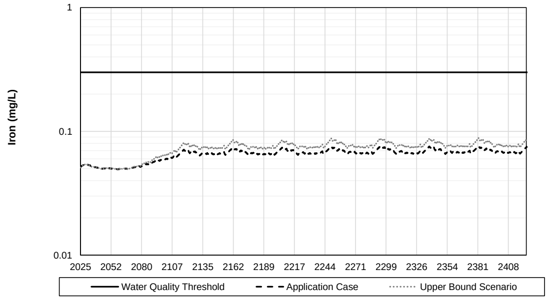
Lake H



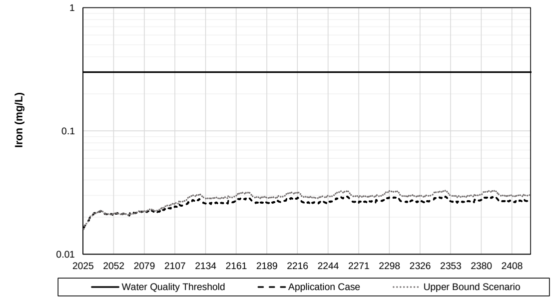
Patterson Lake North Arm – East Basin



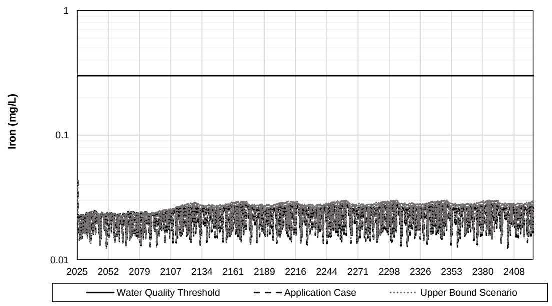
Patterson Lake North Arm – West Basin



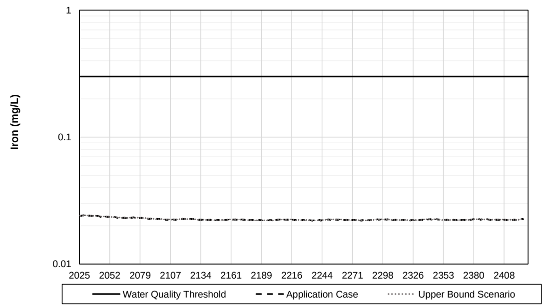
Patterson Lake South Arm



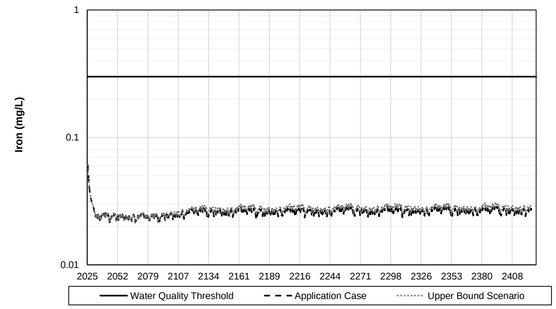
Forrest Lake North Basin



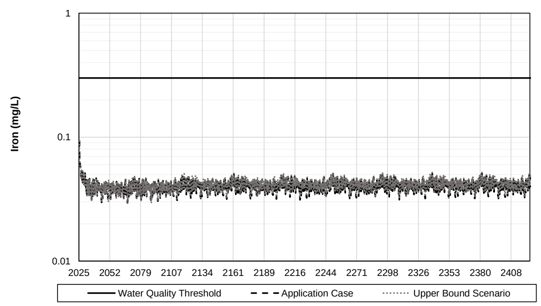
Forrest Lake South Basin

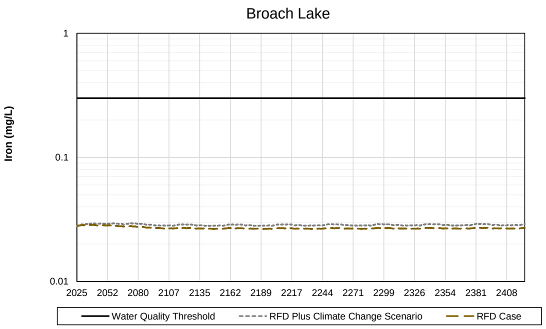


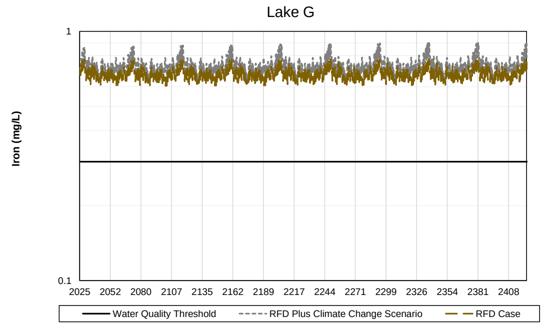
Beet Lake

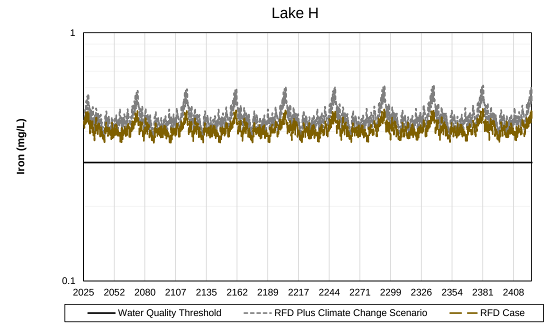


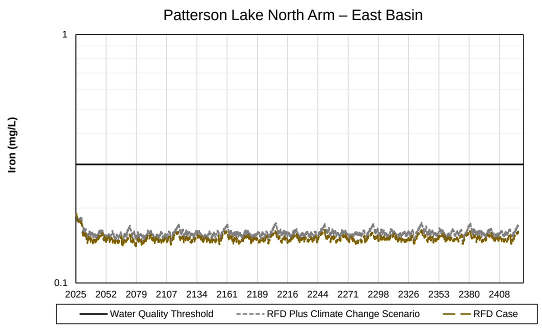
Naomi Lake

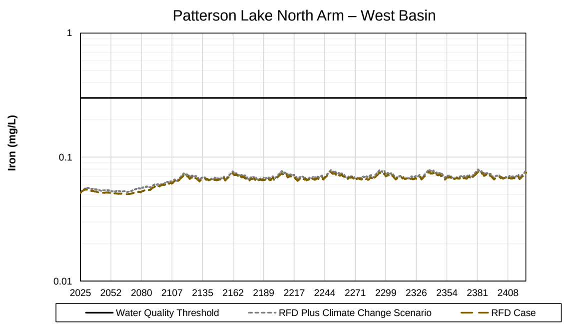


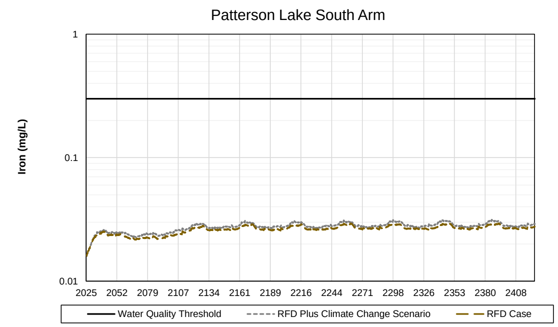

Broach Lake
Iron (mg/L)
1
0.1
0.01
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

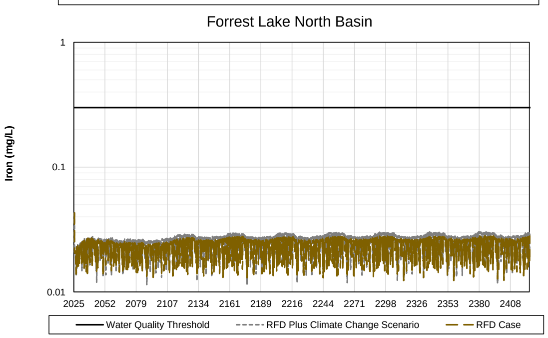

Lake G
Iron (mg/L)
1
0.1
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

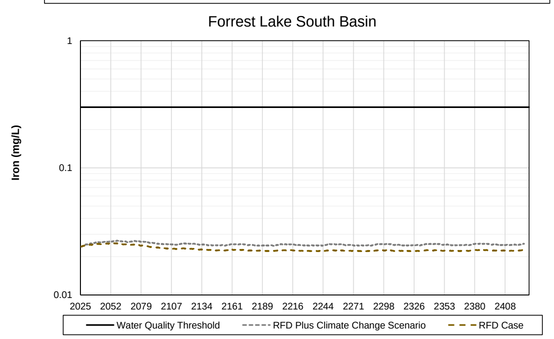

Lake H
Iron (mg/L)
1
0.1
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

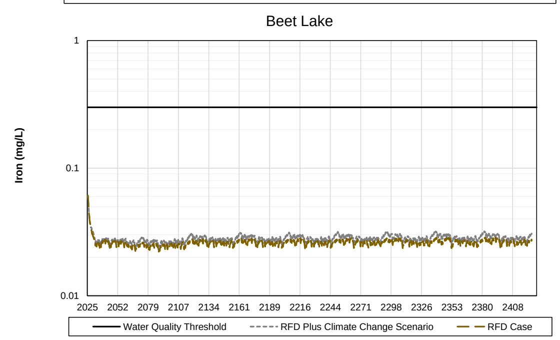

Patterson Lake North Arm – East Basin
Iron (mg/L)
1
0.1
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

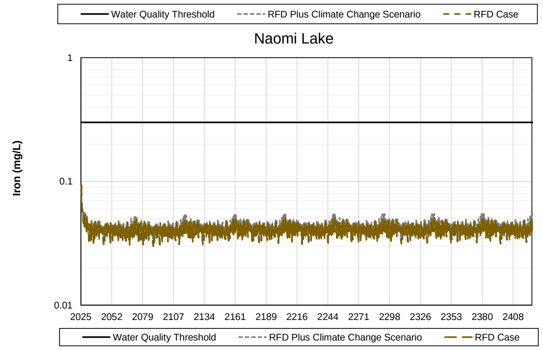

Patterson Lake North Arm – West Basin
Iron (mg/L)
1
0.1
0.01
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake South Arm
Iron (mg/L)
1
0.1
0.01
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

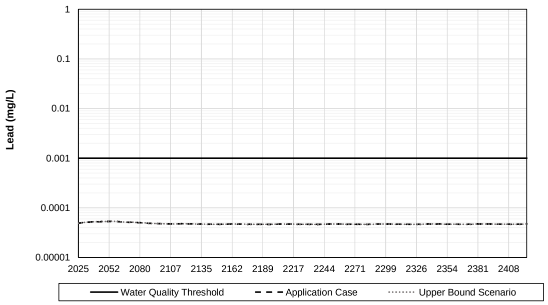

Forrest Lake North Basin
Iron (mg/L)
1
0.1
0.01
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Forrest Lake South Basin
Iron (mg/L)
1
0.1
0.01
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

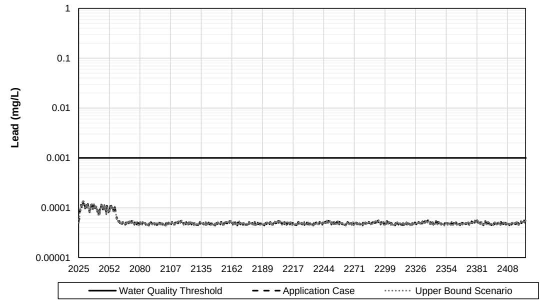

Beet Lake
Iron (mg/L)
1
0.1
0.01
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Naomi Lake
Iron (mg/L)
1
0.1
0.01
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

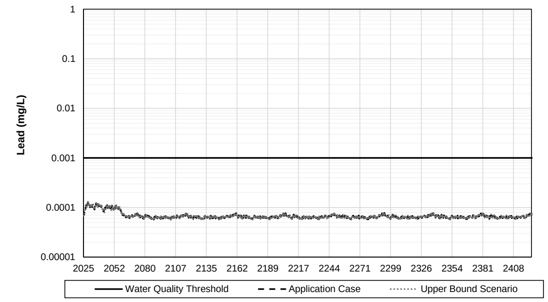
Broach Lake



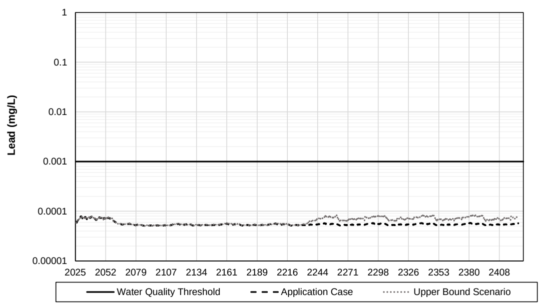
Lake G



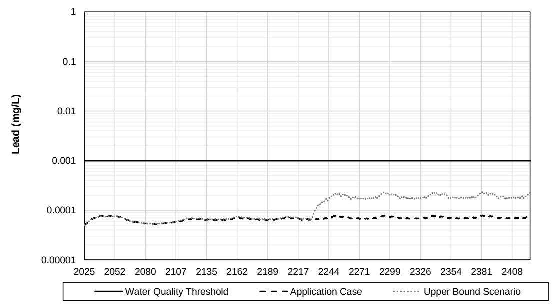
Lake H



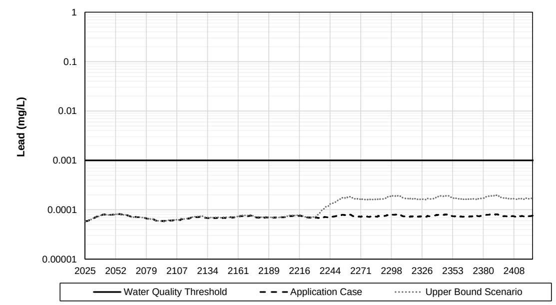
Patterson Lake North Arm – East Basin



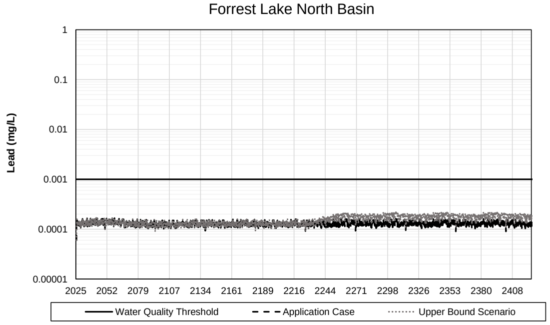
Patterson Lake North Arm – West Basin



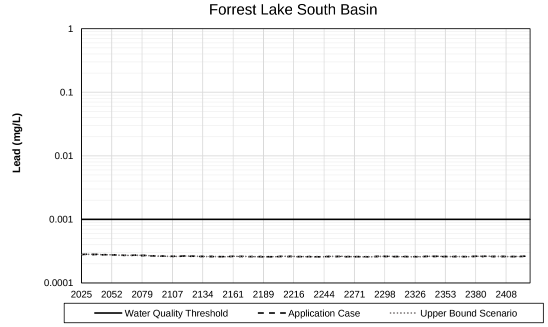
Patterson Lake South Arm



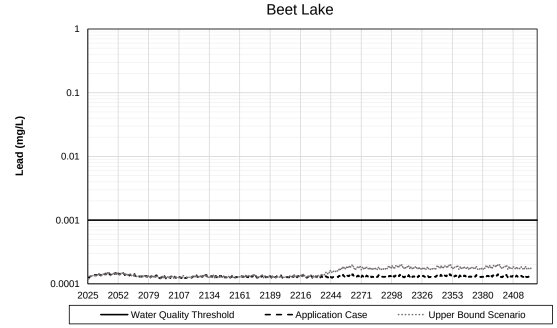
Forrest Lake North Basin



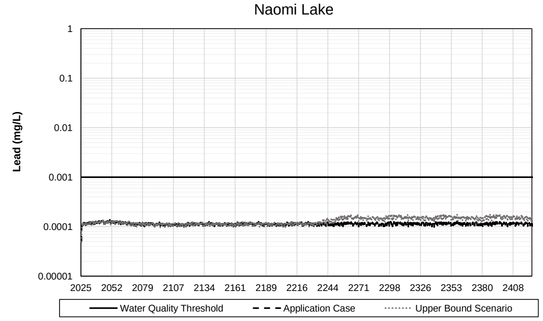
Forrest Lake South Basin

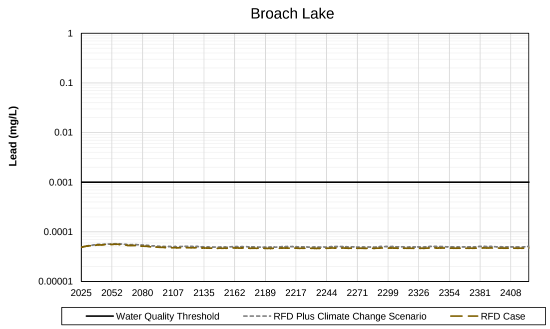


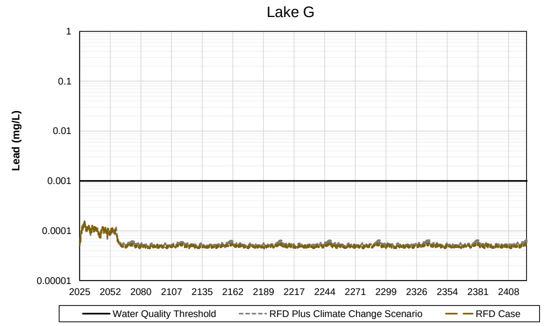
Beet Lake

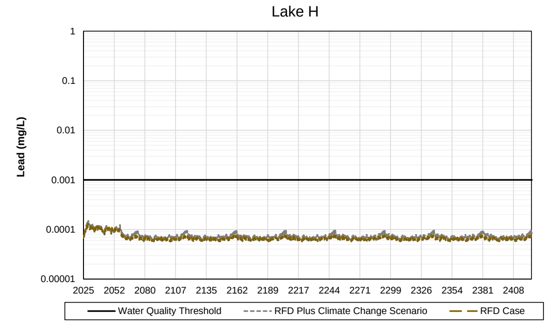


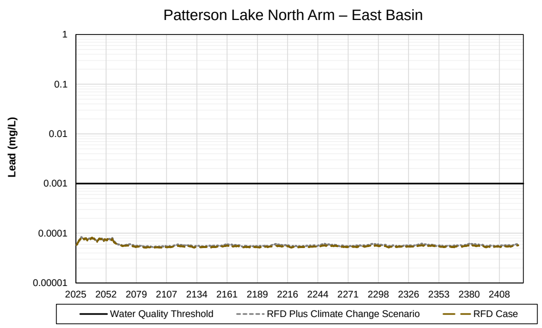
Naomi Lake

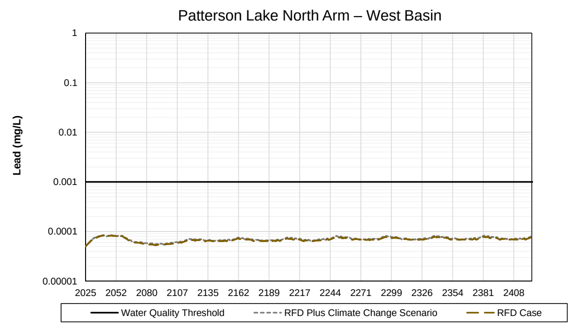


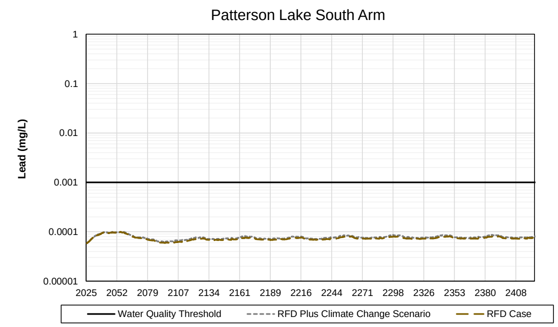

Broach Lake
Lead (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

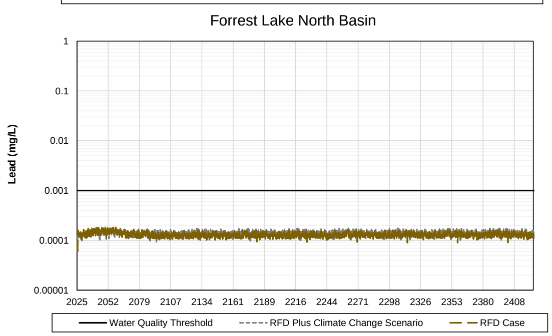

Lake G
Lead (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

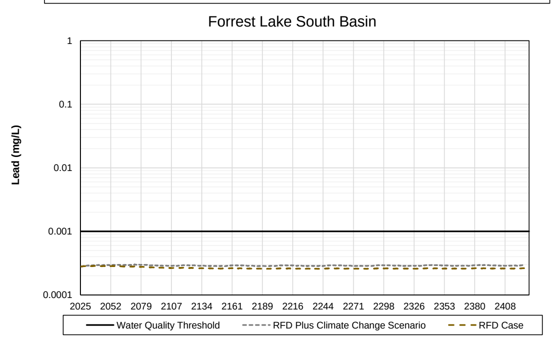

Lake H
Lead (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

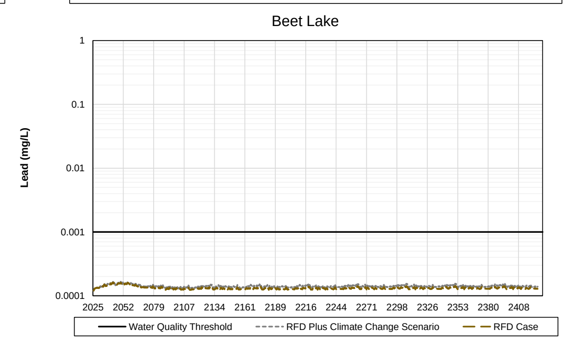

Patterson Lake North Arm – East Basin
Lead (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

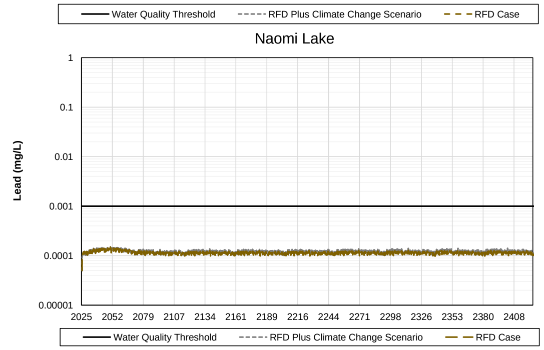

Patterson Lake North Arm – West Basin
Lead (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

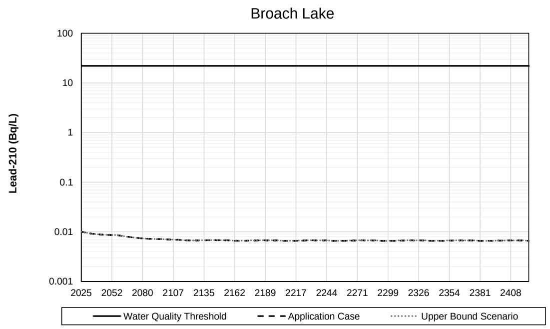

Patterson Lake South Arm
Lead (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

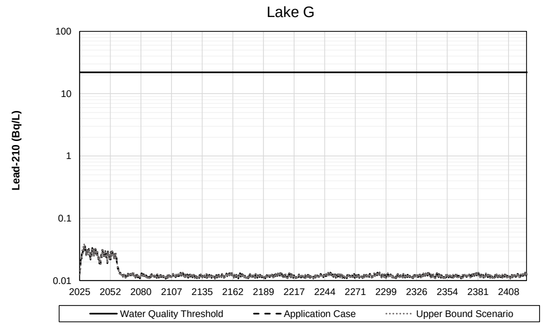

Forrest Lake North Basin
Lead (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

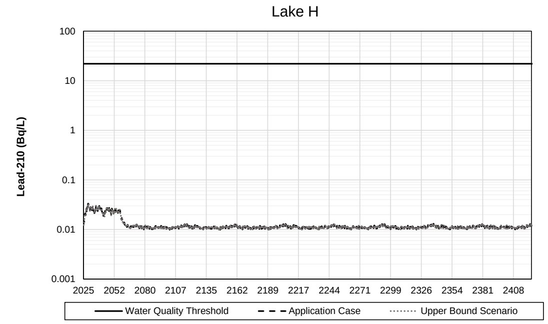

Forrest Lake South Basin
Lead (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

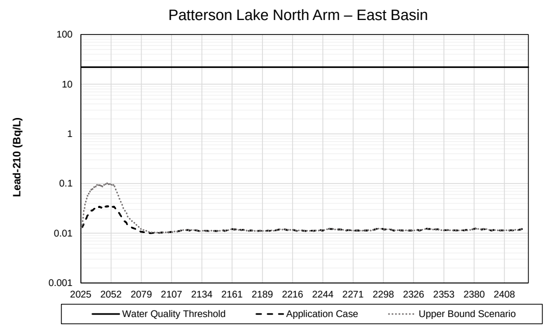

Beet Lake
Lead (mg/L)
1
0.1
0.01
0.001
0.0001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

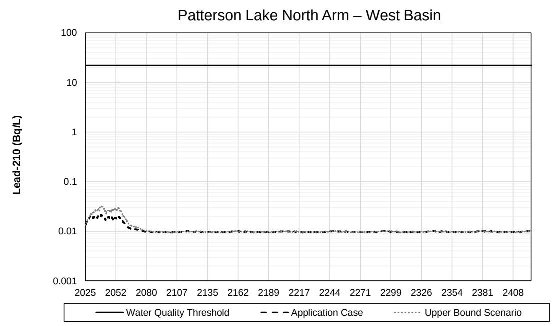

Naomi Lake
Lead (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

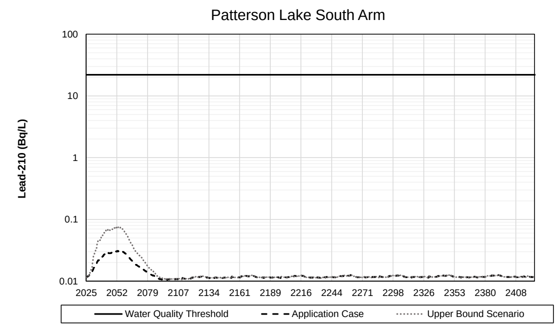

Broach Lake
Lead-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

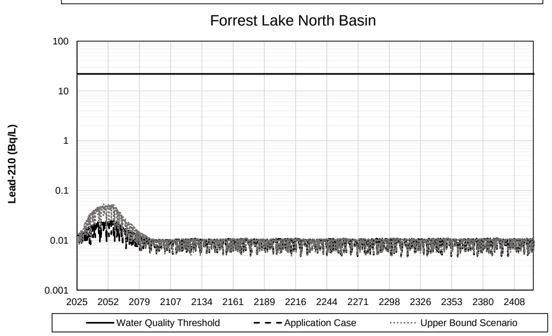

Lake G
Lead-210 (Bq/L)
100
10
1
0.1
0.01
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

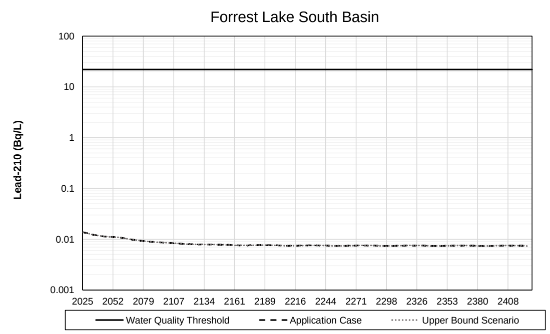

Lake H
Lead-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

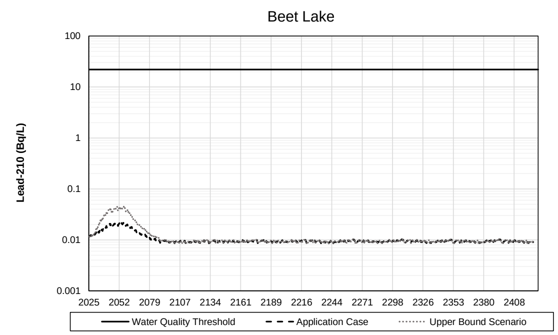

Patterson Lake North Arm – East Basin
Lead-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

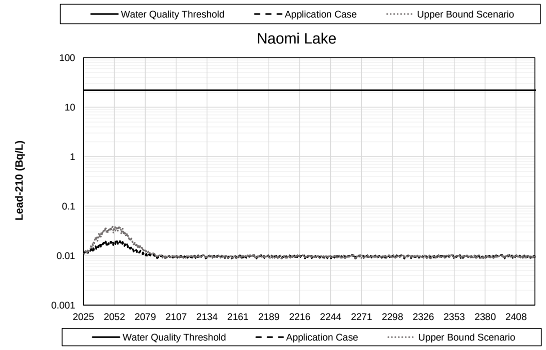

Patterson Lake North Arm – West Basin
Lead-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Patterson Lake South Arm
Lead-210 (Bq/L)
100
10
1
0.1
0.01
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

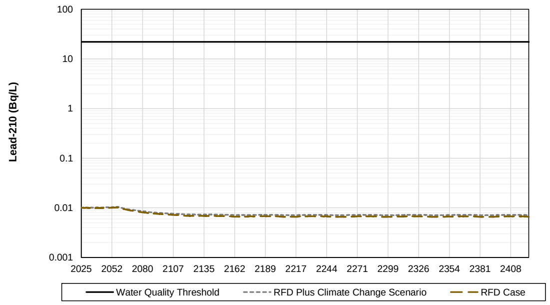

Forrest Lake North Basin
Lead-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Forrest Lake South Basin
Lead-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

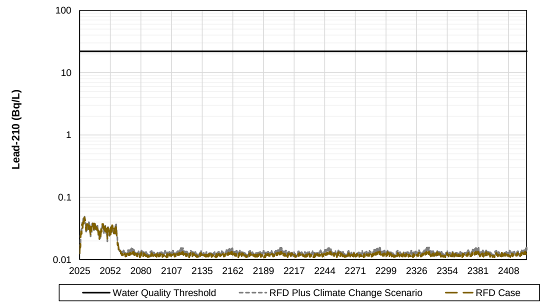

Beet Lake
Lead-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Naomi Lake
Lead-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

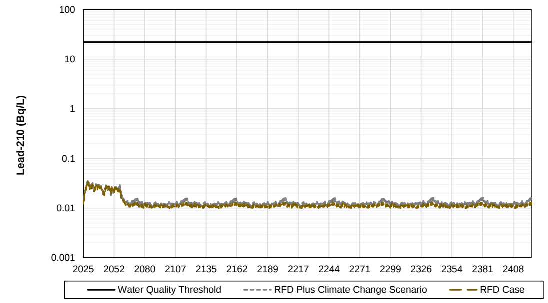
Broach Lake



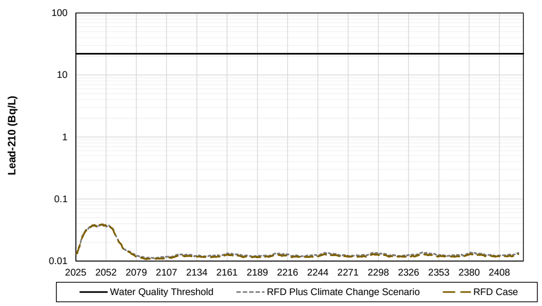
Lake G



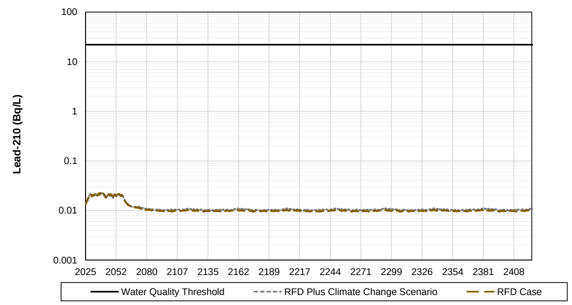
Lake H



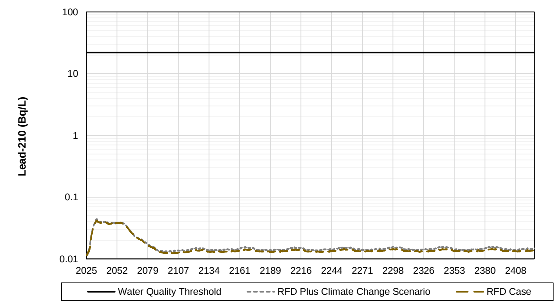
Patterson Lake North Arm – East Basin



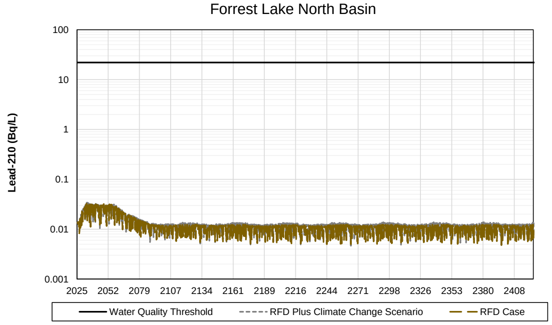
Patterson Lake North Arm – West Basin



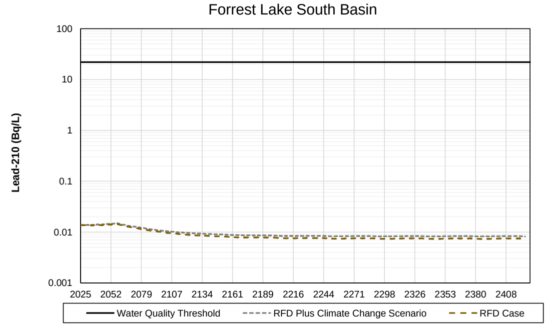
Patterson Lake South Arm



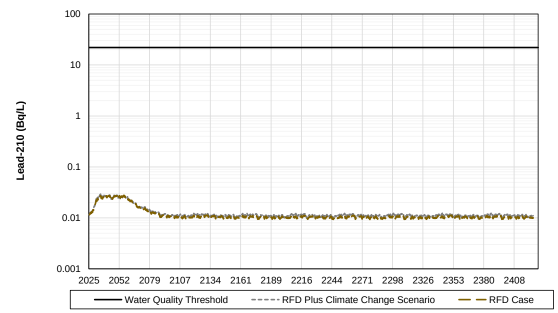
Forrest Lake North Basin



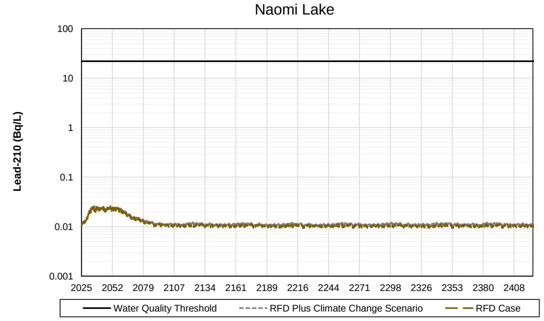
Forrest Lake South Basin



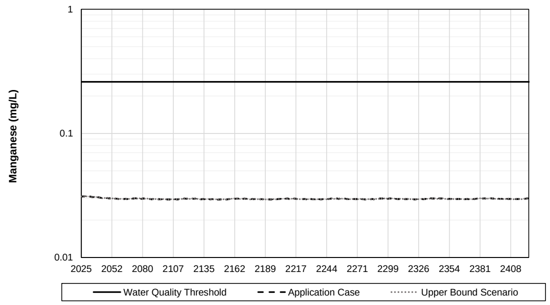
Beet Lake



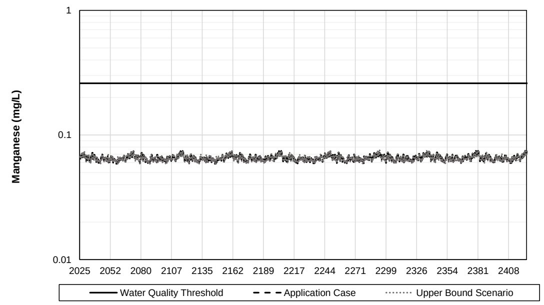
Naomi Lake



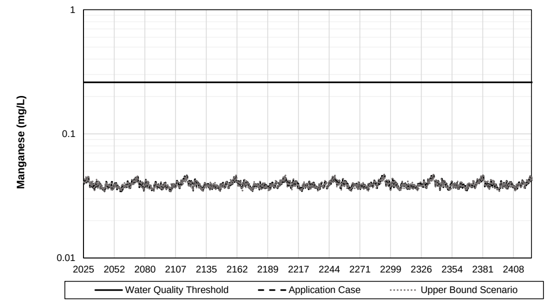
Broach Lake



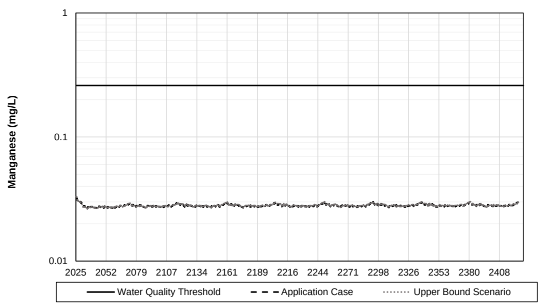
Lake G



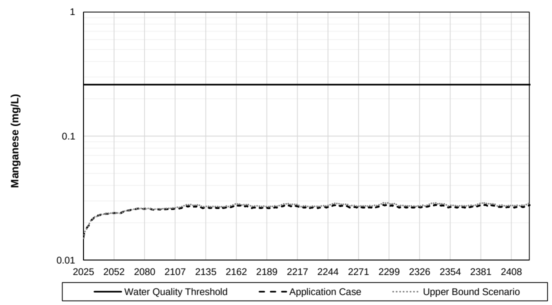
Lake H



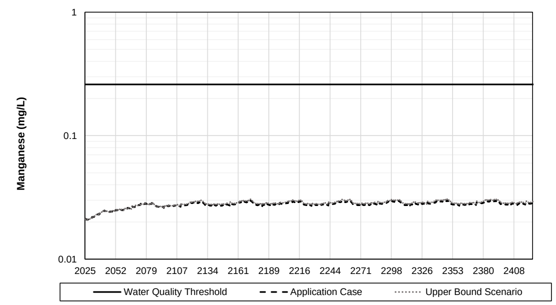
Patterson Lake North Arm – East Basin



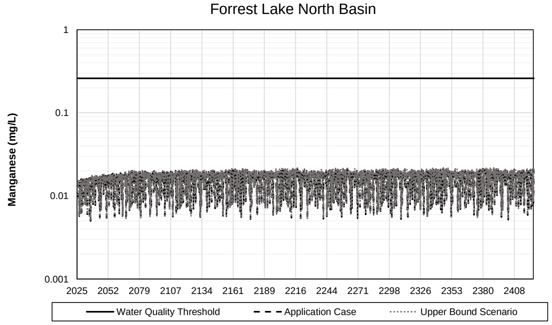
Patterson Lake North Arm – West Basin



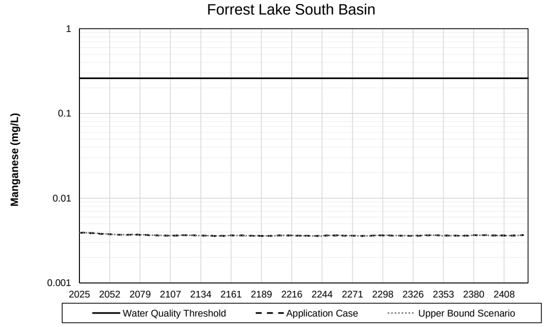
Patterson Lake South Arm



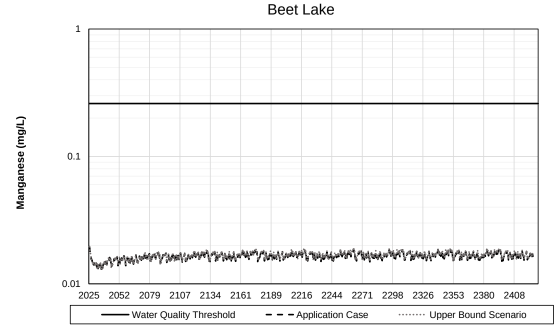
Forrest Lake North Basin



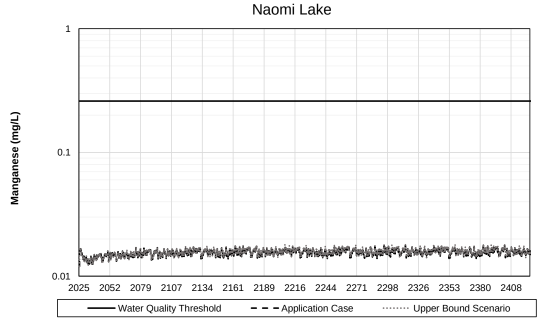
Forrest Lake South Basin

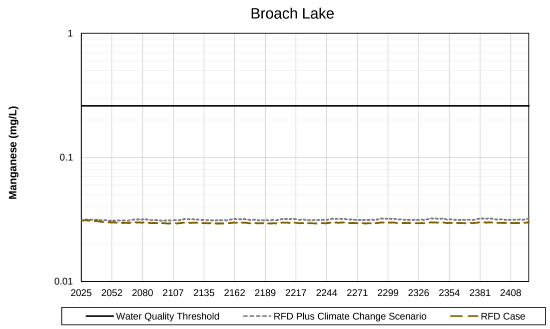


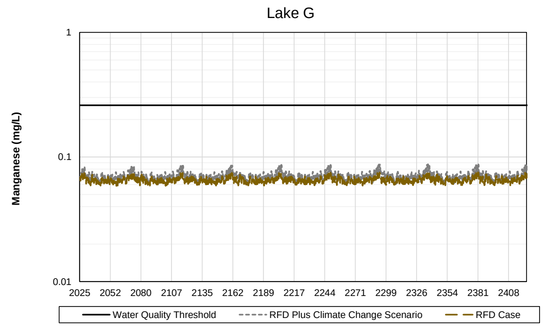
Beet Lake

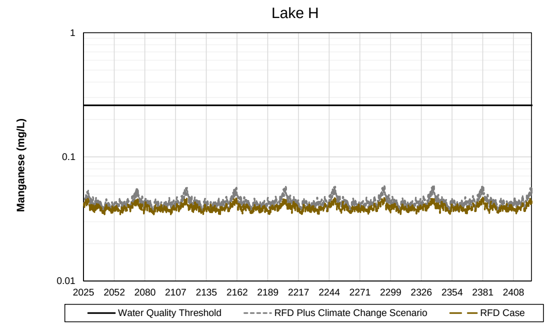


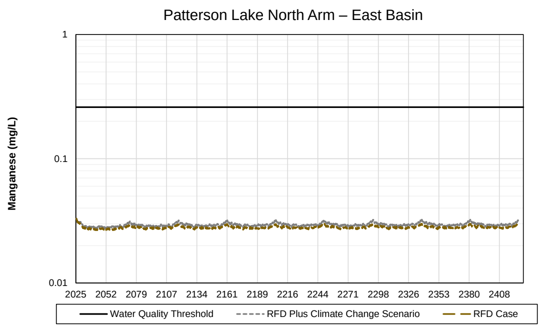
Naomi Lake

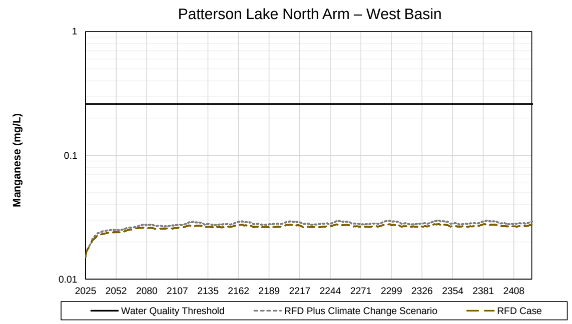


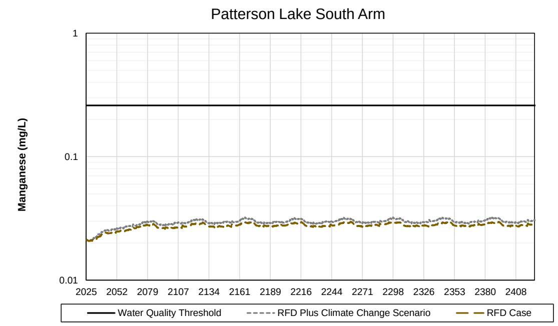

Broach Lake
Manganese (mg/L)
1
0.1
0.01
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

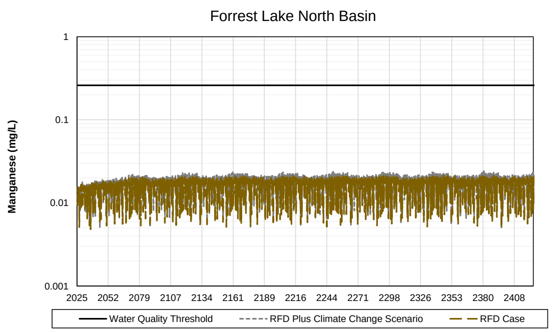

Lake G
Manganese (mg/L)
1
0.1
0.01
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

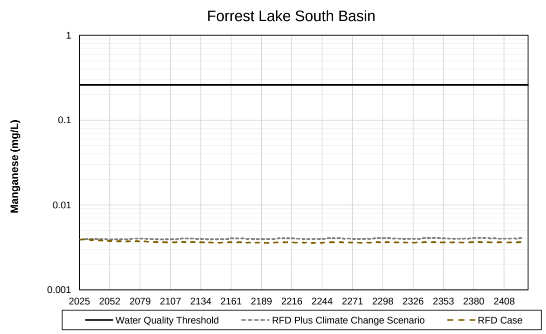

Lake H
Manganese (mg/L)
1
0.1
0.01
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

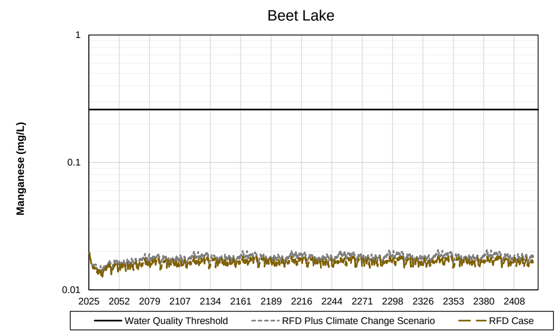

Patterson Lake North Arm – East Basin
Manganese (mg/L)
1
0.1
0.01
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

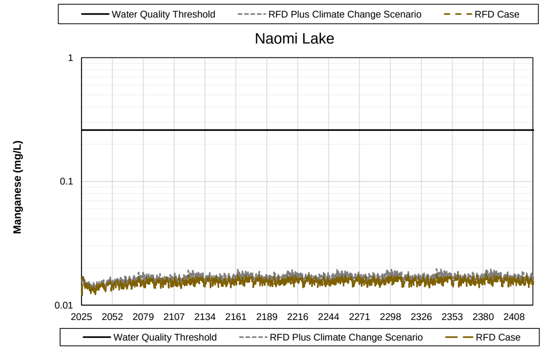

Patterson Lake North Arm – West Basin
Manganese (mg/L)
1
0.1
0.01
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake South Arm
Manganese (mg/L)
1
0.1
0.01
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

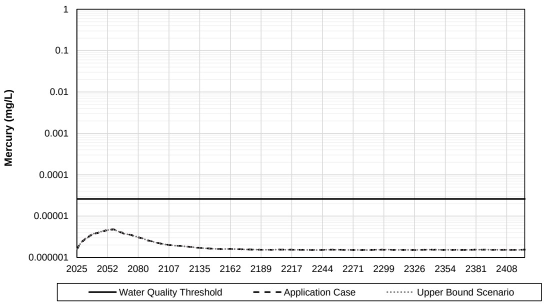

Forrest Lake North Basin
Manganese (mg/L)
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Forrest Lake South Basin
Manganese (mg/L)
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

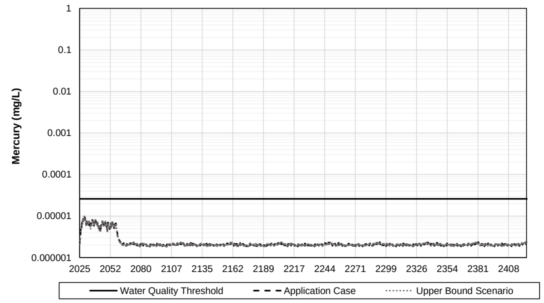

Beet Lake
Manganese (mg/L)
1
0.1
0.01
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Naomi Lake
Manganese (mg/L)
1
0.1
0.01
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

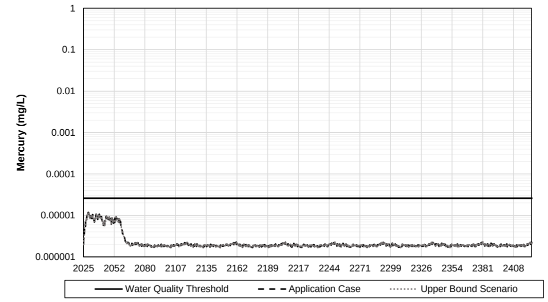
Broach Lake



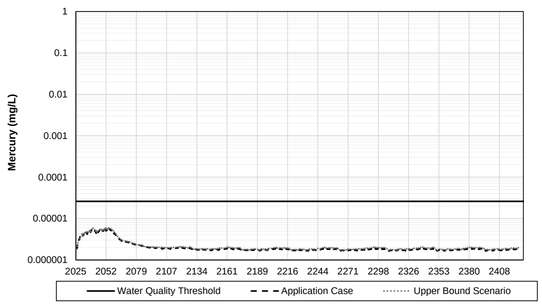
Lake G



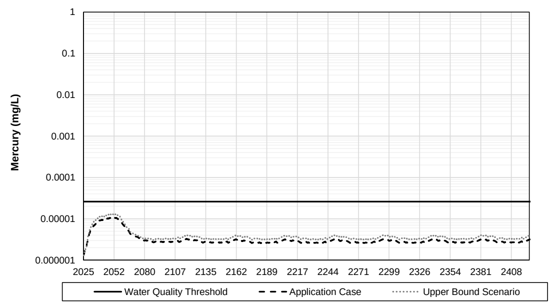
Lake H



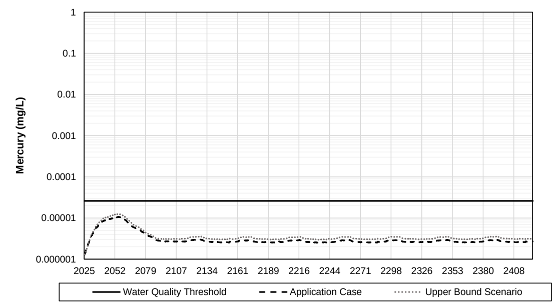
Patterson Lake North Arm – East Basin



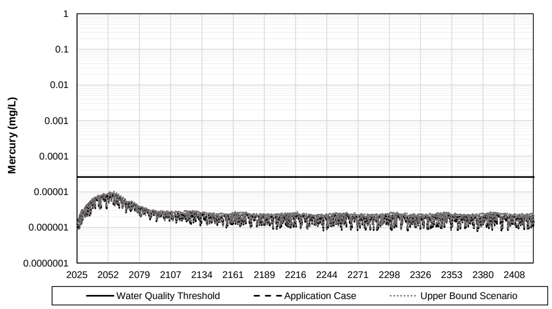
Patterson Lake North Arm – West Basin



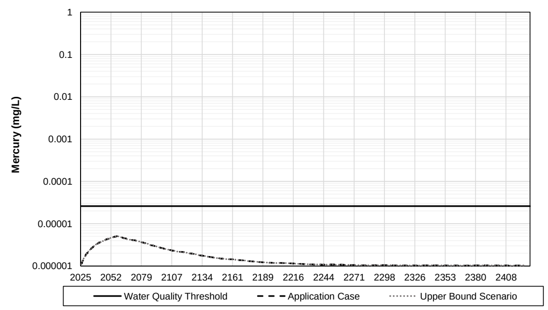
Patterson Lake South Arm



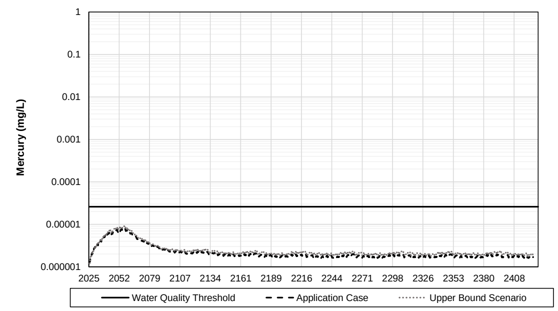
Forrest Lake North Basin



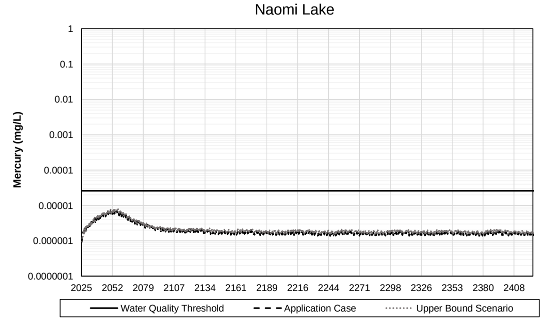
Forrest Lake South Basin

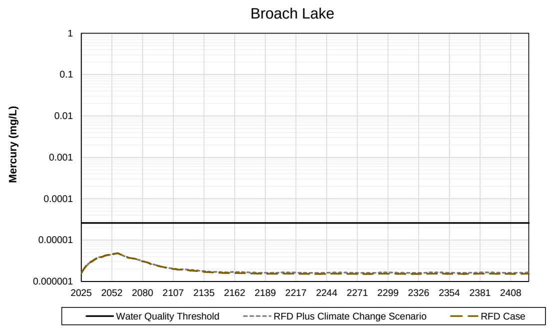


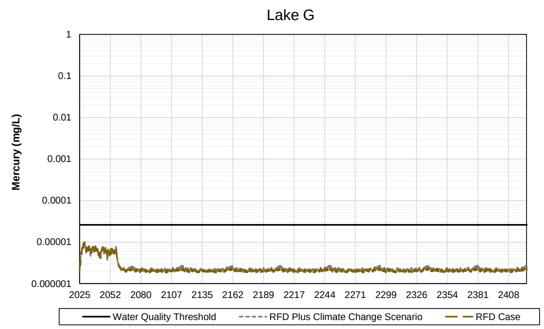
Beet Lake

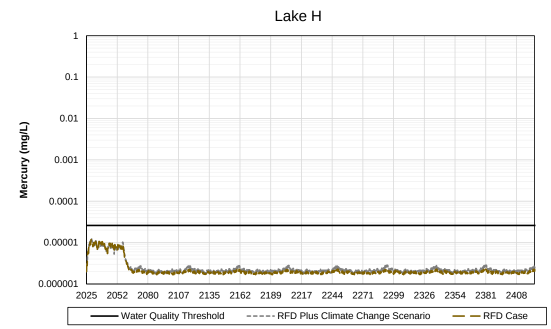


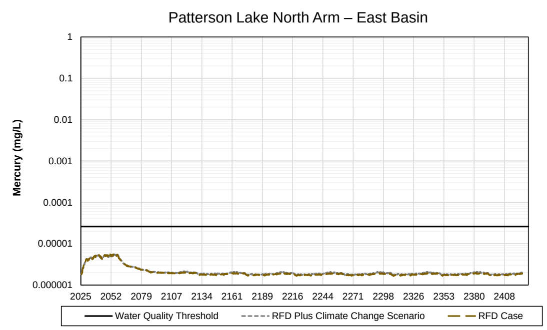
Naomi Lake

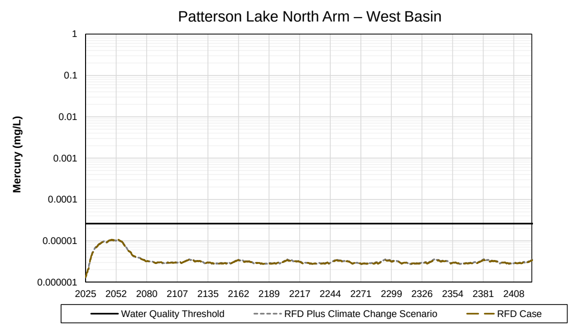


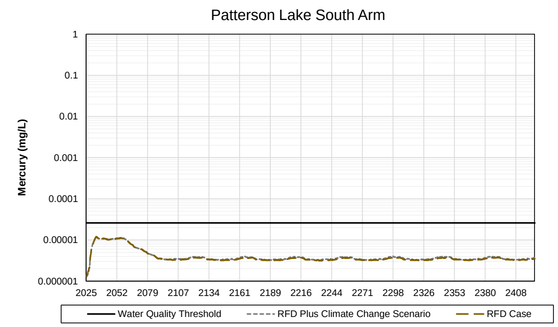

Broach Lake
Mercury (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

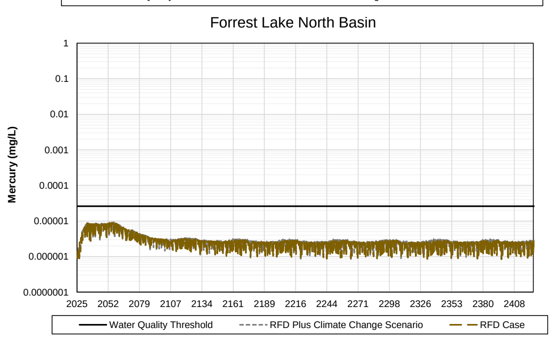

Lake G
Mercury (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

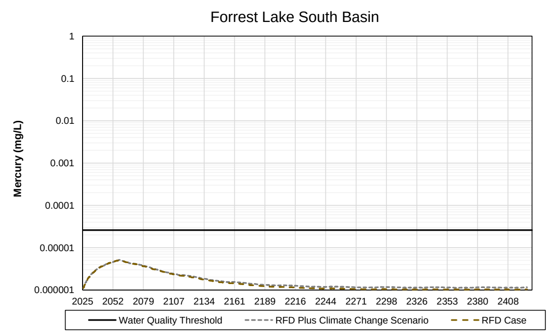

Lake H
Mercury (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

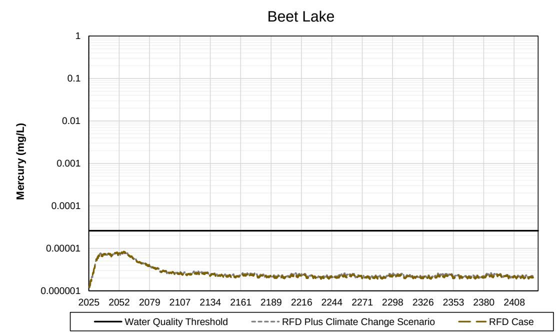

Patterson Lake North Arm – East Basin
Mercury (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

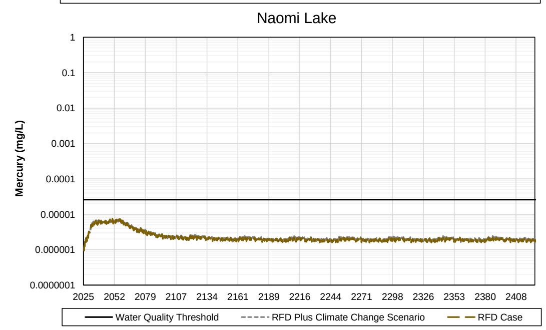

Patterson Lake North Arm – West Basin
Mercury (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

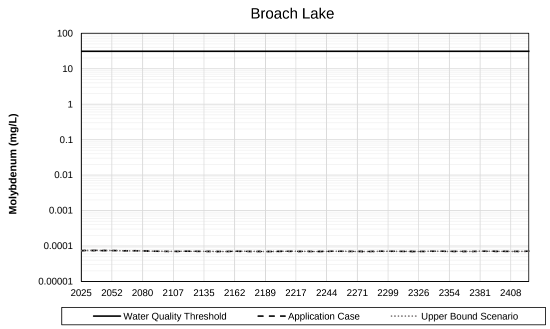

Patterson Lake South Arm
Mercury (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

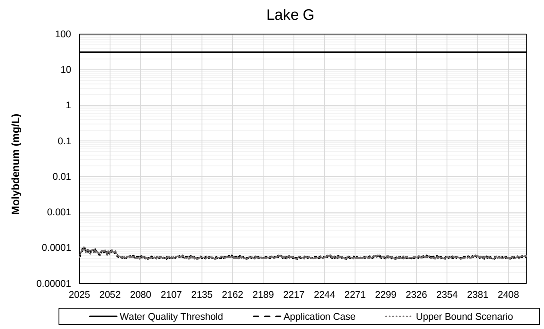

Forrest Lake North Basin
Mercury (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

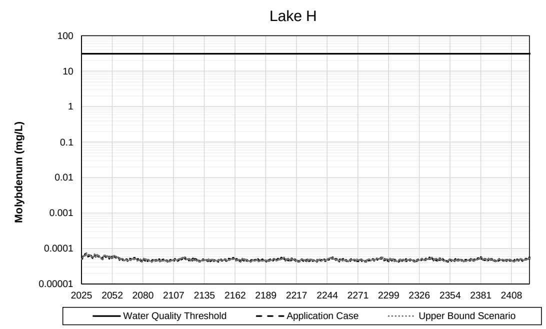

Forrest Lake South Basin
Mercury (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

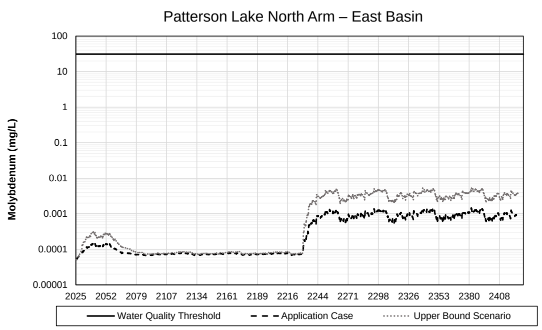

Beet Lake
Mercury (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

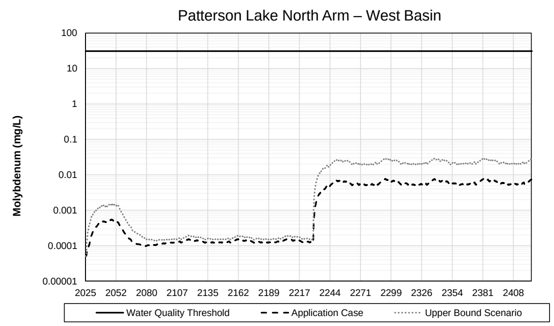

Naomi Lake
Mercury (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

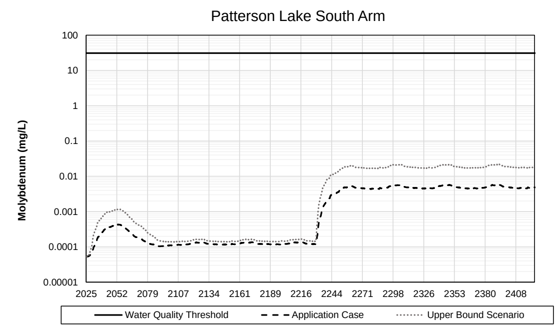

Broach Lake
Molybdenum (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

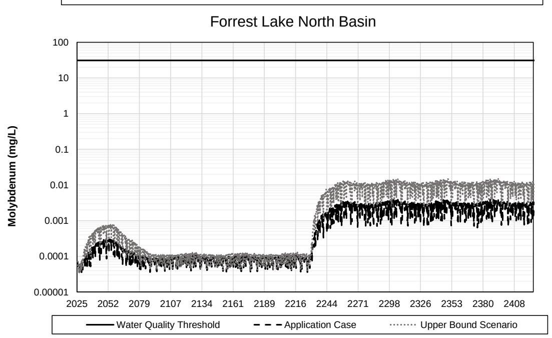

Lake G
Molybdenum (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

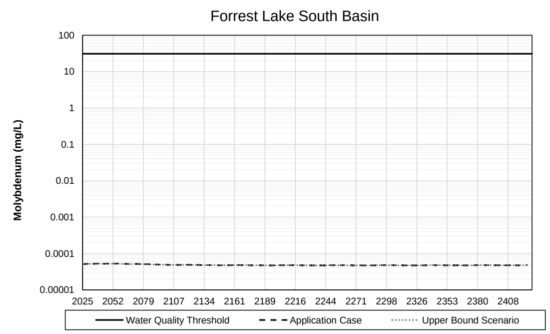

Lake H
Molybdenum (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

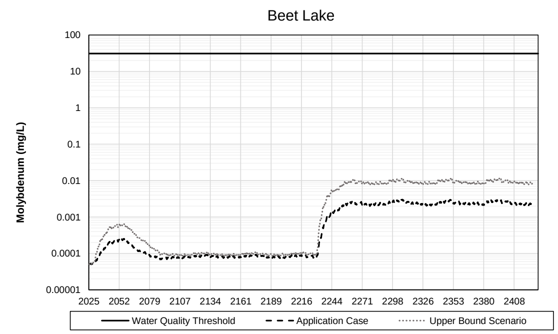

Patterson Lake North Arm – East Basin
Molybdenum (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

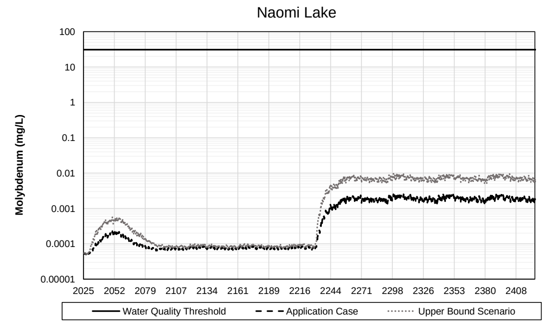

Patterson Lake North Arm – West Basin
Molybdenum (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

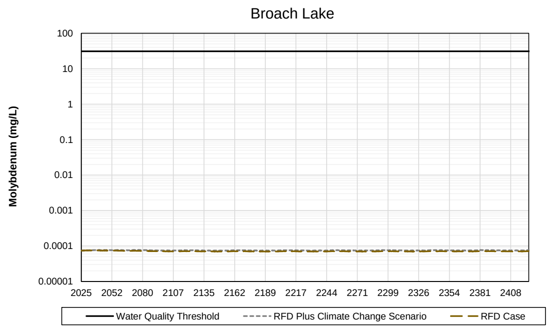

Patterson Lake South Arm
Molybdenum (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

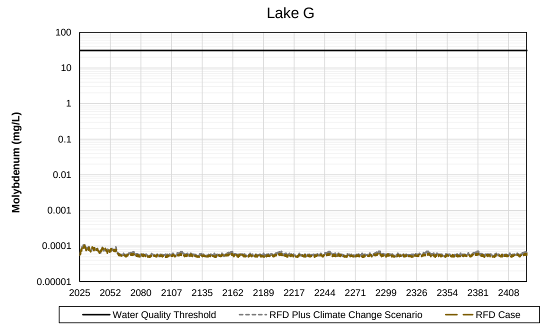

Forrest Lake North Basin
Molybdenum (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

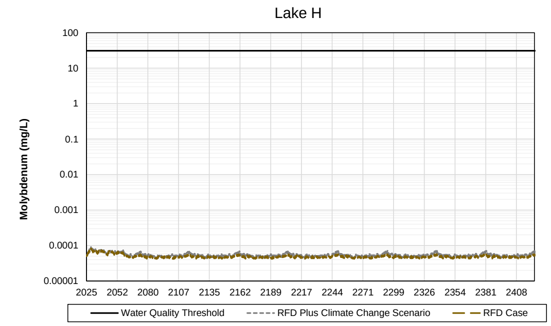

Forrest Lake South Basin
Molybdenum (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

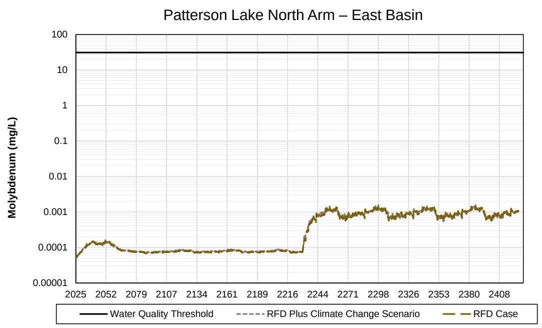

Beet Lake
Molybdenum (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

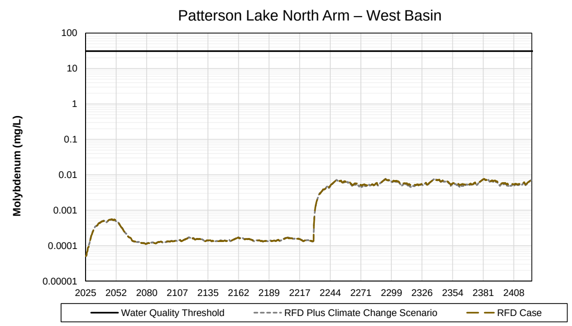

Naomi Lake
Molybdenum (mg/L)
Water Quality Threshold
Application Case
Upper Bound Scenario

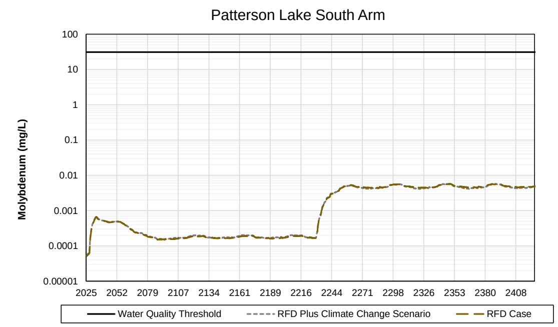

Broach Lake
Molybdenum (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

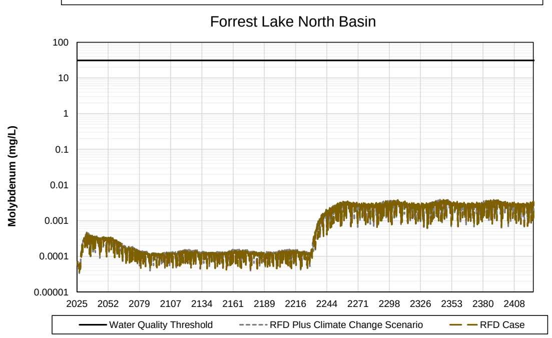

Lake G
Molybdenum (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

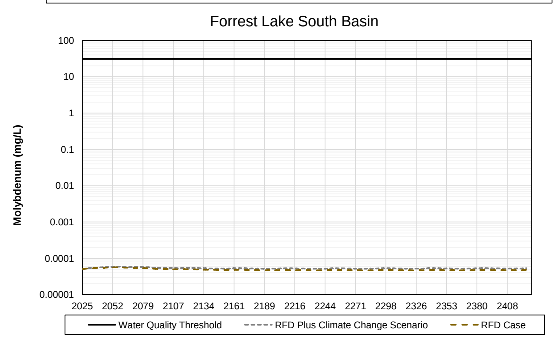

Lake H
Molybdenum (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

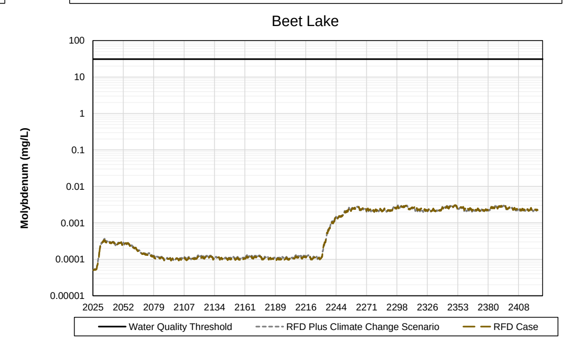

Patterson Lake North Arm – East Basin
Molybdenum (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

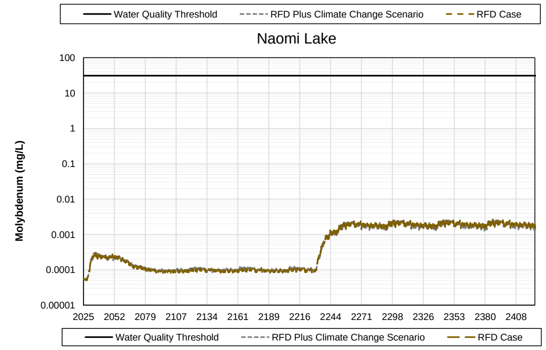

Patterson Lake North Arm – West Basin
Molybdenum (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake South Arm
Molybdenum (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

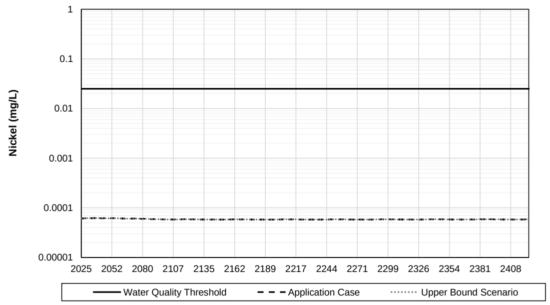

Forrest Lake North Basin
Molybdenum (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Forrest Lake South Basin
Molybdenum (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

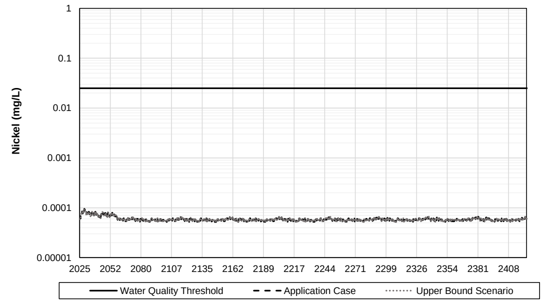

Beet Lake
Molybdenum (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Naomi Lake
Molybdenum (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

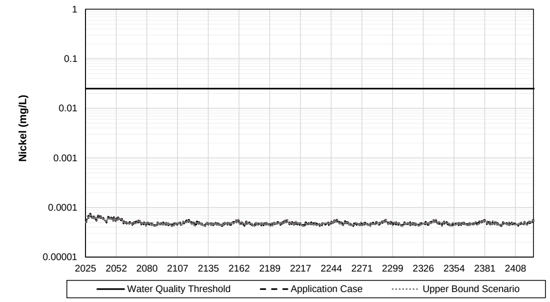
Broach Lake



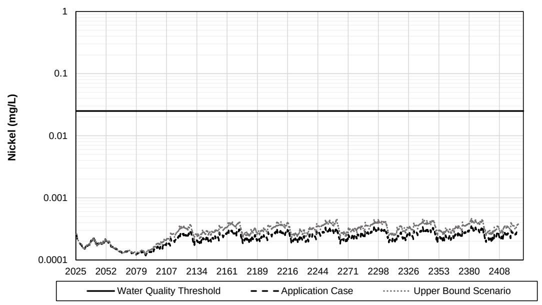
Lake G



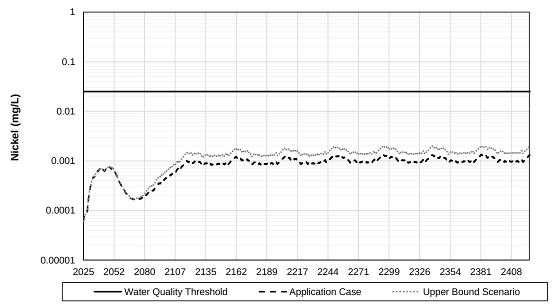
Lake H



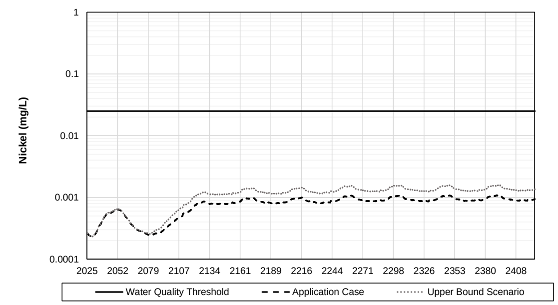
Patterson Lake North Arm – East Basin



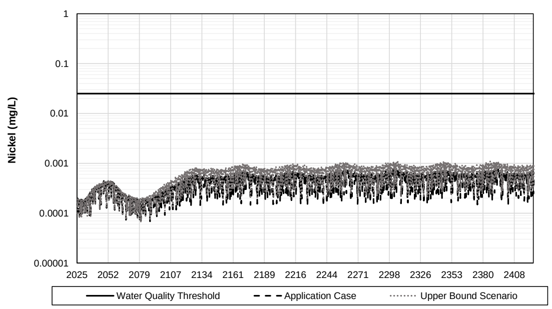
Patterson Lake North Arm – West Basin



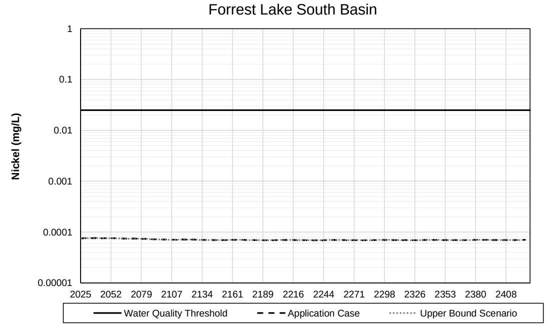
Patterson Lake South Arm



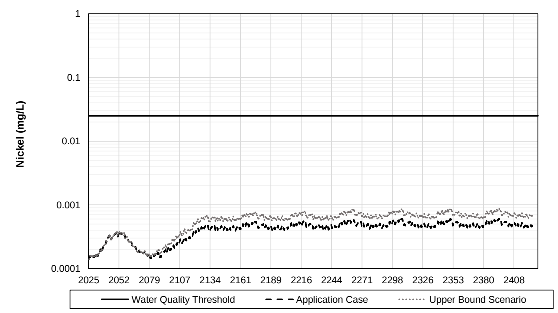
Forrest Lake North Basin



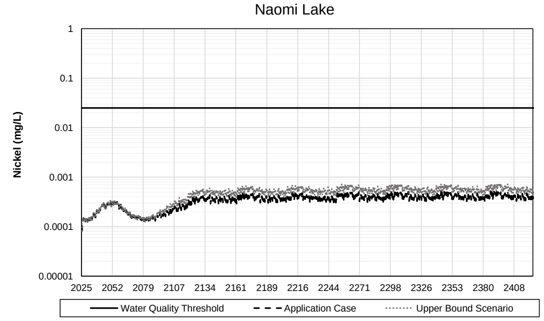
Forrest Lake South Basin

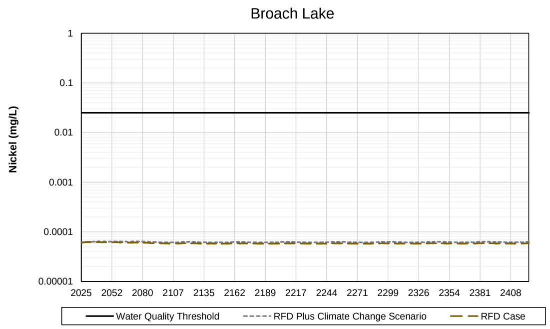


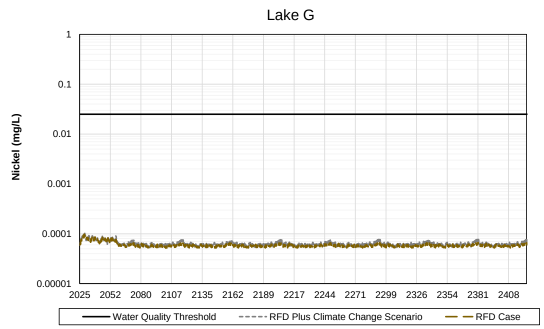
Beet Lake

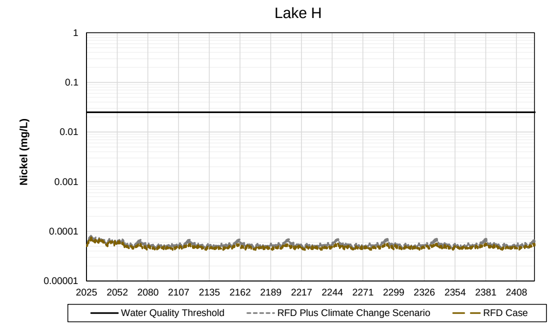


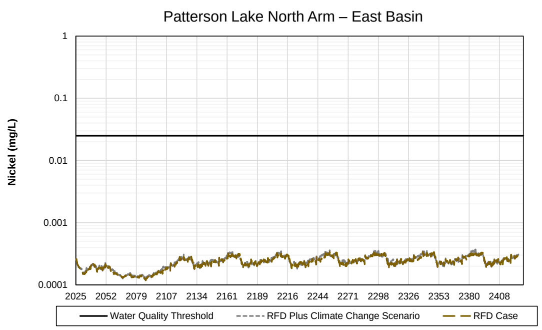
Naomi Lake

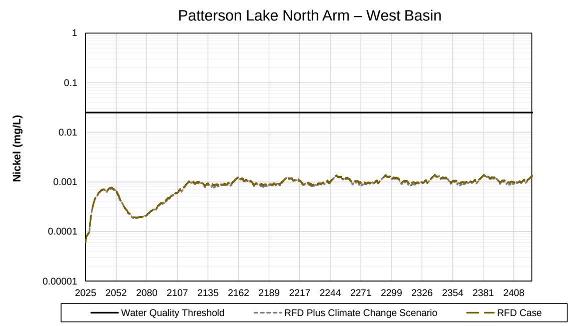


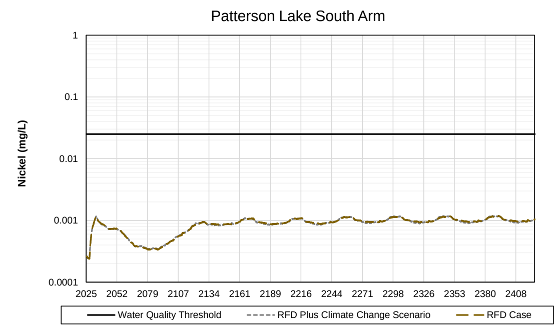

Broach Lake
Nickel (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

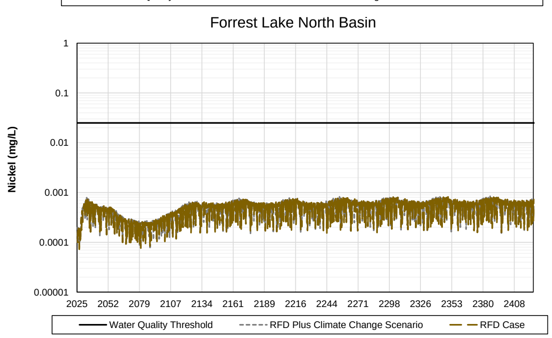

Lake G
Nickel (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

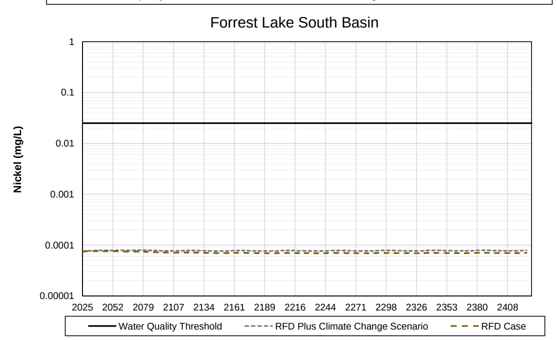

Lake H
Nickel (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

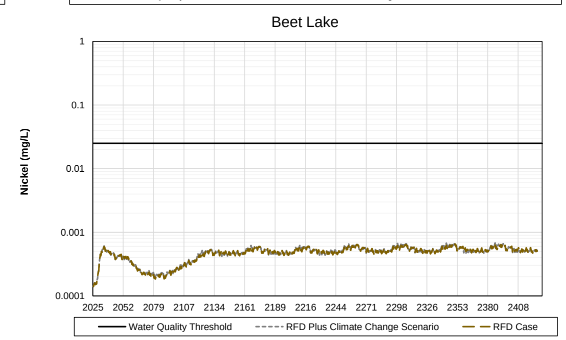

Patterson Lake North Arm – East Basin
Nickel (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

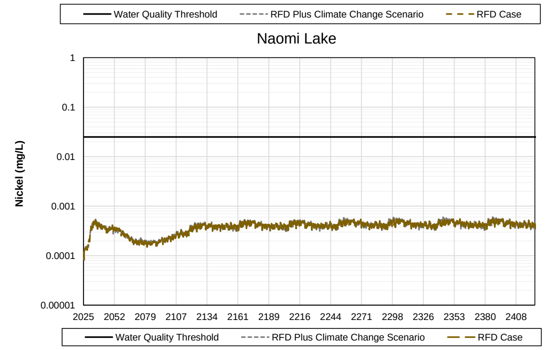

Patterson Lake North Arm – West Basin
Nickel (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

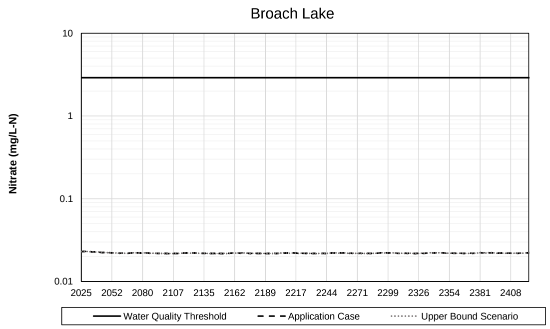

Patterson Lake South Arm
Nickel (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

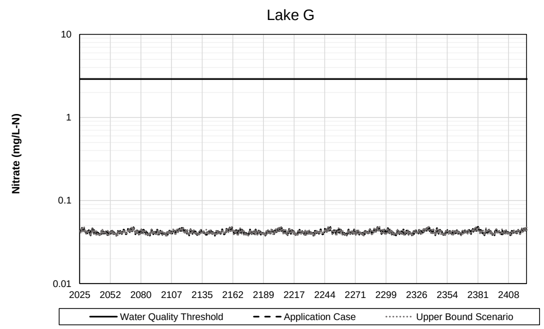

Forrest Lake North Basin
Nickel (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

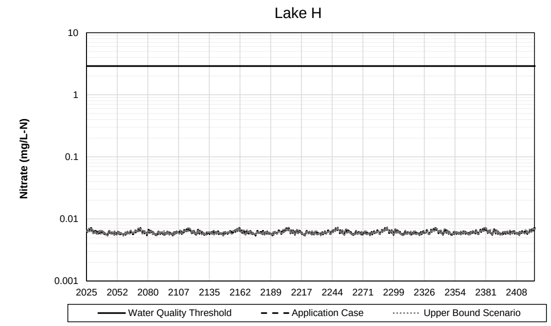

Forrest Lake South Basin
Nickel (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

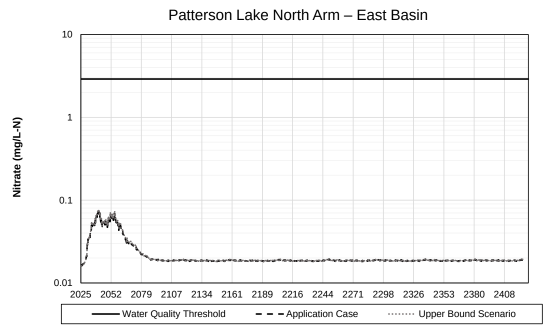

Beet Lake
Nickel (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

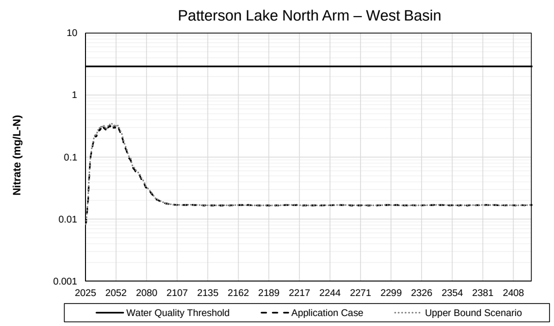

Naomi Lake
Nickel (mg/L)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

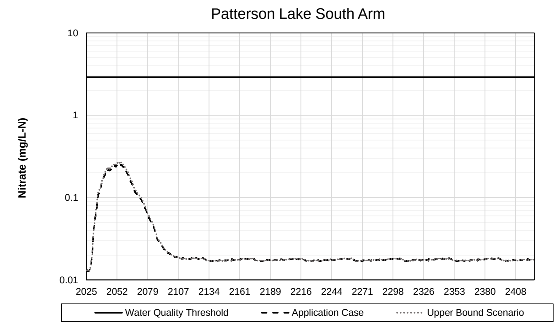

Broach Lake
Nitrate (mg/L-N)
10
1
0.1
0.01
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

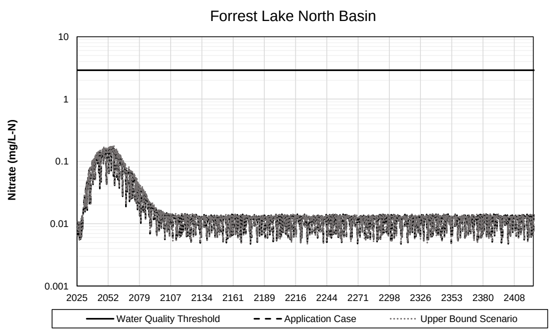

Lake G
Nitrate (mg/L-N)
10
1
0.1
0.01
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

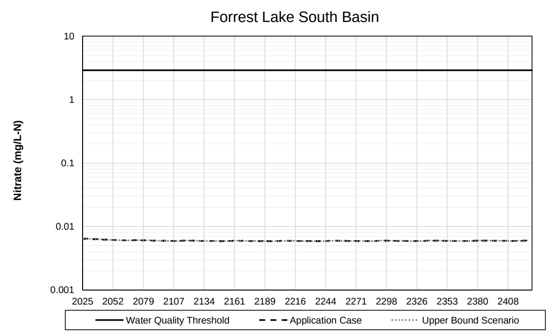

Lake H
Nitrate (mg/L-N)
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

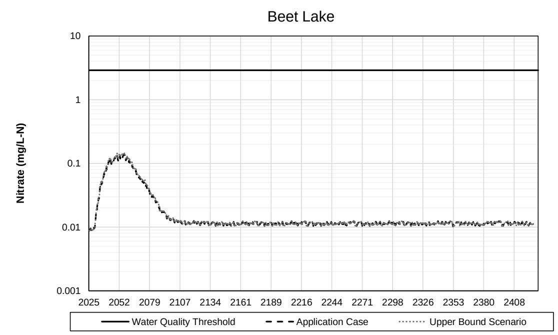

Patterson Lake North Arm – East Basin
Nitrate (mg/L-N)
10
1
0.1
0.01
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

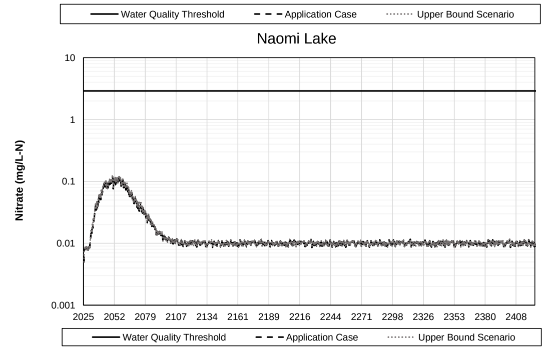

Patterson Lake North Arm – West Basin
Nitrate (mg/L-N)
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

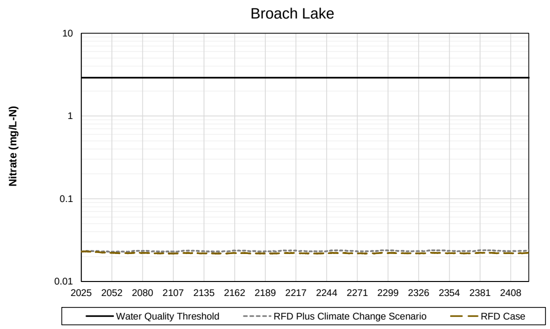

Patterson Lake South Arm
Nitrate (mg/L-N)
10
1
0.1
0.01
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

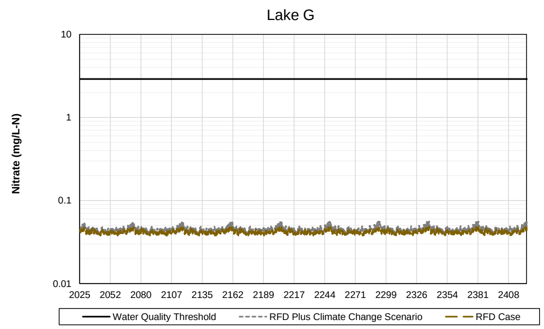

Forrest Lake North Basin
Nitrate (mg/L-N)
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

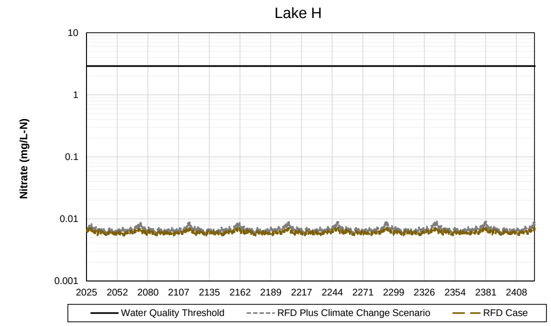

Forrest Lake South Basin
Nitrate (mg/L-N)
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

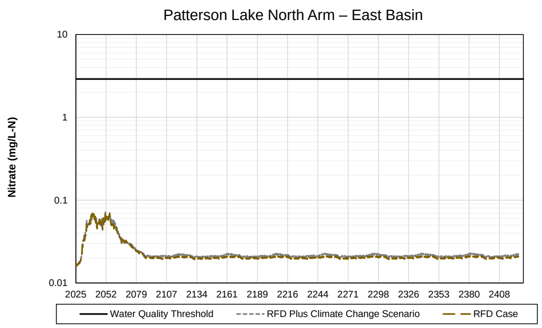

Beet Lake
Nitrate (mg/L-N)
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

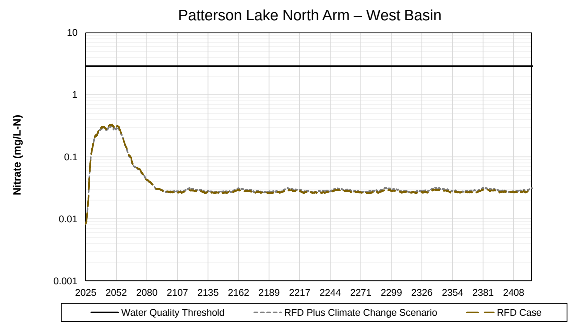

Naomi Lake
Nitrate (mg/L-N)
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

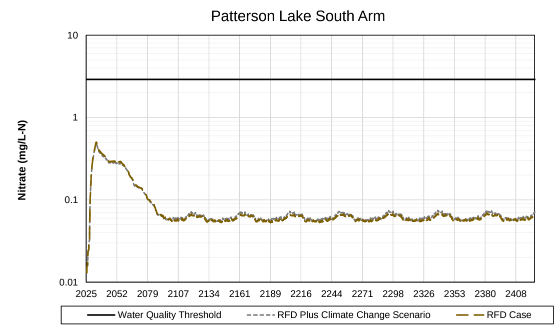

Broach Lake
Nitrate (mg/L-N)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

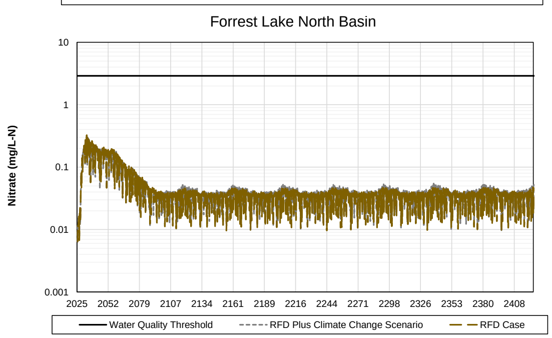

Lake G
Nitrate (mg/L-N)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

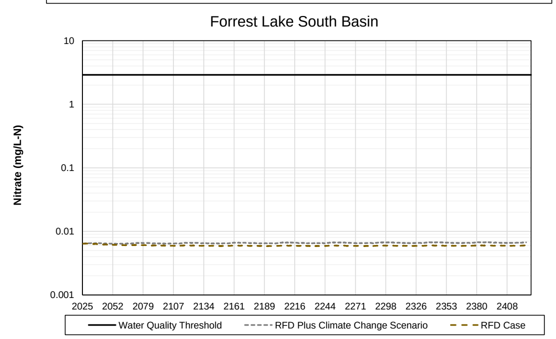

Lake H
Nitrate (mg/L-N)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

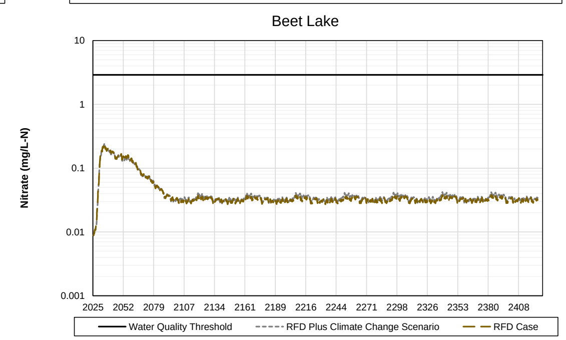

Patterson Lake North Arm – East Basin
Nitrate (mg/L-N)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

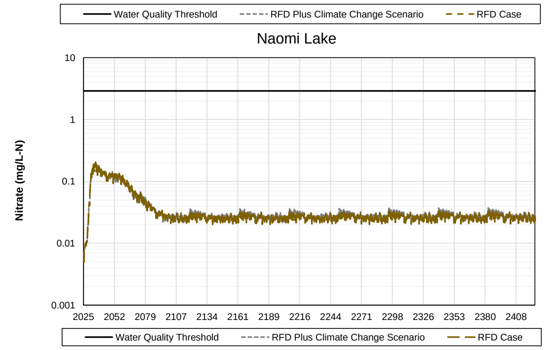

Patterson Lake North Arm – West Basin
Nitrate (mg/L-N)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake South Arm
Nitrate (mg/L-N)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

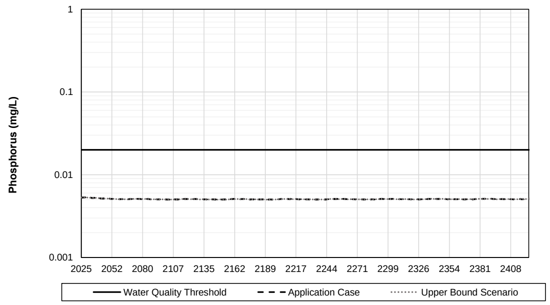

Forrest Lake North Basin
Nitrate (mg/L-N)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Forrest Lake South Basin
Nitrate (mg/L-N)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

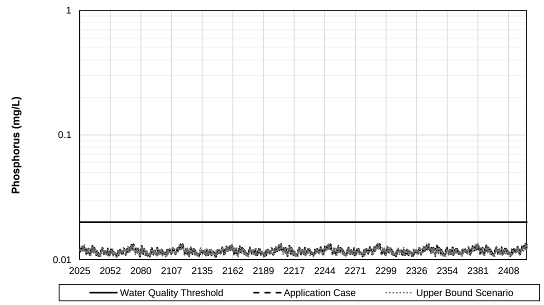

Beet Lake
Nitrate (mg/L-N)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Naomi Lake
Nitrate (mg/L-N)
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

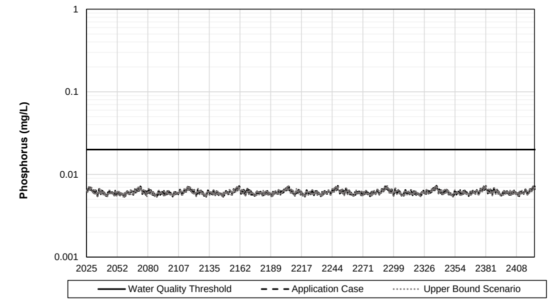
Broach Lake



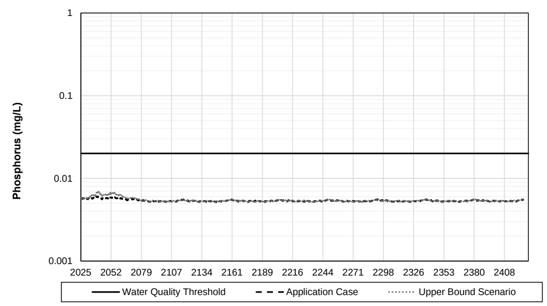
Lake G



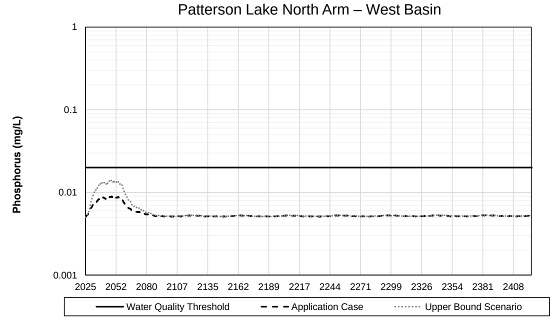
Lake H



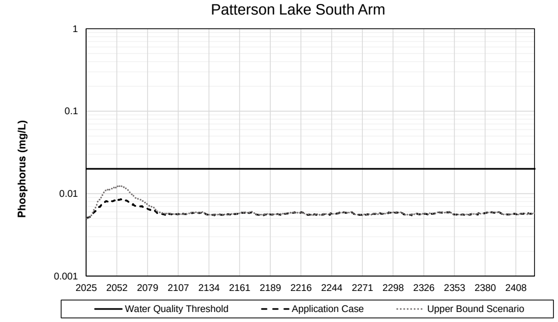
Patterson Lake North Arm – East Basin



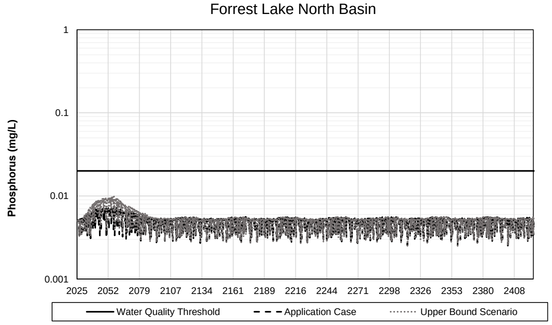
Patterson Lake North Arm – West Basin



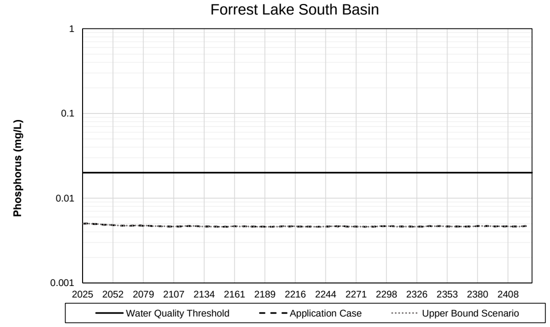
Patterson Lake South Arm



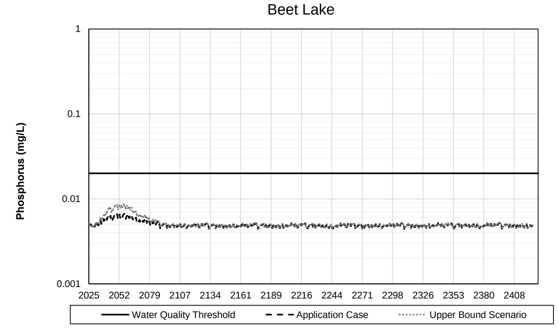
Forrest Lake North Basin



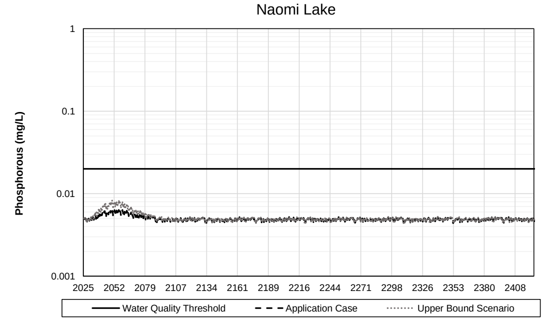
Forrest Lake South Basin



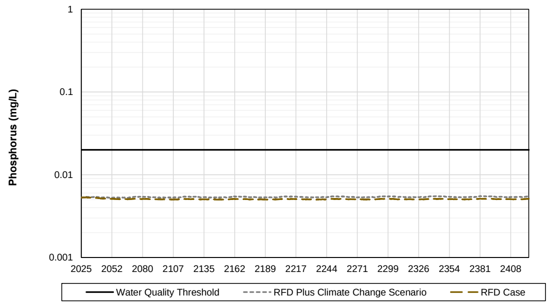
Beet Lake



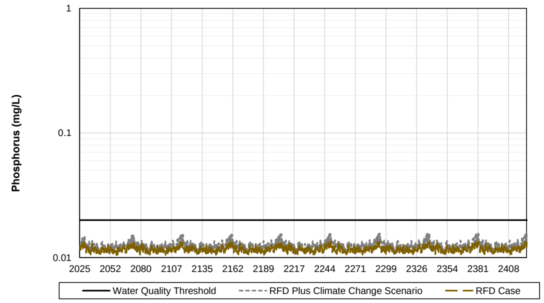
Naomi Lake



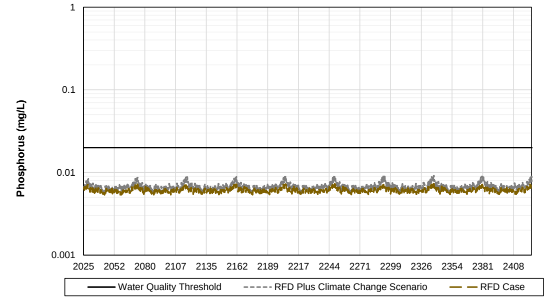
Broach Lake



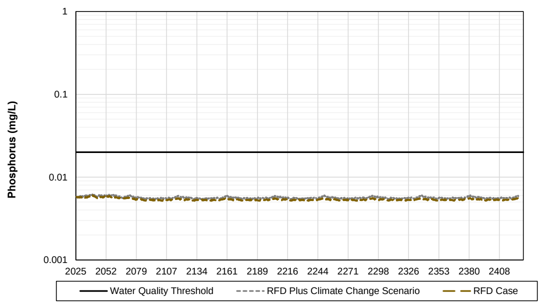
Lake G



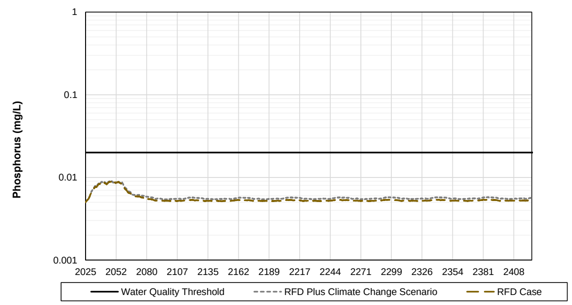
Lake H



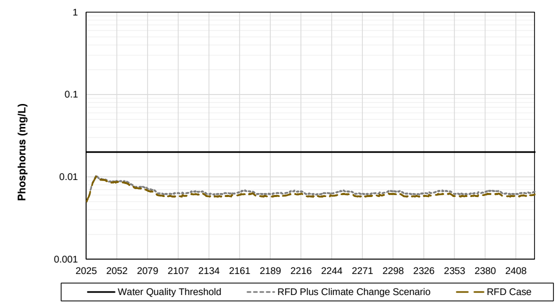
Patterson Lake North Arm – East Basin



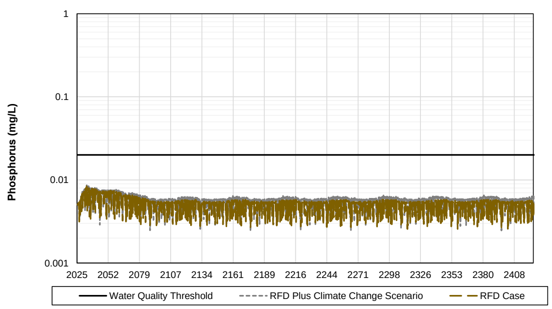
Patterson Lake North Arm – West Basin



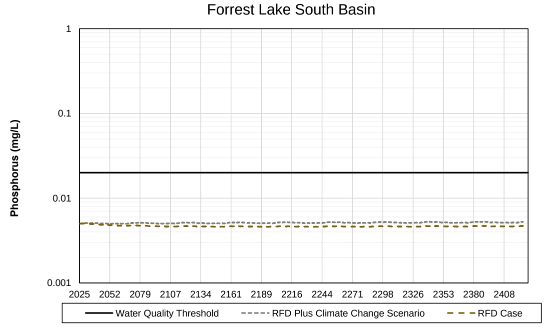
Patterson Lake South Arm



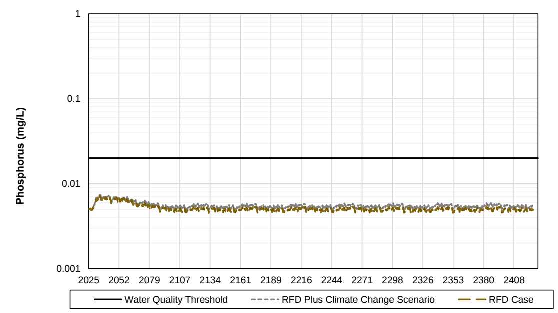
Forrest Lake North Basin



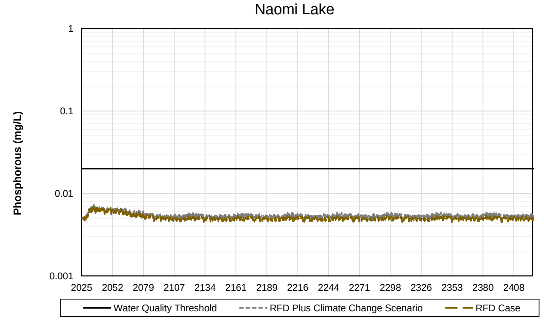
Forrest Lake South Basin



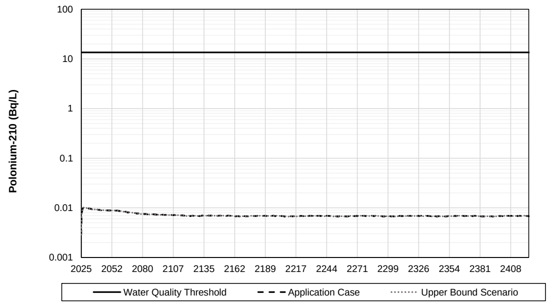
Beet Lake



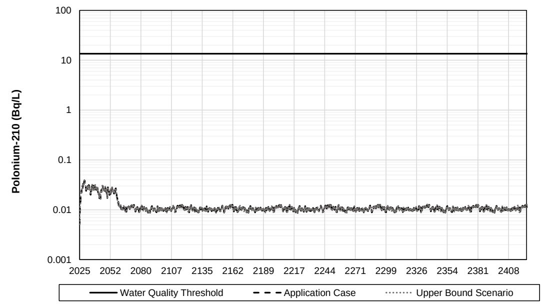
Naomi Lake



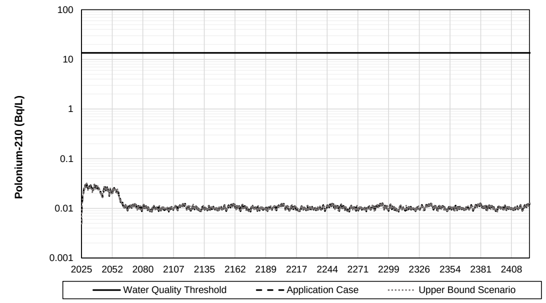
Broach Lake



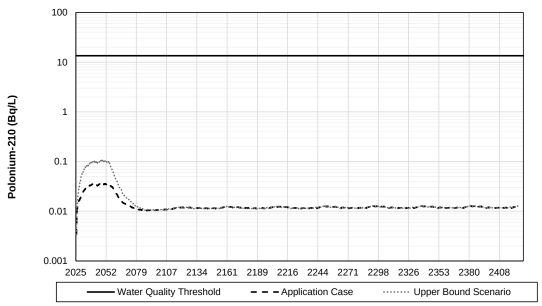
Lake G



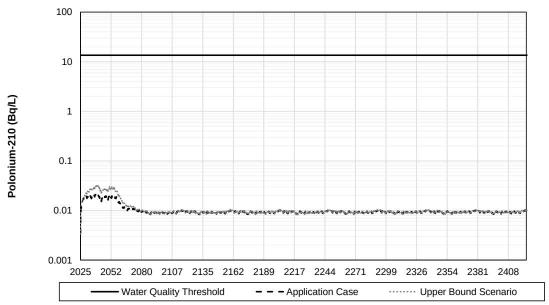
Lake H



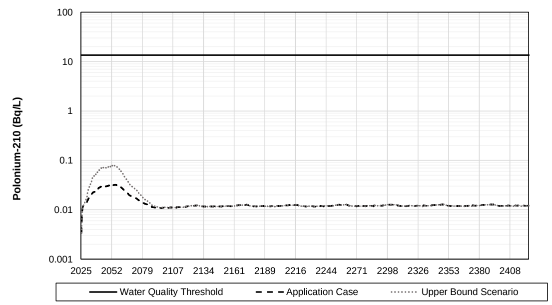
Patterson Lake North Arm – East Basin



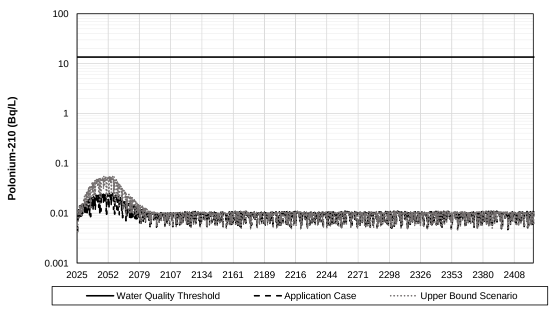
Patterson Lake North Arm – West Basin



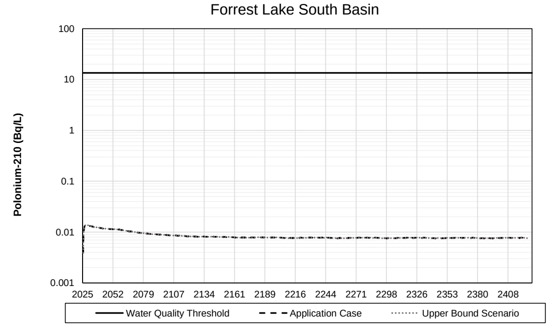
Patterson Lake South Arm



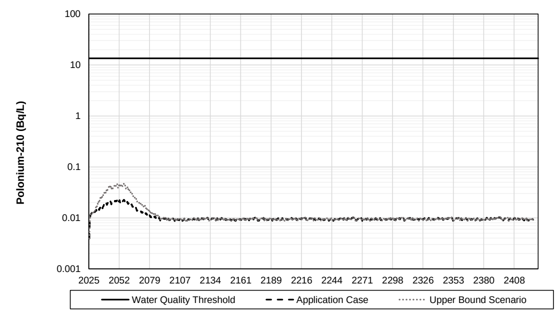
Forrest Lake North Basin



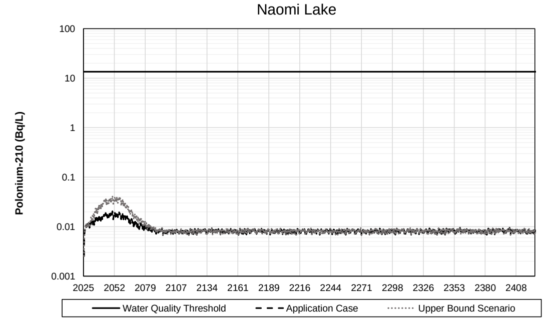
Forrest Lake South Basin

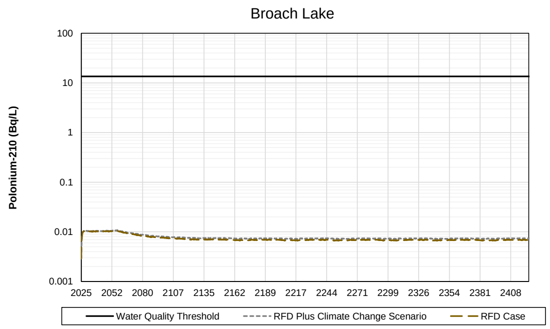


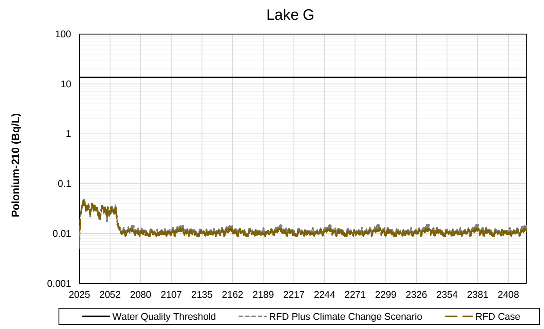
Beet Lake

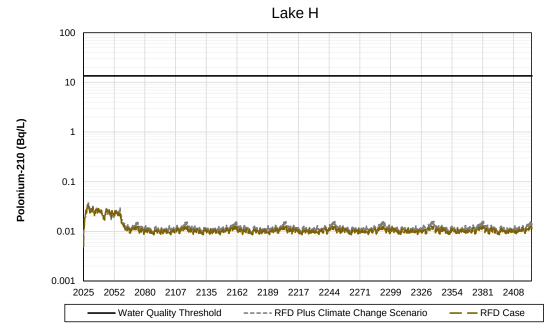


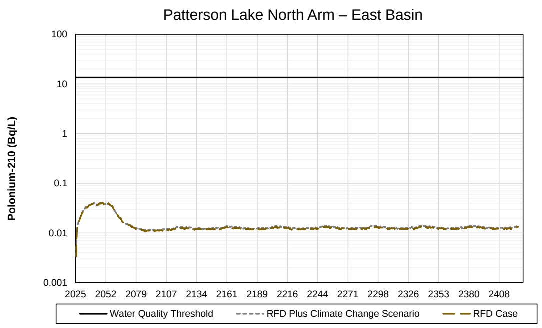
Naomi Lake

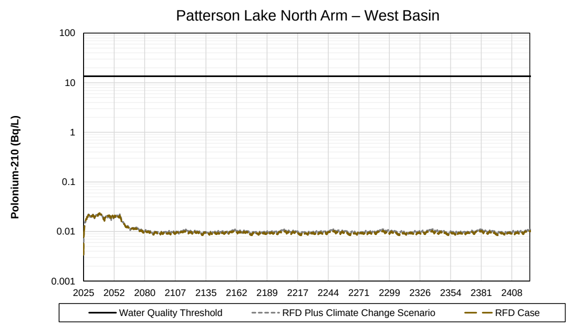


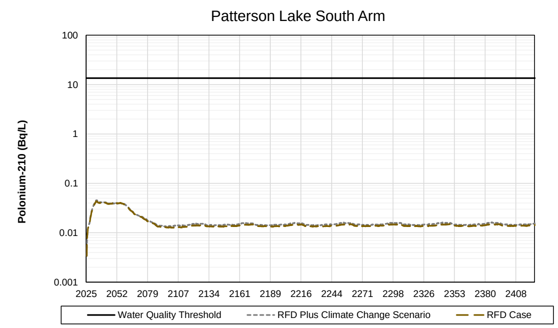

Broach Lake
Polonium-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

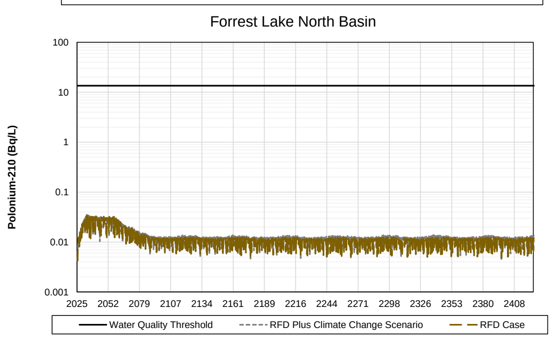

Lake G
Polonium-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

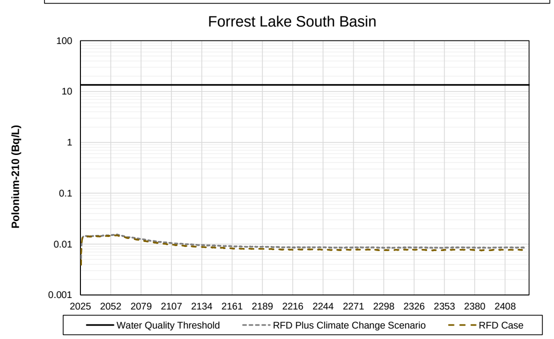

Lake H
Polonium-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

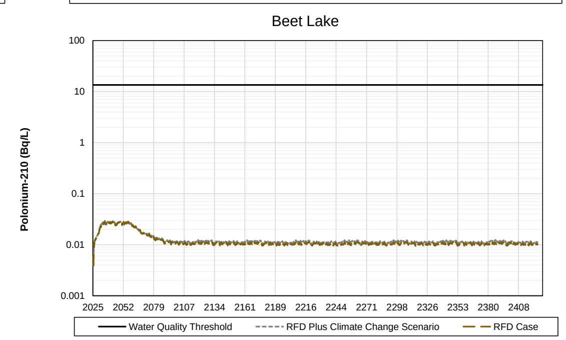

Patterson Lake North Arm – East Basin
Polonium-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

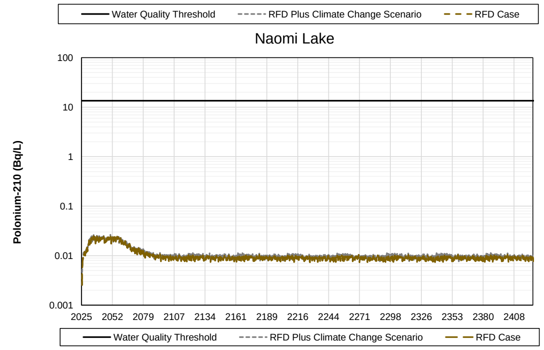

Patterson Lake North Arm – West Basin
Polonium-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

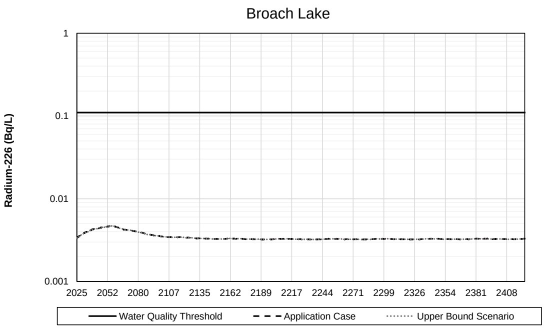

Patterson Lake South Arm
Polonium-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

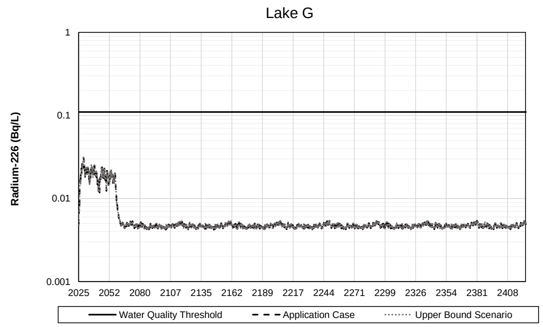

Forrest Lake North Basin
Polonium-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

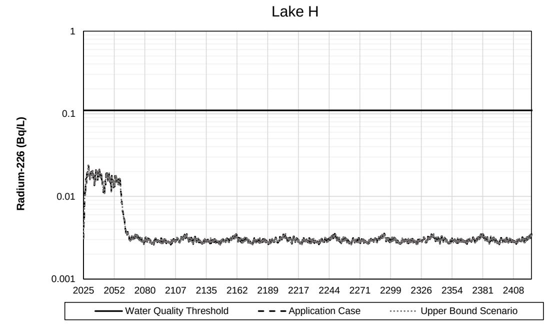

Forrest Lake South Basin
Polonium-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

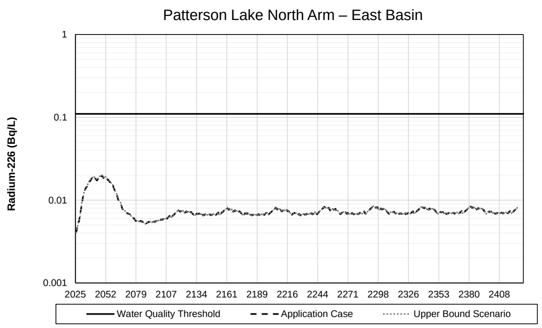

Beet Lake
Polonium-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

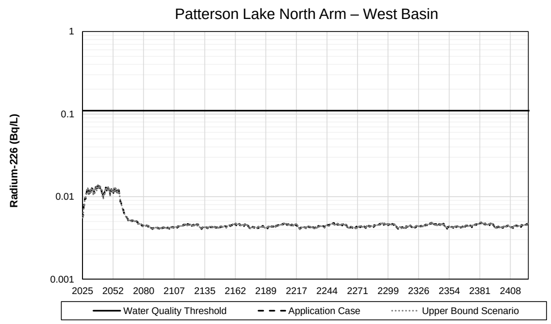

Naomi Lake
Polonium-210 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

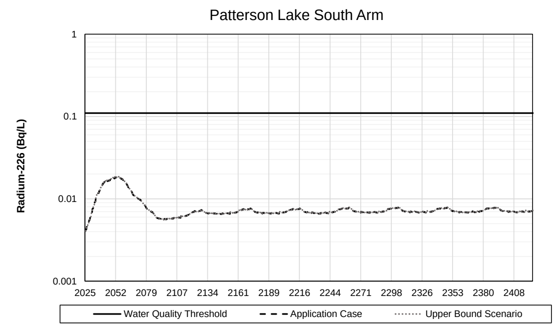

Broach Lake
Radium-226 (Bq/L)
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

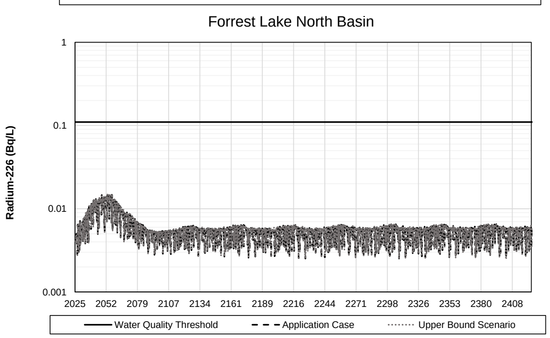

Lake G
Radium-226 (Bq/L)
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

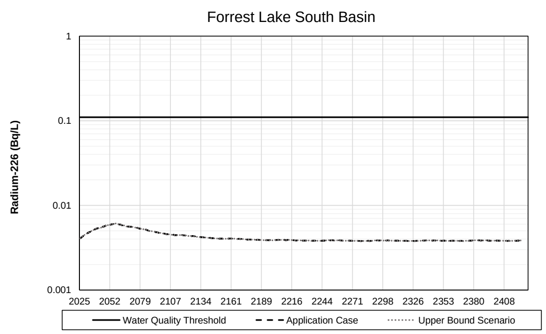

Lake H
Radium-226 (Bq/L)
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

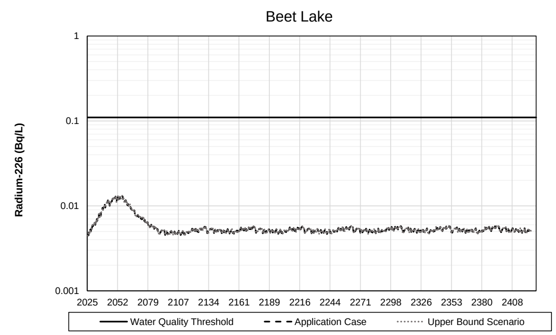

Patterson Lake North Arm – East Basin
Radium-226 (Bq/L)
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

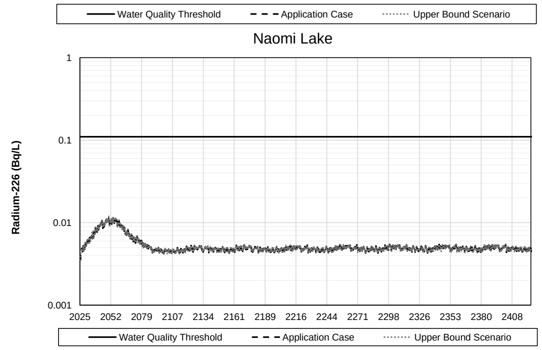

Patterson Lake North Arm – West Basin
Radium-226 (Bq/L)
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Patterson Lake South Arm
Radium-226 (Bq/L)
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

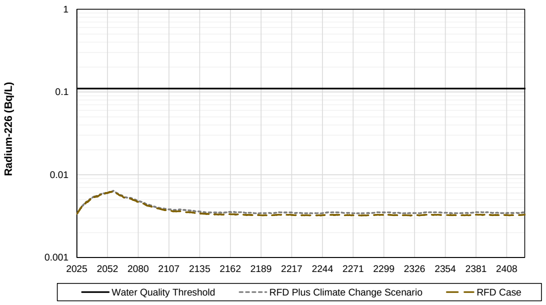

Forrest Lake North Basin
Radium-226 (Bq/L)
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Forrest Lake South Basin
Radium-226 (Bq/L)
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

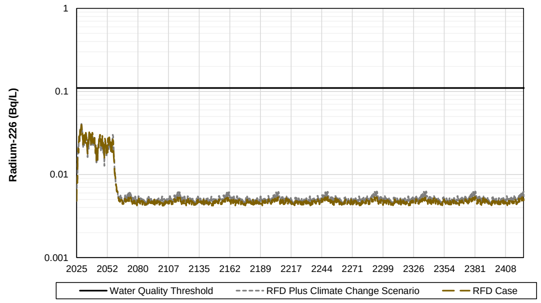

Beet Lake
Radium-226 (Bq/L)
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Naomi Lake
Radium-226 (Bq/L)
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

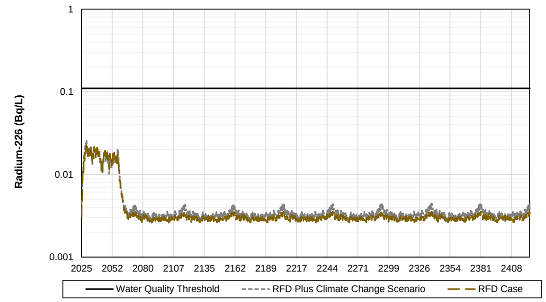
Broach Lake



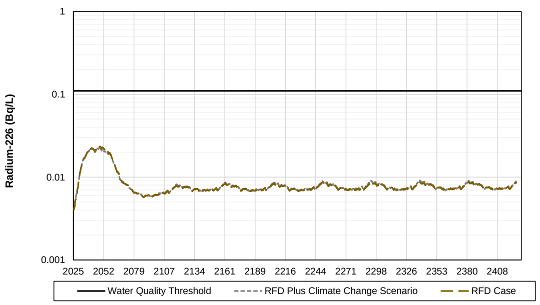
Lake G



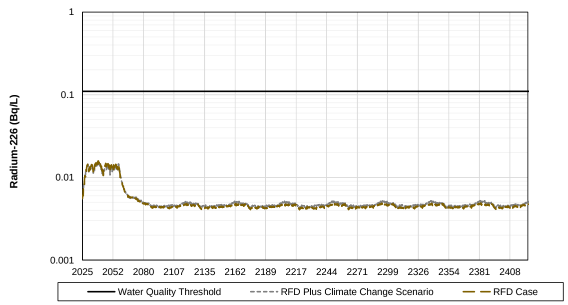
Lake H



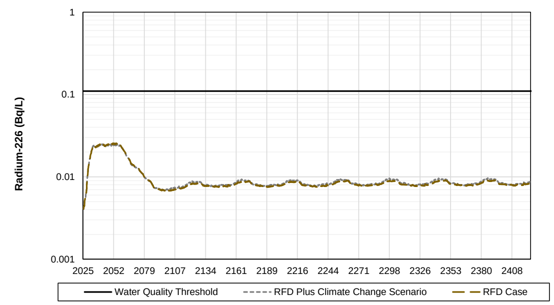
Patterson Lake North Arm – East Basin



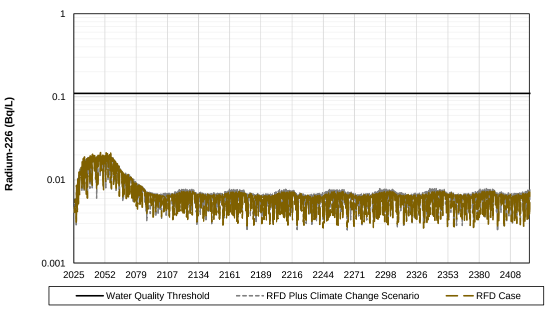
Patterson Lake North Arm – West Basin



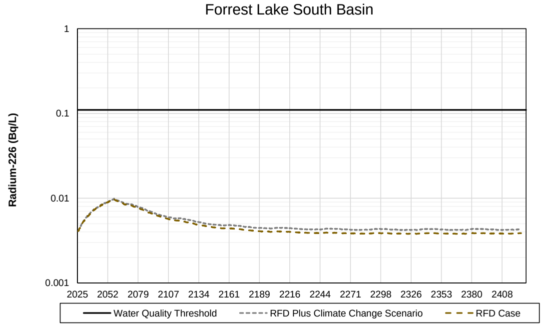
Patterson Lake South Arm



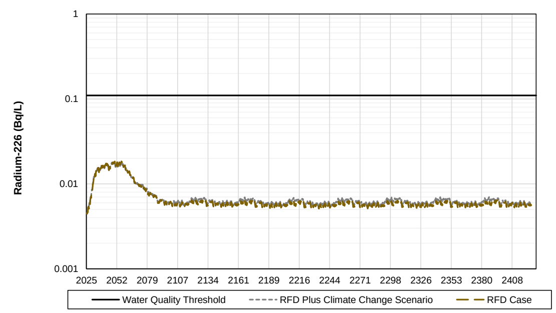
Forrest Lake North Basin



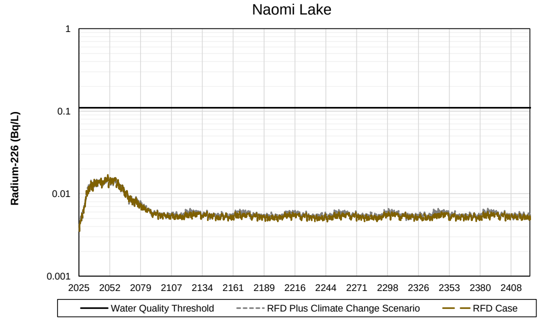
Forrest Lake South Basin

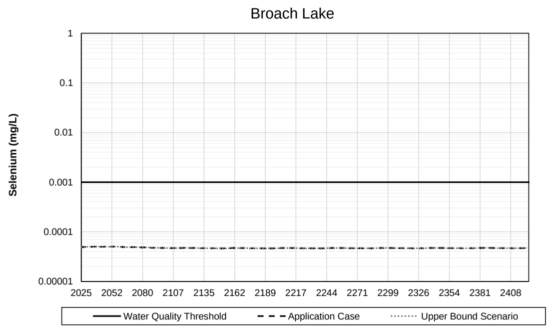


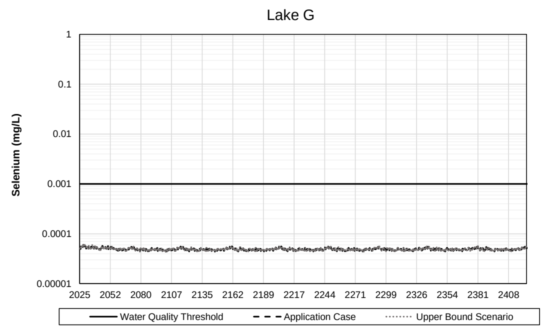
Beet Lake

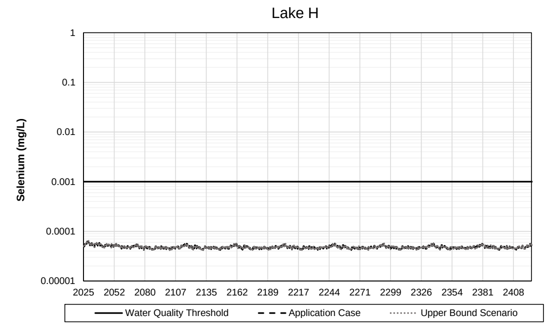


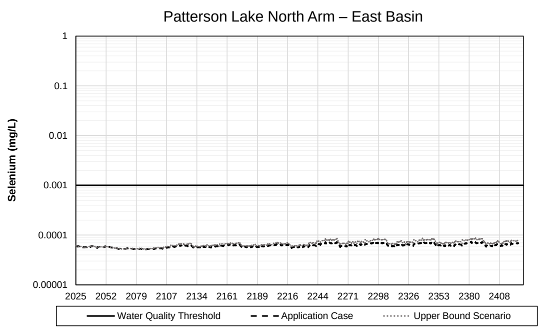
Naomi Lake

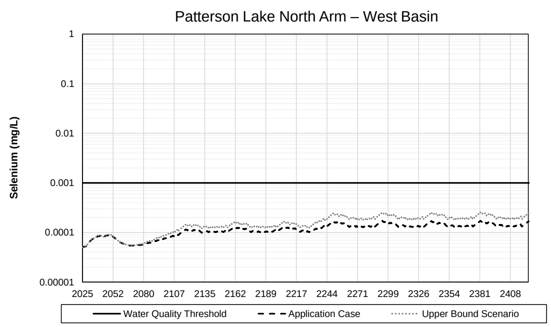


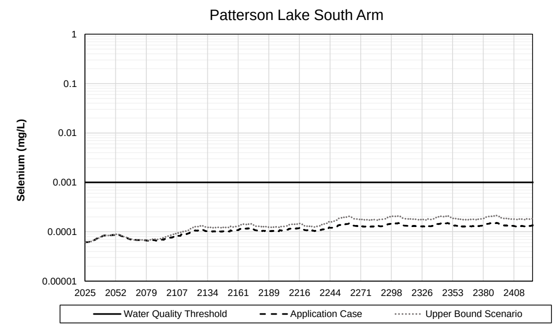

Broach Lake
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

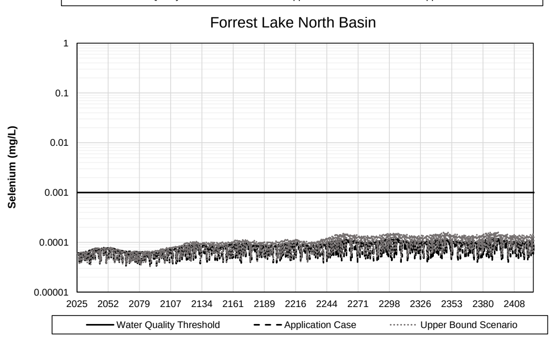

Lake G
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

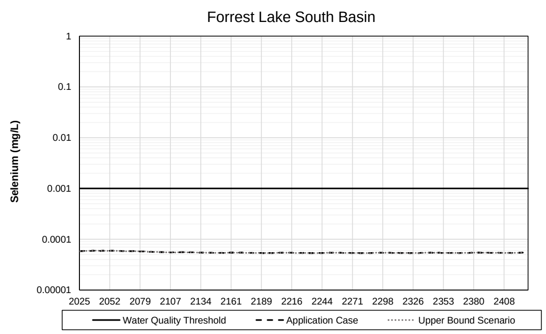

Lake H
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

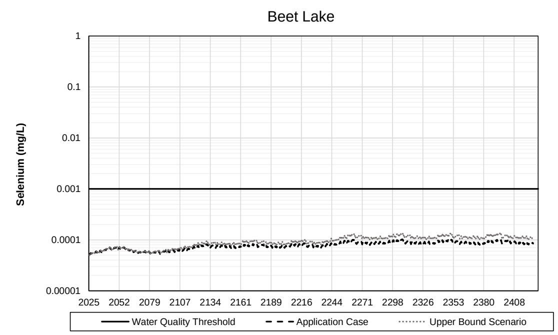

Patterson Lake North Arm – East Basin
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

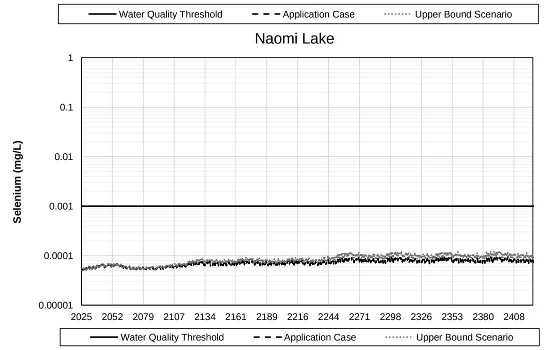

Patterson Lake North Arm – West Basin
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

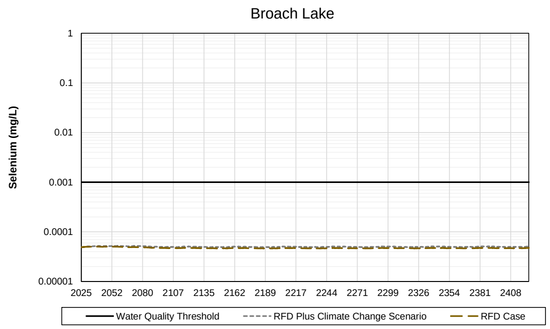

Patterson Lake South Arm
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

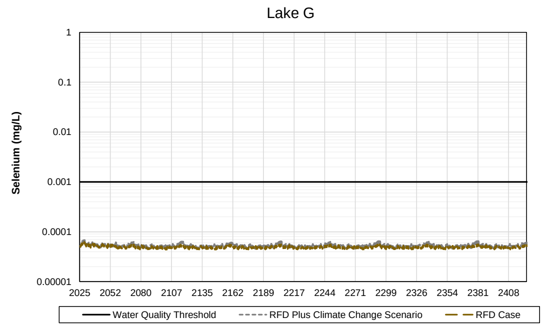

Forrest Lake North Basin
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

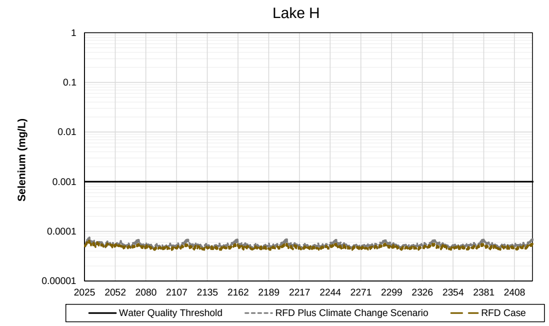

Forrest Lake South Basin
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

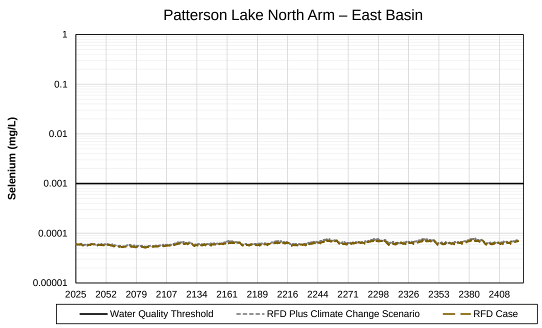

Beet Lake
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

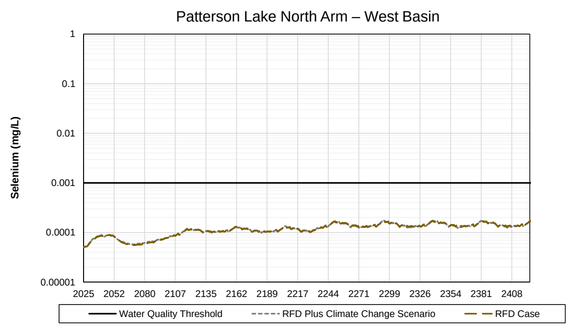

Naomi Lake
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

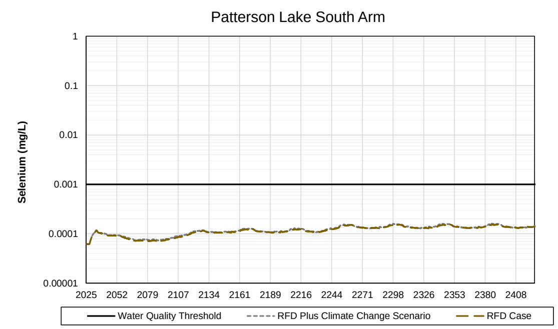

Broach Lake
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

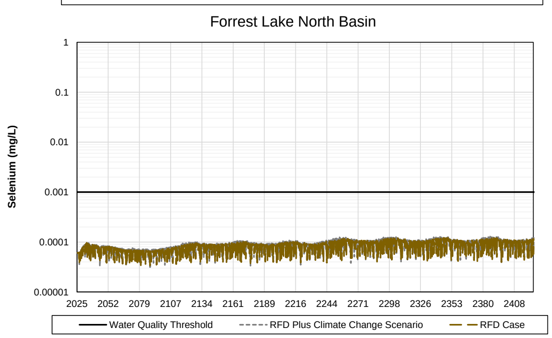

Lake G
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

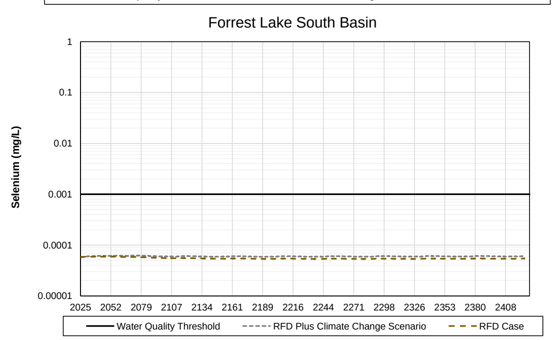

Lake H
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

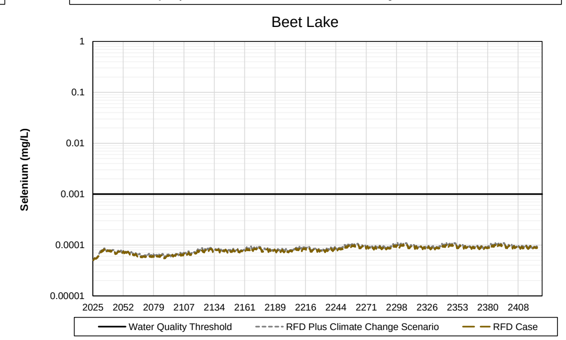

Patterson Lake North Arm – East Basin
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

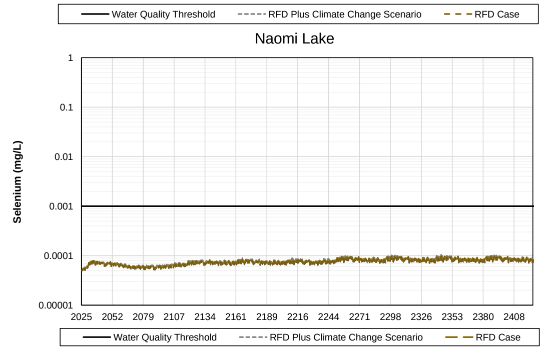

Patterson Lake North Arm – West Basin
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

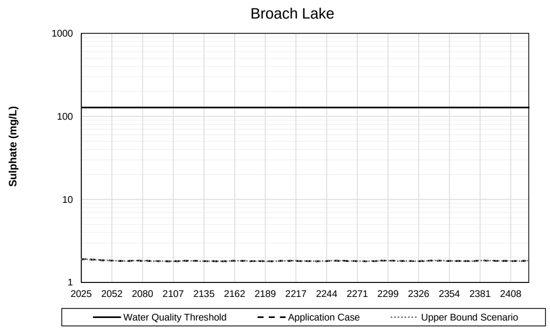

Patterson Lake South Arm
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

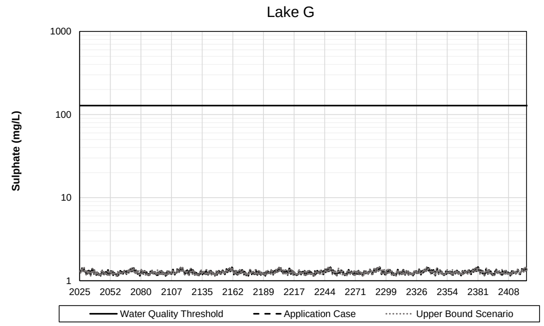

Forrest Lake North Basin
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

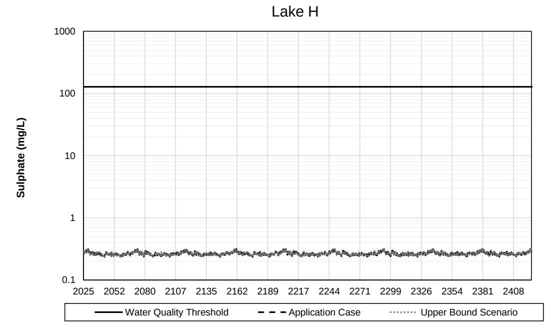

Forrest Lake South Basin
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

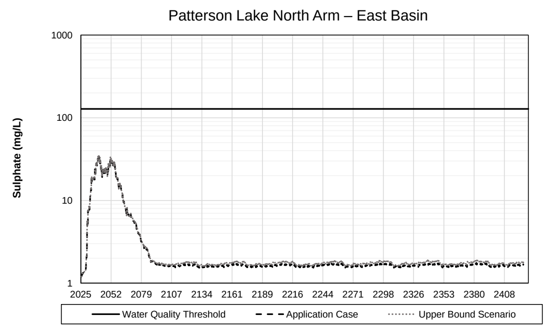

Beet Lake
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

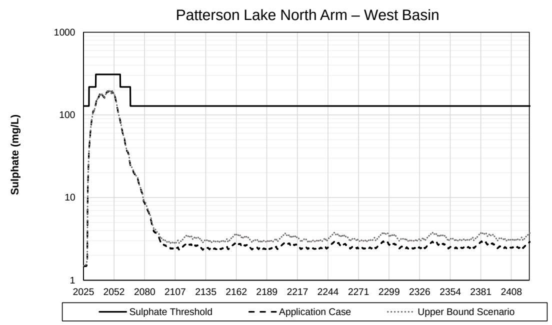

Naomi Lake
Selenium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

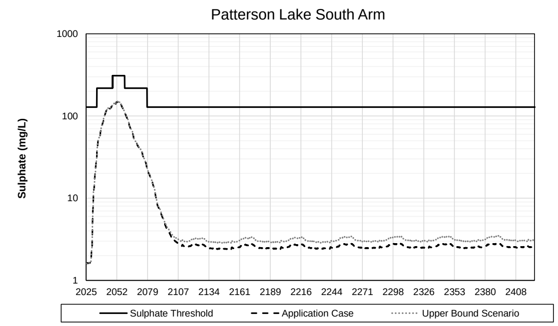

Broach Lake
Sulphate (mg/L)
1000
100
10
1
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

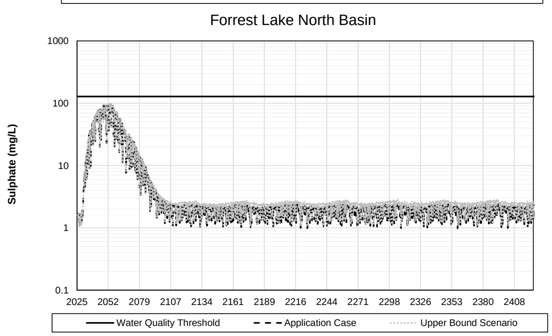

Lake G
Sulphate (mg/L)
1000
100
10
1
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

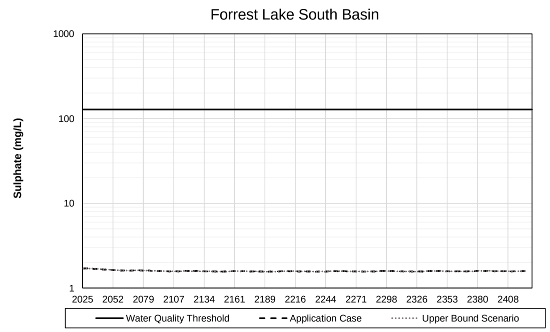

Lake H
Sulphate (mg/L)
1000
100
10
1
0.1
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

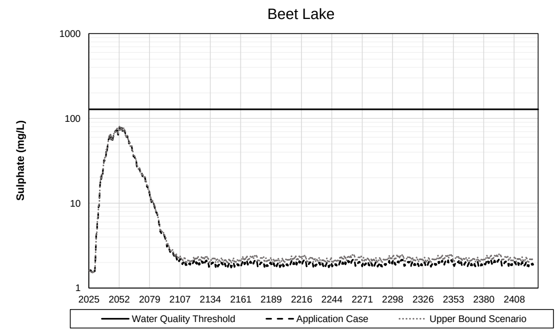

Patterson Lake North Arm – East Basin
Sulphate (mg/L)
1000
100
10
1
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

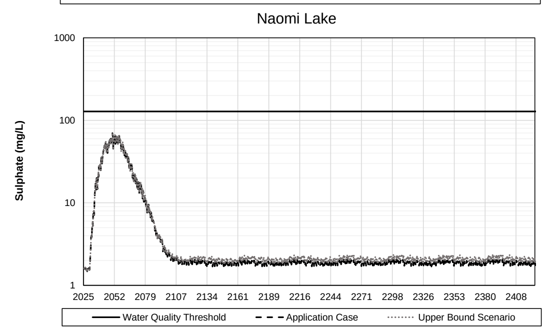

Patterson Lake North Arm – West Basin
Sulphate (mg/L)
1000
100
10
1
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Sulphate Threshold
Application Case
Upper Bound Scenario


Patterson Lake South Arm
Sulphate (mg/L)
1000
100
10
1
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Sulphate Threshold
Application Case
Upper Bound Scenario

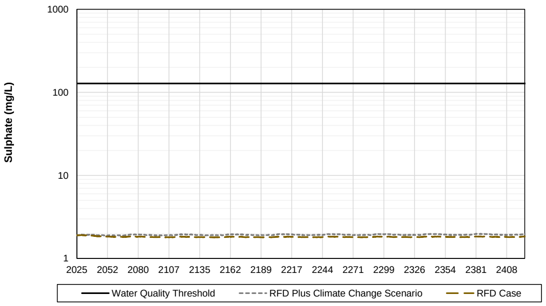

Forrest Lake North Basin
Sulphate (mg/L)
1000
100
10
1
0.1
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Forrest Lake South Basin
Sulphate (mg/L)
1000
100
10
1
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

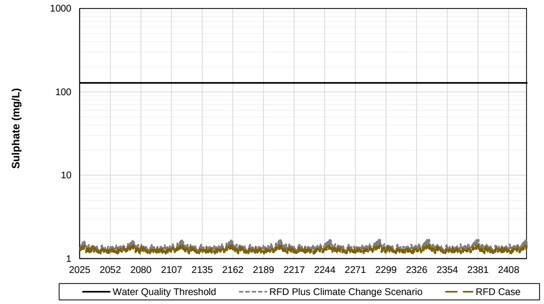

Beet Lake
Sulphate (mg/L)
1000
100
10
1
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Naomi Lake
Sulphate (mg/L)
1000
100
10
1
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

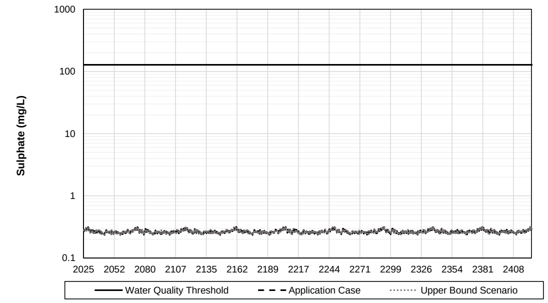
Broach Lake



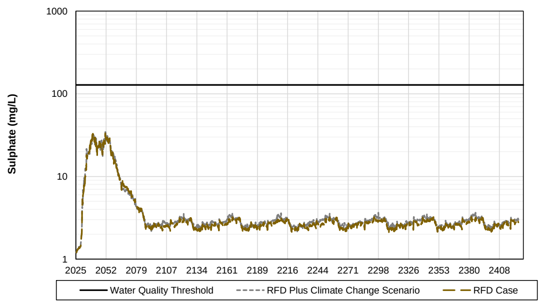
Lake G



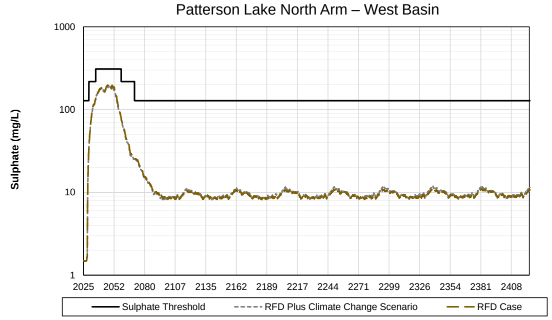
Lake H



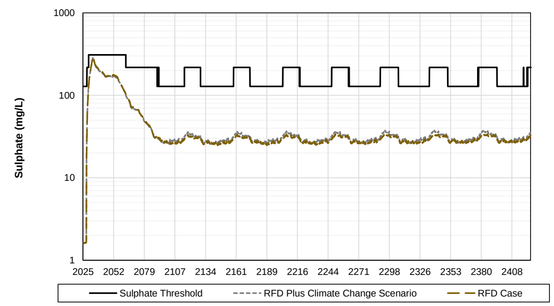
Patterson Lake North Arm – East Basin



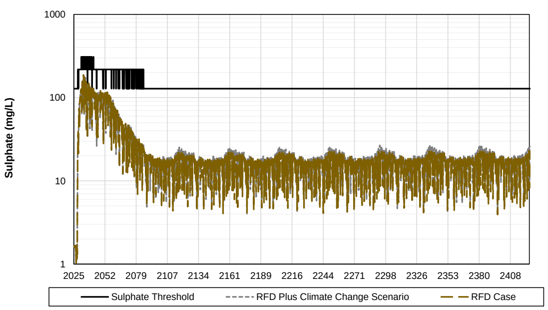
Patterson Lake North Arm – West Basin



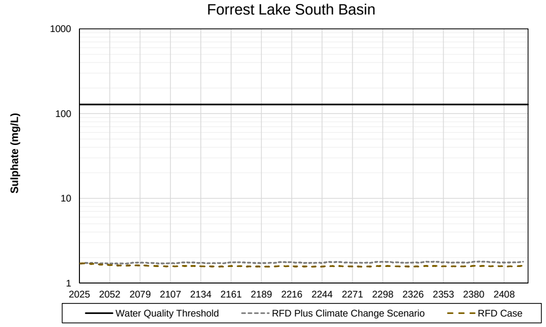
Patterson Lake South Arm



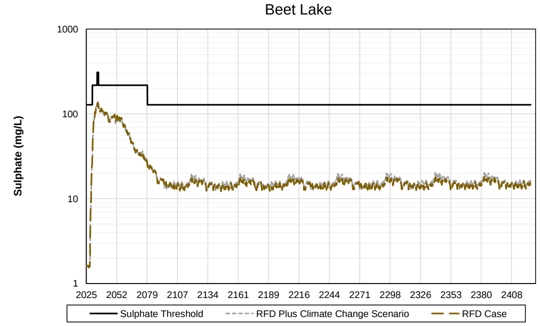
Forrest Lake North Basin



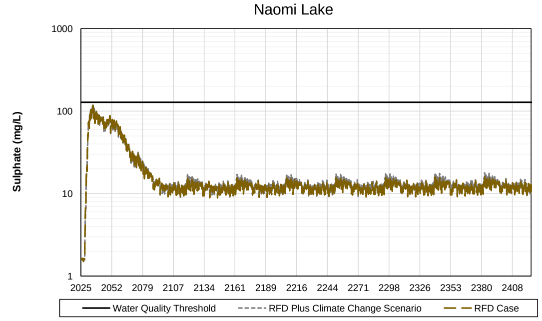
Forrest Lake South Basin

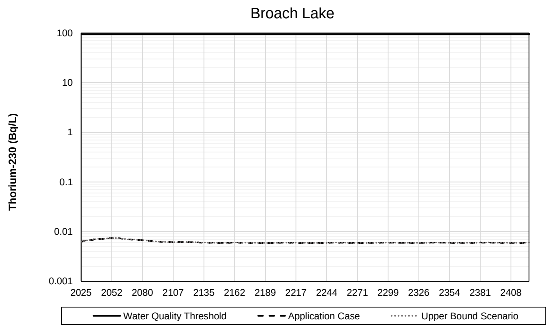


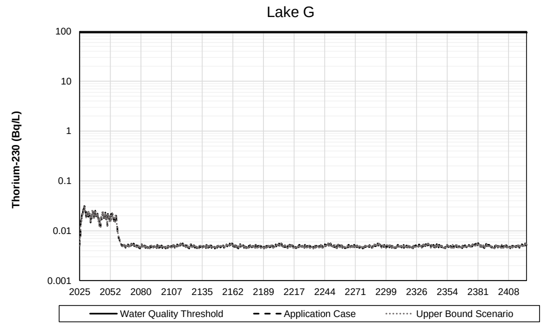
Beet Lake

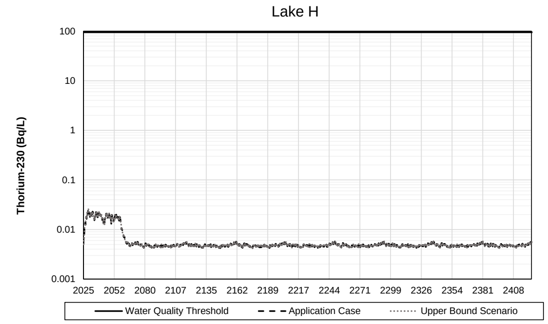


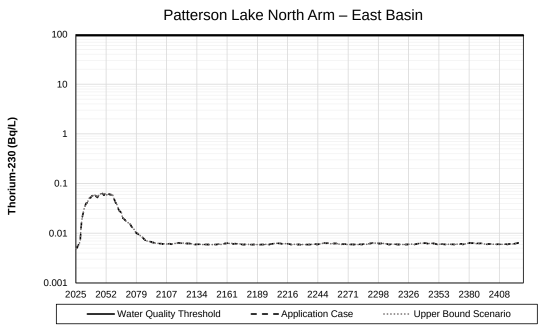
Naomi Lake

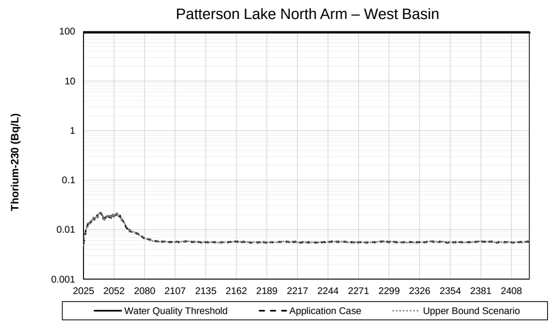


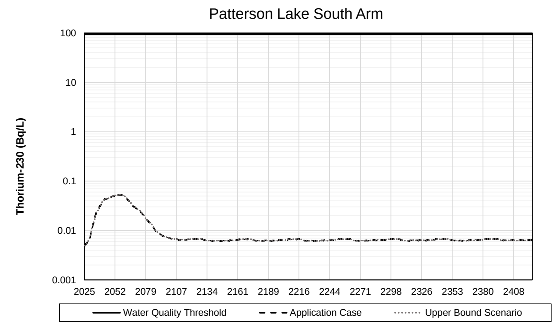

Broach Lake
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

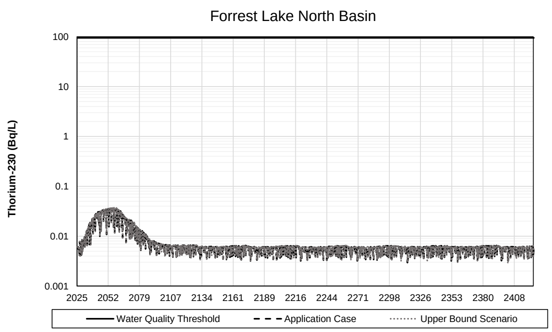

Lake G
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

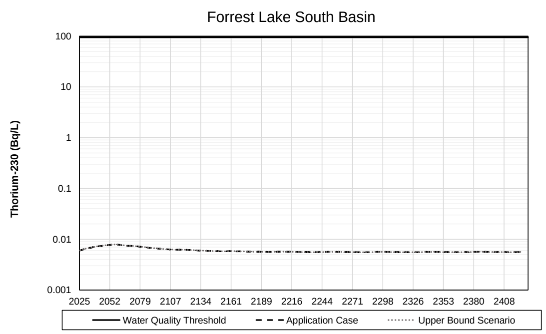

Lake H
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

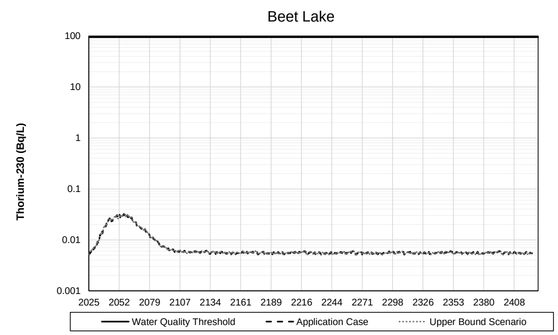

Patterson Lake North Arm – East Basin
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

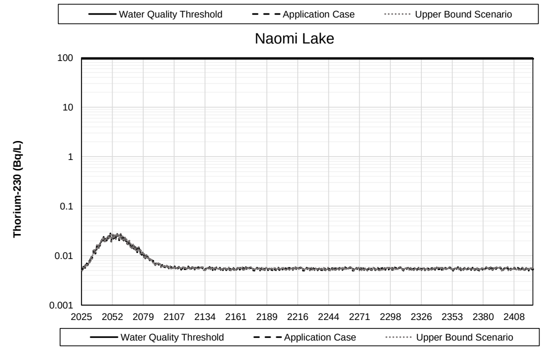

Patterson Lake North Arm – West Basin
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

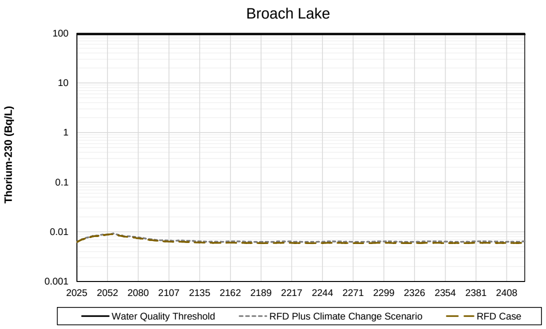

Patterson Lake South Arm
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

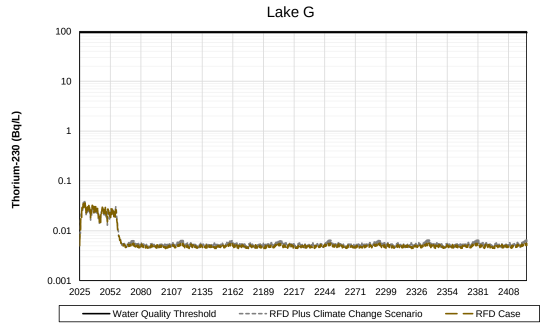

Forrest Lake North Basin
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

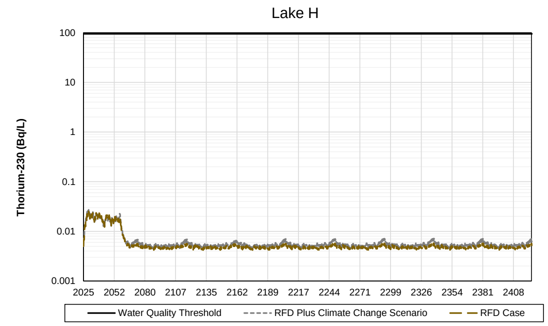

Forrest Lake South Basin
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

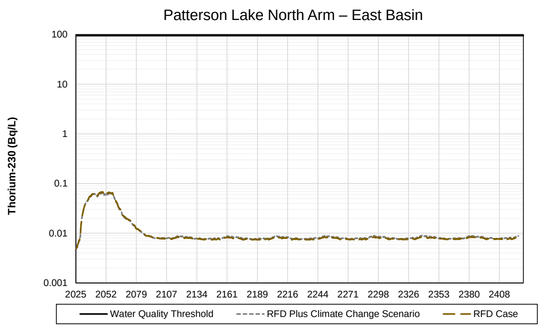

Beet Lake
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

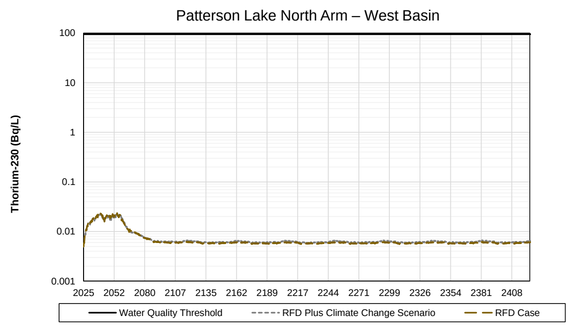

Naomi Lake
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

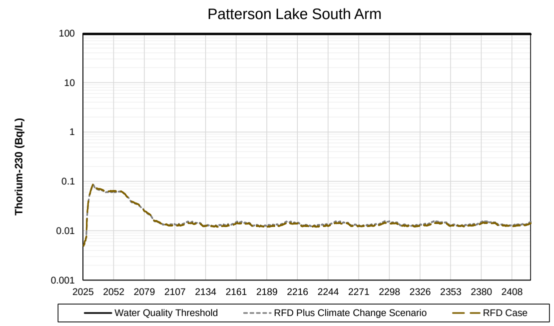

Broach Lake
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

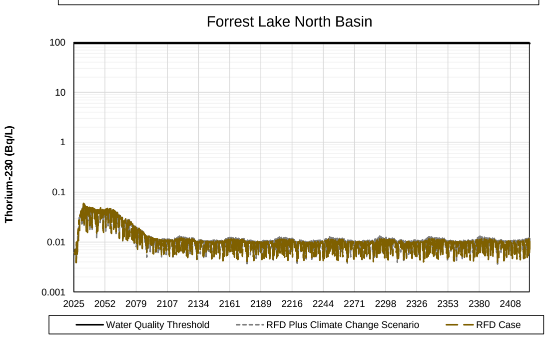

Lake G
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

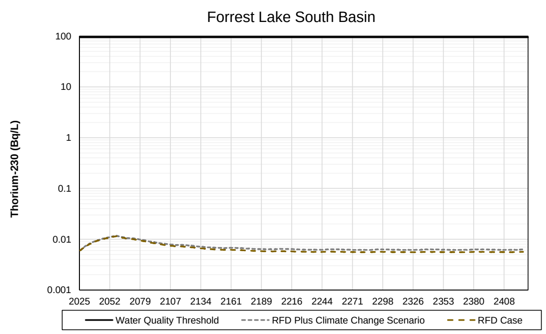

Lake H
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

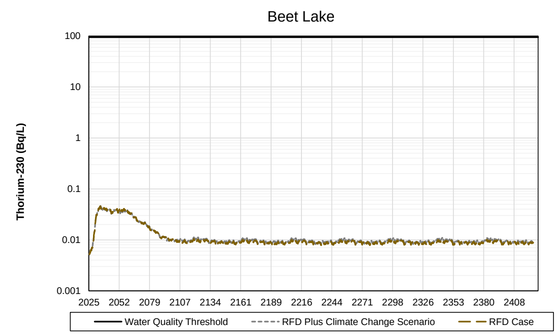

Patterson Lake North Arm – East Basin
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

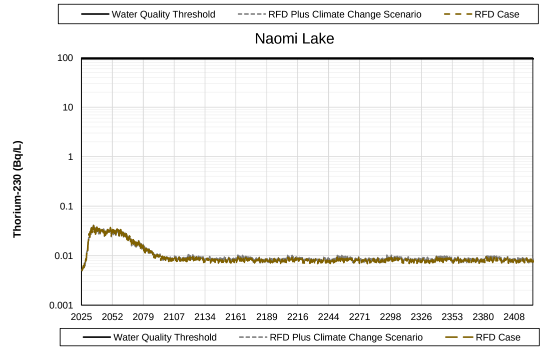

Patterson Lake North Arm – West Basin
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

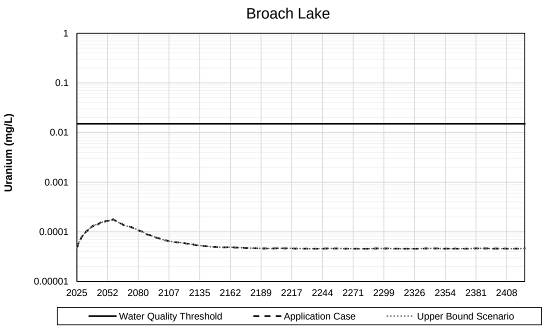

Patterson Lake South Arm
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

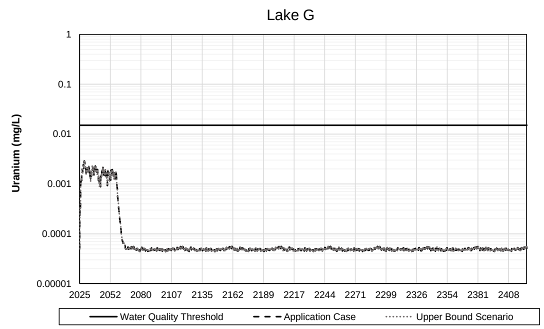

Forrest Lake North Basin
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

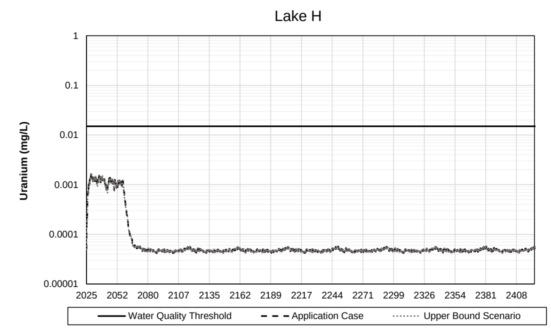

Forrest Lake South Basin
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

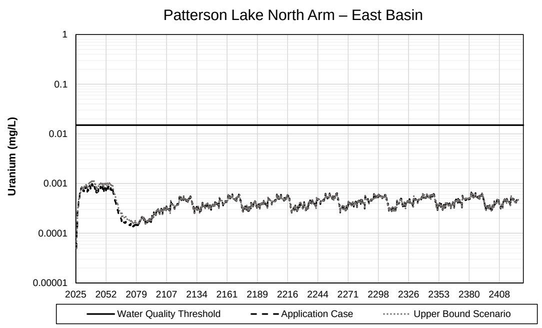

Beet Lake
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

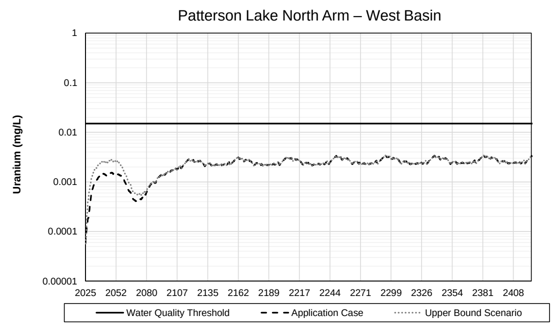

Naomi Lake
Thorium-230 (Bq/L)
100
10
1
0.1
0.01
0.001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

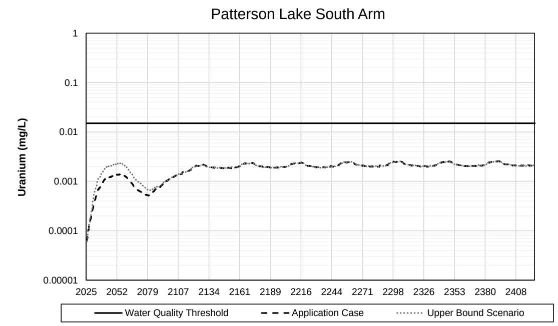

Broach Lake
Uranium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

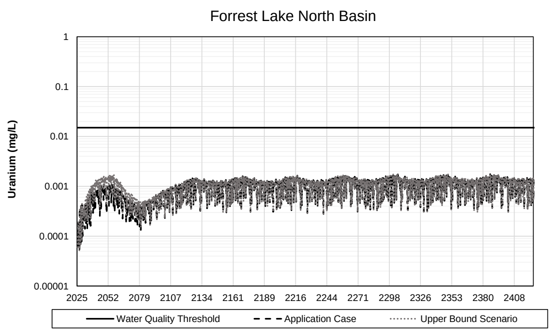

Lake G
Uranium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

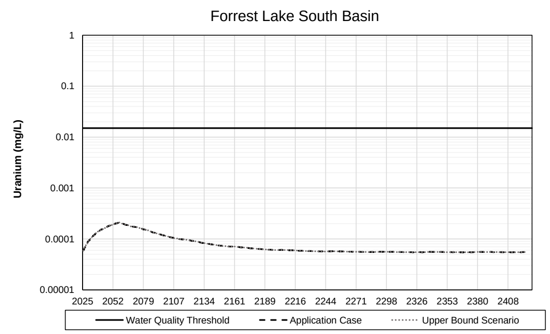

Lake H
Uranium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario

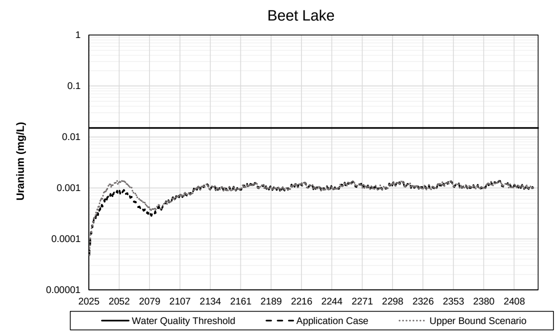

Patterson Lake North Arm – East Basin
Uranium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Patterson Lake North Arm – West Basin
Uranium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Patterson Lake South Arm
Uranium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Forrest Lake North Basin
Uranium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Forrest Lake South Basin
Uranium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Beet Lake
Uranium (mg/L)
1
0.1
0.01
0.001
0.0001
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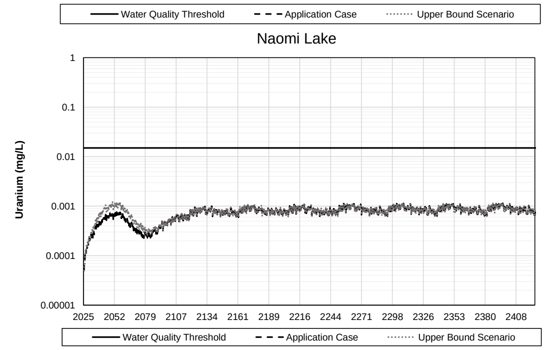
Water Quality Threshold
Application Case
Upper Bound Scenario


Naomi Lake
Uranium (mg/L)
1
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0.001
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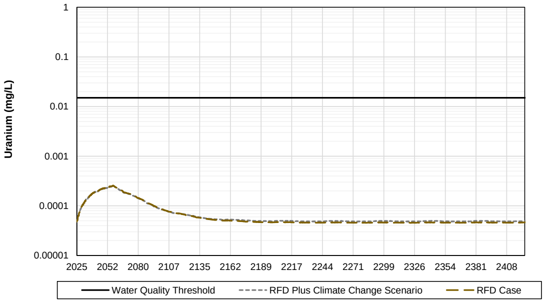
Water Quality Threshold
Application Case
Upper Bound Scenario

Broach Lake



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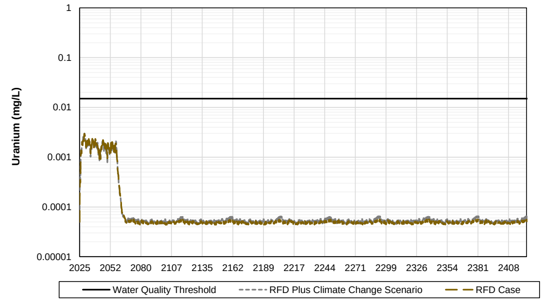

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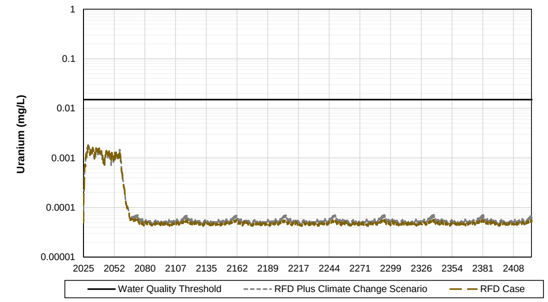

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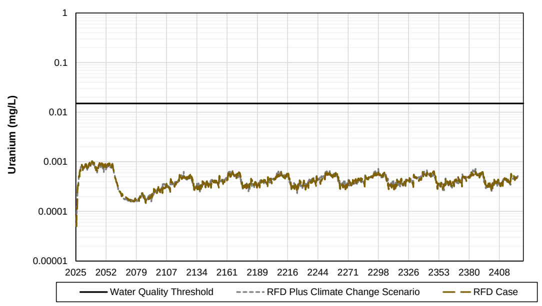

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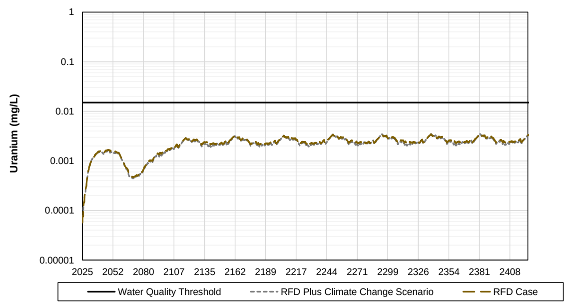

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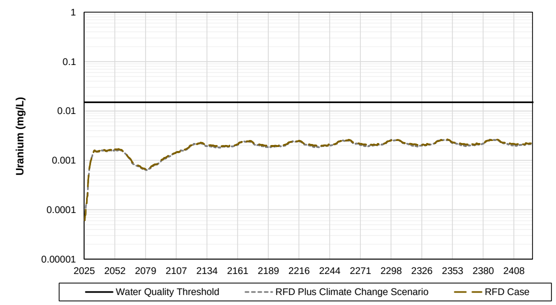
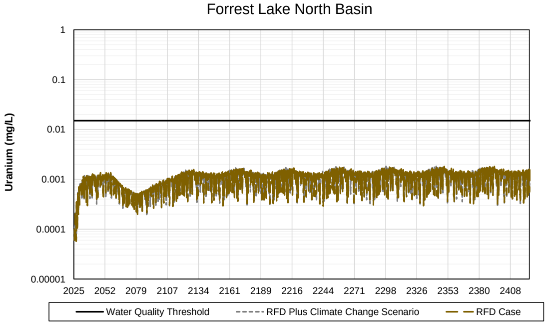


Forrest Lake North Basin



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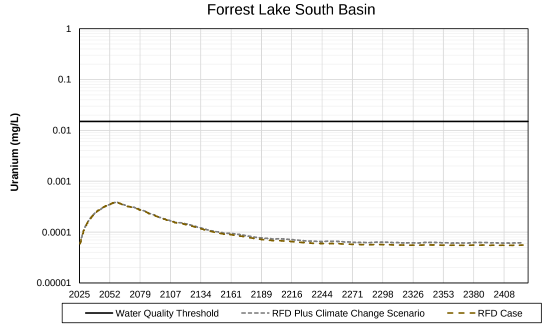

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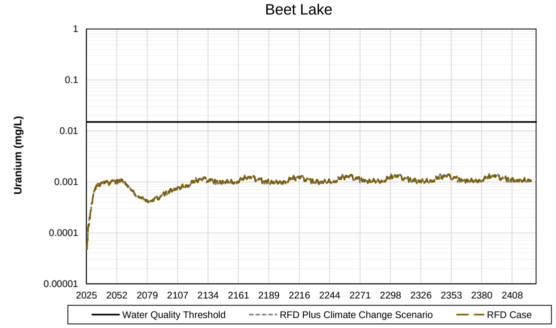
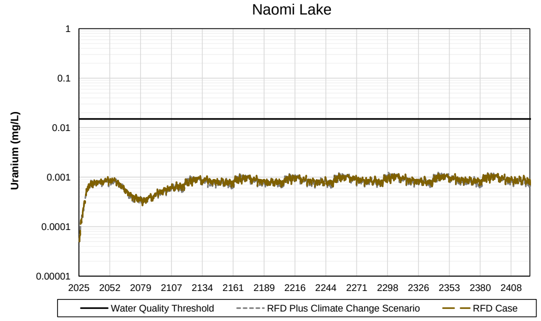
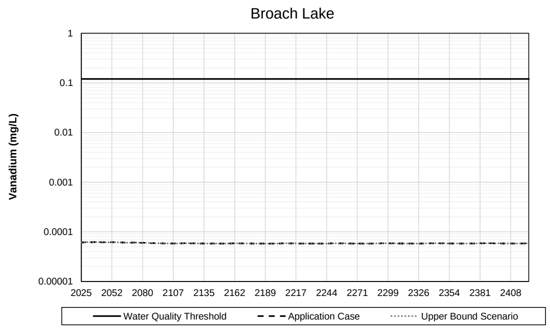
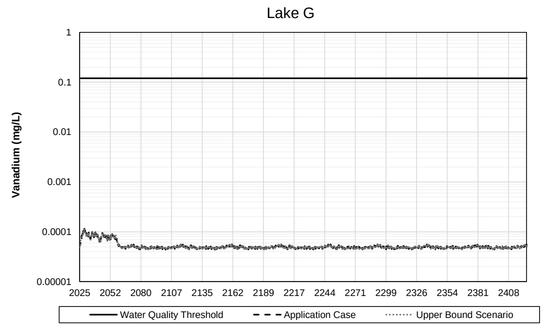
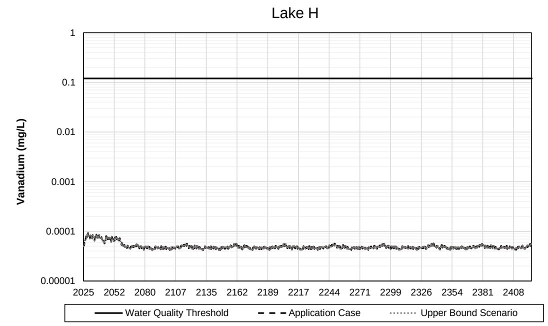


Naomi Lake




Broach Lake
Vanadium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Lake G
Vanadium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Lake H
Vanadium (mg/L)
1
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0.01
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0.0001
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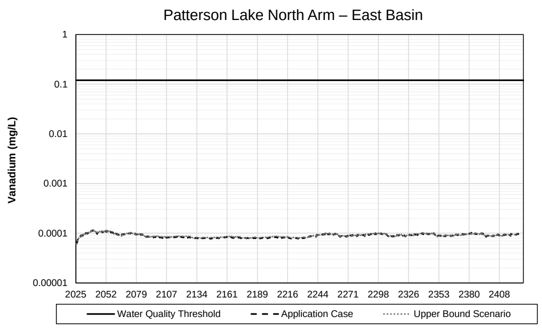
Water Quality Threshold
Application Case
Upper Bound Scenario


Patterson Lake North Arm – East Basin
Vanadium (mg/L)
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0.01
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0.0001
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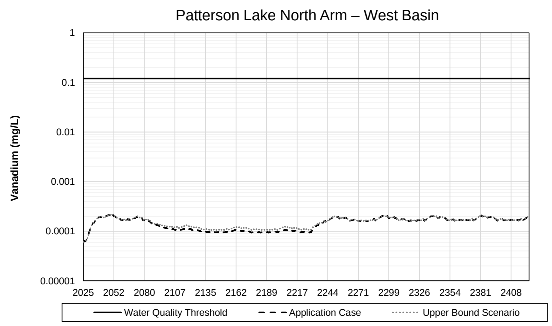
Water Quality Threshold
Application Case
Upper Bound Scenario


Patterson Lake North Arm – West Basin
Vanadium (mg/L)
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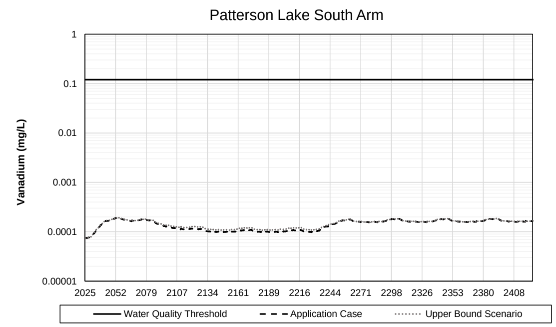
2025 2052 2080 2107 2135 2162 2189 2217 2244 2271 2299 2326 2354 2381 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Patterson Lake South Arm
Vanadium (mg/L)
1
0.1
0.01
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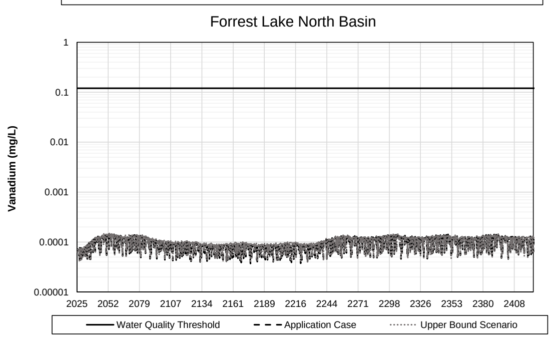
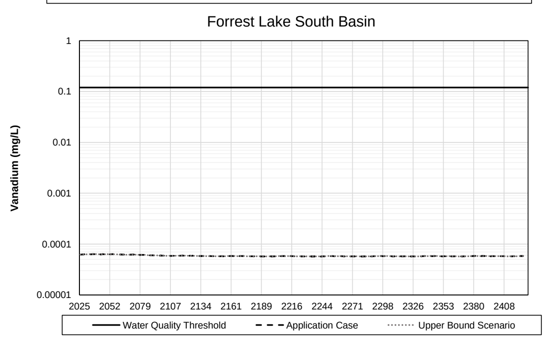
Water Quality Threshold
Application Case
Upper Bound Scenario


Forrest Lake North Basin
Vanadium (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
Application Case
Upper Bound Scenario


Forrest Lake South Basin
Vanadium (mg/L)
1
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0.01
0.001
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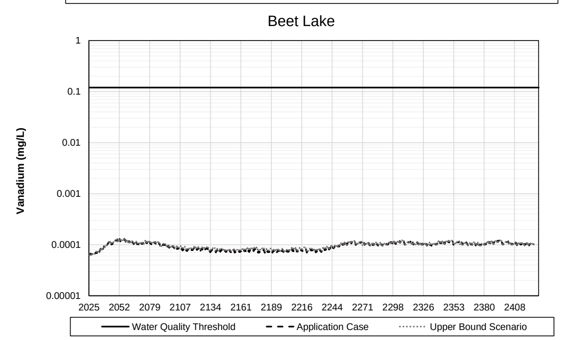
Water Quality Threshold
Application Case
Upper Bound Scenario


Beet Lake
Vanadium (mg/L)
1
0.1
0.01
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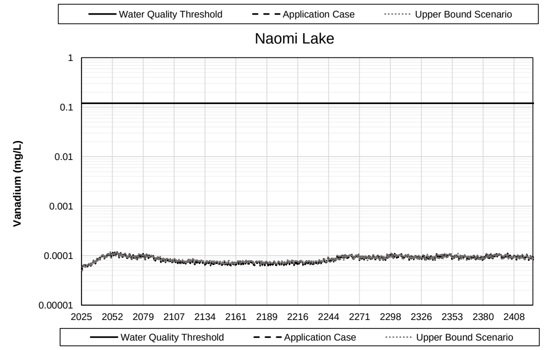
Water Quality Threshold
Application Case
Upper Bound Scenario


Naomi Lake
Vanadium (mg/L)
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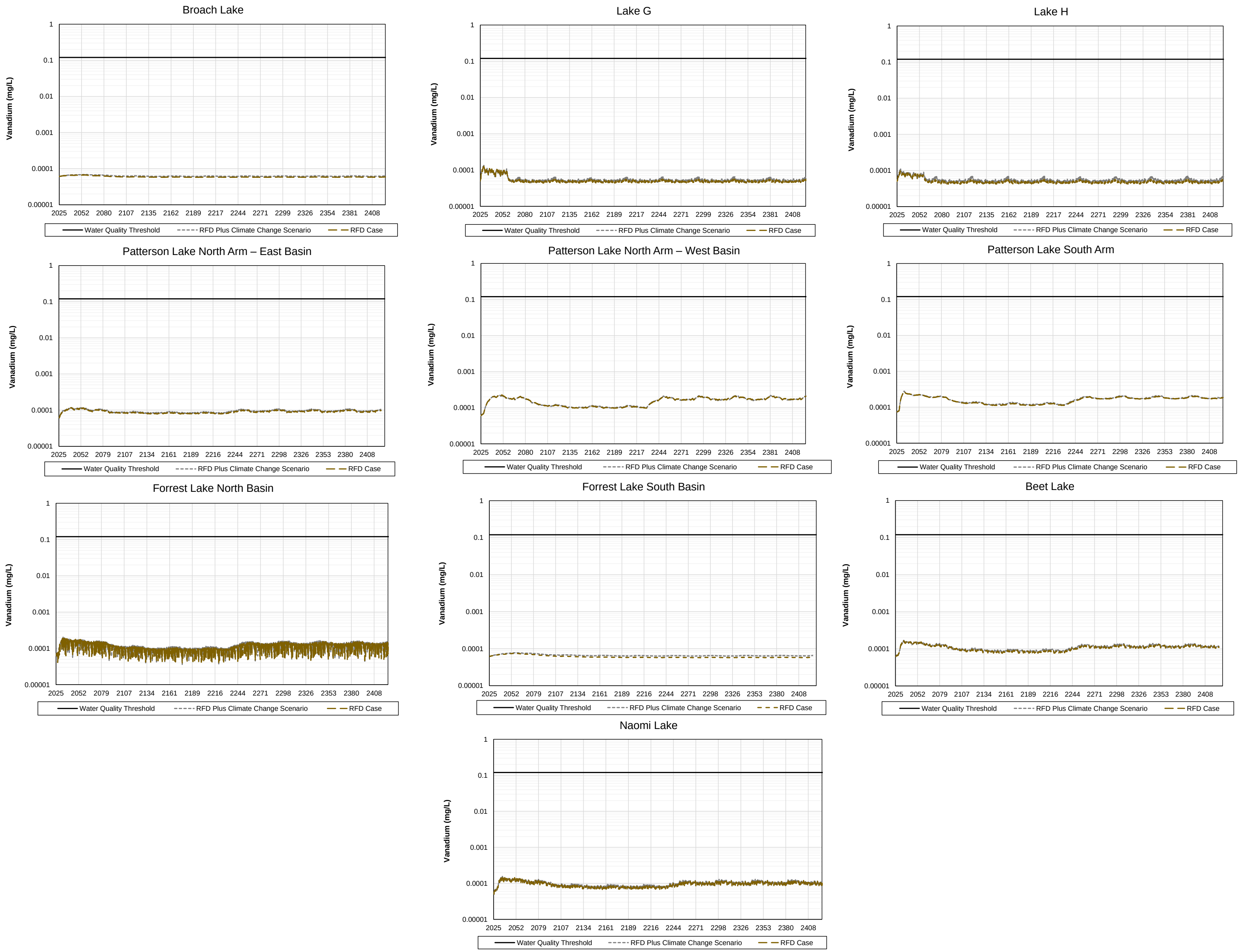
Water Quality Threshold
Application Case
Upper Bound Scenario


Broach Lake
Lake G
Lake H
Patterson Lake North Arm – East Basin
Patterson Lake North Arm – West Basin
Patterson Lake South Arm
Forrest Lake North Basin
Forrest Lake South Basin
Beet Lake
Naomi Lake
Vanadium (mg/L)
1
0.1
0.01
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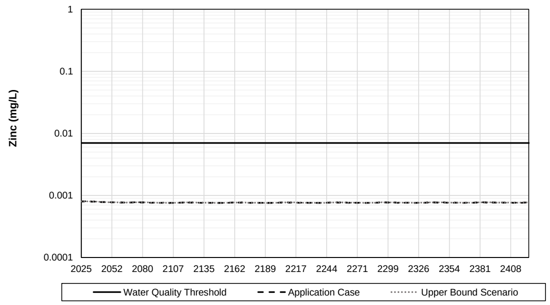
0.0001
0.00001
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

Broach Lake



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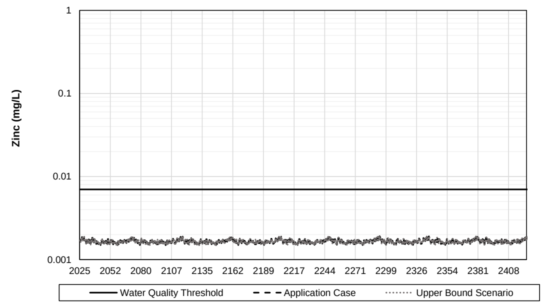

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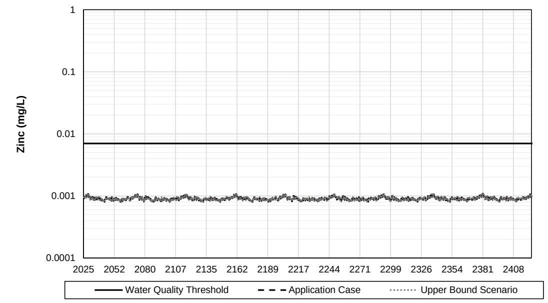

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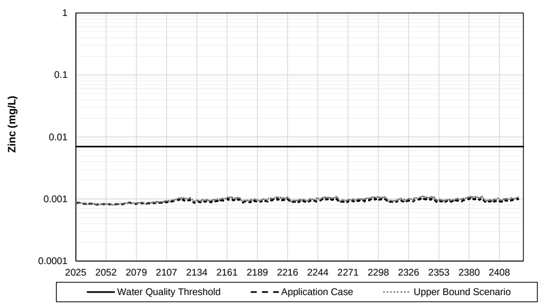

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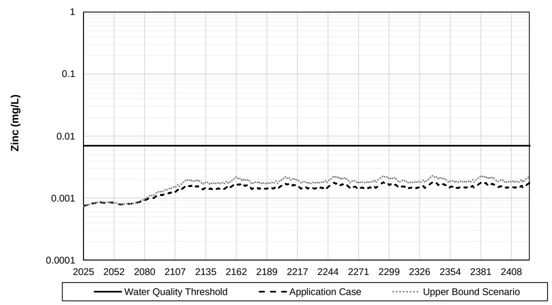
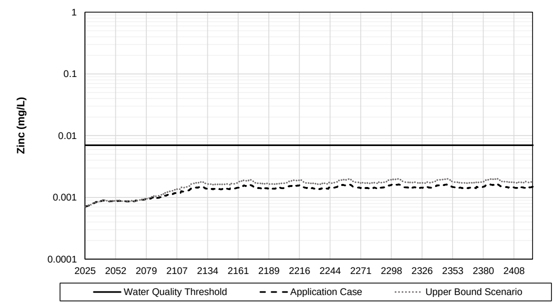
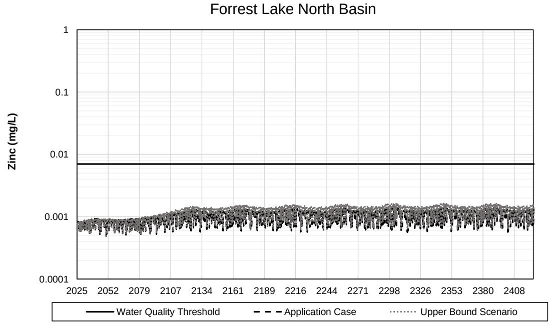


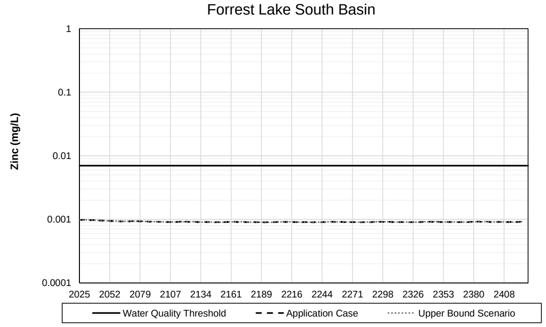
Patterson Lake South Arm



Forrest Lake North Basin



Forrest Lake South Basin



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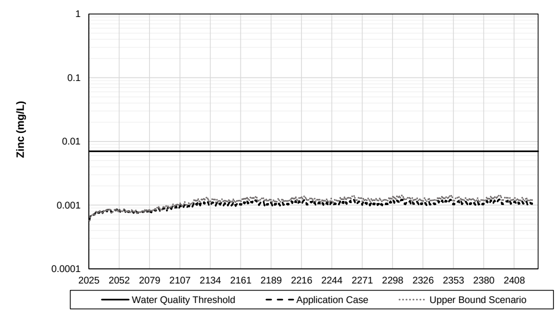
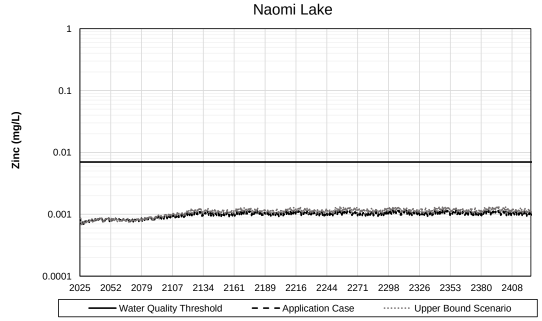
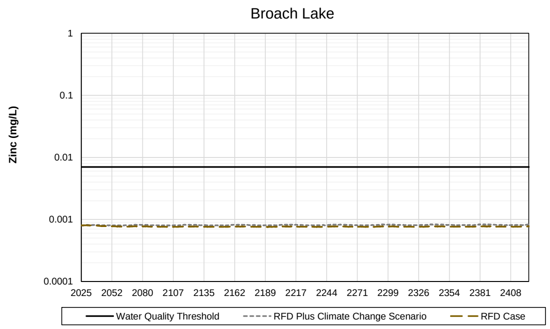


Naomi Lake




Broach Lake
Zinc (mg/L)
1
0.1
0.01
0.001
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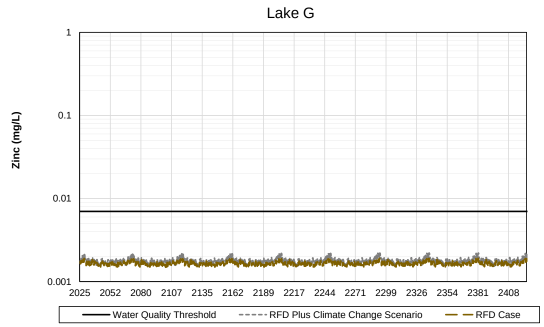
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Lake G
Zinc (mg/L)
1
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0.01
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Water Quality Threshold
RFD Plus Climate Change Scenario
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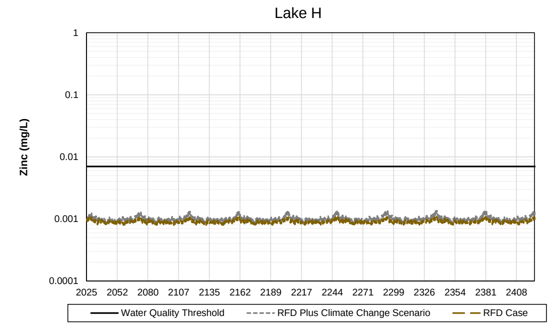
Lake H
Zinc (mg/L)
1
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0.01
0.001
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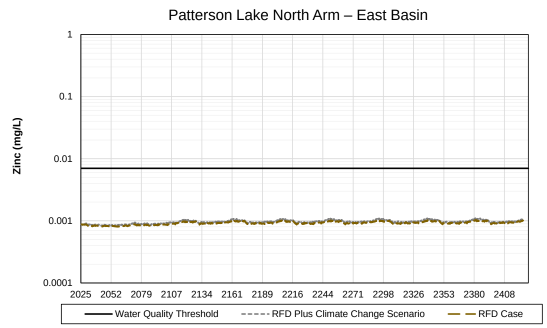
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake North Arm – East Basin
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0.01
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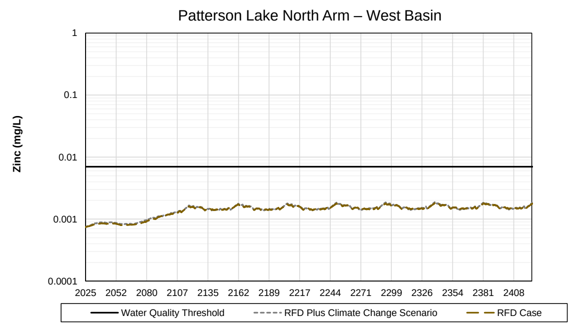
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake North Arm – West Basin
Zinc (mg/L)
1
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0.01
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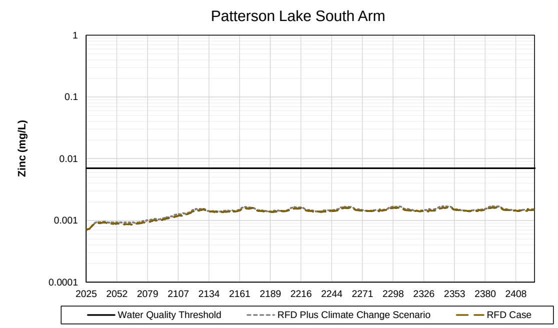
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Patterson Lake South Arm
Zinc (mg/L)
1
0.1
0.01
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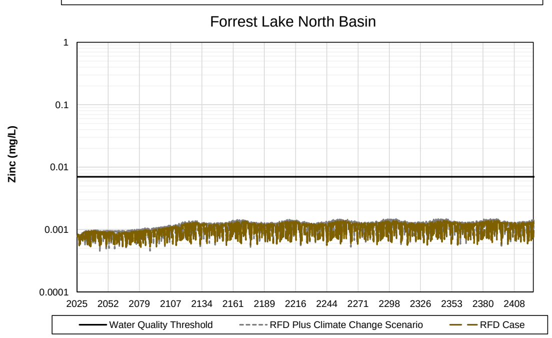
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case


Forrest Lake North Basin
Zinc (mg/L)
1
0.1
0.01
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Water Quality Threshold
RFD Plus Climate Change Scenario
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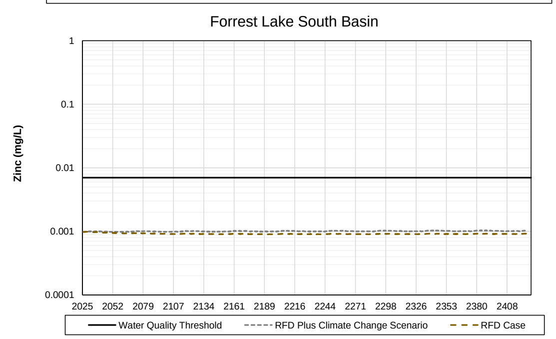
Forrest Lake South Basin
Zinc (mg/L)
1
0.1
0.01
0.001
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2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
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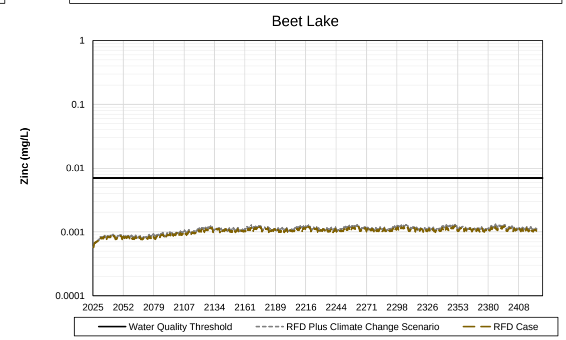
Beet Lake
Zinc (mg/L)
1
0.1
0.01
0.001
0.0001
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Water Quality Threshold
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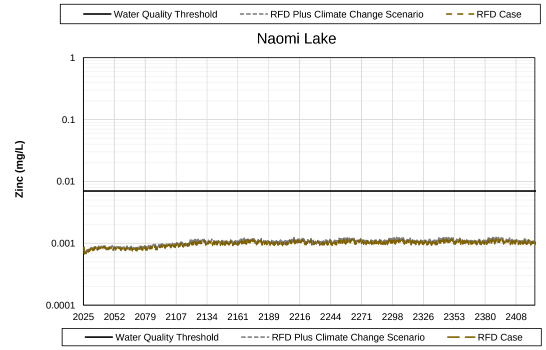
RFD Case


Naomi Lake
Zinc (mg/L)
1
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0.01
0.001
0.0001
2025 2052 2079 2107 2134 2161 2189 2216 2244 2271 2298 2326 2353 2380 2408
Water Quality Threshold
RFD Plus Climate Change Scenario
RFD Case

Appendix 10B Thallium Supplement

Abbreviations and Units of Measure

Abbreviation	Definition
BATTEA	Best Available Technology and Techniques Economically Available
CCME	Canadian Council of Ministers of the Environment
COPC	constituent of potential concern
CNSC	Canadian Nuclear Safety Commission
EA	Environmental Assessment
EIS	Environmental Impact Statement
LSA	local study area
MDMER	Metal and Diamond Mining Effluent Regulations
NexGen	NexGen Energy Ltd.
Project	Rook I Project
RSA	regional study area
TSD	Technical Support Document
WSA	Saskatchewan Water Security Agency

Unit	Definition
%	percent
<	less than
µg/L	micrograms per litre

Table of Contents

List of Tables

10B1 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 proposed Project is subject to both provincial and federal Environmental Assessment (EA) processes, would be licensed as a nuclear facility by the Canadian Nuclear Safety Commission (CNSC), and would be subject to various provincial and federal permits and approvals.

In support of the EA for the Project, NexGen prepared an Environmental Impact Statement (EIS). As part of the EIS, thallium was evaluated as a constituent of potential concern (COPC) but was not carried forward (i.e., was screened out) in the comprehensive list of COPCs for the surface water quality assessment as baseline concentrations were consistently low and initial model estimates of concentrations in the treated discharges were below applicable thresholds (EIS Section 10.2.8.2.1, Surface Water Quality Constituents of Potential Concern). Appendix 10B, Thallium Supplement, validates the results of the screening as presented in EIS Section 10.2.8.2.1 (i.e., confirms that thallium does not represent a COPC for the Project) through the completion of more recent baseline and geochemical test work that has been ongoing since the completion of the screening originally conducted as part of the Project EA.

The Thallium Supplement includes background on how thallium was considered in the EIS, validation of how thallium was screened as a COPC for the Project, and follow-up monitoring proposed for the Project specific to thallium.

10B2 THALLIUM IN THE ENVIRONMENTAL IMPACT STATEMENT

In EIS Section 10, Surface Water Quality and Sediment Quality, NexGen presented a multi-step process to:

- characterize existing conditions in the environment (EIS Section 10.3, Existing Conditions);
- identify potential Project interactions and mitigations (EIS Section 10.4, Project Interactions and Mitigations);
- analyze and classify residual effects (EIS Section 10.5, Residual Effects Analysis);
- describe uncertainty and prediction confidence (EIS Section 10.6, Prediction Confidence and Uncertainty); and
- based on the previous steps, identify monitoring and follow-up programs (EIS Section 10.7, Monitoring, Follow-Up, and Adaptive Management).

The methods applied to complete this multi-step process are outlined in EIS Section 10.2, Component Methods.

As described in EIS Section 10.2.2.2, Measurement Indicators, measurement indicators were used to characterize potential changes to surface water quality. Measurement indicators included:

- **Water quality constituent concentrations (i.e., risk to aquatic and terrestrial life):** includes nutrient, major ion, trace metal, and radionuclide concentrations in waterbodies and watercourses, which are compared to water quality thresholds (e.g., guidelines, objectives, standards) that apply to the protection of aquatic life and terrestrial life.

- **Drinking water quality constituent concentrations:** includes major ion, trace metal, and radionuclide concentrations in waterbodies and watercourses, which are compared to Canadian drinking water quality thresholds.
- **Productivity status constituent concentrations:** includes total phosphorus concentrations in waterbodies and watercourses, which are compared to Canadian waterbody trophic status[1] thresholds.

A series of water quality models were applied to predict constituent concentrations at various locations in the environment as described in EIS Section 10.2.8.1, Water Quality Model Development and Integration. These water quality models incorporated measured baseline data as described in EIS Section 10.2.6, Existing Conditions, and detailed in EIS Annex V.1, Aquatic Environmental Baseline Report. Project activities were included in the water quality models to predict potential effects to the receiving environment under different time frames and Project development scenarios.

The full list of constituents considered in the measurement indicators was reduced to a list of COPCs as described in EIS Section 10.2.8.2, Constituents of Potential Concern. The COPCs are a focused list of constituents determined through a screening process that potentially pose a risk to aquatic life, terrestrial life, and/or human health. Through this screening process, thallium was evaluated as a COPC but was not carried forward in the surface water quality assessment (EIS Section 10.2.8.2.1) because:

- thallium was not identified as a deleterious substance under Metal and Diamond Mining Effluent Regulations (MDMER);
- where source term data were available, thallium concentrations were generally non-detectable and below current applicable guidelines; and
- where source term data for thallium were not available, it was assumed based on the available source data that any contributions from other sources would similarly be negligible.

10B3 VALIDATION OF THALLIUM SCREENING CONDUCTED IN ENVIRONMENTAL IMPACT STATEMENT

To confirm that thallium does not represent a COPC for the Project, further details are provided in Section 10B3 regarding the original screening of thallium as a COPC. This information supplements the discussion in EIS Section 10.2.8.2 and includes a comparison against more recent baseline and geochemical test work datasets that have been ongoing since the completion of the screening originally conducted as part of the Project EA.

10B3.1 Project Thresholds

To understand the potential environmental effects associated with Project activities, the concentrations of water quality, drinking water quality, and productivity status constituents that were predicted by water quality models under development scenarios were compared to environmental thresholds. A set of Project thresholds was derived according to the hierarchy described in EIS Section 10.2.8.3.1, Water Quality Thresholds. The selected thresholds generally consisted of the most stringent chronic (i.e., long-term) water quality guidelines for the

[1] Trophic status describes and classifies waterbodies and watercourses (e.g., lakes and rivers) based on their ability to support aquatic ecosystems (i.e., primary productivity). The ability of a lake to support aquatic biota, such as plants and algae, is dependent on nutrient concentrations and physical conditions, primarily phosphorus and nitrogen nutrients and water clarity, respectively. In Canadian waters, particularly waterbodies on the Canadian Shield, phosphorus is characterized as the principal limiting factor (i.e., limiting nutrient) for primary productivity (CCME 2004).

protection of aquatic life sourced from either the Canadian Environmental Quality Guidelines for the protection of aquatic life (Canadian Council of Ministers of the Environment [CCME] 2021) or the Saskatchewan provincial objectives (Saskatchewan Water Security Agency [WSA] 2015, 2017). NexGen notes that in some cases, guidelines were not available for a given constituent and other thresholds were adopted; however, this condition is not relevant to thallium.

There is no Saskatchewan surface water quality objective for thallium; therefore, the CCME guideline of 0.8 micrograms per litre (µg/L; CCME 1999) was applied as the Project threshold.

Once derived, Project thresholds were applied in four main ways in the EIS:

- to select COPCs (EIS Section 10.2.8.2);
- to characterize existing conditions (EIS Section 10.3.1, Water Quality and EIS Annex V.1);
- to assess residual effects of the Project on surface water quality (EIS Section 10.5); and
- to derive preliminary environmental release targets (EIS Technical Support Document [TSD] XVIII, Site-Wide Water Balance and Water Quality Modelling Report, Appendix H, Section 3.0).

10B3.1.1 Metal and Diamond Mining Effluent Regulations Limits

In addition to the Project thresholds, environmental release targets are limited to the lowest value of those derived from Project thresholds and end-of-pipe limits, including limits described in Schedule 4 (Maximum Authorized Concentrations of Prescribed Deleterious Substances) of the Metal and Diamond Mining Effluent Regulations (MDMER) (Government of Canada 2023). The MDMER Schedule 4 limits exist for Prescribed Deleterious Substances listed in Section 3 (Analytical Requirements for Metal or Diamond Mining Effluent) of the MDMER.

Thallium is not a Prescribed Deleterious Substance under Section 3 of the MDMER; thus, the MDMER Schedule 4 does not apply to thallium. However, thallium is listed in Schedule 5 (Environmental Effects Monitoring Studies) of the MDMER as required for effluent monitoring and thus would be applicable to effluent monitoring for the Project, as explained in Section 10B4 of this memorandum.

10B3.2 Baseline Concentrations

Baseline concentrations of thallium in rivers and lakes within the Project local study area (LSA) and regional study area (RSA) are provided in EIS Annex V.1. As listed in Table 3.2-2 of EIS Annex V.1, total and dissolved thallium were measured at all aquatic baseline stations in 2018, 2019, and 2020. Detailed water chemistry results are provided in Appendix C of EIS Annex V.1; the results demonstrate that thallium was consistently below the detection limit of 0.2 µg/L (i.e., at least 4 times lower than the CCME guideline) in all rivers and lakes in the area of the Project. The baseline dataset included 415 measured values from 4 watercourses and 11 waterbodies (EIS Annex V.1, Table 3.2-1). Ongoing baseline data collection has validated these measured concentrations, with an additional 480 data points below 0.2 µg/L recorded in 2021, 2022, and 2023.

10B3.3 Rook I Project Sources to Effluent

As noted in the CCME fact sheet on thallium:

> Thallium is rarely present as large ore deposits, but can be recovered from sulphide ores of lead, copper, and zinc and may also be associated with cadmium, iron, and potassium minerals such

as feldspars and micas. Thallium minerals such as crookesite, hutchinsonite, lorandite, and avicennite occur naturally but are rare (CCME 1999).

As these minerals were not detected in the Arrow deposit mineralogy (see Section 5.1.1 and 5.2.1 of the Rook I Project – Geochemical Characterization of Waste Rock [SRK 2023] and EIS Annex XI, Geology Baseline Report), thallium is not expected to be present in quantities that pose a potential environmental risk. The CCME (1999) fact sheet further states that "*[n]atural inputs of thallium to aquatic environments occur by weathering processes and are not considered toxicologically significant*". As there are no imports of thallium to Project for industrial use, there is no conceptual pathway for thallium enrichment or contamination at the Project site.

The lack of a conceptual pathway for a source of thallium to the environment from Project activities is confirmed by monitoring data from all types of materials that could contribute to effluent during Construction, Operations, Decommissioning and Reclamation (i.e., Closure), and post-closure. Relevant environmental media have been sampled and analyzed for a suite of metals to screen and assess environmental risk, including data presented in the EIS and ongoing characterization work, as presented in Table 10B3-1.

Table 10B3-1: Summary of Measured Water Concentrations of Thallium in Receiving Environment and Potential Future Sources of Effluent

Environmental Medium	Reported in Draft EIS	Validation Data Measured Since Draft EIS
Baseline data from waterbodies and watercourses in the LSA and RSA	415 values from 4 watercourses and 11 waterbodies measured from 2018 to 2020 reported as <0.2 µg/L. **Reference:** EIS Annex V.1, Appendix C.	480 values from 4 watercourses and 14 waterbodies measured from 2021 to 2023 reported as <0.2 µg/L.
Site runoff	-	9 measured values from 3 stations in 2023, all 9 reported as <0.2 µg/L.
Groundwater in glacial drift and bedrock monitoring wells	142 of 147 values measured in 2017 to 2020 below 0.8 µg/L. The five samples above 0.8 µg/L were all from the first sample collected in each well, likely reflecting well development conditions and not local groundwater concentrations. **Reference:** EIS Annex III (Hydrogeology Baseline Report).	130 samples collected in 2021 to 2023, all below <0.2 µg/L, confirming that: (1) thallium is not measurable in groundwater in the LSA; and (2) first samples from each well likely was not representative.
Groundwater in Westbay well GAR-19-035 (i.e., representing mine development area)	1 measurement from each of 10 depth zones in 2020, all reported as <20 µg/L. **Reference**: EIS Annex III.	7 seasonal samples from each of 10 depths (i.e., 70 samples) from 2020 to 2023, all reported as <0.2 µg/L to <20 µg/L, as detection limits improved with time.
Humidity cells of UGTMF and mine development area for waste rock characterization	262 samples measured in leachate from 13 humidity cells over 56 weeks; all values <0.8 µg/L, with most values reported as <0.005 µg/L. **Reference:** Raw data to support EIS TSD XVII (Waste Rock and Underground Wall Rock Source Term Predictions Report); data not presented in TSD XVII.	304 samples measured in leachate from 9 humidity cells over subsequent 179 weeks; all values <0.8 µg/L, with most values <0.005 µg/L.
Overburden and cover materials	Shake flask extraction leachate of four samples of borrow material in 2021; all four were <0.2 µg/L. **Reference:** Okane (2020) that is referenced in TSD XVIII.	20 samples measured from each of 3 humidity cells over 35 weeks. All 60 values are <0.02 µg/L (52/60 are <0.005 µg/L).

µg/L = micrograms per litre; < = less than; LSA = local study area; RSA = regional study area; TSD = Technical Support Document; UGTMF = underground tailings management facility.

10B3.4 Conclusions of Constituent of Potential Concern Screening

Data gathered for the EIS and more recent data measured from 2021 to 2023 validate the exclusion of thallium as a COPC for the EIS. Reported values are below detection limits. While detection limits vary, the vast majority of data points are below the CCME guideline and, in many cases, orders of magnitude below the CCME guideline. Therefore, there is negligible potential for adverse effects to surface water quality as a result of inputs of thallium to the receiving environment from the Rook I Project.

By extension, there is no need to develop environmental release targets for thallium. According to REGDOC-2.9.2, *Environmental Protection, Controlling Releases to the Environment* (CNSC 2021), which would be applied to Project effluents during licensing to guide the development of the Best Available Technology and Techniques Economically Available (BATTEA) and licensed release limits, thallium would not be defined as a substance that requires control because the data indicate no potential for environmental risk.

10B4 FOLLOW-UP MONITORING

Schedule 5, Part 1, Section 4(1) of the MDMER requires that thallium concentrations be measured as part of effluent characterization. Additionally, Schedule 3 of the MDMER prescribes analytical precision, accuracy, and detection limits for mine effluents; this schedule applies to thallium. The required detection limit for thallium is 0.4 µg/L, which is 50% of the CCME guideline value.

Compliance with the MDMER is a key consideration in the development of the Project effluent monitoring plan that will be applied to treated effluents, assuming approval by the CNSC, as part of licensing for each phase of the Project. Thallium would be monitored in the Project effluent treatment plant as per the requirements outlined in Schedule 3 and Schedule 5 of the MDMER. If monitoring detects increasing trends or values of thallium above the CCME guideline, thallium would be added as a COPC to the next update of the Environmental Risk Assessment, which would occur every five years.

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NexGen Energy Ltd.

Rook I Project

Environmental Impact Statement

Section 11 Fish and Fish Habitat

Submitted to:
Canadian Nuclear Safety Commission
Saskatchewan Ministry of Environment

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Executive Summary

Section Purpose

Section 11 of the Environmental Impact Statement (EIS) provides a comprehensive assessment of potential effects of the Rook I Project (Project) on fish and fish habitat. This assessment included consideration of both potential effects from the Project and cumulative effects from the Project and other reasonably foreseeable developments (RFDs). The fish and fish habitat assessment used widely accepted scientific practices and incorporated Indigenous and Local Knowledge.

Four fish species (i.e., lake trout, lake whitefish, walleye, and northern pike) represented valued components (VCs) in the Environmental Assessment (EA). The selection of these four VCs was based on the respective roles and linkages of each species in the ecosystem and food web, the high traditional and cultural importance of these species to local communities, and the species' presence within nearby waterbodies and watercourses. Additionally, these VCs were selected because they are strong indicators of broader species assemblages and ecosystems, and therefore are suitable for assessing both potential population-level effects and determining potential Project effects on overall biodiversity.

The assessment of potential effects on fish and fish habitat was informed by the assessments completed for air quality, hydrogeology, hydrology, and surface water quality, as well as the results of the Project ecological risk assessment (EcoRA). The fish and fish habitat assessment provided information that was used to support other VC assessments such as wildlife and wildlife habitat, human health, Indigenous land and resource use, and other land and resource use.

Setting

At a regional scale, the Project would be located within the southern Athabasca Basin adjacent to Patterson Lake, along the upper Clearwater River system, approximately 40 km east of the Saskatchewan-Alberta border and 640 km northwest of the city of Saskatoon.

The fish and fish habitat assessment focused on a local study area (LSA), which is in the area of the proposed Project where direct environmental effects would be most likely to occur, and a regional study area (RSA), where cumulative effects may occur. The LSA is the portion of the Clearwater River watershed extending from its headwaters to the outlet of Naomi Lake, representing a surface area of 685 km^2. The RSA includes the LSA and is defined by the portion of the Clearwater River watershed extending from its headwaters to its confluence with the Mirror River, representing a surface area of 1,076 km^2. Broach Lake is located in the northwest corner of both study areas and is considered to be the headwaters of the Clearwater River. The Clearwater River flows through a series of lakes including Patterson Lake, Forrest Lake, Beet Lake, and Naomi Lake. From Naomi Lake, the Clearwater River flows an additional 20 km southeast before reaching the Mirror River confluence. The LSA and RSA used for the assessment of fish and fish habitat are the same spatial boundaries as those used for other aquatic environment components (e.g., hydrology, surface water quality).

Existing Conditions (Section 11.3)

Fish and fish habitat conditions in the LSA and RSA were evaluated for several waterbodies, including Broach Lake, Patterson Lake, Forrest Lake, Beet Lake, and Naomi Lake, and sections of the Clearwater River mainstem. In total, 17 fish species were documented within these waterbodies.

The most abundant large-bodied species captured included white sucker, lake whitefish, yellow perch, longnose sucker, northern pike, walleye, burbot, and lake trout. Commonly captured small-bodied species included trout perch, spottail shiner, and lake chub. This species list is characteristic of northern temperate waterbodies and watercourses in Saskatchewan (Langhorne 2001). Of the 17 species identified, none were classified as species with a designated conservation status by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2021), aquatic species listed under the *Species at Risk Act,* or would be considered rare or unique to the area based on a review of Saskatchewan's Conservation Data Centre taxa lists (SKCDC 2021a).

The results of fish community sampling indicated that the four fish VCs are widely distributed throughout the LSA, with northern pike being the most ubiquitous (i.e., found everywhere) species captured. Lake whitefish, walleye, and northern pike were captured in all larger waterbodies sampled, as well as in the Clearwater River. Lake trout were somewhat less prevalent than the other VC species and were captured only in lake habitats.

Characteristics of surveyed lakes within the LSA include the following:

- surface areas between 0.6 km^2 and 42.8 km^2;
- average depths between 1.4 m and 26.5 m;
- mostly oligotrophic, indicating low levels of nutrients, deep and clear water conditions, and limited amounts of algae;
- riparian zones (i.e., the area along the edge of watercourses and water bodies) that typically consist of trees, shrubs, grasses, and sedges;
- bottom substrates predominantly composed of sand, rock, and organic matter; and
- abundant areas of rocky substrate identified within the littoral zones.

Characteristics of the Clearwater River mainstem within the LSA:

- generally shallow (i.e., <1 m deep);
- meandering channels with predominantly slow-moving glide (i.e., flat-water) habitat;
- limited deeper areas with slower-moving pool habitat and faster-flowing riffle and run habitat;
- riparian zones that typically consist of trees, shrubs, grasses, and sedges; and
- bottom substrates predominantly composed of sand with limited areas of rock and organic matter.

Lower trophic level communities such as plankton and benthic invertebrates were also characterized. Phytoplankton and zooplankton biomass and abundance was typically low in the sampled lakes, which is characteristic of northern oligotrophic lakes. Phytoplankton and zooplankton richness (i.e., the number of taxa present) and diversity were both moderate to high. The average density and richness of benthic invertebrates was also low and within the range typically observed for northern oligotrophic lakes, whereas diversity was moderate to high.

Potential Effects and Proposed Mitigations (Section 11.4)

An analysis was completed to evaluate Project components and activities and associated effects pathways that could potentially affect fish and fish habitat. The evaluation also considered similar combined effects from the Fission Patterson Lake South Property, the identified RFD for the fish and fish habitat assessment.

Project activities that would have the potential to affect fish and fish habitat during the Project lifespan include:

- changes in Patterson Lake surface water quality from effluent treatment plant and sewage treatment plant discharges;
- runoff from the Project footprint;
- Project-related air and dust emissions;
- runoff and seepage from the waste rock storage areas (WRSAs);
- long-term solute transport from the underground tailings management facility (UGTMF) and WRSAs;
- sediment release during in-water construction and from ground disturbance;
- changes to water flows and levels from site water management activities (e.g., water withdrawals, dewatering of the underground mine); and
- altered surface runoff conditions.

An additional potential Project effect is direct physical habitat loss and disturbance associated with the construction and operation of a fresh water intake, treated effluent diffuser, and treated sewage outfall in Patterson Lake. These Project components and activities also have the potential to change the availability of riparian zone vegetation adjacent to Patterson Lake.

Similar activities that could affect fish and fish habitat would be expected to occur for the Fission Patterson Lake South Property.

As part of the pathways analysis, proposed environmental design features and mitigation measures were considered to determine whether effects on fish VCs could be avoided or reduced to negligible, thereby removing the pathway.

Potential effects on fish VCs due to changes in surface water quality during the Project lifespan could be minimized by diverting water generated from undisturbed catchments adjacent to the Project footprint around the site, and by collecting and treating contact water (i.e., water that may have been altered by Project activities) as necessary prior to release to the environment. Proposed mitigations, such as the use of erosion and sediment control best management practices, limiting the disturbance area of Project components, and reclaiming and revegetating disturbed areas, would reduce effects on fish and fish habitat. Additionally, water management infrastructure would be designed to reuse and recycle water wherever possible to minimize the amount of fresh water withdrawn from Patterson Lake and reduce effects on downstream fish habitat.

Infrastructure such as the fresh water intake, treated effluent diffuser, and treated sewage outfall would be designed to minimize the physical footprint and associated habitat loss or disturbance in Patterson Lake. This in-water infrastructure would be located to avoid sensitive or unique habitats in Patterson Lake, to the extent feasible, and would be designed minimize effects on fish and fish habitat. The fresh water intake would be fitted with a fish screen to minimize the potential for fish to be drawn into the intake. Where possible, in-water construction associated with these developments would be scheduled to avoid sensitive spawning and egg-incubation periods for fish in Patterson Lake. NexGen would work with Fisheries and Oceans Canada to determine the need for a *Fisheries Act* Authorization application and offsetting plan for any of the proposed water management infrastructure.

After mitigation measures were considered, the pathways screening analysis determined that some of the potential pathways from the Project to the environment could be removed from the assessment. However, it was identified that the Project could still adversely affect fish and fish habitat from the following pathway:

- runoff and seepage from the WRSAs and groundwater flow from the UGTMF may alter surface water quality in Patterson Lake after Closure and adversely affect fish habitat availability, survival, and reproduction.

This pathway was carried forward into the residual effects analysis.

Residual Effects Analysis (Section 11.5)

A residual effects analysis was conducted to determine the potential effects on fish and fish habitat under two assessment cases: effects of the Project (i.e., Application Case), and combined effects of the Project and the Fission Patterson Lake South Property (i.e., RFD Case). The residual effects analysis considered three measurement indicators:

- habitat availability;
- habitat distribution; and
- survival and reproduction.

The residual effects analysis used a precautionary approach to assess the potential Project-related effects on fish VCs. The evaluation of effects on fish VCs was directly informed by the predictions generated other assessments, which included a similar level of conservatism:

- the surface water quality assessment;
- aquatic health assessment; and
- the EcoRA.

The RFD Case made similar assumptions and considered aspects of the Fission Patterson Lake South Property associated with site runoff from both an above-ground tailings management facility and a covered waste rock storage facility after closure as outlined in the Fission (2019) prefeasibility study.

The residual effects analysis for fish and fish habitat focused on describing the potential effects on fish and lower level trophic organisms that may occur due to changes in water quality after Closure and in the far future. The primary source of loading for constituents in the far future would be the seepage load through the groundwater flow path from stored mine waste on the Project footprint. Changes to water quality in the far future could alter the health of fish and lower trophic organisms that form the fish food base and the subsequent suitability of fish habitat in affected waterbodies and watercourses. These changes could also adversely affect the survival and reproduction of fish VC populations in the RSA or LSA.

In both the Application Case and RFD Case, concentrations of certain metals were predicted to increase in the receiving environment during the far-future modelling timeframe. Of these metals, only copper was predicted to exceed both water quality guidelines for the protection of aquatic life and reference values used in the EcoRA and aquatic health assessment. Therefore, the residual effects analysis focused on assessing the potential effects associated with exposure to elevated copper concentrations in the water column.

Predicted residual effects on fish VC habitat availability, habitat distribution, and survival and reproduction are summarized below, as well as climate change and biodiversity in relation to this assessment. Overall, the outcome of the residual effects analysis for the Application Case and RFD Case were very similar, and the predicted effects described below apply to both assessment cases.

Habitat Availability

The assessment indicated limited potential for changes in habitat availability due to exposure to predicted copper concentrations in Patterson Lake after Closure and in the far future. The results of the EcoRA and aquatic health assessment indicated that predicted copper concentrations would be unlikely to result in population-level and/or community-level effects on lower trophic organisms and forage fish. Additionally, the effects, if realized, would be spatially limited to Patterson Lake North Arm – West Basin. Therefore, adverse effects on the viability and suitability of habitats for use by fish VCs are considered unlikely, and any changes in habitat availability would unlikely be measurable.

Habitat Distribution

Fish would be able to continue using the habitats present and move between habitats to carry out their life processes (e.g., spawning, rearing, overwintering). No effects on habitat arrangement or the spatial distribution and movement of fish in Patterson Lake are expected to occur.

Survival and Reproduction

The survival and reproduction of fish VCs could be directly affected by exposure to copper in the water column or indirectly by changes in habitat availability resulting from potential effects on the lower trophic food base for fish, as described above.

The EcoRA and aquatic health assessment results indicated that effects on the health of fish due to direct exposure to copper in the water column, and therefore survival and reproduction, are not expected for predator fish (e.g., lake trout, walleye, northern pike) and are unlikely for forage fish (e.g., lake whitefish). As described above, only limited effects on the available food supply for fish are possible due to exposure of lower trophic level organisms and forage fish species to predicted copper concentrations. Additionally, these effects would be spatially limited to Patterson Lake North Arm – West Basin. Broad scale changes to the fish food base are not expected to occur. Therefore, any changes in habitat quality are considered unlikely to measurably affect the survival and reproduction of fish VCs.

Climate Change

Climate change effects on fish and fish habitat were considered through the inclusion of a climate change scenario in the surface water quality assessment, which informed the residual effects analysis for fish VCs. Projected future climate extremes indicate a future that is likely to be warmer and wetter on an annual basis. The results of the climate change sensitivity scenario indicated that, based on hydrological projections, climate change effects on surface water quality would be minor within the LSA and RSA. These minor changes in hydrologic conditions did not result in changes to constituent concentrations. Therefore, there would be no change to the predicted effects for fish VCs as outlined above.

Effects on Biodiversity

Effects on aquatic biodiversity were evaluated based on the completed fish VC assessment. The EcoRA and aquatic health assessment results indicated that, after Closure and in the far future, limited effects would be possible on individual taxa or species that may be sensitive to elevated copper concentrations in Patterson Lake.

However, based on the predicted level of exposure and limited spatial extent of elevated copper concentrations, population-level effects are not expected to occur. Therefore, the predicted effects of the Project and RFDs on aquatic biodiversity were considered negligible.

Significance Determination (Section 11.5)

The weight of evidence from the analysis predicts that changes to the habitat availability, habitat distribution, and survival and reproduction of fish VCs (i.e., lake trout, lake whitefish, walleye, northern pike) in the RSA would be within the resilience and adaptability limits for these VCs. The residual effects on fish VCs in the Application Case are predicted to be **not significant**.

The incremental and cumulative effects resulting from the Project, previous and existing developments, and the Fission Patterson Lake South Property on fish and fish habitat are also predicted to be **not significant**.

Prediction Confidence and Uncertainty (Section 11.6)

Overall, there was a moderate to high degree of confidence in the predictions related to the fish and fish habitat assessment. The degree of prediction confidence related to changes in fish VCs from water quality changes were higher during the Project lifespan than for predictions after Closure and in the far future. However, conservatism considered in other assessments and technical support documents, which provided the basis for the fish and fish habitat assessment (i.e., surface water quality assessment, aquatic health assessment, and EcoRA), improved the overall level of confidence that effects were not underestimated and were more likely overestimated.

Monitoring and Follow-Up (Section 11.7)

The Environmental Protection Program, Environmental Monitoring Plan, and associated environmental monitoring would be implemented to verify effects predictions and effectiveness of mitigation on fish and fish habitat, identify unanticipated effects, and apply adaptive management, if required. Monitoring would also be used to address residual uncertainty by evaluating changes to fish and fish habitat, including lower trophic level community conditions (e.g., benthic invertebrates), in the receiving environment.

Key components of aquatic ecology and environmental monitoring are expected to include water and sediment quality, benthic invertebrates, and fish. The Environmental Monitoring Plan would be developed in accordance with the Metal and Diamond Mining Effluent Regulations, the federal *Fisheries Act*, and conditions established through Project authorizations issued by the Canadian Nuclear Safety Commission and Saskatchewan Ministry of Environment.

Abbreviations and Units of Measure

Abbreviation	Definition
BLM	biotic ligand model
BNDN	Birch Narrows Dene Nation
BRDN	Buffalo River Dene Nation
BSA	baseline study area
CanNorth	CanNorth Environmental Services Ltd.
CCME	Canadian Council of Ministers of the Environment
CNSC	Canadian Nuclear Safety Commission
COPC	constituent of potential concern
CPUE	catch per unit effort
CRDN	Clearwater River Dene Nation
DFO	Fisheries and Oceans Canada
DL	detection limit
DO	dissolved oxygen
EA	Environmental Assessment
EEM	environmental effects monitoring
EcoRA	ecological risk assessment
EIS	Environmental Impact Statement
ENV	Saskatchewan Ministry of Environment
ERA	environmental risk assessment
ETP	effluent treatment plant
HDPE	high density polyethylene
HQ	hazard quotient
JWG	Joint Working Group
LSA	local study area
MDMER	Metal and Diamond Mining Effluent Regulations
MLR	multiple linear regression
MN-S	Métis Nation – Saskatchewan
NexGen	NexGen Energy Ltd.
NPAG	non-potentially acid generating
PAG	potentially acid generating
pH	potential of hydrogen; measure of the acidity or alkalinity of a solution on a scale of 0 to 14
Project	Rook I Project
RFD	reasonably foreseeable development
RMZ	regulated mixing zone
RSA	regional study area
RSWQM	regional surface water quality model
SARA	*Species at Risk Act*
SDI	Simpson's Diversity Index
SEI	Simpson's Evenness Index
STP	sewage treatment plant
TP	total phosphorus
TRV	toxicity reference value
TSD	technical support document
TSP	total suspended particulate
TSS	total suspended solids
UGTMF	underground tailings management facility
VC	valued component

Abbreviation	Definition
WRSA	waste rock storage area
YNLRO	Ya'thi Néné Lands and Resources Office

Unit	Definition
%	percent
°C	degrees Celsius
µg/L	micrograms per litre
µm	micron
µS/cm	microsiemens per centimetre
cm	centimetre
g	gram
g/m^2	grams per square metre
ha	hectare
kg	kilogram
km	kilometre
km/h	kilometres per hour
km^2	square kilometre
m	metre
m^2	square metre
m^3/d	cubic metres per day
m^3/h	cubic metres per hour
mg	milligram
mg/L	milligrams per litre
mGy/d	milligrays per day
mm	millimetre
mm/s	millimetres per second
org/L	organisms per litre
org/m^2	organisms per square metre

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11 FISH AND FISH HABITAT

11.1 Introduction

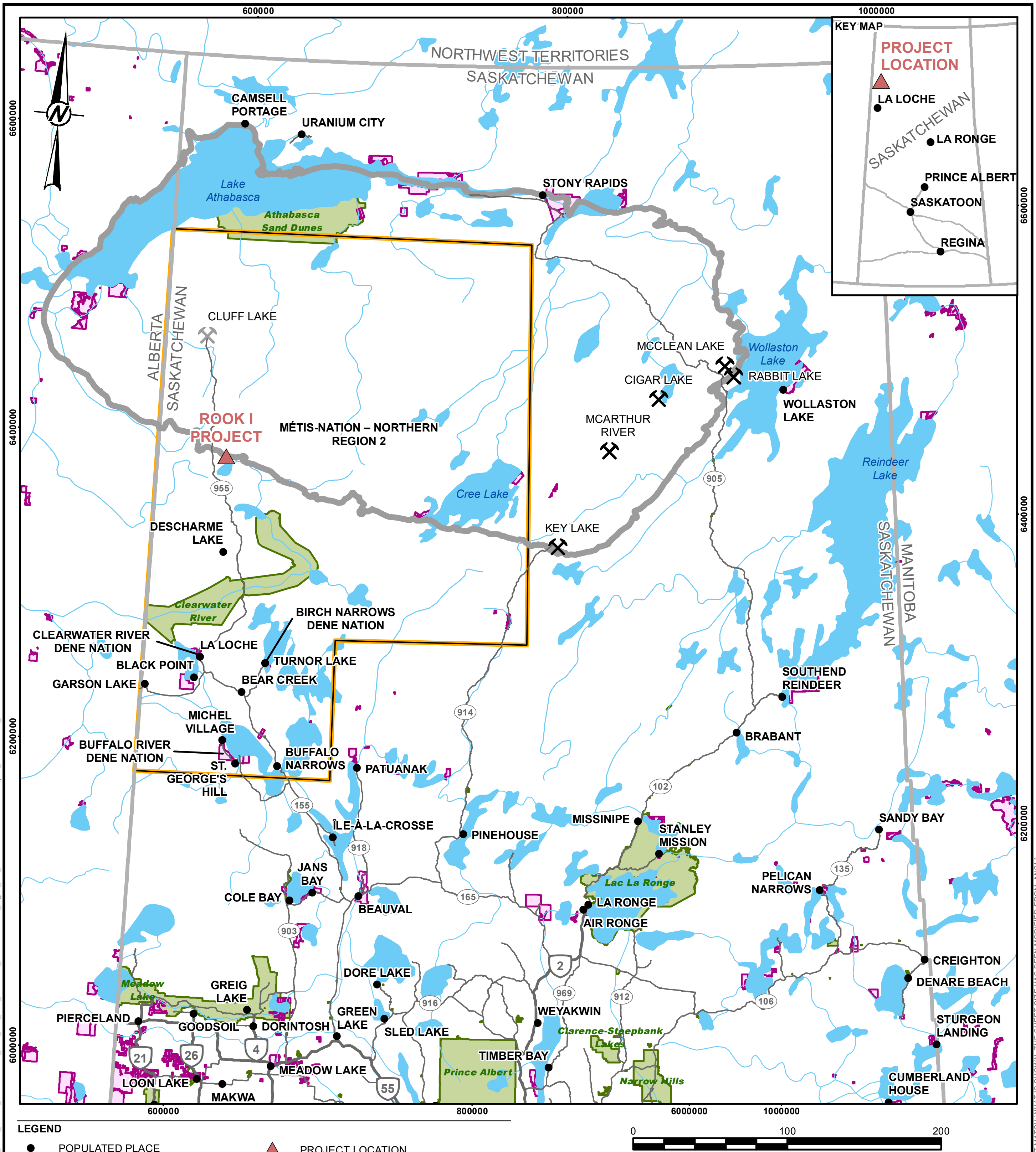
NexGen Energy Ltd. (NexGen) is proposing to develop a new uranium mining and milling operation in northwestern Saskatchewan, called the Rook I Project (Project). The Project would be located approximately 40 km east of the Saskatchewan-Alberta border, 130 km north of the Northern Village of La Loche, and 640 km northwest of the city of Saskatoon (Figure 11.1-1). 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. Patterson Lake is at the interface of the Boreal Shield and Boreal Plain ecozones. Access to the Project would be from an existing road off Highway 955 (Figure 11.1-2), with on-site worker accommodation serviced by fly-in/fly-out access.

Section 11, Fish and Fish Habitat, of the Environmental Impact Statement (EIS) characterizes the potential residual effects of the Project on fish and fish habitat, which are attributes or components of the aquatic environment. Fish and fish habitat represent valued components (VCs) for the Environmental Assessment (EA). The Project has the potential to cause adverse effects on fish VCs primarily through changes in surface water quality resulting from operational discharges and long-term solute transport from the underground tailings management facility (UGTMF) and waste rock storage areas (WRSAs). In addition, the Project could affect fish and fish habitat due to direct habitat loss and disturbance associated with the development of a fresh water intake, treated effluent diffuser, treated sewage outfall, and associated pipelines in Patterson Lake. Changes to water flows and water levels resulting from site water management activities and altered surface runoff conditions also have the potential to affect fish VCs. Baseline data (Annex V.1, Aquatic Environment Baseline Report; Annex V.2, Overwintering Fish Habitat Report; Annex V.3, Naomi Lake Bathymetry Report) and information from the assessments completed for air quality (Section 7.2, Air Quality), hydrogeology (Section 8, Hydrogeology), hydrology (Section 9, Hydrology), surface water and sediment quality (Section 10, Surface Water Quality and Sediment Quality), and terrain and soils (Section 12, Terrain and Soils), as well as the results of the ecological risk assessment (EcoRA) completed for the Project (Technical Support Document [TSD] XXI, Environmental Risk Assessment), were used to form the basis for the fish and fish habitat assessment.

Fish and fish habitat are protected under the federal *Fisheries Act*. For the purpose of the assessment, and consistent with the *Fisheries Act*, "fish" is defined as fish species that occur in the area surrounding the Project and includes eggs and juvenile stages of fish. The definition of "fish habitat" in the *Fisheries Act* is "*water frequented by fish and any other areas on which fish depend directly or indirectly to carry out their life processes, including spawning grounds and nursery, rearing, food supply and migration areas.*"

Fish have an important role in the function of the aquatic food web. Consumption of lower trophic level organisms, such as plankton (i.e., algae and small crustaceans in the water) and benthic invertebrates (i.e., small animals that live in or on the bottom substrate), by fish contributes to regulation of trophic structure and, thus, influences the stability, resilience, and food web dynamics of aquatic ecosystems. Therefore, plankton and benthic invertebrates provide important supporting information for assessing effects to fish and fish habitat and are described and characterized herein. Fish are also important food items for higher trophic level organisms in both aquatic and terrestrial ecosystems. Therefore, the results of the fish and fish habitat assessment provide information that was used to support the assessment of wildlife and wildlife habitat (Section 14, Wildlife and Wildlife Habitat).

Fish are an important resource culturally, economically, and traditionally to local Indigenous communities, and are an important contributor to tourism and recreation in the surrounding region. Changes to the health and productivity (e.g., growth and abundance) of fish and fish habitat could adversely influence the people that rely on these resources for their livelihood, subsistence, and culture. Therefore, the fish and fish habitat assessment provides information that was used to support the assessments of socio-economic VCs, particularly those discussed in human health (Section 15, Human Health), Indigenous land and resource use (Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use), and other land and resource use (Section 17, Other Land and Resource Use). A simplified linkage diagram, Figure 11.1-3, illustrates how proposed Project activities could result in a direct or indirect effect on fish and fish habitat, and the VCs that could be influenced through changes to fish and fish habitat.



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

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	PROJECT 20144150	SCALE AS SHOWN	REV. 0
wsp	FIGURE 11.1-1		

PATH: I:\CLIENTS\NexGen\20144150\Mapping\Products\FINAL_EIS_FIGURES_WSP_LOGO_UPDATED\11_Fish_and_Fish_Habitat\8_5x11\20144150_Fig11_1-1_Location-of-the-RookI-Project_NoTitleblock_Rev0.mxd PRINTED ON: 2023-02-10 AT: 10:33:06 AM

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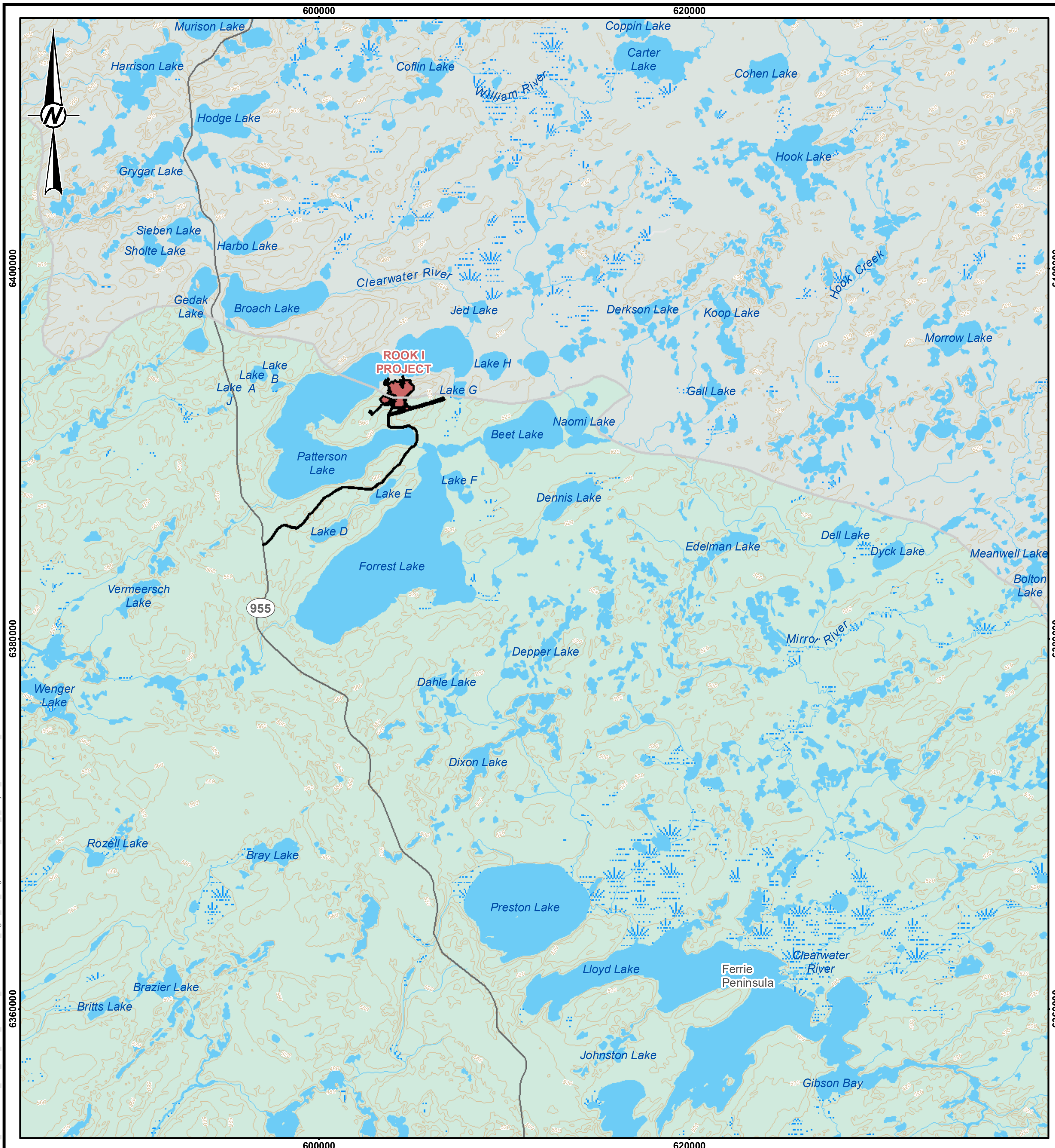
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A



0 5 10

1:300,000 KILOMETRES

LEGEND

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

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

REGIONAL AREA OF THE ROOK I PROJECT

CONSULTANT

wsp

PROJECT	20144150	SCALE AS SHOWN	REV. 0

FIGURE 11.1-2

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

PATH: I:\CLIENTS\NexGen\20144150\Mapping\Products\FINAL_EIS_FIGURES_WSP_LOGO_UPDATED\11_Fish_and_Fish_Habitat\8_5x11\20144150_Fig11_1-2_Regional-Area_Rook_I_Project_NoTitleblock_Rev0.mxd PRINTED ON: 2023-02-08 AT: 11:39:47 AM

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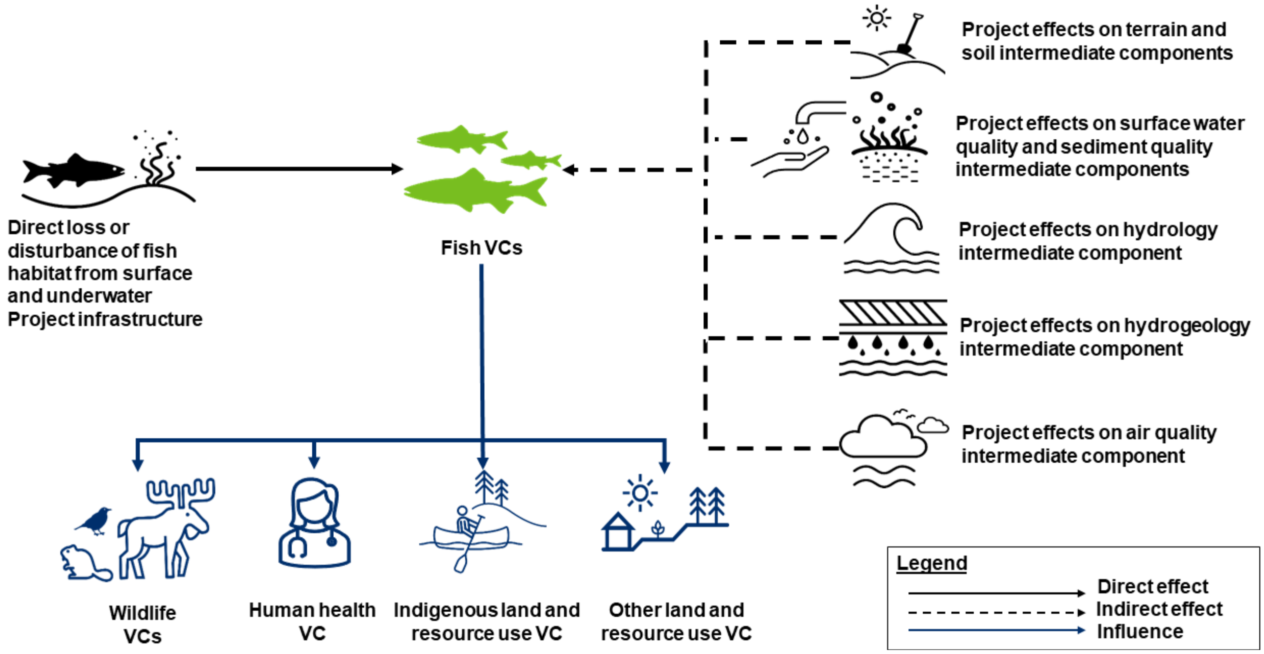
25mm

Figure 11.1-3: Linkage Diagram of Project Effects on Fish and Fish Habitat Valued Components and Influence on other Valued Components



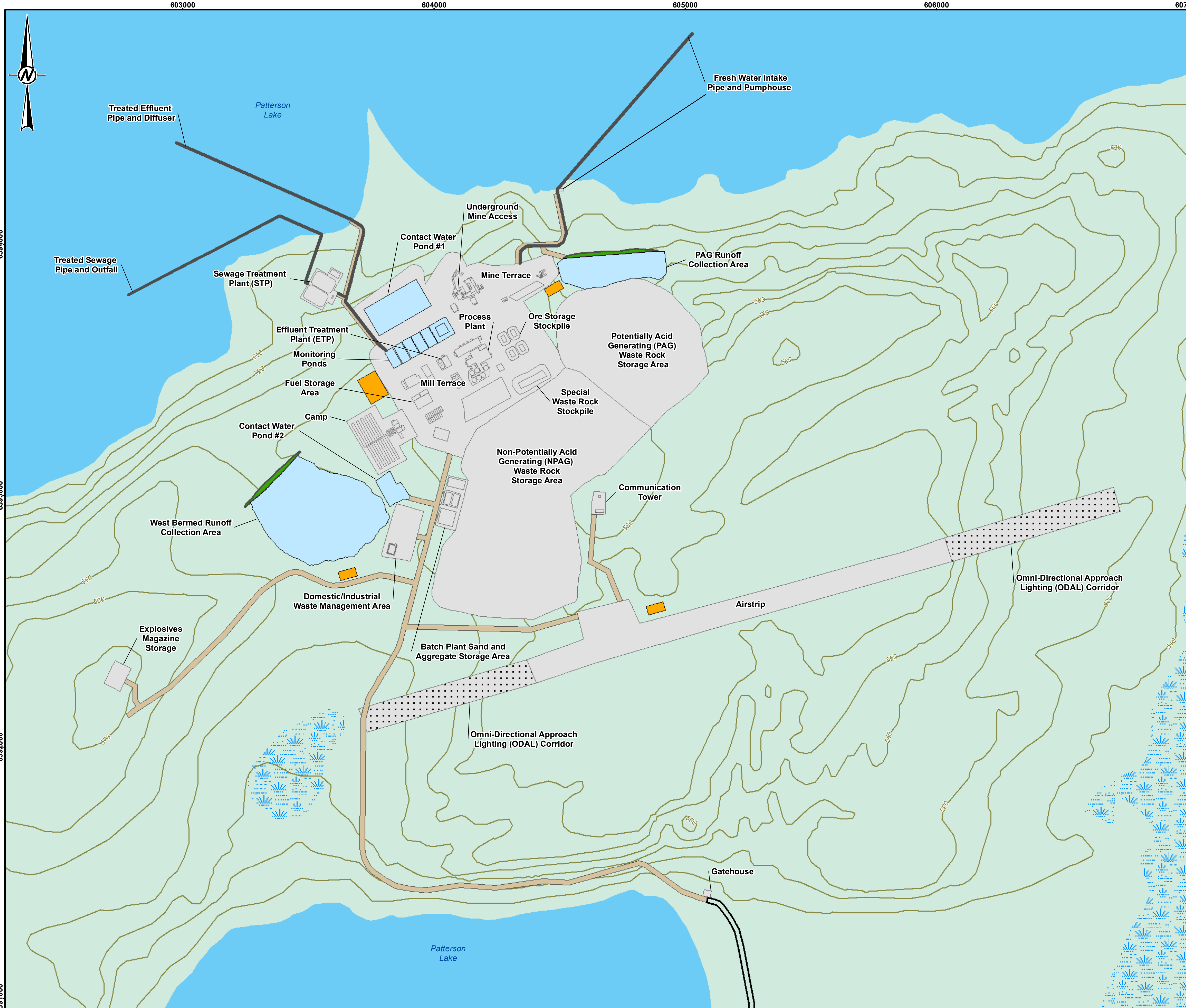
VC = valued component

11.1.1 Project Summary

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 11.1-4):

- underground mine development;
- process plant buildings, including uranium concentrate packaging facilities;
- paste tailings distribution system;
- UGTMF;
- potentially acid generating (PAG) WRSA;
- non-potentially acid generating (NPAG) WRSA;
- special waste rock[1] and ore storage stockpiles;
- surface and underground water management infrastructure, including water management ponds, effluent treatment plant (ETP), and sewage treatment plant (STP);
- 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.

[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.



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	SCALE AS SHOWN	REV. 0

FIGURE 11.1-4

11.1.2 Purpose and Approach to the Assessment

The purpose of Section 11 is to provide a detailed and comprehensive assessment of all potential Project-specific effects and cumulative effects from the Project and other previous, existing, and reasonably foreseeable developments (RFDs), if applicable, on fish and fish habitat. This section meets the Terms of Reference for the Project submitted to the Saskatchewan Ministry of Environment (ENV) and the Canadian Nuclear Safety Commission (CNSC) *Generic Guidelines for the Preparation of an Environmental Impact Statement – Pursuant to the Canadian Environmental Assessment Act, 2012* (Appendix 1A, Concordance Tables). The assessment of fish and fish habitat followed the overall EA approach and methods (Section 6, Environmental Assessment Approach and Methods) and includes the following primary steps:

Step 1 – Define the component-specific methods (Section 11.2, Component Methods): presents the specific approaches and methods used to measure and assess the effects of the Project on fish and fish habitat as well as cumulative effects from the Project, other previous and existing projects and activities, and RFDs, if applicable.

Step 2 – Characterize existing conditions (Section 11.3, Existing Conditions): describes and characterizes existing conditions to provide context and a basis for evaluating potential changes to fish and fish habitat caused by the Project.

Step 3 – Evaluate Project interactions and mitigations (Section 11.4, Project Interactions and Mitigations): identifies Project components and/or activities with the potential to affect fish and fish habitat and provides mitigation policies and actions committed to by NexGen to avoid or minimize potential adverse effects. A pathways analysis was used to focus further assessment on key interactions between the Project and fish and fish habitat by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual adverse effects. Primary pathways anticipated to result in residual adverse effects after incorporation of mitigation are carried forward to Step 4 for further analysis. Where potential adverse effects are adequately mitigated and thus not forwarded for further analysis (i.e., where mitigation results in negligible effects or avoids the pathway altogether), the reasons for concluding the assessment at this stage are provided.

Step 4 – Analyze residual effects (Section 11.5, Residual Effects Analysis): evaluates and describes the potential Project effects on fish and fish habitat that are anticipated to occur through the primary pathways. The residual effects analysis is presented as an integrated narrative that describes the effects of the Project over time and highlights predicted effects at the point when adverse effects of the Project are expected to be greatest. This subsection also completes an analysis of residual cumulative effects from the Project, other previous and existing projects and activities, and RFDs.

Step 5 – Classify residual effects and determine significance (Section 11.5): summarizes the results of the residual effects analysis using effects criteria (i.e., direction, magnitude, geographic extent, duration, reversibility, frequency, and probability of occurrence). Significance was determined using the results of the residual effects analysis and classification. Significance was determined for adverse effects only and for the maximum adverse effects of the Project and the cumulative effects from the Project, other previous and existing projects and activities, and RFDs.

Step 6 – Describe uncertainty and define prediction confidence (Section 11.6, Prediction Confidence and Uncertainty): identifies key uncertainties and explains how these uncertainties have been addressed to achieve a conservative, precautionary assessment. The implications of the approaches used to address uncertainties and the level of confidence in the residual effects analysis are discussed.

Step 7 – Identify monitoring and follow-up (Section 11.7, Monitoring, Follow-up, and Adaptive Management): outlines the proposed actions to verify predicted residual effects. The purpose of these actions is to evaluate effectiveness of planned mitigation designs, policies, and practices, and address key sources of uncertainty.

11.2 Component Methods

11.2.1 Incorporation of Indigenous and Local Knowledge

Indigenous and Local Knowledge included in the assessment of fish and fish habitat was shared by potentially affected First Nations and Métis Groups (collectively referred to as Indigenous Groups) and local priority area (LPA)[2] community members through the Project engagement process. The overall approach and methods for the incorporation of Indigenous and Local Knowledge into the EA is discussed in detail in Section 3, Indigenous and Local Knowledge. Issues and concerns related to fish and fish habitat raised by Indigenous Groups and LPA community members, and how these comments were addressed, are summarized in Appendix 2B, Summary of Issues and Concerns Identified by Indigenous Groups, and identified and addressed in this assessment, where applicable.

A key source of Indigenous and Local Knowledge is the Project specific studies completed by Indigenous Groups, including Traditional Land Use and Occupancy studies, Traditional Knowledge and Use studies, and Indigenous Rights and Knowledge studies (henceforth referred to collectively as Indigenous Knowledge and Traditional Land Use [IKTLU] Studies). The IKTLU Studies that were reviewed and referenced in the EIS as technical support documents (TSDs) are listed below:

- TSD II (BNDN), Birch Narrows Dene Nation Traditional Knowledge and Use Study Specific to NexGen Energy Limited's Proposed Rook I Project;
- TSD III (BRDN), Buffalo River Dene Nation Traditional Knowledge and Use Study Specific to NexGen Energy Limited's Proposed Rook I Project;
- TSD IV (MN-S), Métis Nation – Saskatchewan Northern Region 2 Traditional Land Use & Diet Study for the NexGen Rook I Project;
- TSD V.1 (CRDN), Preliminary Identification of Issues and Concerns Related to the Proposed NexGen Energy Ltd. Rook I Project in the Patterson Lake Area; A Review; Clearwater River Dene Nation; Traditional Land Use and Occupancy Mapping Interviews; 2010 – 2016;
- TSD V.2 (CRDN), Clearwater River Dene Nation Indigenous Rights and Knowledge Survey Related to the Proposed NexGen Energy Ltd. Rook 1 Project in the Patterson Lake Area;
- TSD V.3 (CRDN), Socio-economic and Harvest Study; Clearwater River Dene Nation; NexGen Rook 1 Project; and

[2] The LPA consists of the local communities closest to the Project that would experience most of the Project effects and for which NexGen would prioritize local training, employment, and business opportunities for the Project. These communities are located along, or accessed via, Highways 155 and 955 north of the intersection of Highways 155 and 925.

- TSD VI (YNLR), Provision of Athabasca Denesųłiné Traditional Knowledge, Land Use and Occupancy Information for the NexGen Rook I Project Environmental Assessment.

Another key source of Indigenous and Local Knowledge was information shared by Indigenous Group representatives during Joint Working Group (JWG) meetings. The JWGs represent an agreed upon primary engagement mechanism as outlined in the Study Agreements signed by each Indigenous Group and NexGen. More details regarding the JWGs can be found in Section 2, Indigenous, Regulatory, and Public Engagement and Section 3, Indigenous and Local Knowledge. There are four JWGs with the Project's primary Indigenous Groups (Section 2.4.1, Identification of Indigenous Groups for Engagement):

- Clearwater River Dene Nation (CRDN) JWG;
- Métis Nation – Saskatchewan (MN-S) JWG representing MN S Northern Region 2 (NR2);
- Birch Narrows Dene Nation (BNDN) JWG; and
- Buffalo River Dene Nation (BRDN) JWG.

The leadership of each Indigenous Group selected their JWG participants with consideration of group diversity; where possible, members included Elders, youth, different genders, a range of ages, and land users around Patterson Lake.

In addition to the IKTLU Studies and JWGs, Indigenous and Local Knowledge shared during specific engagement activities undertaken through the EA development process was incorporated into the assessment, where appropriate. These engagement activities included, but were not limited to:

- community information sessions held in four locations in 2019 (NexGen 2019);
- site tours;
- comments from the CRDN (2019a) on the Cluff Lake Mine licence renewal;
- other formal and informal meetings;
- workshops with specific groups (e.g., Fur Block N-19 trapper's workshop); and environmental and socio-economic baseline data collection.

Comments submitted by Indigenous Groups on the Project Description (CRDN 2019b; MN-S 2019; YNLRO 2019; ACFN 2019; CNSC 2019) were also reviewed for applicable Indigenous and Local Knowledge.

Indigenous and Local Knowledge related to fish and fish habitat was incorporated into the assessment by viewing the information as complementary and influential alongside scientific information. Where possible, knowledge from each potentially affected Indigenous Group or LPA community member was described separately and cited accordingly. Where information is described for multiple potentially affected Indigenous Groups, they are collectively referred to as "Indigenous Groups" throughout the assessment.

Indigenous and Local Knowledge was included in the fish and fish habitat assessment in the following ways:

- **Component Methods – Valued Components:** Indigenous and Local Knowledge was considered in the selection of the fish VCs and reflects species identified by Indigenous Groups and LPA communities that are important for traditional purposes. Traditional fishing is valued for cultural purposes, is an important part of traditional diets and contributes to health, and plays a key role in the intergenerational transmission of knowledge (Section 11.2.2.1).

- **Component Methods – Spatial Boundaries:** Indigenous and Local Knowledge supported the spatial boundaries used in the assessment, which includes a portion of the Clearwater River system and connecting waterbodies. Indigenous and Local Knowledge has highlighted the interconnectedness of the region's waterways and the Clearwater River as a holistic river system that has many large lakes that are connected and integral to the river and cannot be viewed in isolation (Section 11.2.3.2).
- **Component Methods – Sampling Locations:** While Indigenous and Local Knowledge was primarily received after the aquatic environmental baseline program was underway, the waterbodies that were sampled were identified as culturally important to Indigenous Groups and LPA communities and used for traditional fishing. The Patterson Lake area was identified as a culturally significant area where fishing has been practiced for generations. Therefore, the locations used to represent existing conditions generally align with Indigenous and Local Knowledge (Section 11.2.6.1).
- **Existing Conditions – Fish Communities:** Fish species observed or fished in the waterbodies and the Clearwater River in the Baseline Study Area, and observations of trends in populations, were included in the discussion of fish communities (Section 11.3.4).
- **Project Interactions and Mitigation:** Indigenous and Local Knowledge helped to inform the scoping of Project interactions, pathway analysis, and consideration of mitigation measures (Section 11.4). This includes observations and experiences of land users related to the cumulative effects of air pollution from industry, including mining activities, on water quality, fish populations, and aquatic health.
- **Monitoring, Follow-Up, and Adaptive Management:** Feedback provided by Indigenous Groups during engagement, including recommendations, was considered in the development of monitoring and follow-up activities (Section 11.7). In addition, it is planned that ongoing feedback from Indigenous Groups on the effectiveness of mitigations would be considered when updating monitoring and management plans. Independent Indigenous Monitors chosen by each primary Indigenous Group would have opportunities to participate in environmental monitoring programs for the proposed Project.

Specific references to Indigenous and Local Knowledge, and Project comments and concerns related to fish and fish habitat raised by Indigenous Groups and LPA community members, are included in the applicable sections of this assessment.

11.2.2 Valued Components, Measurement Indicators, and Assessment Endpoints

11.2.2.1 Valued Components

Valued components are aspects of the biophysical, cultural, and socio-economic environments that are considered to have scientific, social, cultural, economic, historical, archaeological, or aesthetic importance (Beanlands and Duinker 1983; CNSC 2021a). The BNDN and BRDN define VCs as tangible biophysical resources (e.g., particular places and species) and less tangible social, economic, cultural, health, and knowledge-based values (e.g., social cohesion, place names, Indigenous language) (TSD II: BNDN; TSD III: BRDN).

Valued components were identified using many considerations (Section 6.3.1, Valued Components) such as:

- potential for interaction with the Project and degree of interaction, including presence, abundance, and amount of spatial overlap of a VC with the Project;
- sensitivity of a VC to potential Project effects and level of damage or harm that could be realized should an adverse effect occur;
- species conservation status or concern (e.g., rarity, sensitivity, uniqueness);
- ecological and socio-economic/cultural value to Indigenous Groups and local communities, government agencies, and the public;
- recent experience with similar projects in Saskatchewan and other jurisdictions in Canada; and
- avoidance of redundancy with other VCs; for example, if two potential VCs represent the same issues, mitigation actions, and potential effects from the Project, only one was evaluated as part of the assessment.

Seventeen fish species were identified as being present in local waterbodies and watercourses during the aquatic baseline surveys completed for the Project (Section 11.3.4, Fish Communities). None of the fish species identified are classified as provincially or federally listed species or as species with a designated conservation status by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2021). In addition, review of distribution data for aquatic species listed under the federal *Species at Risk Act* (SARA) did not identify the presence of any federally listed fish species in the area of the Project (Government of Canada 2021; DFO 2019a). Therefore, protected species are not expected to occur in waterbodies and watercourses potentially affected by the Project (Section 11.3.4), and having a federally, or provincially, designated conservation status was not a relevant criterion in the selection of VCs for fish and fish habitat. Additionally, none of the fish species identified during the baseline study would be considered rare or unique to the area based on a review of Saskatchewan's Conservation Data Centre taxa lists (Section 11.3.4; SKCDC 2021a), which provide rankings of species rarity for taxa documented to occur in the province.

Selection of fish VCs was informed by Indigenous and Local Knowledge shared during community engagement sessions for the Project in La Loche, Turnor Lake, Buffalo River, and Buffalo Narrows (Section 2 and Section 3), in JWG meetings, and in the IKTLU Studies (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YNLR). Emphasis was placed on aligning fish VCs with species that are targeted or identified as important to Indigenous Groups and LPA community members.

Indigenous Groups spoke of the importance of fishing for subsistence, survival, and livelihood, and highlighted fishing as an important aspect of community and cultural life (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD: V.1: CRDN; TSD V.2: CRDN; TSD VI: YNLR). The importance of commercial fishing in the area surrounding the Project was also noted by Indigenous Groups, with some community members making their living fishing and selling to buyers in the community (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.2: CRDN; BRDN-JWG 2021a).

The CRDN described how "southern Denesųłiné peoples, living . . . within the Upper Churchill River watershed and the southern reaches of the Athabasca Basin primarily depended on fish and more solitary big game animals" (TSD V.2: CRDN). Since fish are a mainstay in the diets of CRDN members, cabins and harvesting camps are typically located near lakes that provide a good supply of fish (TSD V.2: CRDN).

The MN-S consider the Region 2 territory as a vital source of food which provides members “a shared identity, sense of community and permanence” (TSD IV: MN-S). Community members still rely on the land and its resources, and it is estimated that approximately 70% of their food comes from hunting, trapping, fishing, and gathering (TSD IV: MN-S). Fish are an integral part of MN-S members’ traditional diet. Fish are also an important part of the traditional diets for BNDN and BRDN members, and consuming fish promotes good health and is important for community wellbeing (TSD II: BNDN; TSD III: BRDN). The BNDN commented that fishing traditions are learned from Elders and relatives and have been passed down through the generations and are an important aspect of BNDN members’ identities and land use. The YNLR also rely on a variety of fish species for traditional purposes (TSD VI: YNLR).

The BNDN and BRDN reported that fishing traditions include more than just catching and eating fish, but also include cultural activities such as community gatherings, and spending time with others while out on the land (TSD II: BNDN; TSD III: BRDN).

Showing respect for, and giving thanks to the water and resources through ceremonies is an important aspect of traditional fishing (TSD III BRDN; TSD V.2: CRDN; MN-S-JWG 2019a). For example, at harvesting cultural camps, CRDN Elders and teachers select a location next to a lake which is known to have fish, and a prayer and offerings are made to the water are made (TSD V.2: CRDN). The importance of collectively processing and sharing traditional foods, including fish, with extended family and the wider community was also noted by Indigenous Groups as a key cultural practice (TSD II: BNDN; TSD V.2: CRDN).

> When we dry fish is fall time. When we go there, we go for two, three weeks. Then we fish nets, And then we’ll make dry fish to eat there….Dry meat as well there . . . . There’s my family and [another] family are all there . . . . Probably about 10 - 15 people there. And then people that come on a visit, they’ll come and eat with us. (TSD V.2: CRDN)

The BNDN and BRDN noted that specialized knowledge and skills are required to fish successfully, such as understanding the seasonal patterns of fish and where to find prime fishing locations (TSD II: BNDN; TSD III: BRDN). Indigenous and Local Knowledge related to fish and fishing is passed down to younger generations, including cultural protocols, fishing locations and techniques, how to process and store fish, assessing the health of fish and the benefits of consuming traditional foods (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.2: CRDN; TSD VI: YNLR; MN-S-JWG 2020). The intergenerational transmission of knowledge is often experiential, learned from Elders and relatives while out on the land, and therefore requires access to land and high quality, abundant resources (TSD II: BNDN; TSD III: BRDN).

> [My mother] used to make [mesh] nets by herself [using string]. . . . there were [no] store-bought nets. We used to set nets for the dogs, I worked with my dad. We pulled a lot of fish for us and for the dogs. (TSD VI: YNLR)

> I’ve been [fishing] – well, ever since I remember, I was fishing. And then ever since I was old enough to do it on my own, I started for myself and never quit ever since. (TSD II: BNDN)

> Well my dad [taught me to fish] . . . and my grandpa. (TSD II: BNDN)

Fishing plays an important role in the relationship Indigenous Groups have with their traditional lands, especially in their connection to the lakes and rivers in the region (TSD II: BRDN). Their long history of fishing in the same lakes and rivers over generations contributes to sense of place which is "intricately connected to land and place", is tied to people's attachment and affiliation with the land, and is an expression of identity and familiarity (TSD II: BNDN; TSD III: BRDN). Sense of place "depends on particular places… along with their particular features (physical, social, and symbolic) and the values and activities these features foster and enable" (TSD II: BNDN).

Indigenous Groups and LPA community members indicated that land users target a variety of fish species in lakes in the area of the Project (Table 11.2-1):

- The CRDN identified grayling, (Arctic grayling [*Thymallus arcticus*]), jackfish (northern pike [*Esox lucius*]), herring (cisco; *Coregonus artedi*), lake trout (*Salvelinus namaycush*), ling cod (burbot [*Lota lota*]), pickerel (walleye [*Sander vitreus]*), suckers (white sucker [*Catostomus commersonii*] and/or longnose sucker [*Catostomus catostomus*]), and minnows as species that are considered important to community members (TSD V.1: CRDN; TSD V.2: CRDN).
- Members of the MN-S identified all manner of fish, including trout, whitefish, jack (jackfish, or northern pike), pickerel, suckers, burbot, and catfish[3] as being consumed (TSD IV: MN-S; MN-S-JWG 2019a).
- Members of the BNDN pursue and rely on a variety of fish species, including lake trout, whitefish (lake whitefish [*Coregonus clupeaformis]*), jackfish, pickerel (walleye), suckers, and mariah (burbot) (TSD II: BNDN; BNDN-JWG 2019).
- Members of the BRDN described fishing for lake whitefish, lake trout, jackfish, pickerel, and perch (yellow perch [*Perca flavescens]*), and highlighted the importance of Patterson Lake as providing high quality fishing, particularly for species such as lake trout and lake whitefish (TSD III: BRDN; BRDN-JWG 2019a; BRDN-JWG 2020).
- The YNLR identified lake trout, whitefish, northern pike, suckers, and pickerel as species that are considered important to community members (TSD VI: YNLR).

A species-specific approach was considered for the selection of VCs for fish and fish habitat. This is consistent with the approach used for other higher trophic level species in the wildlife and wildlife habitat assessment (Section 14). For the EIS, four fish species were ultimately selected as VCs for assessing the effects of the Project on fish and fish habitat (Table 11.2-1): lake trout, lake whitefish, walleye, and northern pike (Table 11.2-1). These four species were identified as VCs, in part, because they were frequently noted by Indigenous Groups and LPA communities during engagement, including LPA community information sessions (NexGen 2019), JWG Meetings (BNDN-JWG 2019; BNDN-JWG 2020; BRDN-JWG 2019a; BRDN-JWG 2020; MN-S-JWG 2019b), and in IKTLU Studies (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YNLR) as having high value and traditional and cultural importance. Finally, these species represent important ecosystem processes within the local aquatic environment, as they are relatively abundant in Patterson Lake, other nearby lakes, and/or in the Clearwater River, and occupy various habitat niches and trophic positions in the food web.

[3] Biological species identification is uncertain. Catfish are not known to occur in the area of the Project; however, the comment may have been referring to burbot, which have a similar appearance to catfish because of the barbel (feeler) on the chin.

A few fish species noted during engagement and captured during the baseline surveys were excluded from the list of VCs (e.g., white sucker, longnose sucker, burbot, yellow perch, cisco, Arctic grayling). These species were excluded, in part, because they were mentioned relatively infrequently by communities during engagement compared to species retained as VCs (Table 11.2-1). In addition, these species occupy a similar niche, ecological space, and functional role to species retained as VCs. For example, burbot, though identified as important to some Indigenous Groups (e.g., TSD II: BNDN; TSD V.1: CRDN; TSD V.2: CRDN; MN-S-JWG 2019a), was excluded as a VC because its life history (i.e., pattern of survival and reproduction) and functional role in the aquatic food web overlaps with that of lake trout, which is also a representative pelagic (i.e., inhabiting the water column, being neither close to the bottom nor near the shore) predator, and lake whitefish, which is also a representative bottom dwelling species (Table 11.2-1). Additional rationale for excluding certain fish species identified during engagement as VCs is provided in Table 11.2-1.

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Table 11.2-1: Species Considered for Selection as Valued Components

Species	Presence Confirmed by Baseline Surveys[(a)]	Provincially Tracked (Rank)[(b)]	Federally Listed (Schedule 1 SARA)	Comments from Indigenous Groups	Included as a VC	Rationale
Lake trout (*Salvelinus namaycush*)	Confirmed	No (S5)	No	▪ Targeted by Indigenous Groups and LPA community members (TSD II: BNDN; TSD III: BRDN; TSD V.1: CRDN; TSD V.2: CRDN; NexGen 2019) ▪ Patterson Lake provides good fishing for lake trout (BRDN-JWG 2020) ▪ Lake trout is fished in Patterson Lake (TSD II: BNDN; MN-S-JWG 2019b; NexGen 2019) ▪ People travel to Patterson Lake for the opportunity to fish for lake trout (BRDN-JWG 2020) ▪ Important for subsistence purposes (BRDN-JWG 2020)	Yes	▪ Captured in large lakes in the area, including Patterson Lake (Annex V.1) ▪ Less prevalent in waterbodies in the area of the Project compared to other fish VCs (Annex V.1), but highly valued by Indigenous land users ▪ Representative species for cold water fish and fish habitat ▪ Completes its life history in lakes and is therefore suitable for assessing potential changes to lake habitats
Lake whitefish (*Coregonus clupeaformis*)	Confirmed	No (S5)	No	▪ Targeted by Indigenous Groups and LPA community members (TSD II: BNDN; TSD III: BRDN; TSD VI: YNLR; TSD V.2: CRDN; BNDN-JWG 2019; BNDN-JWG 2020; BRDN-JWG 2019a; NexGen 2019 ▪ Patterson Lake provides good fishing for lake whitefish (BRDN-JWG 2020) ▪ Important for subsistence (TSD III: BRDN) ▪ Integral to traditional diet (TSD IV: MN-S); used to make pemican (TSD IV: MN-S) ▪ A lot of lakes have lake whitefish (BNDN-JWG 2020); fished in Patterson Lake (TSD II: BNDN) ▪ Considered a delicacy (TSD III: BRDN; TSD V.2: CRDN) ▪ A bottom feeder and good to include (BNDN-JWG 2019)	Yes	▪ Abundant and widely distributed in local waterbodies, including the Clearwater River mainstem (Annex V.1) ▪ Representative species for cold water fish and fish habitat. Completes most of its life history in lakes, with occasional movements into streams, and is therefore, suitable for assessing potential changes to lake habitats ▪ Important prey of lake trout and walleye, which have been included as VCs; therefore, lake whitefish represent an important food web linkage to other VCs ▪ Receptor for the EcoRA
Walleye (*Sander vitreus*)	Confirmed	No (S5)	No	▪ Targeted by Indigenous Groups and LPA community members (TSD II: BNDN; TSD III: BRDN; TSD V.1: CRDN; TSD V.2: CRDN; BNDN-JWG 2019; NexGen 2019) ▪ Important for subsistence (TSD III: BRDN); integral to traditional diet (TSD IV: MN-S) ▪ Abundance of walleye has increased (BNDN-JWG 2019) ▪ Walleye population is healthy (BNDN-JWG 2019) ▪ Fished in Patterson Lake (TSD II: BNDN; MN-S-JWG 2019b; NexGen 2019)	Yes	▪ Abundant and widely distributed in local waterbodies and watercourses (Annex V.1) ▪ Representative species for cool water fish and fish habitat. Completes its life history in either lacustrine pelagic habitats or in riverine habitats and is therefore suitable for assessing potential changes to both lake and riverine habitats
Northern pike (*Esox lucius*)	Confirmed	No (S5)	No	▪ Targeted by Indigenous Groups and LPA community members (TSD II: BNDN; BNDN JWG 2020; TSD VI: YNLR; TSD III: BRDN; TSD V.2: CRDN; BNDN-JWG 2019; NexGen 2019) ▪ Important for subsistence (TSD III: BRDN); integral to traditional diet (TSD IV: MN-S) ▪ Fished in Patterson Lake (TSD II: BNDN; MN-S-JWG 2019b)	Yes	▪ Abundant and widely distributed in local waterbodies and watercourses (Annex V.1) ▪ Representative species for cool water fish and fish habitat, and as a littoral predator. Species is also suitable for assessing potential changes to watercourse habitats ▪ Receptor for the EcoRA
White sucker (*Catostomus commersonii*)	Confirmed	No (S4)	No	▪ Targeted by Indigenous Groups (TSD II: BNDN; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YNLR) ▪ Integral to traditional diet (TSD IV: MN-S) ▪ Fished in Patterson Lake (TSD II: BNDN)	No	▪ Abundant and widely distributed in local waterbodies and watercourses (Annex V.1) ▪ Represented by lake whitefish. The species occupies a similar niche, ecological space, and functional role as lake whitefish, which is also a representative bottom dwelling and forage species and has been included as a VC ▪ Number of comments received from communities about the importance of sucker species was minimal compared to lake whitefish
Longnose sucker (*Catostomus catostomus*)	Confirmed	No (S5)	No		No	
Burbot (*Lota lota*)	Confirmed	No (S5)	No	▪ Targeted by Indigenous Groups (TSD II: BNDN; TSD V.1: CRDN; TSD V.2: CRDN; MN-S-JWG 2019a)	No	▪ Moderately abundant and widely distributed in local waterbodies and watercourses (Annex V.1) ▪ Life history and functional role as a pelagic predator overlaps with that of lake trout, which has been included as a VC. Functional role as a bottom dwelling species overlaps with lake whitefish, which has been included as a VC ▪ Number of comments received from communities about the importance of burbot was minimal compared to lake trout and lake whitefish
Yellow perch (*Perca flavescens*)	Confirmed	No (S5)	No	▪ Targeted by Indigenous Groups (BRDN-JWG 2020) ▪ Fishing on Patterson Lake includes harvest of yellow perch (BRDN-JWG 2020)	No	▪ Abundant and widely distributed in local waterbodies (Annex V.1) ▪ Represented by lake trout. Functional role as a littoral forage species overlaps with other VCs; yellow perch is a direct competitor with lake trout and salmonid species for planktonic food and smaller fish prey ▪ Number of comments received from communities about the importance of yellow perch was minimal compared to species that have been included as VCs

Table 11.2-1: Species Considered for Selection as Valued Components

Species	Presence Confirmed by Baseline Surveys[(a)]	Provincially Tracked (Rank)[(b)]	Federally Listed (Schedule 1 SARA)	Comments from Indigenous Groups	Included as a VC	Rationale
Cisco (*Coregonus artedi*)	Confirmed	No (S5)	No	▪ Targeted by Indigenous Groups (TSD V.1: CRDN; TSD V.2: CRDN)	No	▪ Infrequently captured during the 2018 and 2019 baseline surveys (Annex V.1). Cisco were captured in only one of eight lakes surveyed (Broach Lake). Therefore, not representative of effects in the RSA ▪ Functional role as a pelagic forage species overlaps with that of lake whitefish, which has been included as a VC ▪ Number of comments received from communities about the importance of cisco was minimal compared to lake whitefish
Arctic grayling (*Thymallus arcticus*)	Confirmed	No (S5)	No	▪ Targeted by Indigenous Groups (TSD V.2: CRDN) ▪ Not specifically mentioned in surveys for VC selection. However, Arctic grayling is targeted by Indigenous and non-Indigenous land users in northern Saskatchewan	No	▪ Infrequently captured during the 2018 and 2019 baseline surveys (Annex V.1). A single Arctic grayling was captured during the baseline surveys, in the Clearwater River downstream of Naomi Lake. Therefore, this species is not representative of effects in the RSA ▪ Functional role as forage species overlaps with that of lake whitefish, which has been included as a VC. Additionally, there is overlap with northern pike, which has been included as a VC, and is considered suitable for assessing potential changes to watercourse habitats ▪ Number of comments received from communities about the importance of Arctic grayling was minimal compared to species that have been included as VCs

a) Based on Annex V.1 Aquatic Environment Baseline Report. All large-bodied fish species captured during the baseline surveys were initially considered in the VC selection process.
b) Provincial Rank Definitions (SKCDC 2021a): S4 – Apparently secure; S5 – Secure/Common.
VC = valued component; EcoRA = ecological risk assessment; SARA = *Species at Risk Act*.

In summary, fish VCs were selected to capture a range of potential effects of the Project on fish and fish habitat, while simultaneously avoiding redundancy by selecting one representative species when multiple species occupy a similar ecological niche and/or functional role in the aquatic food web. To avoid missing functional roles or ecological processes not associated with a specific indicator species, species with a variety of habitat requirements and representing different trophic positions were selected. In addition, ecological health risks were examined in the ecological risk assessment (EcoRA), which is a component of the environmental risk assessment (ERA) (TSD XXI). In the EcoRA, aquatic species were examined to determine the sensitivity of fish and other aquatic biota to exposure of chemical substances and metals that may result from changes in surface water quality. Aquatic species or receptors included benthic invertebrates, zooplankton (i.e., microscopic animals that live suspended in the water), phytoplankton (i.e., algae that live suspended in the water), lake whitefish, and northern pike. Two of these receptors are VCs in the fish and fish habitat assessment (i.e., lake whitefish, northern pike; Table 11.2-1), and the others were evaluated in terms of their importance as food for fish and as a component of fish habitat (i.e., benthic invertebrates, zooplankton, phytoplankton). Results from the EcoRA completed for the Project (TSD XXI) were used to support the assessment of fish VCs and associated habitat.

Fish VCs selected for the Project are as follows:

- **Lake trout**: Lake trout is an important species ecologically, culturally, and socio-economically, and is targeted by both Indigenous and non-Indigenous land users. The species typically occurs in relatively deep waterbodies with cold water (Scott and Crossman 1973; Evans et al. 2002; Richardson et al. 2001; McPhail 2007). During the baseline surveys, lake trout were captured in all the large lakes in the area of the Project, including Patterson Lake (Annex V.1). The species is a long-lived, top trophic level consumer (i.e., found at the top of the aquatic food web) that is primarily piscivorous (i.e., fish-eating) but may also consume crustaceans and insects. The species is suitable for assessing how potential changes in the aquatic food base may affect species at the top of the food web. Lake trout spawn during the fall and typically rely on rocky shoals in lakes for spawning (Scott and Crossman 1973; Richardson et al. 2001; McPhail 2007).
- **Lake whitefish**: Lake whitefish is an important species ecologically, culturally, and socio-economically, and is targeted by Indigenous Groups and valued by LPA communities. Lake whitefish typically occur in lakes with cold water and is primarily a bottom-dwelling species; however, the species may occasionally be pelagic or occur in riverine (i.e., in river or watercourse) environments (McPhail and Lindsey 1970; Scott and Crossman 1973; Ford et al. 1995). The species is abundant and widely distributed in waterbodies in the area of the Project, including the Clearwater River mainstem (Annex V.1). The species is a mid-trophic level consumer (i.e., found in the middle of the aquatic food web) and feeds primarily on benthic-dwelling organisms. The species is suitable for assessing how potential changes to sediment quality and benthic invertebrates may affect fish. Lake whitefish spawn during the fall and typically rely on rocky shoals in lakes for spawning; however, spawning may also occur in rivers (Scott and Crossman 1973).
- **Walleye:** Walleye is an important species ecologically, culturally, and socio-economically, and is targeted by both Indigenous and non-Indigenous land users. Walleye occur in lakes and large rivers and are typically pelagic, moving into deeper water in the summer (Colby et al. 1979; McPhail 2007; Paragamian 1989; Scott and Crossman 1973). The species is abundant and widely distributed in waterbodies in the area of the Project, including the Clearwater River mainstem (Annex V.1). The species is a long-lived, top trophic level consumer that is primarily piscivorous but will also consume invertebrates. The species is suitable for assessing how potential changes in the aquatic food base may affect species at

the top of the food web. Walleye spawn in the late spring, primarily along gravel, boulder, or cobble along nearshore areas of lakes, or nearby tributaries (Scott and Crossman 1973).

- **Northern pike**: Northern pike is an important species ecologically, culturally, and socio-economically, and is targeted by both Indigenous and non-Indigenous land users. The species prefers relatively shallow, vegetated (i.e., weedy), clear waters in lakes and streams with a slow to moderate current (Scott and Crossman 1973; Harvey 2009). The species is abundant and widely distributed in waterbodies in the area of the Project, including in the Clearwater River (Annex V.1). The species is an upper trophic level consumer that is primarily piscivorous but will also consume invertebrates. Northern pike spawn in early spring soon after the ice melts in inundated or submerged vegetation along the floodplains and nearshore areas of rivers, streams, marshes, or shallow areas of lakes (Scott and Crossman 1973; Inskip 1982).

Additional information and description of the biology and life history characteristics of fish species selected as VCs is provided in Section 11.3.6, Fish Valued Component Life Histories.

11.2.2.2 Measurement Indicators

Measurement indicators are used to characterize changes to attributes of the environment from the Project, other human developments, and natural factors. The changes in measurement indicators are used to predict overall effects on VCs and assessment endpoints (Section 6.3.2, Assessment Endpoints and Measurement Indicators). Several measurement indicators were identified and used for the fish and fish habitat assessment (Table 11.2-2). Importantly, the measurement indicators for fish VCs are connected to intermediate components in the EA such as air quality, hydrogeology, hydrology, and surface water quality. Accordingly, the results of the air quality (Section 7.2), hydrogeology (Section 8), hydrology (Section 9), and surface water quality and sediment quality (Section 10) assessments are fundamental to understanding the total effects of the Project on the fish VCs (Section 6.3.3, Intermediate Components). Results from the EcoRA completed for the Project (TSD XXI) are also incorporated into the assessment for fish VCs.

The measurement indicators for the fish VCs are defined as follows:

- **Habitat availability** (i.e., habitat quantity and quality): amount and suitability of available habitat occupied by fish. Includes consideration of the following indicators:
  - hydrology, including water levels in waterbodies and flow velocities and stream channel parameters (e.g., wetted widths) in watercourses;
  - surface water quality, including temperature, dissolved oxygen (DO) levels, suspended sediment concentrations, and the concentrations of major ions, nutrients, metals, and radionuclides; and
  - lower trophic levels, including plankton and benthic invertebrates, which provide the base of the food web.
- **Habitat distribution** (i.e., habitat arrangement and connectivity): arrangement and connectivity of habitat (e.g., habitat fragmentation) and the spatial distribution and movement of fish.
- **Survival and reproduction**: fish populations or population structure related to survival and/or recruitment (i.e., the process by which new individuals are added to a population due to factors such as spawning success).

Each measurement indicator was evaluated quantitatively where sufficient information existed to support a numerical assessment, and qualitatively where necessary.

11.2.2.3 Assessment Endpoints

Assessment endpoints are qualitative expressions that represent the key properties of VCs that should be protected; as such, assessment endpoints incorporate the concept of sustainability and function as significance thresholds (Section 6.3.2). The significance of effects from the Project and other human developments on fish VCs is evaluated by linking changes in measurement indicators to the influence on self-sustaining and ecologically effective fish populations (Table 11.2-2). Details on the application of self-sustaining and ecologically effective populations as a significance threshold is provided in Section 11.2.9, Residual Effects Classification and Determination of Significance. The compilation and interpretation of the results from analyzing changes in measurement indicators provides lines of evidence that collectively provide a determination of whether the assessment endpoints are maintained or achieved (Section 6.3.2). The results from the EcoRA completed for the Project provide another important line of evidence in the determination of significance of effects on fish VCs (Section 6.3.4, Environmental Risk Assessment Receptors).

Table 11.2-2: Valued Components, Rationale, Measurement Indicators, and Assessment Endpoints

VCs	Rationale	Measurement Indicators	Assessment Endpoint
▪ Lake trout ▪ Lake whitefish ▪ Walleye ▪ Northern pike	▪ Traditional and/or current food source ▪ Socio-economic/cultural importance ▪ Ecological importance ▪ Relatively abundant in nearby lakes and/or the Clearwater River	▪ Habitat availability (i.e., habitat quantity and quality) ▪ Habitat distribution (i.e., habitat arrangement and connectivity) ▪ Survival and reproduction	▪ Self-sustaining and ecologically effective fish populations

VC = valued component.

11.2.3 Spatial Boundaries

Spatial boundaries for the fish and fish habitat component were defined separately for the aquatic resource environmental baseline study and the effects assessment completed for the EIS. The spatial boundary applied to the baseline surveys was selected based on an early understanding of the Project description and activities, whereas the boundaries defined for the effects assessment were based on a more advanced understanding of the Project description, footprint, and potential for effects on fish VCs. This subsection provides a description and rationale for the spatial boundaries applied during the baseline surveys and in assessing effects from the Project on fish VCs.

11.2.3.1 Baseline Study Area

The aquatic environment baseline study area (BSA) represents the area established in Annex V.1, Aquatic Environment Baseline Report. In Annex V.1, the BSA is referred to as the “aquatic study area”; however, the convention “BSA” has been applied herein for clarity and to distinguish it from the study areas considered in the fish and fish habitat effects assessment in the EIS (Section 11.2.3.2, Effects Assessment Study Areas). As described in Annex V.1:

> The BSA was selected based on the watershed designated for treated effluent release, knowledge of information needed for an EA and long-term monitoring for similar developments, and consideration of potential cumulative effects.

The detailed rationale used to define the BSA is presented in Annex V.1. The BSA is shown in Figure 11.2-1 and includes the following:

- Waterbodies in close proximity to the proposed Project site: Patterson Lake and adjoining sections of the Clearwater River mainstem, Lake G, and Lake H.
- Waterbodies located along the flow path of the proposed treated effluent discharge: Patterson Lake, Forrest Lake, Beet Lake, Naomi Lake, Lloyd Lake, and adjoining sections of the Clearwater River.
- Waterbodies that could potentially be considered for reference areas during operational monitoring: Broach Lake and Hodge Lake. However, during the EA, Broach Lake was removed as a reference area as it would potentially be affected by the proposed Project as a result of air emissions and related deposition (Section 7.2).

11.2.3.2 Effects Assessment Study Areas

The assessment of fish and fish habitat was completed using the same spatial boundaries as those for other aquatic environment components (i.e., hydrology and surface water quality) and consists of a local study area (LSA) and regional study area (RSA) (Table 11.2-3; Figure 11.2-2). The selection of the LSA and RSA considered VC-specific and ecosystem-centred attributes and boundaries as well as the predicted maximum spatial extent of Project effects and other existing and future activities/developments (CEA Agency 2018).

The selection of spatial boundaries for the LSA and RSA was based on the physical and biological properties of VCs. Spatial scales relevant for the population or fisheries unit under examination are needed to assess project effects on fish VCs (Randall et al. 2013). Spatial scales for estimating effects on the assessment endpoint for fish VCs (Section 11.2.2, Valued Components, Measurement Indicators, and Assessment Endpoints) considered the geographic area that may potentially contribute to the fishery or self-sustaining population. The Project would be located near the headwaters of the Clearwater River system, which flows through several waterbodies, including Patterson Lake, Forrest Lake, Beet Lake, and Naomi Lake. Several smaller lakes and tributary habitats are also present adjacent to the Clearwater River mainstem, within the contributing watershed area.

The approach used to select spatial boundaries aligns with Indigenous and Local Knowledge shared by Indigenous Groups about the interconnectedness of the region's waterways, and how rivers and lakes cannot be viewed in isolation (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.2: CRDN; BNDN-JWG 2021b; BRDN-JWG 2019a; BRDN-JWG 2020; CRDN-JWG 2021).

> But Mother Earth is just like a sponge. It collects everything. And also, water flows. It goes wherever. It goes where – it connects all over the place. (TSD III: BRDN)
>
> But everything works . . . in a circle. And . . . people just think one lake operates in isolation. It has veins everywhere. It has veins going everywhere. If you're going to [speaking Dene] take all the water out from here, you're not only stopping the flow of water that comes from Clearwater. It goes all the way over here. You're stopping the flow of all kinds of veins that come around here. You're going to dry up all these things. (TSD V.2: CRDN)

The CRDN describe the Clearwater River as a holistic river system in which Patterson Lake and Forrest Lake, and downstream lakes (e.g., Beet Lake), are intrinsically connected to and integral to the river (TSD V.2: CRDN). Similarly, Patterson Lake and other lakes are viewed by the CRDN as connected to the network of waterbodies and watercourses in the area, rather than as discrete and separate waterbodies (TSD V.2: CRDN; CRDN-JWG

2021). The MN-S described the importance of Patterson Lake because it is central to the river system for the entire area and feeds the lakes to the south, affecting all the waterways that members use (TSD IV: MN-S). As noted by a member of the CRDN:

> It's all connected, the water, in there. And there. Where's the lake [Patterson], here. Right here. All the way, it's all connected. Lloyd Lake. . . . All this . . . here, that's all connected together. . . . all the way to the Clearwater; goes to the Mackenzie. It's all connected together . . . . That's all one river. Patterson, through Forrest, Beet Lake. The river starts here . . . . to Clearwater. (TSD V.2: CRDN)

The entire watershed boundary of the Clearwater River upstream of the predicted maximum spatial extent of effects was considered in the delineation of study areas, as all suitable habitats in this area may potentially be used by fish VCs to live out their life histories and these areas may be important for the maintenance of self-sustaining VC populations. For example, fish populations may utilize tributary or mainstem river habitat as spawning or rearing habitat, whereas lake habitats may provide adult feeding and overwintering habitat. The use of a watershed-based approach provides the necessary context for interpreting the effects of the Project on fish VCs and is suitable for capturing potential population-level effects, as well as for determining Project effects on overall biodiversity. Additionally, the approach represents the use of both VC-specific and ecosystem-centred approaches to defining the spatial boundaries of assessment.

The LSA and RSA capture the areas where potential hydrologic and surface water quality effects from the Project may occur and may affect fish and fish habitat measurement indicators. Additionally, the spatial extent of the LSA and RSA considers pathways of exposure to constituents of potential concern (COPCs) from the Project, which were evaluated in the EcoRA (TSD XXI), including from air and dust emissions and subsequent deposition, treated effluent discharge, surface runoff, seepage from facilities, and long-term solute transport from the UGTMF and WRSAs.

The LSA for the fish and fish habitat assessment is defined as the area where both potential direct effects and local-scale indirect effects from the Project could occur. Loss of fish habitat associated with the Project's proposed fresh water intake is an example of a direct environmental effect. Potential indirect environmental effects might include changes to habitat quantity from altered stream flow or changes to habitat quality or fish survival and reproduction resulting from sediment release or treated effluent discharge. The LSA for fish and fish habitat is defined by the Clearwater River watershed boundary up to the Naomi Lake outlet (Figure 11.2-2), which covers a surface area of 68,530 ha (685 km^2). There are five larger lakes in the LSA (i.e., Broach, Patterson, Forrest, Beet, and Naomi lakes), as well as several smaller waterbodies including Lake G and Lake H. For assessment purposes, Patterson Lake is divided into a North Arm and South Arm, as shown in Figure 11.2-2. The North Arm is further divided into the West Basin and East Basin. Similarly, Forrest Lake is divided into a North Arm and South Arm (Figure 11.2-2). Further details regarding the delineation of basins within these waterbodies is provided in Section 9.3.2.1, Waterbodies.

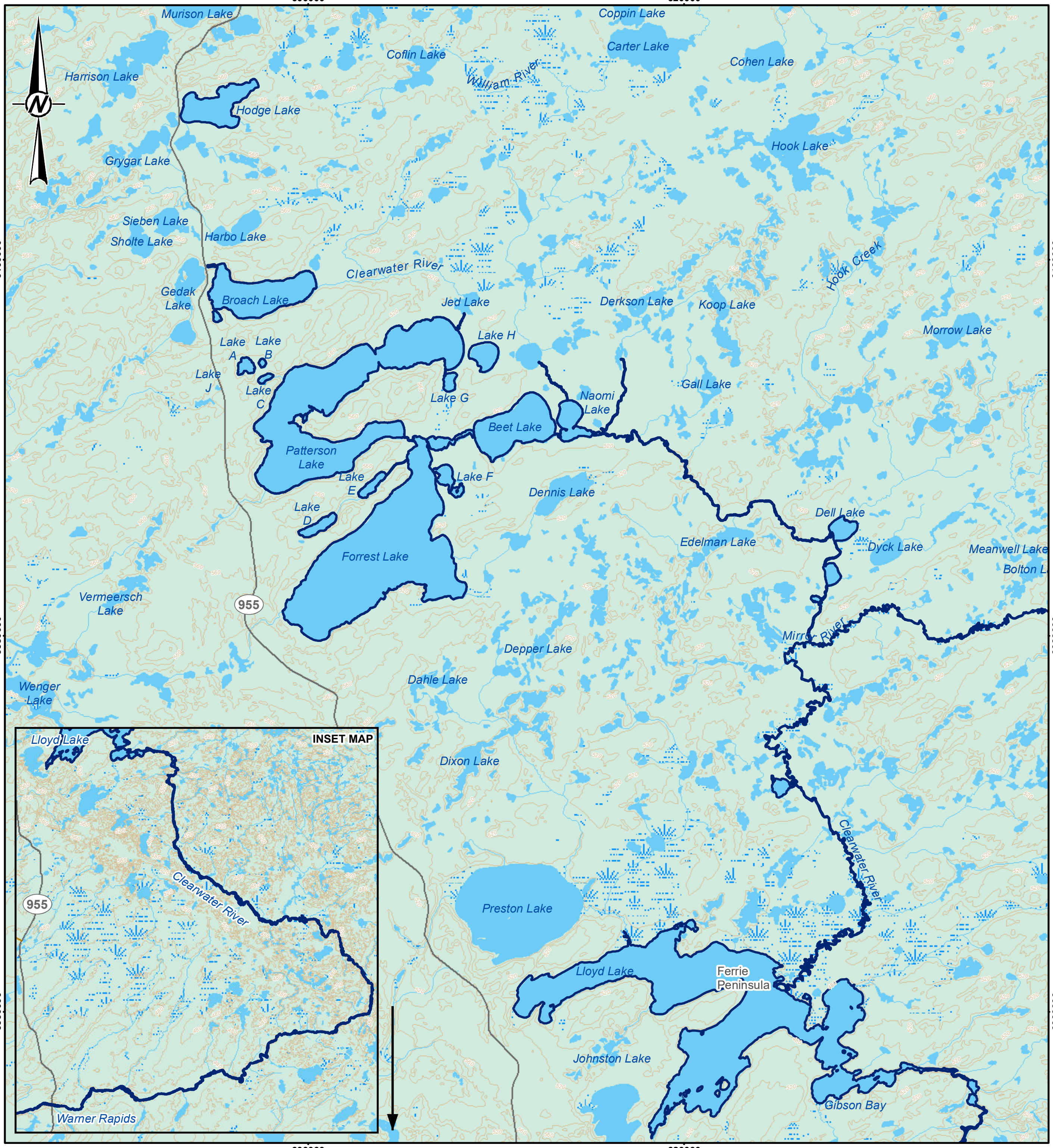
The RSA is the largest scale at which data were collected, compiled, and analyzed, and includes indirect effects that may extend beyond the LSA (CEA Agency 2018). The RSA for the fish and fish habitat component is expected to be large enough to capture the maximum predicted spatial extent of combined direct and indirect effects from the Project on fish and fish habitat. Cumulative and incremental Project effects are also expected to be captured within the RSA. The RSA includes the LSA and is defined by the Clearwater River watershed boundary upstream of the Mirror River confluence, which represents a surface area of 107,490 ha (1,076 km^2). The rationale for selecting the Mirror River confluence as the downstream point defining the fish and fish habitat

RSA is that the potential changes in surface water quantity and quality from the Project would not be greater-than-negligible downstream of this confluence due to the three-fold increase in drainage area and flows, which provide dilution and attenuation of effects associated with potential Project-related changes in hydrology and surface water quality.

Table 11.2-3: Spatial Boundaries for Assessment of Fish Valued Components

Study Area	Area	Description/Rationale
LSA	68,530 ha (685 km^2)	▪ Includes the Clearwater River watershed boundary upstream of the Naomi Lake outlet ▪ Defined by the expected extent of the direct and local-scale indirect effects from the Project ▪ Provides local context for assessing the residual effects on fish VCs
RSA	107,490 ha (1,076 km^2)	▪ Watershed draining to the Clearwater River above the Mirror River confluence ▪ Provides broader scale context to capture and assess Project effects and is linked to aquatic-related exposure pathways in the EcoRA ▪ Provides a large enough area to assess the cumulative effects on fish VCs and is the scale at which significance is determined

LSA = local study area; RSA = regional study area; EcoRA = ecological risk assessment; VC = valued component.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- SECONDARY HIGHWAY
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED AREA
- AQUATIC SAMPLED WATERBODY

0 5 10

1:300,000 KILOMETRES

REFERENCE(S)

1.CANNORTH (CANADA NORTH ENVIRONMENTAL SERVICES). 2020. ROOK I PROJECT AQUATIC AND TERRESTRIAL ENVIRONMENT BASELINE REPORT.
2. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021.
3. 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

AQUATIC ENVIRONMENT BASELINE STUDY AREA

CONSULTANT

wsp

PROJECT		20144150	PHASE	3107 - 2
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CHECK	KM	2023-02-08		
REVIEW	KM	2023-02-08		

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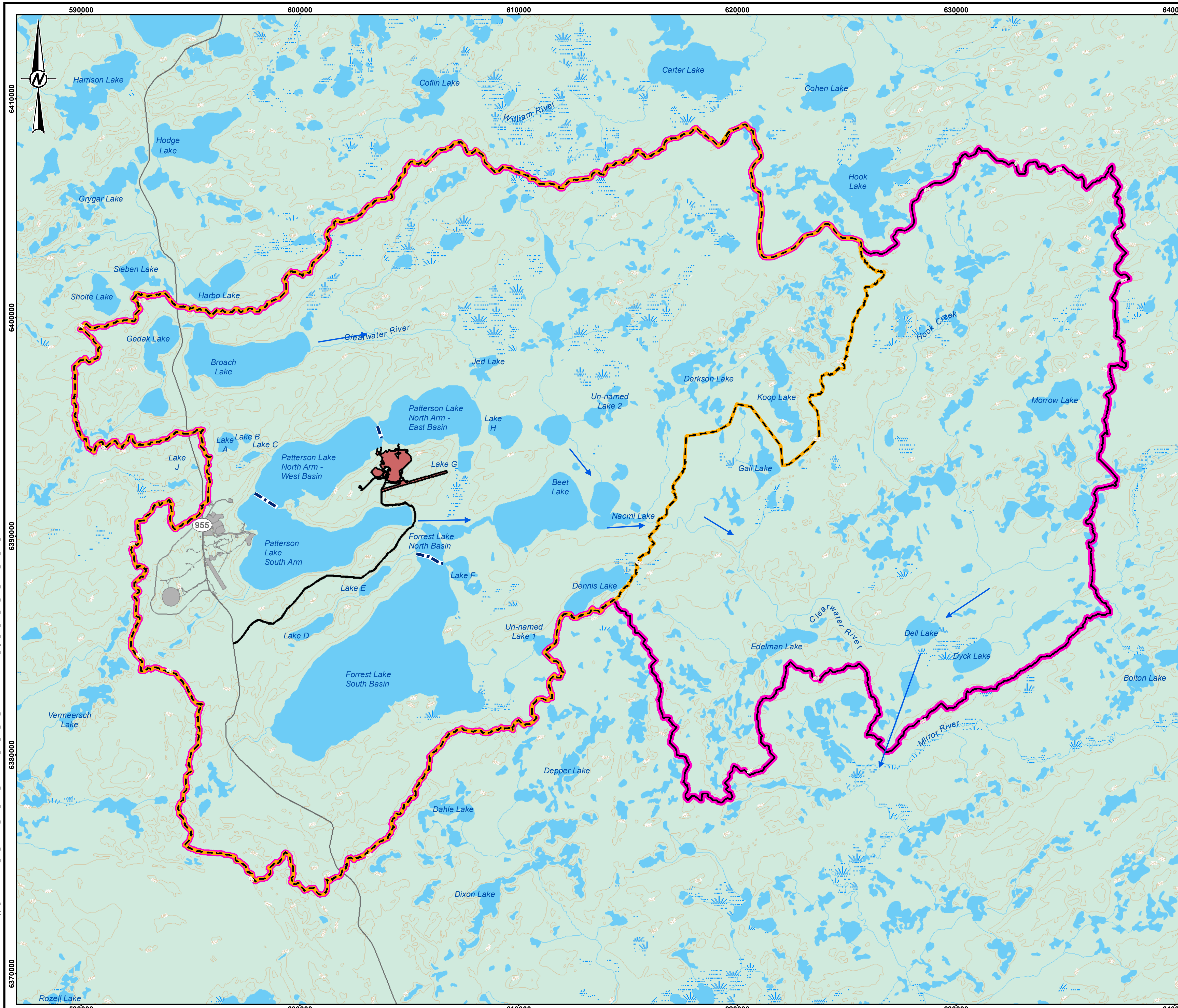


LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- FLOW DIRECTION
- LAKE BASIN DIVISION
- SECONDARY HIGHWAY
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED AREA
- PROPOSED PROJECT FOOTPRINT
- FISSION PATTERSON LAKE SOUTH PROPERTY FOOTPRINT
- FISH AND FISH HABITAT LOCAL STUDY AREA
- FISH AND FISH HABITAT REGIONAL STUDY AREA

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)
1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
2. FISSION (FISSION URANIUM CORP.) OBTAINED FROM 2019 TECHNICAL REPORT ON THE PRE-FEASIBILITY STUDY OF THE PATTERSON LAKE SOUTH PROPERTY USING UNDERGROUND MINING METHODS.
3. 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
FISH AND FISH HABITAT ASSESSMENT STUDY AREAS

CONSULTANT
wsp

PROJECT		20144150	PHASE	3106 - 3
DESIGN	LJ	2021-05-17	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08	FIGURE 11.2-2	
CHECK	KM	2023-02-08		
REVIEW	KM	2023-02-08		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

PATH: I:\CLIENTS\NexGen\20144150\Mapping\Products\FINAL_EIS_FIGURES_WSP_LOGO_UPDATED\11_Fish_and_Fish_Habitat\1x11\20144150_Fig11_2-2_Fish_and_Fish_Habitat_LSA_RSA_Rev0.mxd PRINTED ON: 2023-02-08 AT: 11:37:17 AM

11.2.4 Temporal Boundaries

The temporal scope of the assessment 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 (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 required 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 CNSC licence would be submitted to the CNSC 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 scope of the assessment is intended to evaluate the shorter- and longer-term changes from the Project and the associated Project-specific and cumulative effects on fish VCs. The duration of potential effects on fish VCs is discussed in the effects assessment (Section 11.4 and Section 11.5).

For some pathways of effects, residual effects on fish VCs were evaluated across all phases of the Project, but not necessarily for each specific phase. For example, effects on fish and fish habitat associated with development of the Project’s proposed fresh water intake are anticipated to begin during Construction and continue through Operations, until effects are reversed following Active Closure Stage activities.

Where applicable, residual effects on fish VCs may be assessed in terms of environmental modelling outputs generated by intermediate components that may have a linkage to potential effects on fish VCs (i.e., air quality, hydrology, and surface water quality). For example, the hydrology component (Section 9) summarizes modelled changes in lake levels and watercourse flow rates in terms of mean annual and monthly surface water elevations and flow rate at assessment nodes along the Clearwater River mainstem during each Project phase. Where applicable, environmental modelling outputs generated by intermediate components may be referenced in the fish and fish habitat assessment when interpreting effects on measurement indicators defined for fish VCs, which include consideration of indicators of surface water quantity and quality.

Similarly, the surface water quality component (Section 10) summarizes the results of environmental modelling for the downstream receiving environment (i.e., Patterson Lake and downstream waterbodies and watercourses) in terms of mean annual COPC concentrations for individual lakes or lake basins along the Clearwater River flow path, for each Project phase, to illustrate variation in the aquatic environment over time. For surface water quality, and the potential for corresponding effects on fish VCs, the duration of effects from the Project may occur well beyond Closure and were therefore also assessed for the far future. The far-future projection for surface water quality was considered in the fish and fish habitat assessment when evaluating potential effects on aquatic health and corresponding changes to habitat availability and the survival and reproduction measurement indicators. The far-future projection encompasses the long-term period of extremely slow migration of COPCs from the UGTMF and WRSAs to the environment, and potential for aquatic receptors to be exposed to COPCs. While it is not possible to accurately predict any process thousands of years into the future, the far-future projection is a reasonable representation of the return to steady-state conditions. Additional details and rationale for the defining the far-future projection is provided in the surface water quality assessment (Section 10.2.4, Temporal Boundaries).

The temporal boundaries applied to cumulative effects assessments include the duration of residual effects from previous and existing developments that overlap with residual effects from the Project, and the period during which the residual effects from RFDs overlap with the Project, if applicable.

11.2.5 Assessment Cases

The concept of assessment cases was applied to the fish and fish habitat assessment to estimate the incremental and cumulative effects from the Project and other developments (Section 6.5, Assessment Cases). 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. There are no known approved (but not yet constructed) projects in the LSA and RSA for fish VCs. Assessment cases for the Project included a Base Case, Application Case, and RFD Case.

Base Case for fish and fish habitat is represented by existing conditions. The Base Case describes the existing environment in the LSA and RSA before application of the Project to provide an understanding of the current conditions that may be influenced by the Project. The temporal boundary of the Base Case includes the combined effects from previous and existing human disturbances and natural factors (e.g., fire, floods, drought) on the environment and fish and fish habitat. As such, existing conditions represent the cumulative effects of historical and current environmental pressures that have influenced the observed condition and patterns of the fish VCs (CEA Agency 2018).

Application Case for fish and fish habitat 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 to fish VCs.

Reasonably Foreseeable Development Case for fish and fish habitat includes the Base Case, Application Case, and RFDs that have not yet been approved. Reasonably foreseeable developments are defined as projects and activities that fit any of the first three and both of the last two criteria from the list below:

- are currently under regulatory review or have officially entered a formal regulatory application process;
- have been publicly disclosed by other proponents;
- may be induced by the Project;
- have the potential to change the Project or the effects predictions; and
- occur in the spatial assessment boundary defined by the VCs.

A key criterion for selecting other projects to include in the RFD Case was that the projects must cause similar effects on fish VCs influenced by the Project (Hegmann et al. 1999). The Fission Patterson Lake South Property, which is planned by Fission Uranium Corp. (Fission 2019, 2021), was included in the RFD Case (Figure 11.2-2). Public information describes a projected three-year construction period and seven-year operating period (production and processing) (Fission 2019, 2021). The anticipated start of construction and duration of active decommissioning at the Fission Patterson Lake South Property were not publicly available at the time this assessment was completed. For the assessment, it was assumed that the duration of active decommissioning for the Fission Patterson Lake South Property would be similar to the Active Closure Stage for the Project (i.e., five years; Section 6.5.3, Reasonably Foreseeable Development Case).

The CRDN specifically mentioned the risk of cumulative effects from the Project and the nearby proposed Patterson Lake South Property (CRDN 2019a).

As a scenario within the RFD Case (where applicable), potential effects from climate change, including how natural factors (e.g., changes in precipitation and surface water flows) may be altered resulting from climate change, was considered within the assessment. Indigenous Groups indicated concerns about cumulative effects from human development, government policies and climate change (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN).

The fish and fish habitat assessment includes a quantitative and qualitative analysis of predicted changes on measurement indicators and associated effects from the Fission Patterson Lake South Property on fish VCs. In addition, potential changes from natural disturbance factors and climate change are qualitatively discussed for fish VCs.

11.2.6 Existing Conditions

The fish and fish habitat assessment describes and characterizes existing conditions for fish and lower trophic organisms in the LSA and RSA to provide context and a basis for evaluating potential changes from the Project. The existing conditions represent the expected conditions that exist in 2021 and prior to Project initiation. Existing conditions were evaluated quantitatively where information was available, and qualitatively where necessary, using the most up-to-date information available to provide context. The information used to characterize fish populations and fish habitat was based on a desktop review of existing information and results from field surveys completed between 2015 and 2020.

Sources and data used to characterize existing conditions for fish and fish habitat were as follows:

- *Aquatic Environment Baseline Report* (Annex V.1): This report was the primary information source used to characterize existing conditions for fish and fish habitat in the LSA and RSA. It summarizes baseline conditions for fish and fish habitat based on field surveys completed between 2018 and 2020.
- *Overwintering Fish Habitat Field Program Results Summary Report for the Rook I Project* (Annex V.2 Overwintering Fish Habitat Report): This report presents the results of a supplementary study to the Aquatic Environment Baseline Report (Annex V.1). It summarizes winter fish habitat conditions in watercourses potentially affected by the Project based on field surveys completed in 2019.
- *Naomi Lake Bathymetry Report* (Annex V.3). This report presents the work completed in 2019 to map the bathymetry of Naomi Lake to support water modelling and fish habitat assessments.
- *Background Surface Water Quality Characterization* (Appendix 10A, Surface Water Quality Modelling Report, Attachment 10A-1): This report presents baseline conditions for surface water quality during field surveys completed between 2015 and 2020. The specific relevance of this report in characterizing existing conditions for fish and fish habitat was to describe baseline lake productivity conditions (i.e., lake trophic status, as described in Section 11.2.6.1, Sampling Locations and Activities) in the LSA and RSA. Detailed information related to existing water and sediment quality conditions is provided in Section 10.
- Various technical reports and databases developed by government resource agencies, such as Fisheries and Oceans Canada (DFO) and ENV (e.g., Saskatchewan Conservation Data Centre's Hunting, Angling, and Biodiversity Information of Saskatchewan database; SKCDC 2021b). These resources were reviewed to provide additional information on fish species presence/absence and distribution in the LSA and RSA.
- Species at risk resources:
  - *Aquatic Species at Risk Map* (DFO 2019a): The DFO aquatic species at risk map provides a compilation of critical habitat and distribution data for aquatic species listed under the SARA within Canadian waters. This mapping tool was used to identify the possible presence of federally listed Species at Risk in the LSA and RSA.
  - Saskatchewan Conservation Data Centre's taxa lists (SKCDC 2021a): This online resource maintained by ENV and Nature Saskatchewan provides a centralized database on the status, location, and ecology of Saskatchewan species, including provincially threatened and endangered species in the province. This database was used to identify the possible presence of species of conservation concern.

The aquatic environment baseline sampling program (Annex V.1) was designed to collect information from waterbodies and watercourses located in the BSA (Section 11.2.3, Spatial Boundaries; Figure 11.2-1); however, results are summarized in the existing conditions section (Section 11.3) only for waterbodies and watercourses that are located in the LSA and RSA defined for the fish and fish habitat effects analysis (Section 11.2.3), with emphasis on fish habitats that would be most affected by the Project and the fish species selected as VCs (Section 11.2.2). Full details for the aquatic environment baseline study are presented in Annex V.1. The existing conditions summary for fish and fish habitat in the LSA and RSA includes the following:

- characterization of fish habitat conditions in the waterbodies and watercourse sections in the defined LSA and RSA, including spawning, nursery, rearing, feeding, and overwintering habitats;
- characterization of trophic status of waterbodies and description of lower trophic communities, including plankton and benthic invertebrate communities, as a food source for fish and indicator of habitat productivity;

- description of the fish populations comprising the local fish communities;
- description of habitat use and how fish populations complete their life history activities; and
- description of the biology and life history characteristics of the fish VC populations.

Information on existing fish and fish habitat conditions in the LSA and RSA is summarized both in terms of general conditions that are relevant to all fish VCs (i.e., lake trout, lake whitefish, walleye, and northern pike), and where feasible, specifically for individual VCs. For example, information on basic physical habitat conditions (e.g., water depth, composition of bottom substrates) and lower trophic level communities is summarized once for all fish VCs. Where available, species-specific information on fish species distribution, morphometry (i.e., body size), and presence of suitable habitats is provided for individual VCs.

11.2.6.1 Sampling Locations and Activities

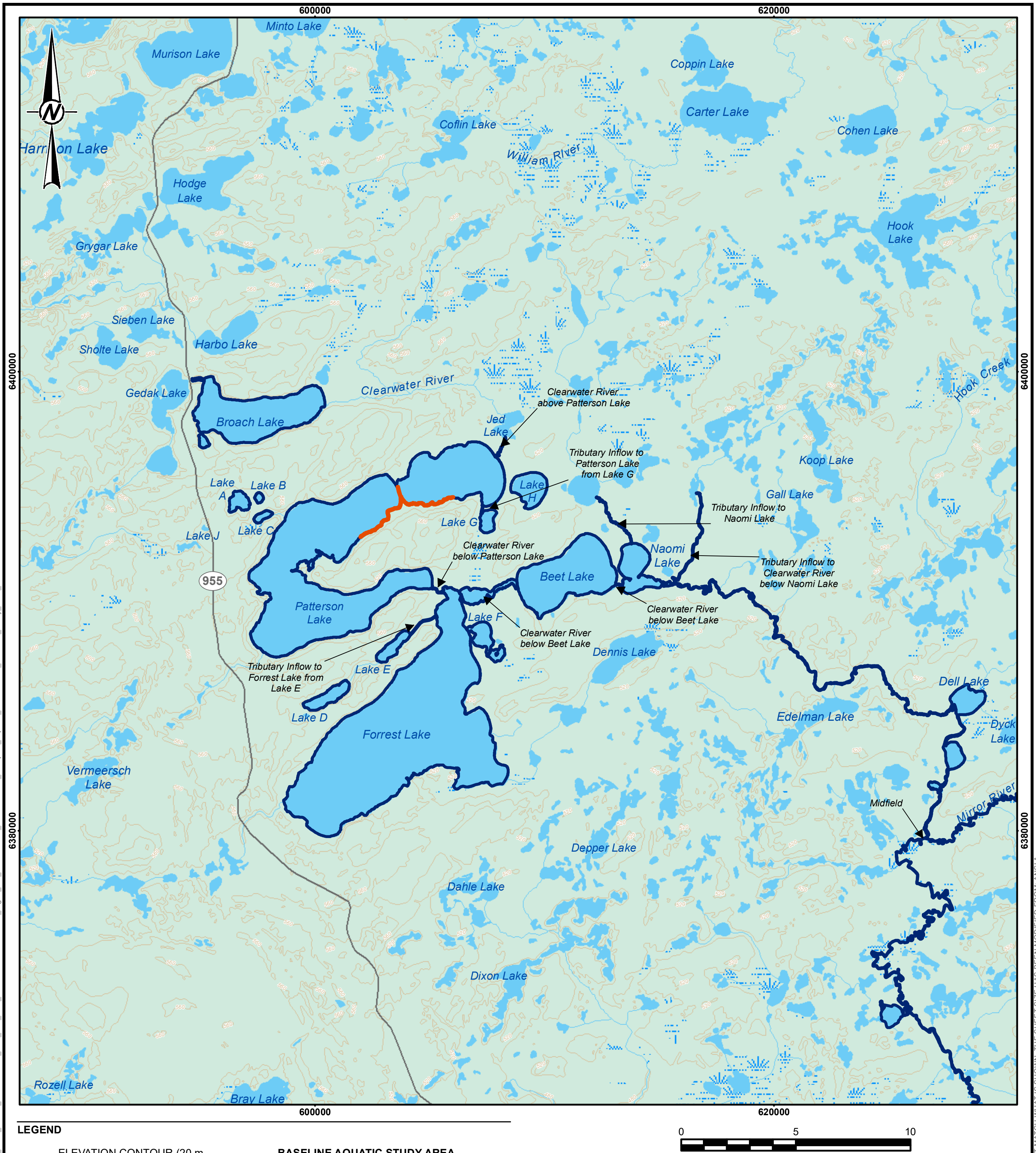
The aquatic environment baseline sampling program was designed to collect information from waterbodies and watercourses located in the BSA (Annex V.1). Sampling activities focused on summarizing fish habitat conditions, including information on lower trophic level communities, and fish populations in Patterson Lake and downstream waterbodies on the Clearwater River flow path, as well as in adjoining mainstem sections of the Clearwater River. Sampling also occurred in smaller waterbodies located adjacent to the Clearwater River mainstem and in tributary habitats (Table 11.2-3; Figure 11.2-3). Notably, the naming conventions used for certain watercourse sections surveyed by Canada North Environmental Services (CanNorth) during the aquatic environment baseline (Annex V.1) differed from those used in the EIS main sections. Differences in naming conventions used between the Annex V.1 and the EIS main sections are summarized in Table 11.2-4.

Sampling activities and survey types completed within each waterbody and watercourse are defined in Table 11.3-1. A detailed description of the sampling locations and timing of individual sampling and survey types is included in Annex V.1. An overview of the sampling methods used to conduct each survey type is provided in Sections 11.2.6.2 to 11.2.6.5; details are included in Annex V.1.

As the Project is proposed to be located adjacent to Patterson Lake, the intensity of sampling for the aquatic environment baseline was greatest in Patterson Lake. Additionally, while Patterson Lake as a whole was surveyed for all aquatic components (i.e., lower trophic communities, fish habitat, fish populations), more detail was given for some surveys within an approximately 5 km long section of the lake shoreline located immediately north of the proposed Project location. This area of the Patterson Lake shoreline adjacent to the Project, referred to in Annex V.1 as "Patterson Lake – Mine Site Area" (Figure 11.2-3), was subject to greater sampling intensity due to its proximity to the proposed Project site, and because the area is intersected by the proposed locations for the treated effluent diffuser, fresh water intake, and treated sewage outfall.

The waterbodies sampled in the in the aquatic environment baseline study, including Broach, Patterson, Forrest, Beet, and Naomi lakes, are culturally important to Indigenous Groups and used for harvesting, occupancy, and travel (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN). The Clearwater River was identified as an ancestral water route that is still used presently to access traditional use areas (TSD IV: MN-S; TSD V.2: CRDN). The CRDN reported that the Patterson Lake, Forrest Lake, Beet Lake, and other lakes further downstream are intrinsically connected and integral to the Clearwater River (TSD V.2: CRDN), and the MN-S highlighted Patterson Lake as being central to the river system for the entire area because it feeds the lakes to the south (TSD IV: MN-S).

The Patterson Lake and Forrest Lake area is particularly significant to the CRDN and have sustained CRDN members for generations (TSD V.1: CRDN). The MN-S have described the Patterson Lake area as being paramount to its members and their lifeblood (TSD IV: MN-S). The BRDN and BNDN have also reported practicing traditional activities in the Patterson Lake area (TSD II: BNDN; TSD III: BRDN). The CRDN view Patterson Lake and Forrest Lake as one large lake with a narrow constriction, rather than two separate waterbodies (TSD V.1: CRDN; TSD V.2: CRDN).



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- SECONDARY HIGHWAY
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED AREA

BASELINE AQUATIC STUDY AREA

- PATTERSON LAKE SHORELINE ADJACENT TO PROJECT
- AQUATIC SAMPLED WATERBODY

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

WATERBODIES AND WATERCOURSES SAMPLED DURING AQUATIC ENVIRONMENT BASELINE STUDY

CONSULTANT

wsp

PROJECT		20144150	PHASE	3107 - 2
DESIGN	JL	2023-02-08	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08	**FIGURE 11.2-3**	
CHECK	KM	2023-02-08		
REVIEW	KM	2023-02-08		

REFERENCE(S)

1.CANNORTH (CANADA NORTH ENVIRONMENTAL SERVICES). 2020. ROOK I PROJECT AQUATIC AND TERRESTRIAL ENVIRONMENT BASELINE REPORT.
2. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021.
3. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PROJECTION: UTM ZONE 12 DATUM: NAD 83

Table 11.2-4: Summary of Sampling Components by Waterbody and Watercourse

Waterbody or Watercourse[a]			In Situ Water Quality	Plankton	Benthic Invertebrates	Fish Habitat	Spring Spawning	Fall Spawning	Overwintering Habitat	Fish Community
Waterbody	Broach Lake		✓	✓	✓	✓	X	X	✓	✓
	Lake H		✓	X	✓	✓	X	X	✓	✓
	Lake G		✓	X	✓	✓	✓	X	✓	✓
	Patterson Lake		✓	✓	✓	✓	✓	✓	✓	✓
	Patterson Lake Shoreline Adjacent to Project (Patterson Lake – Mine Site Area)		X	X	✓	✓	✓	✓	✓[b]	✓
	Forrest Lake		✓	✓	✓	✓	✓	✓	✓	✓
	Beet Lake		✓	✓	✓	✓	✓	✓	✓	✓
	Naomi Lake		✓	✓	✓	✓	✓	✓	✓	✓
Watercourse	Clearwater River	Clearwater River above Patterson Lake (Jed Creek)	✓	X	X	✓	✓	✓	X	✓
		Clearwater River below Patterson Lake (Patterson Creek)	X	X	X	✓	✓	✓	✓	✓
		Clearwater River above Beet Lake (Beet Channel)	X	X	X	✓	✓	X	✓	✓
		Clearwater River below Beet Lake (Beet Creek)	✓	X	X	✓	✓	X	✓	✓
		Clearwater River below Naomi Lake (Clearwater River Nearfield)	✓	X	✓	✓	✓	X	✓	✓
		Clearwater River above the Mirror River Confluence (Clearwater River Midfield 1)	✓	X	X	✓	X	X	✓	✓
	Clearwater River tributaries	Tributary inflow to Naomi Lake (Naomi Creek)	X	X	X	✓	✓	X	✓	✓
		Tributary inflow downstream of Naomi Lake (Clearwater Creek)	X	X	X	✓	✓	X	✓	✓

a) An alternative naming convention was used in Annex V.1 Aquatic Environment Baseline Report compared to that used in the EIS main sections. The naming convention used in Annex V.1 is shown in parentheses.
b) Overwintering fish habitat surveys occurred in the vicinity of the proposed locations for the treated effluent discharge and fresh water intake for mine/mill.
✓ = survey or sampling completed; X = survey or sampling not completed.

11.2.6.2 Fish Habitat Surveys

Fish habitat assessments were completed to characterize the existing fish habitat conditions in the BSA. Surveys were completed during spring, summer, and fall 2018 and during winter and summer 2019 in the waterbodies and watercourses listed in Table 11.2-4. Three types of surveys were completed: general fish habitat surveys, spawning habitat surveys, and overwintering habitat surveys. Information on in situ water quality was also collected to support the characterization of fish habitat conditions in the BSA.

In Situ Water Quality

In situ water quality parameters (i.e., water temperature, specific conductivity, DO, pH) and Secchi depth (i.e., a measure of water clarity or transparency) were measured in a subset of waterbodies and watercourses sampled in the BSA (Table 11.2-4). Water quality conditions are an important component of fish habitat, as described in Section 11.2.2.2, Measurement Indicators. Water temperature, conductivity, DO, and pH were measured using a multi-parameter water quality meter. Existing conditions were characterized based on the parameter ranges presented in Table 11.2-5.

Table 11.2-5: General Water Quality Classification of Waterbodies and Watercourses in the Baseline Study Area

Parameter	Parameter Classification	Parameter Range	Description
Secchi depth (i.e., water clarity or transparency)	Poor	<1 to <2 m	Transparency can be affected by the colour of the water, algae, and suspended sediments. Transparency decreases as colour, suspended sediments, or algal abundance increases (Wetzel 2001).
	Moderate	≥2 to ≤6 m	
	High	>6 m	
pH	Acidic	0 to <7	Most aquatic organisms can tolerate waters with a pH between 6.0 and 9.0 (Wetzel 2001).
	Neutral	7	
	Basic (i.e., alkaline)	>7 to 14	
DO	Low	<6.5 mg/L	Adequate amounts of DO are required to support fish and other organisms in aquatic systems. The DO ranges were based on the CCME water quality guidelines for the protection of aquatic life (CCME 2021; CCME 1999), which consist of guideline values for the protection of aquatic life for both "early" life stages of fish (i.e., embryo/alevin; 9.5 mg/L) and other life stages of fish (6.5 mg/L; CCME 1999).
	Moderate	6.5 to 9.5 mg/L	
	High	>9.5 mg/L	
Specific conductivity	Low	0 to 200 µS/cm	Conductivity is an indirect measure of the salinity of the water. Fish and other organisms that live in fresh water cannot tolerate large increases in salinity. Low conductivity can be an indicator of relatively undisturbed or background conditions. Mid-range conductivity is the normal background for most major rivers. High conductivity is an indicator of saline conditions (Wetzel 2001).
	Moderate	>200 to 1,000 µS/cm	
	High	>1,000 to 10,000 µS/cm	

DO = dissolved oxygen; µS/cm = microsiemens per centimetre; >= greater than; ≥ = greater than or equal to, ≤ = less than or equal to, <= less than; CCME = Canadian Council of Ministers of the Environment.

General Fish Habitat

General fish habitat surveys included characterization of baseline fish habitat conditions in waterbodies and watercourses in the BSA. The surveys were completed during the spring, summer, or fall depending on the waterbody or watercourse. The purpose of the surveys was to characterize existing spawning, nursery, rearing, feeding, and overwintering habitat conditions, and to document potentially sensitive habitats that may be present adjacent to or downstream of the Project. Additionally, the surveys provided information to inform the selection of locations for in-water developments such as the proposed fresh water intake, treated effluent diffuser, and treated sewage outfall. More detailed information on spawning and overwintering fish habitat conditions was obtained during the spawning and overwintering habitat surveys described below.

Each waterbody was divided into a series of habitat sections based on physical characteristics. Habitat surveys included assessment of the upland, riparian, and littoral zones of the surveyed areas. The upland zone refers to the area of higher, dry ground located adjacent to a waterbody or watercourse, the riparian zone refers the transitional area between the upland area and the waterbody or watercourse shoreline, and the littoral zone refers to the nearshore area of a waterbody. Information on bottom substrate composition (i.e., silt/clay, sand, gravel, cobble, boulder, or organic material) and channel characteristics (e.g., presence of riffle, run, pool, and glide habitats) was also collected. Riffles are areas of high-velocity flow and relatively shallow depth and a turbulent water surface. Runs are areas of moderate to high-velocity flow, largely non-turbulent water, and are deeper than riffles. Glides are characterized by very low, near-laminar flow (i.e., smooth flow as opposed to turbulent flow), high channel uniformity, and a lack of scour in the channel bed. Pools are deep areas with the lowest flow velocity relative to other habitat unit types and are formed by scour within the channel bed. The habitat surveys also included characterization of the density of emergent aquatic vegetation (i.e., aquatic plants that grow with their roots under water but their leaves and stems above the water surface) and submergent aquatic vegetation (i.e., aquatic plants that have their roots, leaves, and stems below the water surface), and the amount and type of fish cover present. Cover for fish is defined as aspects of the physical environment that provide resting places or protection from predators and can include physical features such as areas of undercut bank and the presence of woody debris. Additional explanation and definitions for habitat descriptors used in the fish habitat surveys, along with descriptions of the qualitative ranges used to describe the conditions, are provided in Annex V.1, Appendix C, Table 57.

Spawning Habitat

Spring and fall spawning surveys were completed to document the specific locations in the BSA that are used for spawning by large-bodied fish species, including the four fish VCs. Spring spawning surveys were completed during mid- to late May and specifically targeted spring spawning species, including northern pike and walleye. Fall spawning surveys were completed during late September to mid-October and targeted fall spawning species, including lake whitefish and lake trout.

Spawning surveys consisted of fish sampling and egg searches. The purpose of the fish sampling was to determine the spawning condition of captured fish and locate areas where fish in ripe (i.e., ready) spawning condition were most likely to spawn. The fish capture methods used during the surveys included hoop netting, gill netting, and angling. In conjunction with fishing efforts, egg searches were completed to confirm fish use the habitats as spawning habitat. Methods used to target the capture of eggs included vegetation sweeps, egg suctioning, and kick netting.

Habitats were rated for spawning habitat suitability based on known spawning habitat characteristics that are described in the scientific literature. Habitat suitability models were developed for individual species, where available. Habitat suitability models were used to predict fish use through modelling of specific environmental variables, such as water depth and substrate type. Information collected from the spawning surveys for each waterbody or watercourse was incorporated into the habitat suitability models. Habitat suitability ratings were defined as follows: not suitable, marginally suitable, moderately suitable, and most or highly suitable. Annex V.1, Section 9.2.2.2, Spawning Habitat Suitability Index, provides additional detail information regarding the assumptions used to develop the habitat suitability ratings, along with the list of supporting scientific literature considered.

Overwintering Habitat

Overwintering habitat surveys were completed to document winter habitat conditions in watercourses in the BSA. Overwintering habitat is often one of the most important habitat types for fish, particularly in northern regions, which may experience extended periods of ice cover and limited flow. Adequate winter habitat is limiting in many systems and is often an important factor affecting the distribution and abundance of fish in an environment (Cunjak 1996). Overwintering habitat surveys were completed in March 2019 during late ice-cover conditions. The survey targeted the late-winter low flow period, which would represent the most severe winter conditions for fish in these habitats. The surveys included collection of information on under-ice DO concentrations, ice thickness, snow depth, under-ice water depth, and discharge. Any distinguishing habitat features that may influence winter habitat utilization by fish were also noted (e.g., open, ice-free areas, or deep pools). Additional information on overwintering habitat surveys can be found in Annex V.2.

11.2.6.3 Lake Trophic Status

Trophic status is an accepted and widely used means of classifying lakes and describing lake processes in terms of the productivity of the system (Wetzel 2001). In this context, productivity refers to the amount and rate of production (e.g., by phytoplankton) that occurs in an ecosystem over time. Waterbodies are usually categorized into one of three classes: oligotrophic; mesotrophic; or eutrophic (Wetzel 2001). In general, waters with low productivity are classified as oligotrophic, waters with high productivity as eutrophic, and waters with intermediate productivity as mesotrophic. Further sub-classes may also be defined, such as ultra-oligotrophic, oligo-mesotrophic, meso-eutrophic, and hyper-eutrophic (CCME 2004). The trophic status of a waterbody can be assessed based on the concentration of the limiting nutrient (e.g., phosphorus) in a system. The limiting nutrient is that which limits biological productivity. Patterson Lake and the major lakes south of the Project are phosphorus-limited systems (Annex V.1).

The trophic status of each major waterbody in the BSA was evaluated by examining open-water (i.e., May to October) total phosphorus (TP) concentrations. Trophic status was determined using the Canadian Council of Ministers of the Environment (CCME 2004) trophic classification scheme for Canadian waterbodies and watercourses, which is based on TP concentrations in the water column. Following this classification scheme, waterbodies with low TP concentrations can be classified as ultra-oligotrophic (i.e., less than 0.004 mg/L) or oligotrophic (i.e., 0.004 mg/L to 0.01 mg/L); waterbodies with moderate TP concentrations can be classified as mesotrophic (i.e., 0.01 mg/L to 0.02 mg/L) or meso-eutrophic (i.e., 0.02 mg/L to 0.035 mg/L); and waterbodies with high TP concentrations can be classified as eutrophic (i.e., 0.035 mg/L to 0.1 mg/L) or hyper-eutrophic (i.e., greater than 0.1 mg/L; Table 11.2-6).

Table 11.2-6: A General Trophic Classification of Waterbodies

Trophic Classification	TP (mg/L)
Ultra-oligotrophic	<0.004
Oligotrophic	0.004 to 0.01
Mesotrophic	0.01 to 0.02
Meso-eutrophic	0.02 to 0.035
Eutrophic	0.035 to 0.1
Hyper-eutrophic	>0.1

Source: CCME 2004.
>= greater than; <= less than; TP = total phosphorus.

11.2.6.4 Lower Trophic Community Sampling

11.2.6.4.1 Plankton

Plankton is a general term referring to small, usually microscopic organisms that live suspended in the water. Plankton can be subdivided into two different groups: phytoplankton and zooplankton. Phytoplankton refers to the algal component of the plankton community, ranging between 2 µm and 20 µm in size. Zooplankton refers to microscopic animals that live suspended in the water. In general, phytoplankton provide the food base for zooplankton, which in turn are an important food source of many fish species, including early life history stages of piscivorous species. Additional information on the ecology of the dominant zooplankton and phytoplankton groups in the LSA and RSA is provided further below.

Plankton sampling occurred in a subset of waterbodies during open-water conditions in September and October 2018 and included sampling for phytoplankton and zooplankton (Table 11.2-4). The purpose of the plankton sampling was to characterize the phytoplankton and zooplankton communities in the BSA. Phytoplankton samples were collected using a depth-integrated tube sampler from within the euphotic zone (i.e., the region within the water column where photosynthesis typically occurs, defined as twice the Secchi depth). Each sample was a composite of two net hauls through the water column. Zooplankton samples were collected using an 80 µm mesh Wisconsin plankton net with a 20 cm diameter mouth size and consisted of a composite of two hauls drawn vertically through the water column. Phytoplankton and zooplankton samples were analyzed by a qualified taxonomist for taxonomic composition, density (i.e., abundance), and biomass (i.e., weight), or biovolume for phytoplankton. For phytoplankton, biovolume was converted to biomass assuming unit specific gravity.

Phytoplankton and zooplankton taxonomic richness (i.e., the number of individual taxa present, calculated at the family level); Simpson's Diversity Index (SDI; a measure of diversity which considers both the number of family level taxa [richness] and the evenness of distribution of individuals among taxa in a sample); and Simpson's Evenness Index (SEI; a measure of the equitability of distribution of individuals among taxa within the community) were also calculated. Phytoplankton and zooplankton community composition based on major group abundance (i.e., phylum, class, or order, depending on the group) were also calculated.

11.2.6.4.2 Benthic Invertebrates

The term benthic invertebrate is a general term referring to bottom-dwelling organisms (e.g., worms, snails, clams, crustaceans, insects) living on or within the sediments of waterbodies and watercourses. Benthic invertebrates are an important link in aquatic food webs. Most are herbivores, detritivores (i.e., feeding on dead, organic material), or filter-feeders, deriving much of their energy from algae, aquatic plants, and decaying organic material; however, some benthic invertebrates are predators, typically feeding upon other invertebrates. Many fish species, including early life history stages of piscivorous species, rely upon benthic invertebrates as a food source.

Benthic invertebrate samples were collected from a subset of waterbodies and watercourses during September and October 2018 (Table 11.2-4). The objective of the benthic invertebrate sampling was to collect baseline data on benthic invertebrate communities within the BSA. Benthic invertebrate samples were collected using an Ekman dredge (i.e., a grab-sampling device intended for use in soft sediments) as composites of five individual grabs and sieved using a 500 µm mesh. Benthic invertebrate samples were analyzed for abundance, biomass, and community composition. Additional community metrics calculated at the family level included richness, SDI, and SEI (Section 11.2.6.4.1, Plankton, for descriptions of each metric). Benthic invertebrate community composition based on major group abundance was also calculated.

11.2.6.5 Fish Community Sampling

Fish community surveys targeted specific areas within the BSA (Table 11.2-4). Fish community surveys were completed during the spring, summer, or fall depending on the waterbody or watercourse. The purpose of the fish community surveys was to assess species presence, abundance, community composition, and morphometry (i.e., body size including length and weight). Fish capture methods used during the fish community surveys included angling, boat and backpack electrofishing, minnow trapping, gill netting, and dip netting. Catch-per-unit-effort (CPUE) was calculated for the boat and backpack electrofishing effort conducted in waterbodies and watercourses. Catch-per-unit effort is a measure of relative abundance that relates the number of fish captured to the effort spent fishing for a particular gear type (e.g., time spent electrofishing). It can be used to define relative abundance and compare abundances between sites. Fork length (i.e., length from nose to the indent of the caudal/tail fin), or total length where applicable, and weight were measured during selected surveys. Length and weight data for the fish VCs are summarized in the fish VC life history descriptions (Section 11.3.6).

11.2.6.6 Fish Valued Component Life Histories

Species-specific summaries were prepared for each of the four fish VC species (i.e., lake trout, lake whitefish, walleye, northern pike) and are presented in Section 11.3.6 to support the characterization of existing conditions in the LSA and RSA. These summaries are based on a literature review of the biology of the selected VC species and basic information on life history requirements (e.g., preferred habitat conditions, spawning requirements, feeding ecology). Additionally, the available fish and fish habitat baseline information was reviewed to generate species-specific summaries of fish species distribution, catch, morphometry, and documented fish use of habitat types (i.e., spawning, nursery, rearing, feeding) in the LSA and RSA.

11.2.7 Project Interactions and Mitigations

Interactions (i.e., linkages) between Project components or activities, and the corresponding potential changes to measurement indicators, were identified by a pathway analysis that was then used to inform the residual effects assessment for the fish VCs (Section 6.7, Pathways Analysis). The first part of the analysis was to identify all potential effects pathways for all phases of the Project (Section 6.7.1, Identification of Project Interactions). Each pathway was initially assumed to have a linkage to potential effects on fish VCs.

Potential pathways from Project activities to fish VCs were identified using the following:

- review of the Project description (Section 5) and potential effects scoping by the project development, environmental, and socio-economic teams for the Project;
- input from Indigenous, regulatory, and public engagement (Section 2) and Indigenous and Local Knowledge (Section 3);
- scientific knowledge;
- previous experience with mining projects; and
- consideration of potential effects identified from the Terms of Reference (Section 1, Appendix 1A).

Potential adverse effects of the Project were then identified, and practicable mitigation was applied to avoid, minimize, and/or rehabilitate adverse effects on fish VCs (Section 6.7.2, Identification of Mitigation). Avoidance and minimization are widely recognized as the most important approach for biodiversity conservation (BBOP 2021). Avoidance designs and actions integrated into the Project were developed iteratively between the Project's environmental and project development teams. Minimization techniques and technology were also identified and implemented collaboratively between Project teams.

Each potential effect pathway was evaluated using proposed mitigation to predict whether the pathway had the potential to cause residual adverse effects (Section 6.7.3, Pathway Screening). A screening-level assessment was applied using Indigenous and Local Knowledge, scientific knowledge, logic, experience with similar developments, and an understanding of the effectiveness of mitigation (i.e., level of certainty that mitigation would work) to assign each pathway to one of the following categories:

- **No pathway:** Analysis reveals that the pathway could be removed (i.e., the effect is avoided) by mitigation so that the Project would result in no measurable environmental change relative to existing conditions or guideline values and, therefore, would have no residual effect on fish.
- **Secondary pathway:** The pathway could result in a measurable but minor environmental change relative to existing conditions or guideline values, but this change is sufficiently small that it would have a negligible residual effect on fish. Therefore, the pathway is not expected to contribute to effects of RFDs to cause a significant effect.
- **Primary pathway:** The pathway is likely to result in an environmental change relative to existing conditions or guideline values and could cause a greater than negligible effect on fish.

Project interactions determined as no pathway or secondary pathways were not carried forward for further assessment (Section 6.7.3). Pathways that result in changes to the environment with one or more associated measurement indicator and have the potential to cause a greater than negligible effect on fish VCs were carried forward to the residual effects analysis and residual effects classification (Section 11.5).

Where direct effects on fish habitat cannot be avoided or minimized, NexGen would determine through consultation with DFO where there is a harmful alteration, disruption, or destruction of fish habitat, as defined by the federal *Fisheries Act*, and would implement offsetting measures to counterbalance any residual loss through positive contributions to the aquatic ecosystem. Offsetting was not assumed to remove pathways but was considered as a factor that could be used to reduce the residual effects of a pathway on a fish VC. If required, a fish habitat offsetting plan would be developed in consultation with DFO and with engagement of the local communities, and ultimately, authorized by DFO with the goal of maintaining or improving fisheries productivity in the LSA and RSA.

11.2.8 Residual Effects Analysis

The residual effects analysis measures and describes the effects of the Project on fish VCs relative to existing conditions. The residual effects analysis was conducted using spatial boundaries (Section 11.2.3 Spatial Boundaries) and temporal boundaries (Section 11.2.4, Temporal Boundaries) identified for the assessment. The analysis used conservative assumptions and integrated information from intermediate components that may have a linkage to potential effects on fish VCs (e.g., surface water quality [Section 10]) and from relevant TSDs (e.g., TSD XXI). Where applicable, environmental modelling outputs generated in these assessments were used to provide information and context to support the interpretation of potential residual effects on fish VCs.

Residual effects are described for each of the measurement indicators for the primary pathways identified for fish VCs in the LSA and RSA (Section 11.4.3, Primary Pathways). The residual effects analysis was completed for the Application Case and the RFD Case.

The Application Case represents predictions of the cumulative effects of the previous and existing conditions (i.e., Base Case) combined with the effects from the Project. The Application Case is also used to identify the incremental changes from the Project that are predicted to occur between the Base Case and the Application Case. The RFD Case includes the Application Case plus additional RFDs in the study areas, and natural disturbance factors such as climate change.

The residual effects analyses for the Application Case and the RFD Case were completed by estimating and predicting changes to fish VC measurement indicators. Residual effects of the Project are those effects that remain after implementation of all mitigation. Predictions were summarized both in terms of general changes in measurement indicators that are applicable to all fish VCs, and where feasible, specific changes that are applicable to individual fish VCs (i.e., lake trout, lake whitefish, walleye, northern pike). Predicted changes in measurement indicators are very similar among the four species selected as VCs; therefore, instead of repeating similar information on a VC-by-VC basis, the effects were most efficiently summarized collectively for VCs with individual differences noted, where feasible. For example, potential changes to the health of lower trophic level organisms can affect all fish VCs by changing the available food base, and therefore habitat availability for fish. However, the magnitude and specific type of effect may differ among the fish VCs depending on their individual feeding ecology. These similarities and differences were accounted for in the effects analysis.

The residual effects analysis for each primary pathway and VC used logical reasoning to describe anticipated changes to each measurement indicator caused by the Project. This narrative description of anticipated effects was the foundation for the residual effects classification and significance determination detailed in Section 11.2.9.

11.2.9 Residual Effects Classification and Determination of Significance

The residual effects analysis uses a reasoned narrative to describe anticipated changes to each measurement indicator caused by the proposed Project and the associated effects on each VC. The residual effects analysis also considers effects from both the Project and RFDs. These narrative descriptions of anticipated effects represent the foundation for the residual effects classification and significance determination. Residual effects are summarized or classified in tabular form using effects criteria, which are intended to provide structure and comparability across VCs and intermediate components assessed for the Project (Section 6.9.1, Residual Effects Classification).

The residual effects classification used direction, magnitude, geographic extent, duration, reversibility, frequency, and probability of occurrence as criteria. The approach to classify each residual effect criterion is provided in Table 11.2-7.

Table 11.2-7: Definitions Applied to Effects Criteria Classifications for the Assessment of Fish and Fish Habitat

Criterion	Rating	Definition
Direction	Positive	Change in measurement indicator results in net improvement or benefit to the fish VC
	Neutral	Change in measurement indicator results in net balance to the fish VC
	Negative	Change in measurement indicator results in net degradation or loss to the fish VC
Magnitude	Qualitative narrative or numeric quantification	Change in measurement indicator is described by effect size (e.g., quantitative, or qualitative description of change in VC habitat availability or survival and reproduction)
Geographic extent	Project footprint	Change in measurement indicator is confined to the Project footprint
	Local	Change in measurement indicator extends outside the Project footprint but within the LSA
	Regional	Change in measurement indicator extends beyond the LSA but is confined to the RSA
	Beyond regional	Change in measurement indicator extends beyond the RSA
Duration	Qualitative narrative or numeric quantification	Change in measurement indicator is described by effect duration (e.g., months, years, decades, permanent)
Reversibility	Reversible	Change in measurement indicator is reversible within a clearly defined time period
	Irreversible	Change in measurement indicator is predicted to influence the component indefinitely
Frequency	Occasional	Change in measurement indicator is expected to occur rarely (e.g., once or a few times)
	Periodic	Change in measurement indicator is expected to occur consistently at regular intervals or associated with temporal events (e.g., during hot, dry climatic conditions)
	Continuous	Change in measurement indicator is expected to occur all the time
Probability of occurrence	Unlikely	Change in measurement indicator is not expected to occur, but not impossible
	Possible	Change in measurement indicator may occur, but is not likely
	Probable	Change in measurement indicator is likely to occur, but is uncertain
	Certain	Change in measurement indicator will occur

LSA = local study area; RSA = regional study area; VC = valued component.

While most criteria could be assigned categorical ratings for fish VCs, predicted effect sizes were provided in specific terms (i.e., narrative or numeric quantification) in the residual effects characterization (Table 11.2-7). Similarly, duration was described in specific terms (e.g., years). Applying a category rating to a criterion such as magnitude might lead to confusion or misinterpretation of the effects assessment, or result in the criterion not being easily categorized in a meaningful way. For example, characterizing magnitude solely using an ordinal scale (i.e., low, moderate, or high) for fish VCs is often not appropriate as additional context is required to properly characterize the effects. Universal effect size boundaries, such as a 20% change in a measurement indicator at the RSA or LSA scale used to define a high-magnitude effect, work poorly because they fail to consider context. Depending on ecological context, and context from the cumulative effects from previous and existing developments and activities that also interact with a VC, a 20% change from existing conditions in the study area may be required to cause a high magnitude effect for one VC, whereas a 2% change in the study area may be sufficient to cause a high magnitude effect for another VC (Section 6.9.1, Residual Effects Classification).

The significance of adverse residual effects on fish VCs was evaluated using the assessment endpoints as significance thresholds defined for each VC. In general, the determination of significance followed the approach provided in Section 6.9.2, Significance Determination. For fish VCs, the threshold used for significance was the maintenance of self-sustaining and ecologically effective populations at the scale of the RSA. The RSA was set using ecological boundaries at a scale suitable for the application of cumulative effects management strategies for fish VCs, and is therefore an appropriate and relevant scale for evaluating population integrity for fish VCs.

Self-sustaining fish populations are populations that will be maintained into the future with a low risk of extirpation (i.e., loss of a species or population within a defined geographic area). Self-sustaining populations are healthy and viable populations which are, by definition, robust, and capable of withstanding environmental change and accommodating stochastic population processes (Reed et al. 2003). Stochastic population processes refer to chance events such as floods or droughts that can affect population dynamics. Maintaining viable populations is a conservation target frequently applied by conservation biologists and resource managers (Fahrig 2001; Nicholson et al. 2006; Ruggiero et al. 1994; With and Crist 1995). An ecologically-effective population differs from a self-sustaining population if the number of individuals needed to maintain ecological function is greater than the number required to maintain a viable population for the long term.

The ability of a VC to accommodate disturbance was evaluated using the concepts of ecological adaptability and resilience. Adaptable fish species are those that can change their behaviour, physiology, or population characteristics (e.g., reproduction rate) in response to a disturbance such that the integrity of the population remains more or less unchanged. Adaptable species can accommodate substantial disturbance and sometimes thrive in highly modified environments, whereas species with low adaptability can accommodate little or no disturbance.

Resilience is a concept that is distinct from, yet closely related to, adaptability. Biological populations often have inertia, meaning a tendency to resist changes away from current density (Murdoch 1970), and would continue to function after disturbance up to the point where the disturbance becomes severe and long enough that the population undergoes a fundamental change. Adaptability influences the duration and magnitude of effect required for this to happen, whereas resilience defines the ability of a species' population or ecosystem to recover from disturbance. Highly resilient fish species have the potential to recover quickly from disturbance (e.g., after reclamation is achieved or an important mortality source removed), whereas species with low resilience would recover more slowly or may not recover at all (Vasconcelos et al. 2017).

Resilience, adaptability, and existing conditions provide important ecological context for the determination of significance. Existing conditions represent the combined effects of previous and current human activities and natural factors that have shaped the observed condition or patterns of each VC in the LSA and RSA. These conditions represent the starting point for assessing Project effects and were considered as context to help define how close each VC might be to its resilience limits when making the significance determination for the Project, and for future projects or natural factors, if applicable.

Ideally, effect threshold values for adaptability and resilience of a VC are known, and changes in measurement indicators can be quantified accurately and with a high degree of confidence to evaluate whether or not these have been exceeded. However, critical thresholds such as the amount or distribution of habitat required to maintain a self-sustaining population or the specific number of individuals required to maintain an ecologically effective population size, are rarely available for fish VCs. Overall, a detailed and transparent account of whether the predicted effects of the Project could be significant by causing a critical threshold to be exceeded was prepared for each VC by combining available scientific literature, data collected in the LSA and RSA, and logical reasoning (i.e., a weight of evidence or reasoned narrative approach). The determination of significance was also placed in context of how changes from the Project and RFDs could influence biodiversity (Section 6.3.5, Biodiversity). Fish VCs and measurement indicators were reviewed holistically to evaluate the potential for effects on biodiversity.

Confidence in the significance prediction was identified and discussed for each VC as part of the reasoned narrative. If uncertainty was high about where a threshold for a significant effect would occur in the range of potential values, and if the effect could be assessed as significant or not significant, a precautionary approach was applied, and the effect was identified as significant. Additional follow-up actions to reduce uncertainty were proposed.

11.2.10 Prediction Confidence and Uncertainty

The purpose of the assessment is to predict the future conditions for fish and fish habitat with the addition of the Project and the Fission Patterson Lake South Property. As with all predictions of future conditions, the predictions made in this assessment embody some degree of uncertainty. The assessment applied a precautionary (i.e., conservative) approach to address uncertainty by identifying the greatest magnitude, duration, and geographic extent of potential adverse effects when a range of possible outcomes were possible. Consequently, uncertainty was addressed in a manner that increased the level of confidence that residual effects were conservatively estimated. The key uncertainties for fish and fish habitat and the way they were addressed are presented as part of this assessment (Section 11.6).

11.2.11 Monitoring, Follow-Up, and Adaptive Management

Monitoring programs are proposed to address the uncertainties associated with the effects predictions and to evaluate the performance of mitigation. In general, monitoring is used to verify the effects predictions. Monitoring is also used to identify any unanticipated effects and to support the implementation of adaptive management to limit these effects. Typically, monitoring includes one or both of the following categories that may be applied during the Project lifespan:

- **Regulatory compliance monitoring:** monitoring activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation and conditions of approval, and NexGen commitments (e.g., inspecting the installation of a silt fence, monitoring the quality of water discharge from the Project).
- **Follow-up monitoring:** programs designed to test the accuracy of effects predictions, reduce or address uncertainties, determine the effectiveness of mitigation, or provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices (e.g., implementation of adaptive management). Results from these programs can be used to increase the certainty of effect predictions in future EAs.

Where relevant, conceptual monitoring programs would be proposed to confirm predictions and to address the uncertainties associated with the effect predictions and mitigation, and upon Project approval, would be included in NexGen's Integrated Management System.

The implementation of robust, long-term environmental testing and monitoring has also been requested by Indigenous Groups to verify protection of the environment, including community-led monitoring during Construction and Operations of the proposed Project (TSD IV: MN-S; TSD V.2: CRDN; TSD VI: YNLR).

In addition to environmental monitoring programs typically implemented for projects (i.e., as noted above), NexGen is working with local Indigenous Groups to implement independent environmental monitoring. In combination with standard Project monitoring processes, independent Indigenous monitoring would be used to verify Project performance and to determine if mitigations and controls are effective in protecting the receiving environment.

Adaptive management measures may also be proposed to address the uncertainties associated with the effects predictions and mitigation. The process for determining when, how, and where to use adaptive management would be described within the Integrated Management System Manual.

11.3 Existing Conditions

The existing environment for fish VCs is a summary of biological and environmental information collected in the LSA and RSA (Section 11.2.3). Detailed information on existing conditions for fish and fish habitat is provided in Annex V. Summaries of fish habitat conditions, including lake trophic status, lower trophic level community conditions, and fish communities are provided to characterize the Base Case against which Project effects are evaluated. Additionally, summaries outlining the biology and life history of the four fish VC species in the LSA and RSA are provided. Information related to hydrology and water and sediment quality in the LSA and RSA is provided in Section 9 and Section 10, respectively.

11.3.1 Fish Habitat

The following sections summarize the existing fish habitat conditions for each waterbody or watercourse assessed (Table 11.2-4; Figure 11.2-3) in the LSA and RSA (Figure 11.2-1). Results from habitat surveys completed for the aquatic environment baseline study (i.e., general fish habitat assessments, spring and fall spawning surveys, overwintering habitat surveys) are discussed. Detailed descriptions of the areas surveyed, including representative photographs and figures summarizing the habitat conditions within each waterbody or watercourse, are provided in Annex V.1 and Annex V.2.

The Project would be located adjacent to Patterson Lake, within the Clearwater River watershed. The headwaters of the Clearwater River are traditionally known to be situated north of Patterson Lake (CRDN 2019a). The Clearwater River flows from its headwaters at Broach Lake through a series of lakes including Patterson Lake, Forrest Lake, Beet Lake, and Naomi Lake, with a channel that is shallow, flat, and meandering (Figure 11.2-3). From Naomi Lake, the Clearwater River flows an additional 20 km southeast before reaching the Mirror River confluence. Below the Mirror River confluence, the Clearwater River deepens with higher flow volumes from the Mirror River, and the channel form changes to meandering within a well-defined river valley.

11.3.1.1 Waterbodies

Broach Lake

Broach Lake is located upstream of the proposed Project at the headwaters of the Clearwater River. The lake has a surface area of 9.3 km^2, a maximum depth of 82 m, and a mean depth of 26 m. During summer sampling, the average Secchi depth was 7.4 m, indicating high water clarity. Summer DO concentrations were high, averaging 10.3 mg/L, and pH was neutral, averaging 7.0. Conductivity was low, averaging 39.2 microsiemens per centimetre (µS/cm), indicating low salinity, or background conditions (Wetzel 2001).

The upland landscape consists of mature mixed forest stands. The riparian zone consists of forest stands vegetated with trees, shrubs, grasses, and sedges. The littoral zone is predominantly composed of cobble and/or boulder substrates and sections of sand. Aquatic vegetation cover is sparse to non-existent, and large woody debris is sparse. The main types of cover for fish are rock and overhanging vegetation.

Under-ice DO concentrations were observed to be high (average = 10.0 mg/L), indicating there is suitable overwintering habitat present for all species and life stages of fish.

The lake bottom predominantly consists of clean, rocky substrates (i.e., areas where the rock is relatively clear of accumulated silt or algae); these areas provide spawning habitat for fish species that prefer to spawn on rocky substrates, including walleye, lake whitefish, and lake trout. Sparse aquatic vegetation in most areas limits suitability for northern pike spawning.

Lake H

Lake H is located adjacent to the east shore of Patterson Lake North Arm – East Basin and discharges to Patterson Lake via a tributary stream. Lake H has a surface area of 1.7 km^2, a maximum depth of 8.2 m, and a mean depth of 1.4 m. The clarity of the water in Lake H was observed to be poor, with an average Secchi depth of 1.1 m during summer sampling. Summer DO concentrations were moderate, averaging 8.2 mg/L, and pH was slightly alkaline, averaging 7.7. Conductivity was low, averaging 38.5 µS/cm.

Nearly the entire upland zone has been burned as a result of forest fires in the area. The riparian zone consists of wet sandy beaches that have been colonized by dense grasses and sedges or of a band of rock with burnt trees and regenerating shrubs. The dominant substrate type in the littoral zone is sand, which is mixed with small amounts of organic matter. The littoral zone of the southwest portion of the lake is composed of rocky substrates, which are covered in a layer of silt and algae. Variable amounts of emergent aquatic vegetation are common, although floating vegetation is also occasionally present. Cover for fish consists of moderate to dense amounts of aquatic vegetation and undercut banks, sparse amounts of overhanging vegetation, and sparse amounts of large woody debris.

The results of winter water quality sampling in Lake H indicated that DO is naturally low during ice covered conditions (average = 2.2 mg/L). These conditions would limit fish use of the lake as overwintering habitat, particularly for species (e.g., lake whitefish and lake trout) and life stages (e.g., fry and alevin) that require high DO concentrations.

Spawning habitat for walleye, lake whitefish, and lake trout is limited due to a lack of clean, rocky substrates and the presence of aquatic vegetation and organic matter. Two shoreline areas were assessed as moderately to mostly suitable for spawning by northern pike due to the presence of moderate to dense amounts of sedge and sparse to moderate amounts of large woody debris.

Lake G

Lake G is located adjacent to the east shore of Patterson Lake North Arm – East Basin, and discharges to Patterson Lake via a tributary stream. Lake G has a surface area of 0.59 km^2, a maximum depth of 3.4 m, and a mean depth of 1.4 m. The water clarity was observed to be poor in Lake G, with an average Secchi depth of 0.8 m during summer. Summer DO concentrations were moderate, averaging 8.7 mg/L; pH was alkaline, averaging 8.0; and conductivity was low, averaging 38.2 µS/cm.

The upland landscape consists of mature, mixed, or coniferous forest stands, and the riparian zone is vegetated with trees, shrubs, and grasses extending to the shoreline. The dominant substrate found in the littoral zone is sand; in some areas, small amounts of gravel, cobble, or organic matter are mixed with the sand. Cover for fish is abundant, with dense amounts of large woody debris, undercut banks, and overhanging vegetation, and sparse to dense amounts of mainly emergent aquatic vegetation.

The results of winter water quality sampling in Lake G indicated that DO is low during ice-covered conditions (average = 3.45 mg/L). These conditions would limit use of the lake by fish as overwintering habitat, particularly by species and life stages that require high DO concentrations.

Dense amounts of sedge are present along the shoreline in the north and south areas of the lake, making these areas highly suitable for northern pike spawning. The east side of the lake features substrates composed of sand, combined with small amounts of gravel or cobble, and was assessed as marginally suitable for walleye, lake whitefish, and lake trout.

Patterson Lake

Patterson Lake is located along the Clearwater River flow path, downstream of Broach Lake, and upstream of Forrest Lake. Patterson Lake has a surface area of 38.2 km^2, a maximum depth of 52.7 m, and a mean depth of 14.3 m. Patterson Lake is divided into the North Arm and South Arm (Figure 11.2-2). The North Arm is further divided into the West Basin and East Basin, which are separated by a narrow, shallow sand bar. The North Arm – West Basin is the deepest (i.e., 52.7 m) of the three areas of Patterson Lake.

The average Secchi depth during the summer ranged between 5.2 m and 8.7 m depending on the basin, indicating moderate to high water clarity. These results are supported by Indigenous and Local Knowledge from the CRDN about the clarity of Patterson Lake and from the BNDN and BRDN (BRDN-JWG 2019b) about lakes generally in the area of the Project:

> This is all really clear, clean water too. Patterson's really clean. All this. Like this river, in here, like this connects Beet and all this stuff here. Right in this area here, until it gets to the Clearwater, is really really clear water . . . . It's pretty clear into here . . . . But here (tli kli na*/Where the Rivers Meet) it's all really clean clear good water. Like, Patterson, Forrest, all that, is really good water. (TSD V.2: CRDN)

> Well, if it's not as clear as it was back then . . . [there's]probably [something] wrong. Because all these lakes here are just crystal-clear water . . . . If you start seeing algae and all that and just – something's not right because these are all rock and sand lakes – sand bottom, rock. (TSD II: BNDN).

Summer DO concentrations were moderate to high, ranging between 6.4 mg/L and 10.1 mg/L. The pH of the water was neutral to slightly alkaline, ranging between 7.0 and 7.3. Conductivity was low, ranging between 31.2 µS/cm and 39.7 µS/cm.

The upland landscape is composed of a mature coniferous forest and some areas of burnt, regenerating, mixed, or deciduous stands. In the littoral zone, cobble and boulder are the dominant sediment types, followed by sand or a sand/gravel mixture. Limited areas of organic matter and gravel were also identified. Aquatic vegetation cover is sparse or absent. Dense rock cover and dense overhanging vegetation are the main types of fish cover present.

Under-ice DO concentrations were lower overall in the North Arm – East Basin (average = 6.4 mg/L) and higher in the North Arm – West Basin and South Arm (average = 10.1 mg/L and 9.3 mg/L, respectively). These results indicate that all three areas of the lake would provide suitable overwintering habitat for some species; however, overwintering habitat conditions for species and life stages that require higher DO levels may be more suitable in the West Basin and South Arm.

The lake bottom predominantly consists of clean, rocky substrates. These areas provide moderately to highly suitable spawning habitat for lake trout, lake whitefish, and walleye. A rock shoal with clean substrate and good water circulation is present on a point located in the North Arm of the lake, making this area highly suitable for spawning for these species. Two locations had dense emergent vegetation and were assessed as highly suitable for northern pike spawning.

Surveys were also conducted along the Patterson Lake shoreline adjacent to the proposed Project. The surrounding upland along this shoreline consists of mature mixed forest with small patches of deciduous and coniferous forest, and regenerating forest stands. The riparian zone consists of shrubs and trees. The dominant substrate in the littoral zone in approximately half of the survey area consists of sand, while the other half consists of rocky substrates (i.e., gravel, cobble, boulder), or a mixture of sand, cobble, and boulder. Rocky substrates, where present, are often covered in a thin layer of silt. Organic matter is limited to only a few areas. Aquatic vegetation cover is sparse. There were limited amounts of cover for fish. Where present, cover mainly consists of large woody debris, rock cover, and overhanging vegetation.

Similar to the rest of Patterson Lake, high quality northern pike spawning habitat is lacking along the Patterson Lake shoreline adjacent to the Project. Sand and rocky substrate and sparse amounts of emergent vegetation provide marginal spawning habitat in only a few areas. Approximately half of the surveyed area provides moderately to highly suitable spawning habitat for lake trout, lake whitefish, and walleye due to the presence of rocky substrates or a mixture of sand, cobble, gravel, and boulder substrates.

Forrest Lake

Forrest Lake is located along the Clearwater River flow path, downstream of Patterson Lake and upstream of Beet Lake. Forrest Lake has a surface area of 40.1 km^2, a maximum depth of 52.7 m, and a mean depth of 30.5 m. The clarity of the water during summer sampling varied from poor to high depending on the location and ranged between 1.2 m and 11.8 m. Summer DO concentrations were high, averaging 9.8 mg/L; pH was slightly alkaline, averaging 7.4; and conductivity was low, averaging 44 µS/cm.

The upland zone is composed mainly of mature coniferous forest, and some area of wetlands. The riparian vegetation is composed of trees, shrubs, grasses, and sedges. The substrate predominantly consists of cobble and/or boulder or areas of sand, with organic matter, gravel/cobble, or mixture of sand and rock substrates also being present. Aquatic vegetation cover is limited, and large woody debris is sparse. Vegetation is present mainly in the northern portion of the lake and in a bay on the east side. The main cover types for fish are overhanging vegetation and rock.

Under-ice DO concentrations were observed to be high (average = 9.8 mg/L), indicating there is suitable overwintering habitat present for all species and life stages of fish.

The northwest portion of Forrest Lake contains dense emergent vegetation beds that were assessed as moderately to highly suitable for northern pike spawning. Clean cobble and/or boulder substrates are present in several areas and provide moderately or highly suitable spawning habitat for lake trout, lake whitefish, and walleye.

Beet Lake

Beet Lake is located along the Clearwater River flow path, downstream of Forrest Lake and upstream of Naomi Lake. Beet Lake has a surface area of 8.9 km^2, a maximum depth of 33.7 m, and a mean depth of 10.7 m. The water clarity was high during summer sampling, with an average Secchi depth of 6.2 m. Summer DO concentrations were high, averaging 10.4 mg/L; pH was slightly alkaline, averaging 7.2; and conductivity was low, averaging 45 µS/cm.

The upland area is occupied by recently burned forest stands, though a few regenerating and mature stands are also present. The riparian zone vegetation is composed of grasses, shrubs, and trees. The substrate in the littoral zone is primarily composed of sand, with mixtures of gravel, cobble, and/or the presence of boulder substrates. Aquatic vegetation is sparse. The main cover types for fish are overhanging vegetation and rock. Large woody debris and undercut bank were present in moderate to dense amounts in some areas.

Under-ice DO concentrations were observed to be moderate (average = 7.9 mg/L), indicating there is suitable overwintering habitat present for fish, except species and life stages requiring high DO levels.

Spawning habitat for northern pike is limited or absent due to the lack of emergent vegetation. Areas with mostly sand substrate were assessed as marginally suitable as spawning habitat for walleye and lake whitefish. Some of the rocky areas present in the lake had clean or mostly clean rock substrate and were assessed as moderately suitable spawning habitat for lake trout, lake whitefish, and walleye.

Naomi Lake

Naomi Lake is located downstream of Beet Lake along the Clearwater River flow path. Naomi Lake has a surface area of 2.4 km^2, a maximum depth of 8.4 m, and a mean depth of 1.8 m. The water clarity was high during summer sampling, with an average Secchi depth of 6.2 m. Summer DO concentrations were moderate, averaging 7.6 mg/L; pH was slightly acidic, averaging 6.9; and conductivity was low, averaging 26 µS/cm.

The upland landscape consists of mature or burnt coniferous forest stands and the riparian zone is occupied by forest stands, with trees, shrubs, grasses, and sedges. The substrate in the littoral zone is a mixture of nearly entirely sand and organic matter, and very limited areas of cobble and boulder. Overhanging vegetation is the most abundant type of cover for fish and was present in dense or moderately dense amounts. Aquatic vegetation is also moderately abundant as cover for fish. Large woody debris and undercut cover are sparse, while rock cover is typically absent.

Habitat conditions in Naomi Lake were assessed as either not suitable or marginally suitable for spawning for lake trout, lake whitefish, and walleye due to a lack of clean, rocky substrate. The organic and sandy substrate with sometimes abundant or moderately abundant vegetation and large woody debris is more appropriate for northern pike spawning.

11.3.1.2 Clearwater River Mainstem

Clearwater River above Patterson Lake

A 100 m long section of the Clearwater River above Patterson Lake was surveyed immediately upstream of the Patterson Lake inflow. The DO concentrations in this section of the Clearwater River were moderate during summer, averaging 8.8 mg/L; pH was neutral, averaging 7.0; and conductivity was low, averaging 24.5 µS/cm. Mature or burnt coniferous stands occupy the upland zone, while wetlands composed primarily of shrubs, grasses, and sedges are present in the riparian zone. River bottom substrates primarily consist of sand, with small amounts silt/clay, organic matter, and gravel. Mean wetted width is 8 m to 18 m, and mean depth in the centre of the channel was shallow (i.e., 0.3 m to 0.4 m). The surveyed section is composed primarily of glides. Cover for fish includes dense overhanging vegetation with moderate amounts of undercut banks. Sparse to moderate amounts of large woody debris and aquatic vegetation are also present.

The surveyed section is considered to provide good quality overwintering habitat for all life stages and species of fish due to high winter DO concentrations (average = 11.3 mg/L), abundant overhead cover, and ice-free, flowing water conditions.

Occasional areas with dense vegetation beds provide highly suitable spawning habitat for northern pike. Due to the very limited amounts of rocky substrates, the habitat is not considered suitable or only marginally suitable for lake trout, lake whitefish, and walleye.

Clearwater River below Patterson Lake

A 1 km long section of the Clearwater River was surveyed between the Patterson Lake outflow and Forrest Lake inflow. In this section of the Clearwater River, the river is composed of a single channel, except for near its entry into Forrest Lake, where the river branches into a “Y”, separating into two channels. The existing bridge crossing of the site access road is located within this section of the Clearwater River.

Mature coniferous or mixed stands occur in the upland zone and riparian zone along this section of the Clearwater River. Sand is the dominant substrate; however, relatively fast flowing waters with more rocky substrates also occur. Mean wetted width is between 3 m and 15 m, except for the two channels that branch off entering Forrest Lake where the wetted width in each channel is approximately 25 m. Mean depth in the centre of the channel is shallow (i.e., 0.4 m to 1.2 m). The surveyed section is composed predominantly of runs, although riffles, glides, and pools also occur. Cover for fish includes dense overhanging vegetation and undercut banks, with some sections of large woody debris, aquatic vegetation, or rock.

The surveyed section was considered to provide good quality overwintering habitat for all life stages and species of fish due to high DO concentrations (average = 13.6 mg/L), abundant overhead cover, and ice-free, flowing water conditions.

Due to the relatively fast flowing waters near the Patterson Lake outflow and rocky substrates, the area is considered suitable for lake whitefish and walleye spawning. The slow-moving glides and pools with dense vegetation beds provide highly suitable spawning habitat for northern pike. The habitat is considered unsuitable for lake trout spawning.

Clearwater River above Beet Lake

A 1.5 km long section of the Clearwater River above Beet Lake was surveyed between the Patterson Lake outflow and Beet Lake inflow. The upland landscape in the surveyed section of the Clearwater River is predominantly occupied by coniferous forest stands. The vegetation in the riparian zone is composed of trees, shrubs, grasses, and sedges. The substrate in the littoral zone is primarily composed of sand or organic matter, with limited areas of cobble and/or boulder. Water depths at approximately 5 m from shore are typically between 0.2 m and 0.5 m. The main cover types for fish are overhanging vegetation and undercut banks. Aquatic plant cover is usually sparse or moderate.

The surveyed section is considered to provide good quality overwintering habitat for all life stages and species of fish due to high DO concentrations (average = 12.9 mg/L), abundant overhead cover, and ice-free, flowing water conditions.

Clean, rocky substrates are mostly absent; therefore, the spawning habitat is unsuitable, or marginally suitable, for lake trout, lake whitefish, and walleye. Dense vegetation beds in the surveyed section are suitable for northern pike spawning.

Clearwater River below Beet Lake

An approximately 500 m long section of the Clearwater River was surveyed between the Beet Lake outflow and the Naomi Lake inflow. Summer DO concentrations in this section of the Clearwater River were observed to be moderate, averaging 8.4 mg/L; pH was slightly alkaline, averaging 7.5; and conductivity was low, averaging 43.1 µS/cm. Mature coniferous stands are present in the upland zone. The riparian zone is forested, with the vegetation composed of trees, shrubs, grasses, and sedges. The bottom substrate is composed of organic matter, silt/clay, and sand. Mean wetted width is 13 m to 20 m, and mean depth at the centre of the channel is near 1 m. The surveyed section consists predominantly of slow-moving glides. Cover for fish includes dense amounts of large woody debris and undercut banks, with moderate amounts of aquatic vegetation.

Frequent water depths greater than 1 m and high winter DO concentrations (average = 11.9 mg/L) at this site indicate the presence of good quality overwintering habitat for all life stages and species of fish within the surveyed section.

The moderate to dense amounts of emergent vegetation with slow-moving waters provide highly suitable spawning conditions for northern pike. The absence of rocky substrates indicate habitat is marginally suitable for lake whitefish and walleye spawning and not suitable for lake trout.

Clearwater River below Naomi Lake

A 4 km long section of the Clearwater River was surveyed beginning at the outlet of Naomi Lake. Summer DO concentrations in this section of the Clearwater River were observed to be moderate, averaging 9.3 mg/L; pH was slightly alkaline, averaging 7.6; and conductivity was low, averaging 36.9 µS/cm. The upland zone consists of mature coniferous forest stands, and the riparian zone consists of forest extending to the bank, with trees, shrubs, grasses, and sedges present. The bottom substrate consists of sand with smaller amounts of silt/clay and organic matter, and gravel, cobble, and boulder. Water depths at 5 m from the shoreline are moderately shallow, ranging from 0.3 m to 1.4 m. Most areas within the section consist of glides, with limited areas of riffle habitat. The main cover types for fish are overhanging vegetation, and aquatic vegetation.

The surveyed section is considered to provide good suitability overwintering habitat for some life stages and species of fish based on the moderate DO levels (average = 7.9 mg/L), and ice-free, flowing water conditions encountered at the site. Overwintering habitat may be more limiting for sensitive species or life stages (e.g., embryos or newly hatched trout) that require higher DO concentrations.

Dense vegetation beds occur often along this section and provide suitable spawning habitat for northern pike. The surveyed section was assessed as unsuitable or marginally suitable as spawning habitat for lake whitefish and walleye due to the general lack of clean rock. However, limited areas of highly suitable spawning habitat for these species were identified. The habitat is considered unsuitable for lake trout spawning.

Clearwater River above the Mirror River Confluence

An approximately 800 m long section of the Clearwater River was surveyed upstream of the Mirror River confluence. Summer DO concentrations in this section of the Clearwater River were observed to be moderate, averaging 7.8 mg/L; pH was slightly alkaline, averaging 7.3; and conductivity was low, averaging 32.4 µS/cm. The surrounding upland consists of mature coniferous forest, and the riparian zone consists of wetlands vegetated with trees, shrubs, grasses, and sedges. The bottom substrate is predominantly sand mixed with organics, with limited areas of cobble/gravel. Dense amounts of submergent macrophytes are present. Cover for fish consists of aquatic vegetation and overhanging vegetation and limited amounts of large woody debris and undercut banks.

Approximately half of the surveyed section is considered to be moderately to highly suitable spawning habitat for northern pike due to the presence of dense beds of sedge and shallow water depths. Moderately suitable spawning habitat for lake trout, lake whitefish, and walleye was identified in the upstream portion of the surveyed section where sand, gravel, and cobble substrates are present.

11.3.1.3 Clearwater River Tributaries

Tributary Inflow to Naomi Lake

The tributary inflow to Naomi Lake flows south into Naomi Lake at the north end of the lake. An approximately 150 m long section of the tributary was surveyed. The upland area consists of a mature mixed forest stand, with a forested riparian vegetation consisting of trees, shrubs, grasses, and sedges. The bottom substrate consists of organics with small amounts silt/clay and sand. Mean wetted width is 15 m, and mean depth in the centre of the channel is shallow (i.e., 0.4 m). Beaver (*Castor canadensis*) activity was evident during surveying, but fish passage was possible. The surveyed section is composed predominantly of pool habitat with a small amount of glide habitat. Dense aquatic vegetation, overhanging vegetation, and moderate amounts of undercut bank are the main sources of cover for fish. Sparse amounts of large woody debris are present.

The overwintering habitat potential is considered to be suitable for species and life stages of fish that are tolerant of moderate DO concentrations encountered at this site during the winter survey (average = 8.8 mg/L) but may be more limiting for more sensitive species or life stages that require higher DO concentrations. Dense vegetation beds provide suitable spawning habitat for northern pike. Rocky substrates are absent; therefore, the surveyed section is considered to be marginally suitable for lake whitefish and walleye spawning and not suitable for lake trout.

Tributary Inflow Downstream of Naomi Lake

The tributary inflow downstream of Naomi Lake flows south into the Clearwater River. An approximately 150 m long section of the tributary was surveyed upstream of the confluence with the Clearwater River. The upland area consists of mature coniferous forest stands. The riparian zone is forested with vegetation consisting of trees, shrubs, grasses, and sedges. The bottom substrate consists of sand and organic matter. Mean wetted width ranges between 5 m and 22 m, and mean depth in the centre of the channel is shallow (i.e., 0.5 m to 0.6 m). The surveyed section consists of slow-moving pools and glides. Dense aquatic vegetation and moderate amounts of overhanging vegetation are the predominant types of cover for fish.

The vegetation beds present in the surveyed section, combined with slow-moving waters, provide moderately suitable spawning habitat for northern pike. Rocky substrates are absent; therefore, the surveyed section is considered as unsuitable, or at best, marginally suitable for lake trout, lake whitefish, and walleye spawning.

11.3.2 Lake Trophic Status

Open-water concentrations of TP were typically measured at or below the analytical detection limit (DL) of 0.01 mg/L in all waterbodies surveyed, including Broach Lake, Lake H, Patterson Lake, Forrest Lake, Beet Lake, and Naomi Lake (Table 11.3-1). These waterbodies were classified as oligotrophic based on the CCME (2004) classification system (Section 11.2.6.1). The exception was Lake G, which was classified as mesotrophic, based on TP concentrations ranging between 0.01 mg/L and 0.02 mg/L.

Table 11.3-1: Existing Concentrations of Total Phosphorus Concentrations and Trophic Classification by Waterbody

Waterbodies	Existing Conditions			
	TP (mg/L)			Trophic Status
	Min.	Mean	Max.	
Broach Lake	<0.01	<0.01	0.01	Oligotrophic
Patterson Lake	<0.01	<0.01	<0.01	Oligotrophic
Lake H	<0.01	<0.01	0.02	Oligotrophic
Lake G	<0.01	0.01	0.02	Mesotrophic
Forrest Lake	<0.01	<0.01	<0.01	Oligotrophic
Beet Lake	<0.01	<0.01	<0.01	Oligotrophic
Naomi Lake	<0.01	<0.01	<0.01	Oligotrophic

Note: A method detection limit of 0.01 mg/L was used for the open-water monitoring results (Annex V.1).
<= less than; TP = total phosphorus.

11.3.3 Lower Trophic Communities

The following sections provide a summary of lower trophic level community conditions for each waterbody or watercourse assessed in the LSA and RSA, including information related to phytoplankton, zooplankton, and benthic invertebrates. Detailed results for community metrics are provided in Annex V.1.

Based on the results for all waterbodies, sampled phytoplankton abundance ranged from 4.3 million cells per litre to 12.2 million cells per litre, biomass ranged from 0.09 µg/L to 1.83 µg/L, and richness ranged from 18 to 27 taxa. The SDI[4] was moderate to high, ranging from 0.63 to 0.79, and the SEI[5] was low, ranging between 0.10 and 0.21.

The dominant major phytoplankton groups identified in the BSA were:

- **Cyanobacteria (Cyanophycota in Annex V.1), commonly known as blue-green algae:** Cyanobacteria can out-compete other groups when there are increases in available phosphorus, a limiting nutrient for algae in fresh water (Schindler 1974), because most Cyanobacteria species are capable of fixing atmospheric nitrogen (i.e., changing free nitrogen to nitrate, nitrite, or ammonia; Wehr and Sheath 2003). However, if there is a substantial nitrogen load to a waterbody, it can cause continued phosphorus limitation, which reduces the competitive advantage of Cyanobacteria over other groups of phytoplankton.
- **Chrysophyceae or chrysophytes (Chrysophyta in Annex V.1), commonly known as golden-brown algae:** Chrysophytes are known to frequently dominate or co-dominate phytoplankton biomass (i.e., mass of living algal material at a given area in a given period of time) in clear oligotrophic waterbodies with low temperature, light, alkalinity (0 mg/L to 60 mg/L, calcium carbonate), conductivity (less than 50 µS/cm), and nutrient concentrations (Wehr and Sheath 2003).
- **Bacillariophyceae or diatoms (Bacillariophyta in Annex V.1):** Diatoms have high silica requirements for cell wall development (Wehr and Sheath 2003). Silica is often a limiting nutrient for diatom growth in many waterbodies (Wehr and Sheath 2003); however, if there are sustained inputs of silica (i.e., greater than 100 µg/L; Reynolds 2006), diatom growth is not inhibited, and this major group can constitute a large proportion of the phytoplankton community.
- **Chlorophyceae or chlorophytes (Viridiplantae in Annex V.1, commonly known as green algae):** Chlorophytes are a ubiquitous group present in waterbodies with differing nutrient and salinity concentrations; generally, increased salinity does not inhibit chlorophyte growth (Wetzel 2001).

The remaining phytoplankton groups contribute less than 5% to the overall abundance (Annex V.1) and are not considered dominant groups.

Sampled zooplankton abundance ranged between 33 organisms per litre (org/L) and 65 org/L, biomass ranged from 0.06 mg/L to 0.30 mg/L, and richness typically ranged between 7 taxa and 13 taxa. The SDI was moderate to high, ranging from 0.40 to 0.80, and the SEI was low to moderate in all areas, ranging between 0.17 and 0.49.

The dominant major zooplankton groups identified in the BSA were:

- **Cladocera or cladocerans, small crustaceans commonly known as water fleas:** Cladocerans are generally found in eutrophic, phytoplankton-rich waterbodies, while their abundance is often low in oligotrophic waterbodies (de Bernardi et al. 1987). Cladocerans are filter feeders that graze on phytoplankton, bacteria, and detritus (i.e., dead organic material). Cladocerans are a favourite prey for macroinvertebrates and fish and are an important group in waterbodies with regard to energy transfer along the food chain because of their short generation times and their high reproductive efficiency (de Bernardi et al. 1987).

[4] Simpson's Diversity Index values range between 0 and 1 (Renkonen 1938); values between 0 and 0.25 indicate low diversity, values between 0.25 and 0.75 indicate moderate diversity, and values greater than 0.75 indicate high diversity.
[5] Simpson's Evenness Index values range between 0 and 1 (Renkonen 1938); values between 0 and 0.25 indicate low evenness, values between 0.25 and 0.75 indicate moderate evenness, and values greater than 0.75 indicate high evenness.

- **Calanoida and Cyclopoida (or calanoid and cyclopoid copepods), small crustaceans commonly known as copepods:** Copepods are generally the dominant members of the zooplankton in waterbodies and are a major food source for small fish. Cyclopoid and calanoid copepods are examined separately because calanoid copepods are typically herbivorous, feeding on phytoplankton, while cyclopoid copepods are typically omnivorous, feeding on phytoplankton and small zooplankton (Brönmark and Hansson 1998). Calanoid copepods are almost exclusively pelagic (i.e., open-water), while cyclopoid copepods are dominated by littoral (i.e., nearshore) species, although a few pelagic species of cyclopoid copepods can account for a major component of the planktonic community.
- **Rotifera or rotifers (i.e., Collothecaceae, Flosculariaceae, and Ploima in Annex V.1), commonly known as wheeled animals:** Rotifers are generally sessile (i.e., fixed in place) and associated with the nearshore area; however, the few planktonic taxa that do exist can form a major component of the zooplankton community. Rotifers filter feed on food particles less than 12 µm in diameter such as bacteria, small algae, and detritus. Their food requirements are high in relation to their small size (Wetzel 2001).

Most waterbodies sampled had average benthic invertebrate densities that ranged between 1,000 organisms per square metre (org/m^2) and 5,000 org/m^2. Average taxon richness ranged between 8 taxa and 16 taxa per sample in most areas. In more than half of the locations surveyed, average SDI was moderately high, ranging between 0.61 and 0.77. Average SEI was low to moderate, measuring lower than 0.35 in most study areas.

Major benthic invertebrate groups identified in waterbodies and watercourses were:

- **Chironomidae, or chironomids, a member of the group Diptera, or dipterans (i.e., true or two-winged flies), and commonly known as midges:** All larval (i.e., immature forms) chironomids are aquatic and are found in all types of aquatic habitats (Clifford 1991). They are often the dominant aquatic family of dipterans. Some chironomids can withstand low oxygen levels and can live in the oxygen-poor substrata of some deep lakes. Chironomid larvae can be very important in aquatic food chains. Some larvae are predacious, but most are omnivorous.
- **Amphipoda, an order of crustacean, especially the genera *Gammarus* sp. and *Hyalella* sp.:** These amphipods, especially *Gammarus* sp., are sometimes found in large numbers in almost all unpolluted standing waters, primarily in shallow waterbodies and occasionally in slow-moving watercourses (Clifford 1991). *Gammarus* sp. and *Hyalella* sp. are commonly known as scuds and fresh water shrimp and often occur together. They feed mainly on dead animal and plant matter, but some are active carnivores.
- **Oligochaeta, or oligochaetes, commonly known as aquatic earthworms:** Oligochaetes are found in a variety of aquatic habitats (Clifford 1991). Some oligochaetes can tolerate low oxygen levels and may be found in large numbers in polluted habitats. The oligochaete gut is one-way and terminates at the posterior end of the body. Most fresh water oligochaetes feed by passing mud and debris through the gut and extracting organic matter from this material (Clifford 1991).
- **Non-Unionidae Mollusca, or small bivalves, commonly known as fingernail clams:** Fingernail clams are usually found in small watercourses (Clifford 1991). The two sides (i.e., valves) of the shell are the most conspicuous feature of these bivalves. The two valves interlock with each other by teeth. Bivalves are filter feeders, and the gills are very important in feeding. Water containing minute food material (e.g., organic detritus, algae, and zooplankton) enters the mantle cavity and adheres to gill filament surfaces.

- **Ephemeroptera, or ephemeropterans, commonly known as mayflies:** Ephemeropterans have a very brief adult life span; usually adults live less than three days (Clifford 1991). Larvae are found in both unpolluted standing water and unpolluted running water. They achieve their greatest diversity in watercourses and can be an important food item for fish. Mayfly larvae are mainly detritivores, but they might eat substantial amounts of algae, especially diatoms. A few species are entirely carnivorous.
- **Trichoptera, or trichopterans, commonly known as caddisflies:** Caddisfly larvae often construct cases or fixed retreats in which the larvae live (Clifford 1991). Cases can be of a variety of plant or mineral matter or both, depending on the caddisfly. Caddisfly larvae are found in all types of unpolluted aquatic habitats. Most are omnivorous or herbivorous, but some are predacious.

11.3.3.1 Waterbodies

Broach Lake

Phytoplankton

Phytoplankton abundance (9,904,790 cells per litre) and biomass (0.21 µg/L) in Broach Lake were low and within the range characteristic of other oligotrophic temperate waterbodies (Levine and Schindler 1999) and subarctic lakes on the Canadian Shield (De Beers 2021a, 2021b; Golder 2020). There were 22 taxa counted, with a moderate SDI of 0.69, indicating a relatively diverse community. The SEI was low (0.15), indicating the community was represented by only a few taxa. At the major group level (i.e., phylum or class), the community was dominated by Cyanobacteria (92%).

Zooplankton

Zooplankton abundance (35 org/L) and biomass (0.19 mg/L) in Broach Lake were low and within the range characteristic of other oligotrophic temperate waterbodies (Yan 1986) and subarctic lakes on the Canadian Shield (De Beers 2021a, 2021b; Golder 2020). There were 10 taxa counted, with a moderate SDI value of 0.40, indicating a relatively diverse community. The SEI was low (0.17), indicating the community was represented by only a few taxa. At the major group level (i.e., phylum or order), the community was dominated by cyclopoid copepods (76%), followed by cladocerans (26%) and rotifers (17%).

Benthic Invertebrates

Total invertebrate density (average = 1,329 org/m^2) and family-level richness (average = 8 taxa) in Broach Lake were low, and similar to subarctic lakes on the Canadian Shield (De Beers 2019, 2021b; Golder 2020). The average biomass was 2.3 g/m^2. The SDI was moderate, averaging 0.69, indicating a relatively diverse community. The SEI was also moderate, averaging 0.44, indicating the community was represented by a moderate number of taxa. The community was dominated by Chironomidae (51%) followed by Mollusca (24%).

Lake H

Benthic Invertebrates

Total invertebrate density (average = 297 org/m^2) and family-level richness (four taxa) in Lake H were low, and similar to subarctic lakes on the Canadian Shield (De Beers 2019, 2021b; Golder 2020). The SDI was moderate, averaging 0.47, indicating a relatively diverse community. The average biomass was 1.8 g/m^2. The SEI was also moderate, averaging 0.58, indicating the community was represented by a moderate number of taxa. The community was dominated by Chironomidae (67%) followed by Oligochaeta (15%).

Lake G

Benthic Invertebrates

Total invertebrate density (average = 23,581 org/m^2) and family-level richness (average = 15 taxa) in Lake G were moderate and similar to subarctic lakes on the Canadian Shield (De Beers 2019, 2021b; Golder 2020). The average biomass was 52.3 g/m^2. The SDI was moderate, averaging 0.50, indicating a relatively diverse community. The SEI was low, averaging 0.15, indicating the community was represented by few taxa. The community was dominated by Chironomidae (70%) followed by non-Unionidae Mollusca (13%).

Patterson Lake

Phytoplankton

Phytoplankton abundance (12,244,628 org/L) and biomass (0.61 µg/L) in Patterson Lake were low and within the range characteristic of other oligotrophic temperate waterbodies (Levine and Schindler 1999) and subarctic lakes on the Canadian Shield (De Beers 2021a, 2021b; Golder 2020). There were 18 taxa counted, with a moderate SDI of 0.64, indicating a relatively diverse community. The SEI was low (0.15), indicating the community was represented by only a few taxa. At the major group level (i.e., division or class), the community was dominated by Cyanobacteria (82%), followed by chrysophytes (13%).

Zooplankton

Zooplankton abundance (52 org/L) and biomass (0.06 mg/L) in Patterson Lake were low and within the range characteristic of other oligotrophic temperate waterbodies (Yan 1986) and subarctic lakes on the Canadian Shield (De Beers 2021a, 2021b; Golder 2020). There were eight taxa counted, with a high SDI value of 0.84, indicating a diverse community. The SEI was moderate (0.49), indicating the community was represented by a moderate number of taxa. At the major group level (i.e., phylum or order), the community was dominated by rotifers (62%), followed by cladocerans (26%) and cyclopoid copepods (11%).

Benthic Invertebrates

Total invertebrate density (average = 5,510 org/m^2) and family-level richness (11 taxa) in Patterson Lake were low, and similar to subarctic lakes on the Canadian Shield (De Beers 2019, 2021b; Golder 2020). The average biomass was 4.7 g/m^2. The SDI and SEI were moderate, averaging 0.59 and 0.27, respectively, indicating a relatively diverse community. The community was dominated by Chironomidae (51%), followed by non-Unionidae Mollusca (24%).

Total invertebrate density and family-level richness from samples collected along the Patterson Lake shoreline adjacent to the proposed Project were low, averaging 2,097 org/m^2 and 14 taxa, respectively. The average biomass was 2.7 g/m^2. The SDI was high, averaging 0.76, indicating a diverse community. The SEI was moderate, averaging 0.31, indicating the community was represented by a moderate number of taxa. The community was dominated by non-Unionidae Mollusca (35%) followed by Chironomidae (29%).

Forrest Lake

Phytoplankton

Phytoplankton abundance (4,297,915 org/L) and biomass (0.09 µg/L) in Forrest Lake were low and within the range characteristic of other oligotrophic temperate waterbodies (Levine and Schindler 1999) and subarctic lakes on the Canadian Shield (De Beers 2021a, 2021b; Golder 2020). There were 27 taxa counted, with a moderate SDI of 0.63, indicating a relatively diverse community. The SEI was low (0.10), indicating the community was represented by only a few taxa. At the major group level (i.e., division or class), the community was dominated by Cyanobacteria (89%).

Zooplankton

Zooplankton abundance (46 org/L) and biomass (0.21 mg/L) in Forrest Lake were low, and within the range characteristic of other oligotrophic temperate waterbodies (Yan 1986) and subarctic lakes on the Canadian Shield (De Beers 2021a, 2021b; Golder 2020). There were seven taxa counted, with a moderate SDI (0.58) and moderate SEI (0.34), indicating a relatively diverse community. At the major group level (i.e., phylum or order), the community was dominated by cyclopoid copepods (55%) followed by rotifers (40%).

Benthic Invertebrates

Total invertebrate density (average = 8,897 org/m^2) and family-level richness (14 taxa) in Forrest Lake were low, and similar to subarctic lakes on the Canadian Shield (De Beers 2019, 2021b; Golder 2020). The average biomass was 24.3 g/m^2. The SDI and SEI were moderate, averaging 0.67 and 0.278, respectively, indicating a relatively diverse community. The SEI was moderate, averaging 0.27, indicating the community was represented by a few taxa. The community was dominated by Chironomidae (37%), followed by non-Unionidae Mollusca (24%) and Amphipoda (21%).

Beet Lake

Phytoplankton

Phytoplankton abundance (10,666,491 org/L) and biomass (1.07 µg/L) in Beet Lake were low, and within the range of other oligotrophic temperate waterbodies (Levine and Schindler 1999) and subarctic lakes on the Canadian Shield (De Beers 2021a, 2021b; Golder 2020). There were 21 taxa counted, with a moderate SDI of 0.67, indicating a relatively diverse community. The SEI was low (0.14), indicating the community was represented by only a few taxa. At the major group level (i.e., division or class), the community was dominated by Cyanobacteria (72%), followed by chrysophytes (11%) and diatoms (10%).

Zooplankton

Zooplankton abundance (144 org/L) and biomass (0.30 mg/L) in Beet Lake were low and within the range of other oligotrophic temperate waterbodies (Yan 1986) and subarctic lakes on the Canadian Shield (De Beers 2021a, 2021b; Golder 2020). There were 12 taxa counted, with a moderate SDI value of 0.68, indicating a relatively diverse community. The SEI was low to moderate (0.26), indicating the community was represented by a few taxa. At the major group level (i.e., phylum or order), the community was dominated by cyclopoid copepods (51%), followed by rotifers (27%) and cladocerans (22%).

Benthic Invertebrates

Total invertebrate density (average = 2,445 org/m^2) and family-level richness (average = 14 taxa) in Beet Lake were low and similar to subarctic lakes on the Canadian Shield (De Beers 2019, 2021b; Golder 2020). The average biomass was 3.2 g/m^2. The SDI was moderate, averaging 0.61, indicating a relatively diverse community. The SEI was low, averaging 0.18, indicating the community was represented by few taxa. The community was dominated by the Chironomidae (50%) followed by non-Unionidae Mollusca (38%).

Naomi Lake

Phytoplankton

Phytoplankton abundance (11,836,802 org/L) and biomass (1.83 µg/L) in Naomi Lake were low, and within the range of other oligotrophic temperate waterbodies (Levine and Schindler 1999) and subarctic lakes on the Canadian Shield (De Beers 2021a, 2021b; Golder 2020). There were 23 taxa counted, with a moderate SDI of 0.67, indicating a relatively diverse community. The SEI was low (0.21), indicating the community was represented by only a few taxa. At the major group level (i.e., division or class), the community was dominated by Cyanobacteria (59%), followed by chrysophytes (18%), and diatoms (12%).

Zooplankton

Zooplankton abundance (65 org/L) and biomass (0.09 mg/L) in Naomi Lake were low, and within the range of other oligotrophic temperate waterbodies (Yan 1986) and subarctic lakes on the Canadian Shield (De Beers 2021a, 2021b; Golder 2020). There were 11 taxa counted, with a high SDI value of 0.80, indicating a diverse community. The SEI value was moderate (0.45), indicating the community was represented by a moderate number of taxa. At the major group level (i.e., phylum or order), the community was dominated by rotifers (42%), followed by cyclopoid copepods (36%), and cladocerans (19%).

Benthic Invertebrates

Total invertebrate density (average = 2,428 org/m^2) and family-level richness (average = 5 taxa) in Naomi Lake were low, and similar to subarctic lakes on the Canadian Shield (De Beers 2019, 2021b; Golder 2020). The average biomass was 5.2 g/m^2. The SDI and SEI were moderate, averaging 0.68 and 0.60, respectively, indicating a relatively diverse community. The community was dominated by the Chironomidae (47%), followed by the Oligochaeta (25%), and non-Unionidae Mollusca (15%).

11.3.3.2 Clearwater River Mainstem

Clearwater River below Naomi Lake

Total invertebrate density and family-level richness at the Clearwater River below Naomi Lake survey location were moderate and low, respectively, averaging 41,168 org/m^2 and 15 taxa. The average biomass was 47 g/m^2. The SDI was moderate, averaging 0.48, indicating a relatively diverse community. The SEI was low, averaging 0.14, indicating the total invertebrate density was represented by few taxa. The community was dominated by the Chironomidae (68%) followed by the Amphipoda (22%).

11.3.4 Fish Communities

The following sections describe fish community composition in each waterbody and watercourse evaluated in the LSA and RSA (Table 11.2-4). Where available, the results of spring and fall spawning surveys are described. Detailed fish capture results, including information on relative abundance, fish morphometry (i.e., lengths and weights), and any abnormalities identified during sampling, are included in Annex V.1.

A total of 6,045 fish were captured during the aquatic environment baseline surveys during all fish studies completed in 2018 and 2019. A list of the fish species captured in the LSA and RSA waterbodies and watercourses is provided in Table 11.3-2. This list includes species captured by CanNorth during the aquatic environment baseline surveys, as well as any additional species that have been previously documented in the LSA and RSA (Section 11.2.6), based on a review of existing information, including Hunting, Angling, and Biodiversity Information of Saskatchewan (SKCDC 2021b), and other relevant sources (e.g., Saskatchewan Parks and Renewable Resources [1991]). In total, 17 fish species were identified. Overall, the list of fish species documented in the LSA and RSA is characteristic of northern temperate waterbodies and watercourses in Saskatchewan (Langhorne 2001).

During the spring spawning survey, 1,213 fish were captured, of which 94% were spring spawning species. More than half of the spring spawning species (i.e., 67%) were in active spawning condition. A total of 515 fish were captured during the fall spawning surveys, of which 94% were fall spawning species. More than 83% of the fall spawning species were in active spawning condition. These results indicate that the timing of the surveys (i.e., 18 May 2018 to 30 May 2018, and 30 September 2018 to 14 October 2018) overlapped with active spawning conditions in the LSA and RSA.

An LPA community member commented that there are fewer fish in the lakes in the area of the Project (NexGen 2019) and a member of the MN-S also noted less fish in the lakes in general (TSD IV: MN-S). The CRDN have reported that fish populations in Patterson Lake and Forrest Lake have decreased following exploratory drilling on the lake during the late 1970s and 1980s, and that fish populations in the lake have never fully recovered (TSD V.2: CRDN).

> Back in the day, like I think it was 70s . . . . they [were] drilling in that lake [Patterson] . . . . There wasn't—there was no fishing after that. Nothing! I would say...70s to 80s.... And I fished in that lake one time after they've been drilling. I fished in that lake. Two weeks, I don't think I took 400 lbs of fish out of there. I used about 50 nets. Because there was no fish! . . . . After they did the drilling, 1970s, nothing. No fish....[The fish] come back, but not as much as before....I've never tried [fishing in Patterson Lake] again after that. (TSD V.2: CRDN)

As presented in Section 11.2.2, Patterson Lake was also noted as important for high quality fishing by members of the BRDN (TSD III: BRDN; BRDN-JWG 2019a; BRDN-JWG 2020). This observation was supported by the baseline field studies that verified the presence and spawning activity of lake trout, lake whitefish, northern pike, walleye, slimy sculpin, and sucker spp. (Annex V.1). The Indigenous and Local Knowledge shared and baseline studies indicate there have been changes in fish populations over time from previous disturbance, but that the value of fish and fishing in Patterson Lake is currently considered to be high.

11.3.4.1 Waterbodies

Broach Lake

A total of 515 fish were captured in Broach Lake, consisting of 11 species: burbot; cisco; lake trout; lake whitefish; longnose sucker; ninespine stickleback (*Pungitius pungitius*); northern pike; slimy sculpin (*Cottus cognatus*); spottail shiner (*Notropis hudsonius*); white sucker; and yellow perch. Broach Lake had an electrofishing catch per unit effort (CPUE) of 4.05 fish/minute. Longnose sucker (number of individuals [n] = 200) and white sucker (n = 136) were the most common species captured. Broach Lake was the only waterbody where cisco (n = 32) was captured. The CRDN reported fishing for trout in Broach Lake (TSD V.2: CRDN). The MN-S identified Broach Lake as a general harvesting area (TSD IV: MN-S), and the YNLR noted that Broach Lake is an important area for fish (TSD VI: YNLR).

Lake H

A total of 147 fish were captured in Lake H, consisting of four species: burbot, northern pike, spottail shiner, and yellow perch. Lake H had an electrofishing CPUE of 12.62 fish/minute. Spottail shiner (n = 90) was the most common species captured, followed by yellow perch (n = 47), northern pike (n = 7) and burbot (n = 3).

Lake G

A total of 22 fish were captured in Lake G during the fish community surveys, consisting of two species: northern pike (n = 21) and burbot (n = 1). Lake G had an electrofishing CPUE of 0.56 fish/minute. During the spring spawning survey completed in Lake G, no fish were captured, and no eggs were found.

Table 11.3-2: Summary of Fish Species Captured in the Local and Regional Study Areas

Species	Provincially Tracked (Rank)[(a)]	Federally Listed (Schedule 1 SARA)	Waterbody							Watercourse								
										Clearwater River						Clearwater River Tributaries	
			Broach Lake	Lake H	Lake G	Patterson Lake	Forrest Lake	Beet Lake	Naomi Lake	Clearwater River above Patterson Lake	Clearwater River below Patterson Lake	Clearwater River above Beet Lake	Clearwater River below Beet Lake	Clearwater River below Naomi Lake	Clearwater River above the Mirror River Confluence	Tributary Inflow to Naomi Lake	Tributary Inflow Downstream of Naomi Lake
Arctic grayling (*Thymallus arcticus*)	No (S5)	No	X	X	X	X	X	X	X	X	X	X	X	✓	X	X	X
Burbot (*Lota lota*)	No (S5)	No	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X	✓	✓	✓	✓
Cisco (*Coregonus artedi*)	No (S5)	No	✓	X	X	✓ (c)	X	X	X	X	X	X	X	X	X	X	X
Johnny darter (*Etheostoma nigrum*)	No (S5)	No	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lake chub (*Couesius plumbeus*)	No (S5)	No	X	X	X	✓	✓	✓	X	X	✓	X	X	X	X	X	X
Lake trout (*Salvelinus namaycush*)	No (S5)	No	✓	X	X	✓	✓	✓(b)	X	X	X	X	X	X	X	X	X
Lake whitefish (*Coregonus clupeaformis*)	No (S5)	No	✓	X	X	✓	✓	✓	✓	✓	✓	✓	✓	X	X	✓	X
Longnose sucker (*Catostomus catostomus*)	No (S5)	No	✓	X	X	✓	✓	✓	X	✓	✓	X	✓	✓	X	✓	X
Ninespine stickleback (*Pungitius pungitius*)	No (S5)	No	✓	X	X	✓	✓	X	X	X	X	✓	X	✓	✓	X	X
Northern pike (*Esox lucius*)	No (S5)	No	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Slimy sculpin (*Cottus cognatus*)	No (S5)	No	✓	X	X	✓	✓	✓	✓(b)	X	✓	X	✓	X	✓	X	X
Spottail shiner (*Notropis hudsonius*)	No (S5)	No	✓	✓	X	✓	✓	✓	✓	✓	✓	✓	X	✓	X	X	X
Trout perch (*Percopsis omiscomaycus*)	No (S5)	No	X	X	X	✓	✓	✓	✓	✓	✓	X	X	X	X	X	X
Walleye (*Sander vitreus*)	No (S5)	No	✓ (c)	X	X	✓	✓	✓	✓	✓	✓	X	✓	✓	X	✓	X
White sucker (*Catostomus commersonii*)	No (S4)	No	✓	X	X	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X	✓
Yellow perch (*Perca flavescens*)	No (S5)	No	✓	✓	X	✓	✓	✓	✓	X	X	✓	✓	✓	X	X	X
Pearl dace (*Margariscus margarita*)	No (S5)	No	X	X	X	✓ (c)	X	X	X	X	X	X	X	X	X	X	X

a) Provincial Rank Definitions (SKCDC 2021a; SKCDC 2021b):
- S4 – Apparently secure; S5 – Secure/Common.

b) Species not captured during CanNorth aquatic environment baseline study; however, eggs of this species were identified during egg searches completed during the CanNorth aquatic environment baseline study.
c) Species previously documented in LSA/RSA (Source: Saskatchewan Parks and Renewable Resources 1991).
SARA = *Species at Risk Act,* LSA = local study area; RSA = regional study area; ✓ = species documented during CanNorth aquatic environment baseline study or based on the results of a literature review of species presence in the LSA and RSA; X = species not documented during CanNorth aquatic environment baseline study or based on the results of a literature review of species presence in the LSA and RSA.

Patterson Lake

A total of 1,697 fish were captured in Patterson Lake, consisting of 13 species: burbot, lake chub, lake trout, lake whitefish, longnose sucker, ninespine stickleback, northern pike, slimy sculpin, spottail shiner, trout perch, walleye, white sucker, and yellow perch. Patterson Lake had an electrofishing CPUE of 4.06 fish/minute. Trout perch (n = 984) was the most common species captured, followed by spottail shiner (n = 183), lake whitefish (n = 109), and white sucker (n = 105). Patterson Lake and Forrest Lake had the highest number of individual species captured of the waterbodies surveyed.

During the spring spawning survey, 63 fish were captured, including four spring spawning species: longnose sucker (n = 3), northern pike (n = 11), white sucker (n = 17), and yellow perch (n = 8). Of these, 92% were in active spawning condition. During the fall spawning survey, 43 lake whitefish were captured, of which 74% were in active spawning condition. Egg searches identified 6,030 eggs, consisting of eggs of lake trout, lake whitefish, northern pike, slimy sculpin, and walleye, and unidentified sucker species (i.e., eggs could not be identified to species and could be either white sucker or longnose sucker).

A total of 514 fish were captured during fish sampling along the Patterson Lake shoreline adjacent to the proposed Project, consisting of nine species: burbot, lake whitefish, longnose sucker, ninespine stickleback, northern pike, spottail shiner, white sucker, trout perch, and yellow perch. Electrofishing CPUE adjacent to the Project was 3.43 fish/minute. The most abundant species in this area were trout perch (n = 202), spottail shiner (n = 118), and yellow perch (n = 34). Lake trout and walleye were not captured; however, eggs of both species were found.

The results of field studies in Patterson Lake were corroborated by Indigenous and Local Knowledge shared by Indigenous Groups and LPA community members. The CRDN, BNDN, BRDN and MN-S identified Patterson Lake as an important area for fishing (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN). The YNLR identified Patterson Lake as an important area for fish (TSD VI: YNLR). The CRDN noted that the Patterson Lake area has an abundance of resources and is intensively used by community members for harvesting. The BNDN noted that Patterson Lake supports numerous key fish species of historically high quality and large size (TSD II: BNDN). Species that are fished in Patterson Lake include lake trout (BRDN-JWG 2020; TSD II: BNDN; NexGen 2019), whitefish (TSD II: BNDN), walleye (TSD II: BNDN; NexGen 2019), suckers (TSD II: BNDN), and northern pike (TSD II: BNDN; NexGen 2019).

Forrest Lake

A total of 674 fish were captured in Forrest Lake, consisting of 13 species: burbot, lake chub, lake trout, lake whitefish, longnose sucker, ninespine stickleback, northern pike, slimy sculpin, spottail shiner, trout perch, walleye, white sucker, and yellow perch. Forrest Lake had an electrofishing CPUE of 3.61 fish/minute. Trout perch (n = 375) was the most common species captured and lake whitefish (n = 44) was the most common large-bodied species.

During the spring spawning survey, 23 fish were captured, including three spring spawning species: longnose sucker (n = 5), northern pike (n = 11), and white sucker (n = 1). Of these, 17% were in active spawning condition. During the fall spawning survey, 27 lake whitefish were captured, of which 70% were in active spawning condition. Egg searches identified 1,730 eggs, consisting of eggs of lake trout, lake whitefish, northern pike, slimy sculpin, and walleye, as well as unidentified sucker species.

The results of field studies in Forrest Lake were corroborated by Indigenous and Local Knowledge shared by Indigenous Groups. The CRDN, BNDN, and MN-S fish in Forrest Lake (TSD II: BNDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN). The YNLR identified Forrest Lake as an important area for fish (TSD VI: YNLR). The CRDN reported that Patterson Lake and Forrest Lake is an important lake for both traditional and commercial fishing (TSD V.1: CRDN).

Beet Lake

A total of 404 fish were captured in Beet Lake, consisting of 11 species: burbot, lake chub, lake whitefish, longnose sucker, northern pike, slimy sculpin, spottail shiner, trout perch, walleye, white sucker, and yellow perch. Beet Lake had an electrofishing CPUE of 4.84 fish/minute. Spottail shiner was the most common species (n = 138) captured, followed by trout perch (n = 91). Yellow perch (n = 40) was the most common large-bodied species present. Although no lake trout were captured, eggs were found during the fall spawning survey, confirming the species presence in the waterbody.

During the spring spawning survey, 30 fish were captured, including three spring spawning species: longnose sucker; northern pike; and white sucker. Of these fish, 46% were in active spawning condition. During the fall spawning survey, 13 lake whitefish were captured, of which, 85% were in active spawning condition. Egg searches identified 498 eggs, consisting of eggs of lake trout, lake whitefish, walleye, and unidentified sucker species.

The MN-S reported fishing in Beet Lake (TSD IV: MN-S), and the YNLR identified Beet Lake as an important area for fish (TSD VI: YNLR).

Naomi Lake

A total of 1,697 fish were captured in Naomi Lake, consisting of eight species: burbot, lake whitefish, northern pike, spottail shiner, trout perch, walleye, white sucker, and yellow perch. Naomi Lake had an electrofishing CPUE of 3.41 fish/minute. Spottail shiner (n = 75), yellow perch (n = 67), lake whitefish (n = 48), northern pike (n = 42), and white sucker (n = 40) were the most common species captured. Although no slimy sculpin were captured, eggs were found during the spring spawning survey, confirming the species presence.

During the spring spawning survey, seven fish were captured, of which northern pike (n = 6 in unknown spawning condition) was the only spring spawning species. During the fall spawning survey, 44 lake whitefish were captured, of which 84% were in active spawning condition. Egg searches identified 265 eggs, consisting of eggs of northern pike, slimy sculpin, walleye, and unidentified sucker species. Egg searches were not conducted during the fall survey due to near shore ice buildup.

The MN-S reported fishing in Naomi Lake (TSD IV: MN-S), and the YNLR identified Naomi Lake as an important area for fish (TSD VI: YNLR).

11.3.4.2 Clearwater River Mainstem

Clearwater River above Patterson Lake

A total of 687 fish were captured in Clearwater River above Patterson Lake, consisting of eight species: burbot, lake whitefish, longnose sucker, northern pike, spottail shiner, trout perch, walleye, and white sucker. This section of river had an electrofishing CPUE of 22.11 fish/minute. Walleye (n = 311), lake whitefish (n = 170), white sucker (n = 90), and trout perch (n = 59) were the most common species captured.

During the spring spawning survey, 403 fish were captured. The most abundant spring spawning species captured was walleye (n = 310), of which 65% were in active spawning condition. During the fall spawning survey, 168 lake whitefish were captured, of which, 94% were in active spawning condition. Egg searches identified 123 eggs, consisting of eggs of northern pike, walleye, and unidentified sucker species.

The CRDN and MN-S reported fishing in the Clearwater River (TSD IV: MN-S; TSD V.2: CRDN), and the YNLR identified the Clearwater River as an important area for fish (TSD VI: YNLR).

Clearwater River below Patterson Lake

A total of 320 fish were captured in the Clearwater River below Patterson Lake, consisting of 10 species: lake whitefish, northern pike, spottail shiner, trout perch, white sucker, longnose sucker, lake chub, slimy sculpin, walleye, and burbot. This section of river had an electrofishing CPUE of 2.59 fish/minute. Lake whitefish (n = 208) and northern pike (n = 69) were the most common species captured.

During the spring spawning survey, 99 fish were captured, including four spring spawning species: longnose sucker, northern pike, white sucker, and walleye. Of these fish, 71% were in active spawning condition. During the fall spawning survey, 43 lake whitefish were captured, of which 74% were in active spawning condition. Egg searches identified 232 eggs, consisting of eggs of lake whitefish, northern pike, walleye, and unidentified sucker species.

Clearwater River above Beet Lake

A total of 295 fish were captured in the Clearwater River above Beet Lake, consisting of six species: lake whitefish, northern pike, spottail shiner, white sucker, ninespine stickleback, and yellow perch. This section of river had an electrofishing CPUE of 5.83 fish/minute. Spottail shiner (n = 217) and yellow perch (n = 43) were the most common species captured.

Northern pike (n = 5) was the only spring spawning species captured during the spring spawning survey. Only one of the individuals captured (20%) was in active spawning condition. No eggs were found during egg searches.

Clearwater River below Beet Lake

A total of 192 fish were captured in the Clearwater River below Beet Lake, consisting of seven species: longnose sucker, northern pike, lake whitefish, walleye, white sucker, yellow perch, and slimy sculpin. This section of river had an electrofishing CPUE of 1.34 fish/minute. Longnose sucker (n = 145), northern pike (n = 22), and lake whitefish (n = 15) were the most common species captured.

During the spring spawning survey, 183 fish were captured. The most abundant species in active spawning condition was longnose sucker (n = 111), of which 71% were in active spawning condition. The abundance of spawning longnose suckers captured during the spring spawning survey aligns with Indigenous and Local Knowledge shared by the CRDN, who noted that the section of the river which connects Beet Lake to the Clearwater River is full of red (spawning) suckers in the spring (Figure 25; TSD V.2: CRDN).

> This river, in here . . . this connects Beet . . . . Right in this area here, until it gets to the Clearwater, is really really clear water and full . . . it's red of suckers in the spring. If you go down in the spring it's just red; there's so many . . . . when you go over them you'll feel them on the boat there's so many suckers in there sometimes. (TSD V.2: CRDN)

Egg searches identified 150 eggs, consisting of eggs of northern pike, walleye, and yellow perch, and unidentified sucker species.

Clearwater River below Naomi Lake

A total of 203 fish were captured in the Clearwater River below Naomi Lake, consisting of nine species: white sucker, northern pike, spottail shiner, walleye, burbot, yellow perch, longnose sucker, ninespine stickleback, and Arctic grayling. This section of river had an electrofishing CPUE of 1.47 fish/minute. White sucker (n = 83), northern pike (n = 66), and spottail shiner (n = 14) were the most common species captured. The Clearwater River below Naomi Lake survey location was the only location where Arctic grayling (n = 1) was captured.

During the spring spawning survey, 192 fish were captured, which included four spring spawning species: northern pike, longnose sucker, white sucker, and walleye. Of these fish, 57% were in active spawning condition. Egg searches identified 192 eggs, consisting of eggs of Arctic grayling, northern pike, and unidentified sucker species.

Clearwater River above the Mirror River Confluence

A total of 12 fish were captured in the Clearwater River at the surveyed location above the Mirror River confluence, consisting of four species: burbot, northern pike, ninespine stickleback, and slimy sculpin. This section of river had an electrofishing CPUE of 0.65 fish/minute. Slimy sculpin (n = 5) and northern pike (n = 4) were the most common species captured.

11.3.4.3 Clearwater River Tributaries

Tributary Inflow to Naomi Lake

A total of 22 fish were captured at the tributary inflow to Naomi Lake survey location, consisting of five species: burbot, lake whitefish, longnose sucker, northern pike, and walleye. The inflow had an electrofishing CPUE of 2.59 fish/minute. Longnose sucker (n = 9), northern pike (n = 5), and walleye (n = 5) were the most common species captured. The overall number of fish captured at this location was likely limited due to damage to nets by bears, which allowed fish to escape. The nets were not deployed at this location for the remainder of the survey.

During the spring spawning survey, nine fish were captured, which included two spring spawning species: northern pike and walleye. A total of 67% of the individuals were in active spawning condition. Egg searches identified 226 eggs, consisting of eggs of northern pike and unidentified sucker species.

Tributary Inflow Downstream of Naomi Lake

A total of 205 fish were captured at the tributary inflow to Naomi Lake survey location, consisting of three species: burbot, northern pike, and white sucker. This tributary had an electrofishing CPUE of 1.41 fish/minute. White sucker (n = 187) was the most common species captured.

During the spring spawning survey, a total of 230 fish were captured, including northern pike (n = 11) and white sucker (n = 219). Of the fish captured, 81% were in active spawning condition. Egg searches identified 50 eggs, consisting of eggs of northern pike and unidentified sucker species.

11.3.5 Species of Conservation Concern

Seventeen fish species were identified in the LSA and RSA (Table 11.3-2). Of these, none were classified as provincially or federally listed species or species with a designated conservation status by the Committee on the Status of Endangered Wildlife in Canada (Table 11.3-2; COSEWIC 2021). In addition, review of distribution data for aquatic species listed under SARA did not identify the presence of any provincially or federally listed species in the LSA or RSA (Government of Canada 2021; DFO 2019a; SKCDC 2021a). Therefore, protected species are not expected to occur in waterbodies and watercourses potentially affected by the proposed Project.

11.3.6 Fish Valued Component Life Histories

11.3.6.1 Lake Trout

Lake trout primarily inhabit deep, cold, well-oxygenated waterbody habitats (Scott and Crossman 1973; Evans et al. 2002; Richardson et al. 2001; McPhail 2007). Lake trout is a highly valued and sought-after fish species in Canada's inland waters (Scott and Crossman 1973). Lake trout were captured in all the large waterbodies in the LSA, including Broach Lake, Forrest Lake, Hodge Lake, Lloyd Lake, and Patterson Lake.

Northern populations of lake trout are especially long lived, and fish older than 20 years old are common. The species spawns in the fall (i.e., September or October) when water temperatures fall below approximately 10°C (Scott and Crossman 1973; Richardson et al. 2001; McPhail 2007). Northern populations typically grow slowly and mature between the ages of 7 and 10 years. Spawning occurs at night, with females depositing eggs over beds of large boulder or rubble. The fertilized eggs settle into the interstitial spaces within the substrate to incubate. Lake trout eggs are relatively large (i.e., 4 mm to 5 mm), and fecundity (i.e., maximum potential offspring in a lifetime) is low compared to other fish species (McPhail 2007). Eggs remain in the substrate over winter, and hatch during spring.

Spawning habitat for lake trout is readily available in the LSA (Annex V.1). Moderate to high quality spawning habitat was observed throughout Patterson Lake, including in the shoreline area surveyed in detail near the proposed Project. Moderate to high quality spawning habitat for lake trout was also identified in Broach Lake, Lake H, Forrest Lake, Beet Lake, and in the Clearwater River Downstream of Naomi Lake. Incubating eggs of lake trout were found in Patterson Lake, Forrest Lake, and Beet Lake during fall spawning surveys. No vegetation was present in any of the areas where eggs were found, and substrates were composed mostly of gravel, cobble, and boulders.

Nursery and early-stage rearing habitat for lake trout is similar to that of spawning habitat, as the larvae do not disperse until the yolk sac is absorbed approximately one month after hatching. The prevalence of spawning habitat for lake trout in the LSA indicates that nursery and early-stage rearing habitat is available. Young lake trout feed in the shallows for several months before they are large enough to venture into deeper water. However, in some northern waterbodies, where water temperatures remain low throughout the year, lake trout may remain in nearshore areas for months to years (Martin 1956; Scott and Crossman 1973). There is evidence that adults in some populations return to their natal spawning sites (Scott and Crossman 1973).

Lake trout are predacious and feed on zooplankton, aquatic and terrestrial invertebrates, and fish (Scott and Crossman 1973). The food types consumed are dependent upon life stage, season, and availability. Young lake trout feed primarily upon plankton and aquatic insect larvae until they reach an adequate size to prey on fish, such as cisco. Adult lake trout often have a preferred diet of cisco, which were found in conjunction with lake trout exclusively in Broach Lake; however, other fish species such as lake whitefish, yellow perch, stickleback, trout perch, and longnose sucker are common prey items. A variety of small- and large-bodied prey species were captured during baseline surveys, indicating that suitable feeding habitat exists in the waterbodies where lake trout occur. Seasonal changes in diet are common and are often associated with water temperature. For example, in the spring, adults may feed on forage fish and terrestrial insects in shallow water, or near the waterbody surface. If the waterbody warms and stratifies, the cold, denser water sinks to the lake bottom and the lake trout follow it down as a refuge from the higher water temperatures in the upper layer of the waterbody. Under these conditions in waterbodies, lake trout may switch to feeding on plankton.

The morphology and catch data for lake trout based on fishing efforts in the LSA and RSA are presented in Table 11.3-3. A total of 33 lake trout were captured during baseline sampling. Of the 33 lake trout captured, 3 were captured in Patterson Lake. In Patterson Lake, lake trout ranged in size from 57.7 cm to 59.4 cm for length and 2,620 g to 3,300 g for weight (Table 11.3-3).

Table 11.3-3: Morphology and Catch Data for Lake Trout for Fishing Efforts in the Local and Regional Study Areas

Waterbody	N	Length (cm)				Weight (g)			
		Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Broach Lake	14	53.4	6.6	47.5	69.8	1,750	904	940	4,050
Patterson Lake	3	58.6	0.9	57.7	59.4	3,033	363	2,620	3,300
Forrest Lake	14	57.4	5.8	46.2	66.0	1,949	455	1,080	2,620

N = number; SD = standard deviation.

11.3.6.2 Lake Whitefish

Lake whitefish are found throughout much of Saskatchewan (McPhail and Lindsey 1970; Scott and Crossman 1973). The species commonly occurs in waterbodies but is also found in larger watercourses. Lake whitefish is one of the most valuable commercial fresh water fish species in Canada (Scott and Crossman 1973). Lake whitefish are widely distributed throughout the LSA and were captured in both waterbody and watercourse habitats. Lake whitefish were captured in all the large waterbodies surveyed, including Broach Lake, Forrest Lake, and Patterson Lake. Lake whitefish were also captured in Naomi Lake and in the Clearwater River at the surveyed sections above and below Patterson Lake and Beet Lake.

Northern populations of lake whitefish spawn about every two or three years (Scott and Crossman 1973). Spawning usually occurs from mid-September to mid-October in northern regions (Richardson et al. 2001) but may occur as early as late summer and as late as December. Spawning may occur in waterbodies or watercourse environments, over large boulders to gravel and occasionally sand (Richardson et al. 2001). Spawning usually takes place in shallow water areas, but deeper spawning has been reported (Scott and Crossman 1973). Eggs are released over substrate (Scott and Crossman 1973) and settle into crevices where they incubate for several months before hatching in approximately March to May (Richardson et al. 2001).

Spawning habitat for lake whitefish is readily available in the LSA (Annex V.1). Moderate to high quality spawning habitat was observed throughout Patterson Lake, including in the shoreline area surveyed in detail near the proposed Project. Moderate to high quality spawning habitat for lake whitefish was also identified in Broach Lake, Lake H, Forrest Lake, Beet Lake, and in the Clearwater River at the sections surveyed below Patterson Lake, below Naomi Lake, and above the Mirror River confluence. During fall spawning surveys, incubating lake whitefish eggs were found in Patterson Lake, including along the Patterson Lake shoreline adjacent to the proposed Project, as well as in Forrest Lake, Beet Lake, and the Clearwater River at the section surveyed below Patterson Lake. The highest lake whitefish egg densities occurred in areas with no vegetation cover and substrates composed of gravel, cobble, and boulder (Annex V.1).

Newly hatched lake whitefish may form aggregations (i.e., groups) along steep shorelines characterized by the presence of boulders, rocks, and gravel stretching out into the deeper waters. Lake whitefish generally leave shallow nearshore areas to move into deeper open waters by early summer, to depths of 5 m to 10 m over substrates of boulder, cobble, gravel, and sand (Lane et al. 1996). These types of habitats were present throughout most waterbodies in the LSA, providing suitable nursery and early stage rearing habitat for lake whitefish. This species was found to be abundant and widely distributed throughout the LSA, indicating that habitat is not limiting.

Adult lake whitefish tend to leave the spawning grounds shortly after spawning and return immediately to deep water habitat to overwinter (Ford et al. 1995). They are often found at depths greater than 10 m for most of the year and can occur at depths greater than 100 m (McPhail and Lindsey 1970). Despite being primarily bottom dwelling, they may be occasionally found in the pelagic (i.e., open-water) zone of waterbodies (Ford et al. 1995).

The diet of lake whitefish includes snails, clams, aquatic insects, plankton, and small fish (Scott and Crossman 1973). Examinations of the stomach contents of lake whitefish captured during the aquatic environment baseline study (Annex V.1) revealed the presence of unidentified, digested invertebrates as well as what appeared to be fish eggs. Copepods and cladocerans are a major part of the young lake whitefish diet and by early July, bottom-dwelling organisms begin to enter their diet. As the young move into deeper waters, their diet closely resembles that of adult lake whitefish but still includes zooplankton. Lake whitefish are preyed upon by lake trout and other piscivores in both the juvenile and adult life stages (Scott and Crossman 1973).

Morphology and catch data for lake whitefish based on fishing efforts in the LSA and RSA are presented in Table 11.3-4. A total of 637 lake whitefish were captured during baseline sampling in the LSA or RSA. Of these, 109 were captured in Patterson Lake. In Patterson Lake, lake whitefish ranged in size from 15.1 cm to 48.2 cm for length and 20 g to 1,260 g for weight (Table 11.3-4).

Table 11.3-4: Morphology and Catch Data for Lake Whitefish for Fishing Efforts in the Local and Regional Study Areas

Waterbody/Watercourse		N	Length (cm)				Weight (g)			
			Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Waterbody	Broach Lake	16	38.0	14.0	4.1	48.3	1,057	225	640	1,420
	Patterson Lake	109	35.3	5.3	15.1	48.2	598	230	20	1,260
	Forrest Lake	44	40.7	6.5	3.9	49	1,017	311	500	1,960
	Beet Lake	24	39.8	5.6	25.6	48.2	880	361	120	1,520
	Naomi Lake	48	42.8	2.3	35.8	48.3	1,071	176	740	1,620
Clearwater River	Clearwater River above Patterson Lake	170	37.1	2.8	32.7	55.3	675	149	440	1,420
	Clearwater River below Patterson Lake	208	41.8	28.0	18.0	440.2	741	189	80	1,240
	Clearwater River below Beet Lake	1	40.6	n/a	40.6	40.6	680	n/a	680	680
	Clearwater River below Naomi Lake	15	42.1	1.9	38.4	45	1,071	224	740	1,600
Clearwater River tributary	Tributary inflow to Naomi Lake above the Mirror River Confluence	2	44.3	0.1	44.2	44.3	1,190	42	1,160	1,220

N = number; SD = standard deviation; n/a = not applicable.

11.3.6.3 Walleye

Walleye primarily inhabit large waterbodies and watercourses where the depth or turbidity of the water provides cover from bright sunlight (Scott and Crossman 1973). Walleye is a highly valued and sought-after fish species in Canada's inland waters (Scott and Crossman 1973). Walleye were captured in both waterbody and watercourse habitats, including Patterson, Forrest, Beet, and Naomi lakes, and in the Clearwater River at the surveyed sections above and below Patterson Lake, Beet Lake, and Naomi Lake.

In watercourses, walleye move into still pools that are up to 3.5 m deep or into shallow current breaks and regions with slight currents over gravel, cobble, and boulder substrates (Colby et al. 1979; McPhail 2007; Paragamian 1989; Scott and Crossman 1973). Male walleye reach maturity at two to four years and females at three to six years (Scott and Crossman 1973). Spawning occurs in the early spring, shortly after ice breaks up, when water temperatures reach 6.7°C to 8.9°C (Scott and Crossman 1973). Northern populations may not spawn every year if water temperatures are not favourable (Scott and Crossman 1973). Spawning in watercourses occurs at night in rocky areas below rapids and impassable falls (Scott and Crossman 1973). Eggs fall into crevices of the substrate where they remain for 12 to 18 days before hatching (Scott and Crossman 1973).

Spawning habitat for walleye is readily available in the LSA. Moderate to high quality spawning habitat was observed throughout Patterson Lake, including in the shoreline area surveyed in detail adjacent to the proposed Project. Moderate to high quality spawning habitat for walleye was also identified in Broach Lake, Lake H, Forrest Lake, Beet Lake, and in the Clearwater River at the sections surveyed below Patterson Lake, below Naomi Lake, and above the Mirror River confluence. Incubating eggs of walleye were widespread and were found in Patterson Lake, including along the Patterson Lake shoreline adjacent to the proposed Project, as well as in Forrest Lake, Beet Lake, Naomi Lake, and the Clearwater River at the sections surveyed above and below

Patterson Lake and Beet Lake during spring spawning surveys. Walleye eggs were predominantly found in cobble/gravel substrates.

Nursery and early-stage rearing habitat for walleye is similar to spawning habitat, as the larvae do not disperse until the yolk sac is absorbed. Egg yolk absorption takes approximately 10 to 15 days, after which the young disperse into the upper strata of open water. By late summer, the young-of-the-year move into deeper waters and can be found at depths ranging from 6 m to 9 m (Scott and Crossman 1998). Deeper waters to which the young-of-the-year walleye can migrate are readily available in LSA waterbodies and watercourses, indicating that nursery and early-stage rearing habitat is not limiting.

Walleye feed throughout the day in turbid waters (i.e., water lacking clarity due to suspended material), but in clear water, feeding is restricted to twilight or nighttime (Scott and Crossman 1973). Adult walleye tend to feed on any species of fish and invertebrates that are readily available; however, some populations of walleye, even as adults, feed almost exclusively on emerging larval or adult mayflies or chironomids for part of the year (Scott and Crossman 1998). During the first six weeks of development, walleye diet consists primarily of copepods, cladocerans, invertebrates, and small-bodied fish. As the young walleye shift in size, the diet shifts very quickly from invertebrates to fish. Small-bodied fish species such as lake chub, ninespine stickleback, slimy sculpin, spottail shiner, and trout perch, which all comprise a typical walleye diet, were found throughout the LSA and RSA. The abundance of small-bodied fish and invertebrates provided suitable and abundant prey for walleye in all life stages. Juvenile walleye are preyed upon by a variety of predator fish, including adult walleye (Scott and Crossman 1973).

Morphology and catch data for walleye based on fishing efforts in the LSA and RSA are presented in Table 11.3-5. A total of 336 walleye were captured during baseline sampling in the LSA or RSA. However, a large majority of the walleye documented were captured in the Clearwater River above Patterson Lake (n = 298; Table 11.3-5). Of the 336 walleye captured, 10 were captured in Patterson Lake. In Patterson Lake, walleye ranged in size from 26.6 cm to 66.5 cm for length and 140 g to 2,720 g for weight (Table 11.3-5).

Table 11.3-5: Morphology and Catch Data for Walleye for Fishing Efforts Local and Regional Study Areas

Waterbody/Watercourse		N	Length (cm)				Weight (g)			
			Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Waterbody	Patterson Lake	10	47.0	14.7	26.6	66.5	1,267	935	140	2,720
	Forrest Lake	1	52.5	n/a	52.5	52.5	1,700	n/a	1,700	1,700
	Beet Lake	4	35.7	15.9	12.7	49.4	847	352	560	1,240
	Naomi Lake	6	42.9	7.5	29.0	50.0	677	402	80	1,080
Clearwater River	Clearwater River above Patterson Lake	298	50.3	6.1	31.2	71.3	1,559	562	420	3,860
	Clearwater River below Patterson Lake	1	61.3	n/a	61.3	61.3	1,560	n/a	1,560	1,560
	Clearwater River below Beet Lake	5	54.1	7.7	46.5	62.1	1,844	549	1,200	2,420
	Clearwater River below Naomi Lake	6	42.1	6.8	28.6	46.8	761	260	280	980
Clearwater River tributary	Tributary inflow to Naomi Lake above the Mirror River Confluence	5	48.4	5.1	41.8	55.6	1,416	483	720	2,080

N = number; SD = standard deviation; n/a = not applicable.

11.3.6.4 Northern Pike

Northern pike occurs throughout Saskatchewan and inhabits fresh water waterbodies and watercourses. The species is most commonly found in nearshore areas of waterbodies and slow-moving watercourses that are relatively shallow (i.e., less than 4 m) and contain vegetative cover (Harvey 2009). Where northern pike are found in watercourses, they are likely to seek out areas with low velocities, such as side channels, back waters, or sloughs. Northern pike is a popular species among recreational anglers.

Northern pike were documented in all waterbodies and watercourses surveyed during the aquatic environment baseline study, making the species the most ubiquitous among the four fish VCs. Northern pike were captured in Broach Lake, Lake G, Lake H, Patterson Lake, Forrest Lake, Beet Lake, and Naomi Lake. The species was captured in all sections of the mainstem Clearwater River surveyed, as well as in all Clearwater River tributaries.

Northern pike spawning occurs in spring, usually in April to early May, after the ice has melted and water temperatures have reached approximately 4.4°C to 11.1°C (Scott and Crossman 1973). Individuals may ascend tributaries to spawn, and typically seek out flooded marshes or shallow areas that contain abundant aquatic or terrestrial vegetation (Inskip 1982). Each female is generally accompanied by one or two males. Females broadcast (i.e., release) their adhesive eggs over vegetation; eggs are fertilized as they are released from the female (Scott and Crossman 1973; Stewart and Watkinson 2004). The eggs sink and stick to vegetation or the substrate. Hatching occurs approximately two weeks later (Billard 1996). After emerging, the young attach themselves to nearby vegetation and remain relatively inactive for 6 to 10 days, until the yolk sac is absorbed (Harvey 2009; Scott and Crossman 1973).

The results of the aquatic environment baseline study (Annex V.1) indicated a general lack of highly suitable spawning habitat for northern pike in the surveyed waterbodies; however, each of these waterbodies contained limited areas that were deemed at least marginally suitable for spawning, except for Beet Lake. Limited areas of moderate to high quality spawning habitat were observed in Broach Lake, Patterson Lake, Lake H, Lake G, and Forrest Lake. All the surveyed sections of the Clearwater River mainstem and tributary habitats in the LSA and RSA were found to contain moderately to highly suitable spawning habitat for northern pike. During spring spawning surveys, incubating eggs were widespread and were found in Patterson Lake, including along the Patterson Lake shoreline adjacent to the proposed Project, as well as in Forrest Lake, Naomi Lake, and the Clearwater River at the sections surveyed above and below Patterson Lake, below Beet Lake, below Naomi Lake, and above the Mirror River Confluence. Northern pike eggs were found in areas that contained dense vegetation cover.

Nursery and early-stage rearing habitat for northern pike is generally the same as that of spawning habitat, as larvae tend to remain immobile after hatching until the yolk sac is absorbed. The young-of-the-year are also reported to utilize the same type of habitat sought for spawning, and prefer silt or organic substrate, emergent macrophytes or flooded vegetation, and woody debris at depths of less than 1 m (Inskip 1982; Scott and Crossman 1998). The types of habitats also provide abundant nursery and early-stage rearing habitat for northern pike in the LSA and RSA. Habitat availability was also evident by the widespread distribution of northern pike in the LSA and RSA.

Young-of-the-year northern pike start out on a diet of zooplankton. As they grow larger, they rely more heavily on aquatic insects and small fish (Scott and Crossman 1973). Adult northern pike are opportunistic predators; they typically hide within aquatic vegetation and ambush potential prey (Harvey 2009). Northern pike are primarily piscivorous but have been known to consume a variety of prey, including crayfish, frogs, aquatic mammals, and birds (Stewart and Watkinson 2004). Examination of the stomach contents of northern pike captured from several of the waterbodies within the LSA and RSA during the aquatic environment baseline study (Annex V.1) revealed that fish, invertebrates, and even small birds or waterfowl are part of the diet.

Morphology and catch data for northern pike for fishing efforts in the LSA and RSA are presented in Table 11.3-6. A total of 388 northern pike were captured during baseline sampling. Of these, 22 were captured in Patterson Lake. In Patterson Lake, northern pike ranged in size from 5.9 cm to 82.6 cm for length and 760 g to 4,220 g for weight (Table 11.3-6).

Table 11.3-6: Morphology and Catch Data for Northern Pike for Fishing Efforts in the Local and Regional Study Areas

Waterbody/Watercourse		N	Length (cm)				Weight (g)			
			Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Waterbody	Broach Lake	14	65.3	22.6	12.4	103.5	3,231	2,547	580	9,200
	Lake H	7	38.6	16.2	15.6	55.6	464	387	30	960
	Lake G	21	29.5	16.0	11.8	54.8	620	342	200	1,240
	Patterson Lake	22	49.9	22.8	5.9	82.6	1,813	1,123	760	4,220
	Forrest Lake	30	54.1	24.0	7.8	105.0	2,044	2,117	60	9,060
	Beet Lake	27	55.1	15.3	10.9	73.9	1,521	598	630	2,660
	Naomi Lake	42	35.5	18.0	6.6	72.9	834	499	80	2,500
Clearwater River mainstem	Clearwater River Above Patterson Lake	18	58.1	11.7	26.8	71.0	1,847	682	520	3,000
	Clearwater River Below Patterson Lake	69	55.8	15.7	18.3	100.0	1,549	1,103	66	7,880
	Clearwater River Above Beet Lake	26	31.5	21.6	8.7	78.5	1,084	1,074	70	3,800
	Clearwater River Below Beet Lake	21	53.8	16.7	6.4	68.8	1,463	374	780	2,140
	Clearwater River Below Naomi Lake	66	48.9	7.7	18.3	68.5	891	388	300	2,900
	Clearwater River Above the Mirror River Confluence	4	12.5	5.5	8.7	20.5	35	20	20	65
Clearwater River tributaries	Tributary inflow to Naomi Lake	5	41.8	10.2	32.6	58.0	596	369	320	1,220
	Tributary inflow downstream of Naomi Lake	16	40.4	14.1	15.2	64.0	632	455	90	1,680

N = number; SD = standard deviation.

11.4 Project Interactions and Mitigations

The pathway analysis identified potential adverse effects of the Project on fish VCs, identified practicable mitigation for these potential effects, and determined whether any of the potential effects could be sufficiently mitigated such that they are not expected to cause a residual adverse effect. As described in Section 11.2.7, Project Interactions and Mitigations, the pathway analysis assigned each potential effect as:

- no pathway (i.e., mitigation results in no effect on fish VCs);
- secondary pathway (i.e., mitigation results in a negligible effect on fish VCs); or
- primary pathway (i.e., effect that is greater than negligible and carried forward for further assessment).

The pathway analysis is summarized in Table 11.4-1. The subsections following the table provide the rationale used to assign potential effects to the no pathway and secondary pathway categories and list primary pathways. Each Project interaction identified as a primary pathway was carried forward for detailed assessment in Section 11.5. Effects pathways apply to all Project phases and all fish VCs unless otherwise noted.

The environmental design features and mitigations in Table 11.4-1 represent the list of key actions used to inform the pathway analysis as part of preparing the EIS. In addition to this list of key actions, NexGen would implement the Environmental Protection Program, which would describe the processes required to monitor and characterize emissions from Project facilities and activities. This program would be used to periodically evaluate mitigation performance and identify additional mitigation, where required, and prompt potential adaptive management measures (Section 11.7). Where relevant, adaptive management measures may also be proposed to address uncertainties associated with effects predictions and mitigation. The process for determining when, how, and where to use adaptive management would be described within the Integrated Management System Manual. Potential accidents and malfunctions that have the capability to influence biophysical or human environments are discussed in Section 21, Accidents and Malfunctions.

Table 11.4-1: Potential Effects Pathways for Fish and Fish Habitat

Path ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
F-01	Project components/activities that may change surface water and sediment quality and aquatic health **after Closure and in the far future**: ▪ WRSAs ▪ storage of tailings in the UGTMF and backfilled stopes	**Changes in surface water quality from WRSAs and UGTMF after Closure:** ▪ Runoff and seepage from the WRSAs and groundwater flow from the UGTMF may alter surface water quality in Patterson Lake after Closure and adversely affect fish habitat availability, survival, and reproduction	▪ **Install engineered cover** of compacted clean material and growth medium layer on PAG WRSA and install growth medium cover on NPAG WRSA ▪ Use **engineered cemented paste backfill and tailings** to control source concentrations ▪ **Apply binder** to reduce permeability in backfill and tailings ▪ **Revegetate** NPAG and PAG WRSAs during reclamation to limit TSS in surface runoff ▪ Develop and implement a **Preliminary Decommissioning and Reclamation Plan**	Primary pathway
F-02	Project components/activities that may cause temporary disturbance to fish habitat, including riparian habitat, in the vicinity of the existing access road crossing location of the Clearwater River during **Construction, Operations, and Closure**: ▪ use of a crane to move heavy equipment and infrastructure across the Clearwater River ▪ land clearing and site access development ▪ reclamation and revegetation of disturbed areas	**Disturbance at river crossing:** ▪ Movement of heavy equipment and infrastructure across the Clearwater River at the existing access road crossing location may adversely affect fish habitat availability, survival, and reproduction	▪ **Employ a crane** to move heavy equipment and infrastructure across the Clearwater River only in instances where loads exceed the legal rating or capacity of the bridge and options for reducing load size/weight are not feasible or practical (e.g., dismantling equipment, breaking down a load into smaller units) ▪ **Minimize the footprint of work** areas adjacent to the Clearwater River, and associated ingress/egress, to limit the area of disturbance. Fording of the Clearwater River, or activities that could result in a direct disturbance to the bed or banks of the river, would not occur ▪ To the extent practical, construct work areas to **avoid critical or sensitive habitat** (e.g., riparian zones) following best practices and regulatory requirements ▪ **Implement DFO's** *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2019b) to minimize potential adverse effects on aquatic resources ▪ **Install appropriate erosion and sediment control** measures, as required. Regularly inspect erosion and sediment control measures to confirm they are functioning as planned, and perform any required maintenance, as needed ▪ Confirm **heavy equipment (e.g., crane) used on site is properly maintained** and is free of leaks o Inspect loads to be moved across the Clearwater River for leaks ▪ If an upgrade to the existing Clearwater River bridge is required, **avoid any permanent disturbance** below the high-water mark of the Clearwater River ▪ Implement a Project-specific **Environmental Protection Program** ▪ Develop and implement a **Preliminary Decommissioning and Reclamation Plan** to decommission and transfer the site to the province under the Institutional Control Program	Secondary pathway
F-03	Project components/activities that may divert water from its natural course and influence hydrological processes and water balance during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ underground shaft and mine development ▪ process plant and underground operations ▪ handling and storage of waste rock and special waste rock, and ore ▪ treated effluent discharge following treatment at ETP ▪ domestic treated sewage discharge following treatment at sewage treatment plant ▪ additional infrastructure (e.g., roads, airstrip, existing exploration camp, maintenance shop, and offices) ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure	**Altered site drainage affecting water levels and flow:** ▪ Altered site drainage, runoff, and discharge may cause changes to water levels and flows and channel/bank stability in downstream waterbodies and watercourses and affect fish habitat availability and distribution	▪ Design and **install appropriate site drainage** and water containment and conveyance structures on site ▪ Provide **adequate contact water storage capacity** to allow controlled rate of release during both routine and non-routine operation scenarios ▪ **Install appropriate erosion and sediment control** measures, as required o Regularly inspect erosion and sediment control measures to confirm they are functioning as planned, and perform any required maintenance, as needed ▪ **Install and operate an ETP and a STP** to reduce release of COPCs (e.g., major ions, metals, radionuclides) to the environment and discharge treated effluent and treated sewage to Patterson Lake ▪ Design new roads such that the alignments **minimize water crossings and avoid potentially sensitive habitat** to the extent possible ▪ **Limit the Project footprint** to the extent practical using practices such as: o optimizing use of cleared areas for Project activities o using existing road infrastructure, including the existing access road and bridge crossing o storing tailings underground o designing an efficient infrastructure footprint (i.e., buildings clustered together) ▪ Implement **progressive reclamation and revegetation** of disturbed areas no longer required ▪ **Reclaim and revegetate areas** where non-permanent Project facilities have been decommissioned ▪ **Recycle and reuse process water** to reduce fresh water intake and release to Patterson Lake, to the extent practical ▪ Adhere to guidance from regulators such as DFO as to the **allowable rate and timing of water withdrawals** from the point of supply ▪ **Apply DFO's** *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2019b) to minimize potential adverse effects on aquatic resources ▪ **Monitor water flows** in the downstream aquatic environment at the outlet of Patterson Lake and apply adaptive management if changes in flows are larger than predicted and are affecting fish habitat ▪ Implement a Project-specific **Mine Waste Management Plan** ▪ Implement a Project-specific **Environmental Protection Program** and a Project-specific **Environmental Monitoring Plan** ▪ Develop and implement a **Preliminary Decommissioning and Reclamation Plan** to decommission and transfer the site to the province under the Institutional Control Program	Secondary pathway
F-04		**Water use affecting water levels and flows:** ▪ Water supply requirements (potable and process) for the Project may cause changes to water levels and flows and channel/bank stability, which can affect fish habitat availability and distribution		Secondary pathway
F-05		**Changes to sediment transport:** ▪ Changes to water flows may alter channel sediment transport conditions in the Clearwater River downstream of Patterson Lake, which can affect fish habitat availability and distribution		Secondary pathway

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Table 11.4-1: Potential Effects Pathways for Fish and Fish Habitat

Path ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
F-06	Project components/activities that may cause sediment release during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ handling and storage of waste rock, special waste rock, and ore ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure	**Sediment release:** ▪ Sediment release during in-water construction and from ground disturbance may alter fish habitat availability, survival, and reproduction in downstream waterbodies and watercourses	▪ Where feasible, **locate Project footprint components and associated construction activities away from waterbodies and watercourses** to avoid or minimize the potential for sediment transfer to the surface water environment ▪ **Minimize timeframes for site clearing** and activities that expose soils, to the extent practical ▪ To the extent practical, **work in sensitive areas** (i.e., erosive soils, wetland features, and fish habitats) would be scheduled **to avoid periods that may result in high flow volumes and/or increase erosion and sedimentation** (e.g., spring freshet) ▪ Install appropriate **erosion and sediment control** measures, as required o Regularly inspect erosion and sediment control measures to confirm they are functioning as planned, and perform any required maintenance, as needed ▪ Perform routine inspection and maintenance of **water containment and conveyance structures** (i.e., roadside ditches and culverts) to limit the risk of road wash-out or sediment release to the environment ▪ **Minimize areas of vegetation clearing** and soil disturbance ▪ **Minimize steepness and length of slopes of disturbed areas** and stockpiled soils ▪ **Avoid placing soil stockpiles near waterbodies** (i.e., maintaining 150 m buffer from waterbodies and watercourses), and near natural drainage features, unless required for temporary storage ▪ Establish **appropriate site drainage** o Where feasible, **preserve natural drainage** features to minimize alteration to drainage conditions in the area o Minimize interaction between the surface water system and erodible soils ▪ **Apply DFO's** *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2019b) to minimize potential adverse effects on aquatic resources ▪ Where possible, **schedule in-water** activities to avoid work during DFO's *Saskatchewan Restricted Activity Timing Windows for the Protection of Fish and Fish Habitat* (DFO 2013a). Restricted activity periods for fish are as follows: o fall/winter spawning fish in northern Saskatchewan with lake trout present (1 September to 15 July) o spring spawning fish in northern Saskatchewan without lake sturgeon (1 May to 15 July) ▪ Implement **progressive reclamation and revegetation** of disturbed areas no longer required ▪ **Reclaim and revegetate areas** where non-permanent Project facilities have been decommissioned ▪ Implement a Project-specific **Mine Waste Management Plan** ▪ Implement a Project-specific **Environmental Protection Program** ▪ Implement a Project-specific **Environmental Monitoring Plan** ▪ Develop and implement a **Preliminary Decommissioning and Reclamation Plan** to decommission and transfer the site to the province under the Institutional Control Program	Secondary pathway
F-07	Project components/activities that contribute to emissions and deposition of fugitive dust during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ underground shaft and mine development ▪ site traffic ▪ transportation of personnel and material to and from the site ▪ handling and storage of waste rock, special waste rock, and ore ▪ additional infrastructure (e.g., maintenance shop, offices) ▪ non-hazardous waste incineration ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure	**Air and dust emissions affecting water quality:** ▪ Air and dust emissions, including emissions of criteria air contaminants and fugitive dust, and subsequent deposition (e.g., particulate matter, metals, and radionuclides) may cause changes to surface water quality, which may adversely affect fish habitat availability, survival, and reproduction in local waterbodies and watercourses	▪ **Apply water and/or suppressants to site roads, access road, and airstrip**, as necessary o Use dust suppressants that minimize environmental risk and are government approved for use ▪ Establish and enforce **speed limits** on site and access roads to reduce dust production ▪ **Optimize haul routes** to reduce fuel consumption and emissions from equipment ▪ Primarily **use liquified natural gas for power generation** ▪ **Use and maintain emissions control devices** on combustion-based equipment ▪ **Maintain mobile mining equipment and vehicles** and monitor for leaks ▪ Evaluate opportunities to **reduce fuel combustion requirements** of infrastructure and equipment, to the extent practical, during detailed design. ▪ Conduct **regular equipment maintenance** ▪ **Limit idling** of vehicles and equipment to the extent practical ▪ Identify and implement **procurement criteria** to confirm stationary and mobile engines meet applicable performance standards ▪ Implement a Project-specific **Environmental Protection Program** ▪ Implement a Project-specific **Effluent and Emissions Plan** ▪ Implement a Project-specific **Environmental Monitoring Plan** that includes ambient air monitoring and adaptive management based on ambient air quality standards	Secondary pathway

Table 11.4-1: Potential Effects Pathways for Fish and Fish Habitat

Path ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
F-08	Project components/activities that may result in direct physical changes to fish habitat during **Construction, Operations, and Closure**: ▪ fresh water intake for potable and process water ▪ treated effluent discharge pipe and diffuser ▪ treated sewage outfall ▪ associated pipelines	**Loss or alteration of fish habitat:** ▪ Physical loss or alteration of fish habitat in Patterson Lake from the Project footprint, including the fresh water intake, treated effluent diffuser, treated sewage outfall, may affect fish habitat availability	▪ **Design in-water developments so that the structures minimize adverse effects** on fish and fish habitat and avoid a harmful alteration disruption or destruction of fish habitat, as defined by the federal *Fisheries Act*, to the extent practical ▪ If required, **develop a fish habitat offsetting plan** in consultation with DFO and with engagement of the local Indigenous communities ▪ Design and locate shoreline developments (e.g., site roads, shoreline infrastructure, physical footprints of the conveyance pipes for the fresh water intake, treated effluent diffuser, and treated sewage outfall) to **minimize riparian vegetation loss and/or disturbance**, to the extent practical ▪ **Revegetate temporarily disturbed areas** with suitable, native species after construction activities are complete ▪ **Minimize the physical footprint of in-water developments** (i.e., fresh water intake, treated effluent diffuser, and treated sewage outfall) to the extent practical ▪ To the extent practical, locate in-water developments to **avoid potentially sensitive or unique fish habitats** ▪ **Apply DFO's** *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2019b) to minimize potential adverse effects on aquatic resources ▪ Implement a Project-specific **Environmental Protection Program** ▪ Develop and implement a **Preliminary Decommissioning and Reclamation Plan** with government and Indigenous communities to decommission and transfer the site to the province under the Institutional Control Program	Secondary pathway
F-09	Project components/activities that may result in risk of injury/mortality to fish during **Construction, Operations and Closure**: ▪ installation of fresh water intake, treated effluent diffuser, and treated sewage outfall, associated pipelines, and associated maintenance activities ▪ removal of infrastructure	**Disturbance during in-water construction:** ▪ In-water construction and related activities for the fresh water intake, treated effluent diffuser, and treated sewage outfall can cause injury or mortality to fish, including fish eggs, and disturb fish habitats in Patterson Lake, which may adversely affect fish habitat availability, survival, and reproduction	▪ To the extent practical, locate in-water developments (i.e., proposed fresh water intake, treated effluent diffuser, and treated sewage outfall) **away from sensitive or unique fish habitats** ▪ **Design in-water components** of site water management infrastructure (i.e., proposed fresh water intake, treated effluent diffuser, and treated sewage outfall) to minimize the potential for adverse effects on the aquatic environment and such that discharged flow does not interact with sediment, to the extent practical ▪ Where possible, **schedule in-water** activities to avoid work during DFO's *Saskatchewan Restricted Activity Timing Windows for the Protection of Fish and Fish Habitat* (DFO 2013a). Restricted activity periods for fish are as follows: o fall/winter spawning fish in northern Saskatchewan with lake trout present (1 September to 15 July) o spring spawning fish in northern Saskatchewan without lake sturgeon (1 May to 15 July) ▪ Employ construction methods that **avoid or minimize the potential to cause injury or mortality to fish or disturb nearby habitats**, to the extent practical. Assemble in-water structures on shore, where practical, and float into position in Patterson Lake, and then submerged and anchored on the lake bottom ▪ Construct in-water developments in **adherence with the conditions of any permits or authorizations** that may be issued for the Project from the appropriate regulatory agencies ▪ **Apply DFO's** *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2019b) to minimize potential adverse effects on aquatic resources ▪ Implement a Project-specific **Environmental Protection Program**	Secondary pathway
F-10	Project components/activities that may result in risk of injury/mortality to fish during **Construction, Operations and Closure**: ▪ installation of fresh water intake, treated effluent diffuser, and treated sewage outfall, associated pipelines, and associated maintenance activities ▪ removal of infrastructure	**Impingement and entrainment of fish in the fresh water intake:** ▪ Impingement and entrainment of fish in the fresh water intake may cause injury or mortality to fish and affect the survival of fish	▪ **Locate the fresh water intake** in an area and depth of water that avoids sensitive or unique fish habitats, to the extent practical ▪ **Locate the intake screen above the bottom** of the waterbody to prevent entrainment of sediment and aquatic organisms associated with the bottom area ▪ Design and **install a fish screen** on the fresh water intake in Patterson Lake to avoid or reduce entrainment or impingement of fish. Pump intake screens would be designed in accordance with DFO's *Freshwater Intake End-of-Pipe Fish Screen Guideline* (DFO 1995) ▪ Develop and implement a **Preliminary Decommissioning and Reclamation Plan** to decommission and transfer the site to the province under the Institutional Control Program	Secondary pathway
F-11	Project activities that directly alter fish habitat during **Construction, Operations, and Closure**: ▪ operation of the treated effluent diffuser	**Habitat disturbance from treated effluent diffuser:** ▪ The area of water turbulence around the treated effluent diffuser may affect local fish habitat availability in Patterson Lake	▪ Locate proposed treated effluent diffuser **away from sensitive or unique habitats**, to the extent practical ▪ Locate the diffuser **discharge ports above the lake bed** to avoid or minimize erosion ▪ Discharge pumped contact water through an **engineered diffuser** to minimize effects from changes in velocity ▪ Develop **appropriate discharge flow rates and monitor** treated effluent flow to address erosion concerns ▪ Develop and implement a **Preliminary Decommissioning and Reclamation** to decommission and transfer the site to the province under the Institutional Control Program	Secondary pathway

Table 11.4-1: Potential Effects Pathways for Fish and Fish Habitat

<table>
<tr><th>Path ID</th><th>Project Components/Activities</th><th>Effects Pathway</th><th>Environmental Design Features and Mitigation</th><th>Pathway Assessment</th></tr>
<tr><td>F-12</td><td>Project activities that change access for Indigenous and other land users during **Construction, Operations, and Closure**:
▪ development and improvement of access road and site roads
▪ removal of infrastructure
▪ reclamation and revegetation of facilities and infrastructure</td><td>**Public access affecting survival:**
▪ Changes in public access to recreational fishing areas on the Clearwater River and in Patterson Lake, and increased density of people (e.g., Project staff and contractors) in the area, may affect the survival of fish</td><td>▪ **Use existing roads**, where feasible. Development of new public roads would not be required; the existing road from Highway 955 would be upgraded (i.e., widened to a surface width of 8 m) to support increased traffic volume and heavy vehicle/equipment use, allow for two-way traffic travel, and improve safety
▪ Transport employees and contractors to site by aircraft, or by bus from La Loche until the on-site airstrip is operational, to **limit the opportunity for people to fish along the access road for the Project**
▪ **Install a gate at the site entrance** (i.e., gatehouse) to control public access
▪ Implement **progressive reclamation and revegetation** of disturbed areas no longer required
▪ **Reclaim and revegetate areas** where non-permanent Project facilities have been decommissioned
▪ Develop and implement a **Preliminary Decommissioning and Reclamation Plan** to decommission and transfer the site to the province under the Institutional Control Program
▪ Work with local Indigenous Groups and communities to **develop fishing policies** that consider both fisheries protection and traditional use activities</td><td>Secondary pathway</td></tr>
<tr><td>F-13</td><td rowspan="4">Project components/activities that may change water and sediment quality and aquatic health during **Construction, Operations, and Closure**:
▪ land clearing, site preparation, and construction of facilities and infrastructure
▪ underground shaft and mine development
▪ process plant and underground operations
▪ handling and storage of waste rock and special waste rock, and ore
▪ surface water management activities (e.g., water withdrawal, diversion, collection, storage, and treatment)
▪ treated effluent discharge following treatment at ETP
▪ domestic waste water discharge following treatment at STP
▪ removal of infrastructure
▪ reclamation and revegetation of facilities and infrastructure</td><td>**Project activities affecting water and sediment quality and aquatic health:**
▪ Project activities and discharge (e.g., treated effluent and treated sewage discharge, runoff from the Project footprint, air and dust emissions, and runoff and seepage from the WRSAs) may cause changes to water and sediment quality during Construction, Operations, and Closure and adversely affect fish habitat availability, survival, and reproduction</td><td rowspan="4">▪ **Install engineered cover** of compacted clean material and growth medium layer on PAG WRSA and install growth medium cover on NPAG WRSA
▪ **Segregate PAG material** from NPAG material and store separately
▪ Collect, store, and routinely **monitor contact water** to confirm discharge water meets water quality criteria appropriate for release
▪ Confirm discharge meets **water quality discharge criteria** prior to release to the environment
▪ **Develop a site-specific ETP and STP** to reduce release of COPCs (e.g., major ions, metals, radionuclides) to the environment
▪ Collect contact water, monitor, and treat where necessary
▪ **Monitor treated effluent and treated sewage** flow and quality
▪ Locate proposed treated effluent diffuser **away from sensitive or unique habitats**, to the extent practical
▪ Design the treated effluent diffuser and treated sewage outfall to **provide effective mixing and dilution of the effluent** to limit the area of the receiving environment affected by mine discharge
▪ **Recycle and reuse process water** to reduce fresh water intake and release to Patterson Lake, to the extent practical
▪ **Limit seepages** from the PAG WRSA through the use of an engineered physical liner under the storage area
▪ **Limit seepages** from the special waste storage area with double liner and leak detection system
▪ Implement a Project-specific **Mine Waste Management Plan**
▪ Implement a Project-specific **Environmental Protection Program**
▪ Implement a Project-specific **Environmental Monitoring Plan** that includes monitoring in the vicinity of the Project, as required, in accordance with licence requirements and the federal MDMER to monitor the potential effects of Project discharges on water and sediment quality, and on the fish population and benthic invertebrate community
▪ Develop and implement a **Preliminary Decommissioning and Reclamation Plan** to decommission and transfer the site to the province under the Institutional Control Program</td><td>Secondary pathway</td></tr>
<tr><td>F-14</td><td>**Nutrient changes from Project activities:**
▪ Project activities and discharge (e.g., treated effluent and treated sewage discharge, runoff from the Project footprint, and air and dust emissions) may change nutrient concentrations in the aquatic receiving environment, and affect fish habitat availability, survival, and reproduction during Construction, Operations, and Closure</td><td>Secondary pathway</td></tr>
<tr><td>F-15</td><td>**Temperature and dissolved oxygen changes from Project activities:**
▪ Project activities and discharge (e.g., development of the Project footprint, surface water management activities including pumping and storage of contact water, water withdrawals, and treated effluent discharge) may change the temperature and DO regime of receiving waters, which can alter fish habitat availability, survival, and reproduction</td><td>No pathway</td></tr>
<tr><td>F-16</td><td>**TSS changes from Project activities:**
▪ Discharge of treated effluent can increase TSS concentrations in receiving waters, and affect fish habitat availability, survival, and reproduction</td><td>No pathway</td></tr>
</table>

Table 11.4-1: Potential Effects Pathways for Fish and Fish Habitat

Path ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
F-17	Project components/activities that may cause disturbance to natural drainage features along site and access roads during **Construction, Operations, and Closure**: ▪ upgrades to the existing access road from Highway 955 ▪ construction of new site roads ▪ installation of cross-drainage structures (e.g., culverts) along site access roads, and associated maintenance activities ▪ removal of infrastructure	**Drainage infrastructure affecting habitat and movement:** ▪ Placement of new or upgraded cross-drainage structures (e.g., culverts) along site and access roads may adversely affect fish habitat availability in downstream fish-bearing environments	▪ Design new roads such that road alignments **minimize the number of water features crossed and avoid sensitive areas** to the extent feasible ▪ Design stream crossing structures to **limit the area disturbed** and in a manner that protects the banks from erosion and maintains the flows ▪ **Design cross-drainage structures** to provide a conveyance for the maximum instantaneous flow resulting from a 1:100-year 24-hour storm event ▪ Construct and install water crossings in a manner that **follows best practices and regulatory requirements** ▪ **Inspect culverts regularly and perform maintenance**, as required, to prevent blockages from forming and causing ponding or backwater effects ▪ Implement **Environmental Protection Program** ▪ Develop and implement a **Preliminary Decommissioning and Reclamation Plan** to decommission and transfer the site to the province under the Institutional Control Program	No pathway
F-18	Project activities that use explosives during **Construction and Operations**: ▪ underground shaft and mine development	**Explosives harming fish:** ▪ Use of explosives near fish-bearing water can affect fish survival and reproduction	▪ **Implement DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat*** (DFO 2019b) to minimize potential adverse effects on aquatic resources ▪ **Follow DFO's *Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters*** (Wright and Hopky 1998) for setback distances from Patterson Lake. If setback distances are approached, develop site-specific operating mitigations in consultation with DFO ▪ Implement a Project-specific **Environmental Protection Program**	No pathway

Bolded text represents the key topic of the environmental design features and mitigation.
> = greater than; DFO = Fisheries and Oceans Canada; UGTMF = underground tailings management facility; COPC = constituent of potential concern; ETP = effluent treatment plant; TSP = total suspended particulate; TSS = total suspended solids; STP = sewage treatment plant; MDMER = Metal and Diamond Mining Effluent Regulations; PAG = potentially acid generating; NPAG = non-potentially acid generating; WRSA = waste rock storage area; DO = dissolved oxygen.

11.4.1 No Pathways

The following Project interactions were predicted to result in no pathway to fish VCs and were not carried forward in the assessment.

F-17: Drainage infrastructure affecting habitat and movement:

- Placement of new or upgraded cross-drainage structures (e.g., culverts) along site and access roads may adversely affect fish habitat availability in downstream fish-bearing environments.

Project activities would include upgrades to the existing access road from Highway 955 and the development of new roads on the Project site (Figure 11.1-3). Changes to the existing access road alignment are not planned except to avoid a wetland; however, the road would be widened during Construction to support increased traffic volume and heavy vehicle/equipment use during the Project lifespan. Access and site road development would require the installation of cross-drainage structures (e.g., culverts) or upgrades to existing structures along the road alignments. There are 23 locations along the existing access road where culverts may need to be constructed, replaced, or extended in conjunction with planned upgrades to the road. Additional culverts would also be required for new site roads and on the proposed Project site to provide conveyance of surface runoff within the Project footprint.

A review of geospatial hydrography mapping data (GeoGratis CanVec Series; NRCan 2021) was conducted for the Project footprint. The GeoGratis CanVec Series is a reliable, widely used mapping resource that originates from the best available geospatial data sources covering Canadian territory. These data include detailed delineation of waterbodies, watercourses, and drainage features in Canada (NRCan 2021). Based on the review of the GeoGratis CanVec Series data, none of the planned access road upgrades or new site roads would intersect mapped waterbodies or watercourses. Therefore, any culverts located along the access roads and site roads would provide cross-drainage and prevent upstream ponding but do not cross waterbodies or watercourses with a defined bed and banks that may be habitat for fish. As a result, construction, maintenance, and removal activities related to culverts are not expected to directly affect fish-bearing habitats. Likewise, no change in the distribution of fish habitats within the LSA is expected.

The placement of culverts and associated maintenance activities are not expected to affect fish VC habitat quality in downstream environments, such as Patterson Lake, due to the physical distance between the area of disturbance and fish-bearing habitats and the incorporation of environmental design features and mitigation into the design and maintenance of culverts. In accordance with the Environmental Protection Program: the design of new cross-drainage structures would convey the maximum instantaneous flow resulting from a 1 in 100-year 24-hour storm event and incorporate erosion protection features to prevent localized erosion from high-velocity flows; construction would follow best practices for culvert installations; and culverts would be inspected regularly and maintained to prevent blockages. These measures would limit effects on downstream habitats.

Additionally, the alignments for the existing access road and new site roads would be set back from the Patterson Lake shoreline at most locations (i.e., setback distance typically ranging between 300 m and more than 1 km); there are limited sections with a narrower setback distance, but the distance remains more than 30 m from nearby waterbodies or watercourses, except for ramps and roads needed for installation and maintenance of pipelines and foreshore and lake infrastructure. These setbacks provide a buffer that would prevent effects from construction and operation of proposed roads on downstream fish-bearing environments.

As Project roads and components are not expected to cross water features frequented by fish, installation and/or upgrades to culverts would not affect fish VC habitat quantity or distribution in the LSA. Similarly, effects on downstream, fish-bearing habitats are not expected due to the incorporation of identified environmental design features and mitigations. Therefore, this pathway was determined to have no linkage to effects on lake trout, lake whitefish, walleye, and northern pike and was not carried forward in the assessment.

F-18: Explosives harming fish:

- Use of explosives near fish-bearing water can affect fish survival and reproduction.

Pressure changes and vibrations caused by blasting on land during Project Construction and Operations can cause injury or mortality of fish in nearby Patterson Lake. Post-detonation compression shock waves caused by detonations of explosives near water can cause internal damage to the swim bladder and other soft organs of fish and can cause changes to fish behaviour (Wright 1982; Wright and Hopky 1998; Cott and Hanna 2005; Goddard et al. 2008). The severity of effects is related to the type of explosive, method of detonation, distance away from fish, water depth, and the weight and pattern of the explosive charges. The species, size, and life stage of fish also play a role in the severity of effects of blasting. Fish eggs incubating in spawning beds near blasting zones can be damaged by movement of the substrate in which eggs are imbedded, causing mortality or disrupting development (Wright 1982; Faulkner et al. 2006, 2008). Peak particle velocities (i.e., vibrations) can increase mortality of incubating eggs close to blasting zones (Wright 1982).

The YNLR have expressed concerns about the potential effects of using explosives on fish and other resources.

> It would affect the water, and wildlife especially if they have to blast in the water and land. It would also affect the moose, and fish – there is good fish in that area. There are similar mine sites in this area, they say it okay, eventually it does affect the water. It will affect the fish and wildlife. (TSD VI: YNLR)

Blasting is not planned adjacent to or within waterbodies or watercourses.

All applicable DFO-recommended measures to avoid causing harm to fish from the use of explosives would be followed for the proposed Project (DFO 2019b). The DFO guidelines (Wright and Hopky 1998) and recommendations (Cott and Hanna 2005) for the use of explosives in or near fish-bearing waters provide a maximum allowable limit for overpressure (i.e., peak pressure level; 50 kilopascals) and peak particle velocity (i.e., 13 mm/s). For example, assuming a detonation of a confined explosive with a heavy charge weight of 100 kg, a conservative setback distance of 77 m from the blast location would be applied to avoid effects to fish from pressure changes, and a distance of 150.9 m would be applied to avoid effects to incubating eggs from increased peak particle velocities (Wright and Hopky 1998: Cott and Hanna 2005). Several studies have demonstrated the effectiveness of DFO recommended setback distances for detonations in avoiding effects to fish (Faulkner et al. 2006, 2008).

Blasting for the Project would occur in conjunction with development of the underground mine and UGTMF at the locations of the production shaft and exhaust shaft, All Project blasting would occur on land and not in Patterson Lake. The minimum separation distance between Patterson Lake and the anticipated location of Project blasting is 345 m; however, much of the blasting activity would occur at distances typically greater than away 450 m (UGTMF blasting) to 750 m (production blasting) from Patterson Lake. Peak pressure level and peak particle velocity vibration levels were predicted for Project blasting at the nearest anticipated location to

Patterson Lake. Blasting activities would be located at distances greater than the DFO recommended setback distances referenced above (TSD X, Vibration Effects Analysis Report), and thus avoid harm to fish. If these setback distances are approached, site-specific operating mitigations could be implemented, as required, to protect fish.

Thus, survival and reproduction rates of fish in nearby surface waters would remain unchanged as a result of the use of explosives during Project Construction and Operations. Therefore, the effect of pressure changes and vibrations from blasting on fish is considered as no pathway because blasting would occur at a considerable distance from Patterson Lake. As a result, there are no predicted residual effects on lake trout, lake whitefish, walleye, and northern pike survival and reproduction, and this pathway was not carried forward in the assessment.

F-15: Temperature and DO changes from Project activities:

- Project activities and discharge (e.g., development of the Project footprint, surface water management activities including pumping and storage of contact water, water withdrawals, and treated effluent discharge) may change the temperature and DO regime of receiving waters, which can alter fish habitat availability, survival, and reproduction.

Project components and activities, such as pumping and storage of contact water, treated effluent discharge, and other activities associated with surface water management and site preparation, have the potential to alter the temperature and DO regime of downstream receiving environments and to affect the suitability and availability of habitat for fish VCs in the LSA. Water temperatures or DO levels outside of the preferred range for a fish species can affect survival and reproduction. Changes to water temperature or DO conditions could occur directly through mixing of treated effluent with ambient water, or indirectly, through changes in environmental factors or processes that may mediate the physicochemical characteristics of surface water. For example, changes to surface water flows and levels (Caissie 2006), increases in nutrient concentrations (Wetzel 2001), or losses and/or disturbance to riparian vegetation (Broadmeadow and Nisbet 2004; DeWalle 2010) can be factors affecting the temperature and/or DO regime of surface waters.

Prior to releasing treated effluent to Patterson Lake, mine water and contact water would be captured and stored in treatment ponds at ambient temperatures. Based on the design of the water treatment infrastructure, water storage and treatment are not expected to thermally alter the treated effluent discharge relative to ambient conditions. Effluent would be conveyed to the treated effluent diffuser and treated sewage outfall using above-ground heat-traced pipelines to prevent the effluents from freezing; however, the heat-tracing would not be expected to appreciably raise the temperature of the effluents.

Changes in water temperature and DO conditions in the Patterson Lake receiving environment were assessed in the surface water quality assessment using the approach and conservative assumptions described in Section 10A 6.4.2 of Appendix 10A. The results indicate that increases in water temperature would be less than 1°C at the edge of the regulated mixing zones (RMZs) for the treated effluent diffuser and treated sewage outfall, during both ice-cover and open-water conditions. These predicted increases are considered to be within the natural range of variability for Patterson Lake (Section 10.3) and are not likely to be measurable. Similarly, decreases in DO concentrations were estimated to be less than 0.1 mg/L, and would be within the natural range of variability for Patterson Lake and not likely measurable. Additionally, the treated effluent diffuser and treated sewage outfall would be designed to provide effective mixing and dilution of the treated effluent, such that water temperatures and DO conditions would be well mixed within the adjacent Patterson Lake receiving environment, with no measurable changes from existing conditions (TSD XX, Downstream Use and Impact Study for Proposed

Treated Sewage Discharge Report) beyond the 100 m RMZ. Consequently, the implementation of environmental design features would avoid residual effects on fish habitat quality, such that effects on fish VCs are not expected.

The proposed Project is not expected to adversely affect the function of the riparian zone of Patterson Lake in providing adequate shading of surface water from solar radiation, which can be an important factor moderating water temperature (Broadmeadow and Nisbet 2004; DeWalle 2010). Only very minimal losses or disturbance to riparian vegetation are expected due to the Project, as Project components would generally be located more than 30 m away from waterbodies and watercourses. Additionally, in cases where infrastructure footprints are required within 30 m of a waterbody (e.g., the construction of a fresh water intake pumphouse adjacent to Patterson Lake), the developments would be sited in previously disturbed areas, where feasible. Further assessment and description of predicted riparian habitat losses or disturbance associated with the proposed Project is provided in Section 11.4.2, Secondary Pathways, under pathway F-08: Loss or alteration of fish habitat. Changes to water temperature related to riparian habitat loss would not be expected, but if they were to occur, effects would be localized and limited to shoreline areas immediately adjacent to the disturbances; these localized changes are likely unmeasurable and would not affect the lake as a whole. As a result, there would be no corresponding effects on fish VC populations.

Project-related changes in hydrology are not expected to be of sufficient magnitude to affect the temperature and/or DO regime of surface waters. Changes in hydrologic conditions can affect the local environment by altering environmental variables such as waterbody residence time, turnover conditions, lake inflow/outflow conditions, and other dynamic processes, which are factors that can mediate water temperature and/or DO conditions in receiving waters (Wetzel 2001; Caissie 2006). The results of the hydrology assessment (Section 9.6.1.2) indicate that changes to watercourse flow rates, lake levels, and stream channel parameters are predicted to be small and not measurable at hydrometric stations. Therefore, changes in hydrology are not expected to meaningfully alter the physicochemical characteristics of waterbodies and watercourses or affect fish VC habitat quality.

The results of the surface water quality assessment (Section 10) indicate that proposed Project activities and discharge would result in increased nutrient concentrations in Patterson Lake and other downstream environments, particularly during Operations. An analysis of potential effects from increased nutrient concentrations on fish VCs is provided in Section 11.4.2 under pathway F14: Nutrient changes from Project activities (Table 11.4-1). A minimal (i.e., less than 0.005 mg/L) increase in TP concentration is expected in the receiving environment during the 43-year Project lifespan. With an increase in TP concentration of approximately 0.005 mg/L, a minor corresponding increase in the productivity of phytoplankton may be expected; however, at the predicted magnitude of effect, reductions in DO that could affect habitat use or suitability for fish VCs are not expected (Anderson 2002; Wetzel 2001).

Overall, changes in water temperature and DO conditions are predicted to remain within the natural range of variability for Patterson Lake and are expected to be not measurable in the receiving environment. Consequently, changes to fish habitat availability, survival, and reproduction are not expected. Therefore, this pathway was determined to have no linkage to effects on lake trout, lake whitefish, walleye, and northern pike and was not carried forward in the assessment.

F-16: TSS from Project activities:

- Discharge of treated effluent can increase TSS concentrations in receiving waters and affect fish habitat availability, survival, and reproduction.

Discharge of treated effluent and treated sewage to Patterson Lake has the potential to result in an increase in total suspended solids (TSS; i.e., particles suspended in the water column) and turbidity (i.e., a measure of relative clarity of the water) in the receiving environment. During engagement for the Project, the BNDN expressed concern that the Project could cause changes to water clarity (TSD II: BNDN). An increase in TSS or turbidity has the potential to adversely affect fish habitat quality and the survival and reproduction of fish. Total suspended solids may affect fish by altering their physiology, behaviour, and habitat, all of which may lead to physiological stress and reduced survival or reproduction rates (Bash et. al. 2001). The nature and extent of adverse effects of increased TSS is influenced by both the TSS concentration and the duration of exposure. Fish can typically tolerate lower concentrations of TSS for longer periods and higher concentrations for shorter periods before potentially experiencing harmful effects (Newcombe and Jensen 1996).

Total suspended solids loadings to the receiving environment from the treated effluent discharge are anticipated to be low. The diffuser and outfall designs would provide effective mixing and dilution of the treated effluent, which would limit the area of the receiving environment expected to experience an increase in TSS concentrations. The surface water quality assessment (Section 10) provided a conservative analysis (Appendix 10A, Section 10A6.4.2) estimating effects of discharge on TSS concentrations at the edge of the RMZs for the treated effluent diffuser and treated sewage outfall in Patterson Lake. Total suspended solids concentrations during peak effects (i.e., Operations) are predicted to be 1.8 mg/L and 1.1 mg/L at the edge of the RMZs for the treated effluent diffuser and treated sewage outfall, respectively, during both ice-cover and open-water conditions. These predictions reflect increases of 0.8 mg/L and 0.1 mg/L at the RMZs for the treated effluent diffuser and treated sewage outfall, respectively, relative to baseline values (Appendix 10A). These predicted increases are within the range of natural variability for Patterson Lake (Appendix 10A) and are unlikely to be measurable in the environment.

It is expected that TSS in the effluent would settle within a short distance of the treated effluent diffuser and treated sewage outfall resulting in minor, localized changes to water and sediment quality in the immediate, adjacent receiving environment of Patterson Lake relative to baseline conditions. Settling of sediment on the lake bottom is not expected to adversely affect sensitive or unique fish habitats due to the low magnitude of the predicted TSS increases and because the diffuser and outfall have been sited away from unique or sensitive fish habitats. Additional description and assessment of the effects of in-water developments, including the treated effluent diffuser and treated sewage outfall, on fish habitats in Patterson Lake is provided in Section 11.2.4, Temporal Boundaries.

Surface water quality would be protected and managed in accordance with the Environmental Protection Program. The ETP would be designed to remove TSS such that the concentrations in the treated effluent discharge would be below the maximum authorized monthly mean concentration of 15 mg/L, set out in Schedule 4, Table 1, of the Metal and Diamond Mining Effluent Regulations (MDMER). These criteria are set to be protective of fish and aquatic life. The rate of discharge from the ETP would be managed by having adequate surface water storage capacity to allow for controlled release rates. Effluent from the ETP would be stored in ponds and only released to Patterson Lake in batches after treated effluent is tested to confirm water quality objectives are met.

Site drainage from non-mineralized areas of the site that is not treated in the ETP would have the potential to entrain TSS. However, this water would be collected in sedimentation ponds or discharged through infiltration to remove TSS. For example, runoff from the NPAG WRSA would be collected in site runoff pond #2, (i.e., contact water pond #2) which would then be pumped to the west bermed runoff collection area, after being tested and passing water quality criteria. From the west bermed runoff collection area, water would then infiltrate and report to Patterson Lake via shallow groundwater. This flow pathway would remove virtually all TSS before the water reaches Patterson Lake.

Given that predicted increases in TSS are expected to be minor and localized, discharge of TSS to the receiving environment is not expected to measurably affect fish habitat quality or alter the survival and reproduction of fish VCs. Therefore, this pathway was determined to have no linkage to effects on lake trout, lake whitefish, walleye, and northern pike and was not carried forward in the assessment.

11.4.2 Secondary Pathways

The following Project interactions were predicted to result in secondary pathways to fish VCs and were not carried forward in the assessment.

F-02: Habitat disturbance at river crossing:

- Movement of heavy equipment and infrastructure across the Clearwater River at the existing access road crossing location may adversely affect fish habitat availability, survival, and reproduction.

At certain stages of the proposed Project, it may be necessary to employ a crane to move heavy mobile equipment and infrastructure over the Clearwater River at the existing access road crossing location. The existing Clearwater River bridge along this existing access road is a light duty, clear span structure that accommodates single lane traffic. The structural capacity and width of the bridge would be adequate for most vehicles and equipment accessing the Project site; however, the capacity of the bridge may be insufficient to support some large loads during Construction, Operations, and the Active Closure Stage. Operation of a crane adjacent to the Clearwater River, and movement of heavy equipment and infrastructure over the river, could adversely affect fish VC habitat quality by disturbing riparian vegetation and through the potential for increased erosion and sedimentation and/or water quality effects.

Access to the Project site would be provided by the existing access road from Highway 955. Upgrades to the access road are planned to support increased traffic volume and heavy vehicle/equipment use and to widen the road surface. This additional development of the road would include upgrades to cross-drainage structures to accommodate the wider road width and anticipated use. An upgrade to the Clearwater River bridge is not planned, because in most circumstances, the existing bridge would provide sufficient capacity for the planned use. Therefore, the preferred approach for the Project is to maintain the existing bridge and to use a crane to move equipment over the river in limited instances where loads may exceed the legal rating or capacity of the bridge. An alternative option would be to upgrade the existing bridge to provide additional capacity; however, this approach would be taken only if the preferred approach is not feasible, as determined during detailed design. An assessment of potential effects on fish VCs is provided below for the preferred approach, as well as the alternative option.

Movement of materials over the Clearwater River at the existing bridge location by crane would occur only in instances where loads exceed the legal rating or capacity of the bridge and options for reducing load size/weight are not feasible or practical (e.g., dismantling equipment, breaking down a load into smaller units). The crane would be used to lift and move heavy equipment or materials horizontally over the river, and would operate above the bank, adjacent to the Clearwater River. Fording of the river by the crane and equipment would not occur. Use of a crane adjacent to the river may require the development of site access and staging areas. This could result in a temporary loss of, or disturbance to, riparian vegetation in the immediate work area. There is also potential for increased soil erosion and runoff to surface water due to site preparation activities and heavy equipment operation near the watercourse. Additionally, sediment-laden runoff and the potential for leaks from equipment could alter the chemical properties of the water (e.g., increase turbidity and TSS, introduce hydrocarbons) and adversely affect fish habitat quality, survival, and reproduction.

If feasible, staging areas would be constructed to avoid critical or sensitive habitat (e.g., riparian zones), following best practices and regulatory requirements. The footprint of staging areas would be limited to the extent practical to minimize the area of disturbance. The development of staging areas and operation of the crane would be managed so that the activities do not result in any disturbance to the bed and banks of the river. Crane pads would be used to reduce erosion and disturbance to soils. Disturbed areas would be reclaimed and revegetated after the activities are complete. Construction practices and mitigation measures would follow DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2019b) to minimize adverse effects on aquatic resources.

To prevent deleterious substances from entering the watercourse, the crane and any equipment or infrastructure to be moved over the river would arrive in good working order and be well maintained and free of leaks in accordance with the Environmental Protection Program. The crane would be routinely inspected throughout the duration of use and would be removed from the work area upon completion of the activities, or during extended periods where it is not in use. Standard best management practices and mitigations related to spills would be implemented in accordance with the Emergency Preparedness and Response Program (Section 11.4.1, No Pathways).

In the event that an upgrade to the existing Clearwater River access road bridge is deemed necessary, the bridge would be upgraded to a larger clear span structure that would have no permanent footprint below the high-water mark. The upgraded bridge, if required, would be designed to maintain the natural channel and hydraulic conditions of the Clearwater River. Clearing of riparian vegetation would be limited to the footprint and the immediate work area. Some limited disturbance to the watercourse bed or banks and to riparian vegetation may occur during bridge construction, and there is potential that limited in-water work may be required depending on the final design and plan for construction. Where possible, in-water work would be scheduled outside of the DFO restricted activity timing windows, which are: 1 September to 15 July for fall/winter spawning fish in northern Saskatchewan with lake trout present; and 1 May to 15 July for spring spawning fish in northern Saskatchewan without lake sturgeon (DFO 2013a). Permanent alterations to riparian vegetation may occur due to installation of the bridge footprint (e.g., abutments) on the shoreline. Construction practices and mitigation measures would follow DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2019b) and incorporate design and mitigation guidance from DFO and Saskatchewan government's *Fish Habitat Protection Guidelines: Road Construction and Stream Crossings* (1995) to minimize adverse effects on aquatic resources.

With implementation of best management practices and mitigation, effects on fish VC habitat quality, survival, and reproduction from the use of a crane to transport equipment and infrastructure over the Clearwater River are expected to be of short duration (i.e., primarily limited to periods when the crane is in use) and negligible in magnitude. In the event that an upgrade to the existing access road bridge is required, the activities would be expected to result in negligible changes to fish habitat availability. Therefore, this pathway was classified as a secondary pathway and not carried forward for further assessment.

F-03: Altered site drainage affecting water levels and flow:

- Altered site drainage, runoff, and discharge may cause changes to water levels and flows and channel/bank stability in downstream waterbodies and watercourses and affect fish habitat availability and distribution.

AND

F-04: Water use affecting water levels and flows:

- Water supply requirements (potable and process) for the Project may cause changes to water levels and flows and channel/bank stability in downstream waterbodies and watercourses, which can affect fish habitat availability and distribution.

AND

F-05: Changes to sediment transport:

- Changes to water flows may alter channel sediment transport conditions in the Clearwater River downstream of Patterson Lake, which can affect fish habitat availability and distribution.

For brevity, the pathways F-03, F-04, and F-05 are discussed together because they share similar potential causes, assessment methods, and mitigations.

Potential effects on fish habitat availability and distribution may occur due to changes in hydrology during Construction, Operations, and the Active Closure Stage. Natural flow regimes are essential for sustaining fish populations and the ecosystem structure and function that supports these populations (DFO 2013b). Fish VC populations in the LSA and RSA could be adversely affected through the alteration of natural lake levels, watercourse flow rates, and the potential for subsequent effects on natural channel and bank conditions. Changes to flow rates can also affect sediment transport conditions in a watercourse by changing the natural loading and movement of sediment and bed material within the watercourse, which can alter the quality and distribution of available habitats for fish.

The Project mechanisms (e.g., fresh water withdrawal) and site water management features, facilities, and activities that could contribute to potential changes in hydrometric conditions in waterbodies and watercourses in the LSA and RSA are described in the hydrology assessment (Section 9.6). Development of the proposed Project footprint would remove drainage area from the Patterson Lake watershed, which would locally alter drainage and runoff conditions to Patterson Lake. Water would be withdrawn from Patterson Lake to supply the site water system for mining and domestic potable water consumption. Non-contact water generated from undisturbed catchments adjacent to the Project footprint would be diverted around the area using diversion ditches and conveyed directly to Patterson Lake. Contact water that may have been physically or chemically altered by construction, mining, or milling activities would be controlled and monitored. Then, depending on water management requirements, water would be either reused, discharged if it meets discharge criteria, or treated at the ETP to ensure it meets discharge criteria prior to release. Treated effluent would be released to Patterson Lake via an engineered diffuser. Treated sewage generated from the use of fresh water or treated fresh water by domestic sources would be discharged back into Patterson Lake via a treated sewage outfall. These Project activities would result in a net discharge of water to Patterson Lake during Construction, Operations, and the Active Closure Stage.

During engagement for the Project, Indigenous Groups communicated the value of the lakes, rivers, and streams in the area of the Project (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YNLR). The YNLRO expressed concern regarding the sustainable and responsible use of water resources and the potential for corresponding effects on aquatic communities (YNLRO 2019).

The Environmental Protection Program developed for the Project outline the mitigation measures and policies that would be used to avoid or minimize effects on downstream water resources and fish habitat (Table 11.4-1). The YNLRO commented about the importance of responsibly managing water on site and recommended that water use for the Project be minimized by recycling and reusing water on site wherever possible (YNLRO 2019). Proposed infrastructure has been designed to reuse and recycle water wherever possible to minimize the amount of fresh water withdrawn from Patterson Lake (Table 11.4-1). Effects on hydrology would also be reduced by the compact design of surface infrastructure, which would limit changes to drainage areas and runoff pathways, as well as the amount of water that needs to be collected and treated. Site water management facilities and systems are designed in a manner that minimizes Closure activities where possible.

An evaluation of Project-related effects on surface water quantity is presented in the hydrology assessment (Section 9.6.1). A summary of the results of this assessment and potential for resulting effects on fish VCs is provided below.

Predicted Changes to Hydrology

The hydrology assessment (Section 9.6.1) quantitatively evaluated the potential Project-related changes in hydrometric measurement indicators, which included water surface elevation (i.e., lake water levels), watercourse flow rates, stream channel parameters (e.g., wetted area), and fluvial sediment transport conditions. These indicators represent important fish habitat parameters that are considered in the evaluation of the habitat availability and habitat distribution measurement indicators for fish VCs (Section 11.2.2; DFO 2013b; Bradford et al. 2014). Residual effects on lake water levels, watercourse flow rates, and stream channel parameters were evaluated via the development of a regional hydrological model. Predicted effects were modelled for each Project phase, and at key evaluation nodes on waterbodies and watercourses downstream of the Project. Potential Project-related changes in fluvial sediment transport conditions were evaluated using a fluvial sediment transport model for the Clearwater River below Patterson Lake. Both the regional hydrological model and sediment transport model considered all potential effect mechanisms in the upstream watershed area, including changes in site drainage conditions, runoff, water collection and storage, discharge, and water supply requirements.

The hydrology assessment results indicated that the proposed Project would result in minor increases in lake water levels and watercourse flow rates in the receiving environment, with the largest increases expected in Patterson Lake and the Clearwater River below Patterson Lake (Section 9.6.1). These increases would propagate downstream but diminish in magnitude as the watershed area and ambient flows increase. Predicted increases in watercourse flow rates could result in minor changes to stream channel parameters and sediment transport conditions in the Clearwater River downstream of Patterson Lake. These predicted changes could affect fish VCs by modifying the amount and suitability of available habitat and the connectivity of habitats in the LSA and RSA.

Project-related changes in hydrometric measurement indicators are predicted to peak during Operations when the proposed Project footprint is fully developed and when water is discharged to Patterson Lake at maximum rates. During Closure, discharge to Patterson Lake would cease, and baseline drainage conditions would be restored. Consequently, Closure activities would result in the reestablishment of natural flow rates, water levels, and volumes at Patterson Lake and its outflow.

Predicted changes in fish VC habitat availability and distribution from modelled changes in lake water levels, watercourse flow rates, stream channel parameters, and fluvial sediment transport conditions are summarized below, with emphasis on changes occurring during Operations, when peak effects are expected to be realized.

Effects from Changes to Lake Levels

Natural fluctuations in water surface elevations are important for the maintenance of fish habitat in waterbodies (DFO 2013b), including potentially sensitive habitats such as shoals and areas of inundated vegetation, which may serve as important spawning and nursery habitats for fish (Snodgrass et al. 1996; Keddy and Reznicek 1986). Proposed Project activities are predicted to result in a small net change in lake water levels during Construction, Operations, and the Active Closure Stage. Peak increases in mean monthly lake levels relative to Base Case conditions would occur during Operations and are estimated to be consistently less than 1 cm for Patterson Lake and less than or equal to 0.5 cm for Forrest, Beet, and Naomi lakes. Expressed as a percentage, these changes would be less than 1.2% for Patterson, Forrest, Beet, and Naomi lakes. These changes are well within the natural variability of lake levels for Patterson Lake and downstream waterbodies and are unlikely to be measurable at any of these waterbodies (Section 9.6.1). The projected increases are not expected to meaningfully alter water depth in potentially sensitive areas, such as identified spawning areas along the Patterson Lake shoreline (Annex V.1; Section 11.3), or in shallow nearshore nursery habitats such that changes to the suitability of these habitats for use by VC fish species would occur. Overall, changes in lake water levels are predicted to have a negligible residual effect on fish habitat availability and distribution in downstream waterbodies.

Effects from Changes to Watercourse Flow Rates

Maintaining characteristics of the natural flow regime in terms of timing, magnitude, and frequency of flow is an important consideration in sustaining the health of riverine ecosystems (Poff et al. 1997; Arthington et al. 2006; Richter et al. 2012). Increases in flow can alter fish habitat availability by changing available habitat area and other characteristics (e.g., flow depth) that can affect the suitability of the habitat for use by fish. Changes in habitat distribution may occur through alteration of flow depth and velocity conditions, which can alter fish passage conditions.

Applicable guidance to avoid or reduce the potential for adverse effects on fish from flow alterations was considered for the Project. A broadly applied “presumptive standard” for evaluating flow departure from natural conditions is presented in Richter et al. (2012), which recommends that a departure from natural flow conditions of less than or equal to 10% would result in a high level of ecological protection whereby the natural structure and function of the ecosystem would be maintained. The DFO *Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada* (2013b) also applies a percent-of-flow approach and recommends that cumulative flow alterations remain within 10% of natural instantaneous flow. Maintaining flows within 10% of natural flow was expected to have a low likelihood of having detectable negative effects on the ecosystem.

Flows in the Clearwater River below Patterson Lake are predicted to increase in response to a net discharge of water to Patterson Lake resulting from proposed Project activities during Construction, Operations, and the Active Closure Stage. Expressed as a percentage relative to Base Case conditions, increases in mean monthly flow would be between 1.3% and 1.9% at the worst-case assessment node on the Clearwater River below Patterson Lake. For the evaluation nodes farther downstream on the Clearwater River, percent increases in mean monthly flow would be less than or equal to 1.4%, with the predicted changes decreasing in magnitude moving in a downstream direction. These changes would not be detectable during operational monitoring and would be within the natural range of variability for the Clearwater River at both daily and seasonal time scales (Section 9.6.1). Consequently, the natural timing of peak flows and the relative seasonal magnitude of flow conditions would remain unchanged. Additionally, no channel or bank stability effects are expected because the magnitude of predicted flow-related effects is small relative to the Base Case. The predicted changes in watercourse flow rates are well within recommended guideline values (i.e., cumulative flow alterations of less than 10% of natural instantaneous flow; DFO 2013b; Richter et al. 2012) for reducing or avoiding negative effects on fish habitat and are therefore expected to have a negligible effect on fish VCs.

Effects from Changes in Wetted Area

Predicted increases in flows downstream of the proposed Project may result in limited changes to stream channel parameters (e.g., wetted area) in the Clearwater River. In riverine environments, changes to habitat size (i.e., areas of available habitat) due to flow alterations can affect the productivity of fish (e.g., growth, population size; Bradford et al. 2014). Changes in stream channel parameters using wetted area as the representative parameter were predicted to be less than 1% at the Clearwater River evaluation nodes at the mean annual flow and would not be large enough in magnitude to be detectable (Section 9.6.1). No effects on fish VCs are expected due to changes in stream channel parameters.

Effects from Changes in Sediment Transport Conditions

Increases in flow may change sediment transport conditions by altering the rate and nature of sediment movement downstream, which can affect fish habitat availability through changes in substrate conditions, channel geomorphology, and distribution of channel unit types (e.g., riffles, runs, pools) within the watercourse (Hassan et al. 2018). Changes in fluvial sediment transport conditions were assessed for the Clearwater River below Patterson Lake along the section from Patterson Lake to the north end of Forrest Lake. Estimated sediment transport, expressed as cumulative mass change along the section, was predicted to increase slightly (i.e., 2%); however, erosional losses in the upstream areas would be largely counterbalanced by increased sediment deposition in the downstream areas (Section 9.6.1). Predicted changes in fluvial sediment transport conditions in the LSA are not expected to be measurable and are not expected to be of a sufficient magnitude to meaningfully alter fish habitat conditions such that residual adverse effects on fish VCs would occur.

Summary

With implementation of mitigation and environmental design features incorporated into the proposed Project, changes to hydrology are expected to be minor and not large enough to be detectable in downstream waterbodies and watercourses. Based on the quantitative outcome of the hydrology assessment, predicted changes in lake water levels, watercourse flow rates, stream channel parameters, and fluvial sediment transport, conditions are not expected to meaningfully affect fish habitat availability and distribution in waterbodies and watercourses downstream of the Project. Therefore, these pathways were determined to have a negligible residual effect on lake trout, lake whitefish, walleye, and northern pike, and were not carried forward in the assessment.

F-06: Sediment release:

- Sediment release during in-water construction and from ground disturbance may alter fish habitat availability, survival, and reproduction in downstream waterbodies and watercourses.

Increases in the concentrations of suspended sediment in surface water can result directly from disturbance and re-suspension of bed material during in-water construction or indirectly from site runoff. These increased concentrations could increase TSS and turbidity in downstream aquatic ecosystems and result in an adverse effect on fish habitat quality, and the survival and reproduction of fish VCs. During engagement for the Project, the BNDN expressed concern that Project activities could adversely affect water clarity in Patterson Lake (TSD II: BNDN).

Exposure to suspended sediment can affect the health of fish and lower trophic organisms, with effects ranging from minor physiological stress to mortality (Coen 1995; Berli et al. 2014). The magnitude of the effect depends on a combination of the suspended sediment concentration, particle size (Muck 2010; Lake and Hinch 1999), and the duration of exposure. Excess suspended sediment can also an result in changes in behaviour (Schreck et al. 1997), such as feeding (Berg and Northcote 1985) and predator avoidance (Miner and Stein 1996). Fish can tolerate low TSS concentrations for long periods and high concentrations for short periods without suffering adverse effects (Caux et al. 1997; Newcombe 2003; Fleming et al. 2005). The effects of sediment deposition can include infilling of interstitial spaces between substrate particles that provide habitat for spawning, rearing of fry, or incubation of eggs (Bash et al. 2001; Muck 2010). Infilling of substrates can also affect habitat conditions for benthic invertebrates, which are an important food source for fish. Sediment can cover aquatic plants that can provide habitat for fish, particularly northern pike. The severity of the effect depends on the type of habitat and its use by fish (Bash et al. 2001; Muck 2010).

The main Project activities and mechanisms that may result in sediment release to waterbodies and watercourses are in-water construction activities associated with the installation of water management infrastructure components in Patterson Lake, and runoff from ground disturbance (e.g., site clearing, contouring, excavation) during Construction. Changes in natural erosion and sedimentation conditions may also occur during Operations and Closure of the Project due to altered site runoff conditions. However, the magnitude of predicted effects from sediment release is expected to be greatest during Construction and during the subsequent removal of Project components in the Active Closure Stage.

Sediment release from in-water construction activities may occur as a direct result of installing the proposed fresh water intake, treated effluent diffuser, and treated sewage outfall in Patterson Lake during Construction, associated maintenance activities during Operations, and infrastructure removal during the Active Closure Stage. In-water developments planned for the Project have been designed to reduce adverse effects on the aquatic environment. Construction methods for these structures would be relatively unobtrusive in terms of the potential for sediment to be released to the aquatic environment. Structures would be assembled on shore and floated into position in Patterson Lake and then submerged and weighted to the lake bottom. Pipelines intersecting the Patterson Lake shoreline and riparian zone would be installed above ground, and in-water sections of pipe would be installed on the lake bottom.

The installation methods that would be used for in-water developments typically do not cause extensive entrainment of sediments or high TSS levels, as there is limited potential for disturbance to the lake bed substrate and shoreline areas. Consequently, the potential for sediment-related effects would be lower than for more invasive construction methods, such as activities that require excavation, open-trenching, the use of isolation measures (i.e., to allow work in the dry), or construction of coffer dams (DFO 2019b). However, some degree of disturbance to the lake bed substrate and along shoreline areas would be expected during installation of these Project components, which could result in sediment release and temporary increases in TSS concentrations in water.

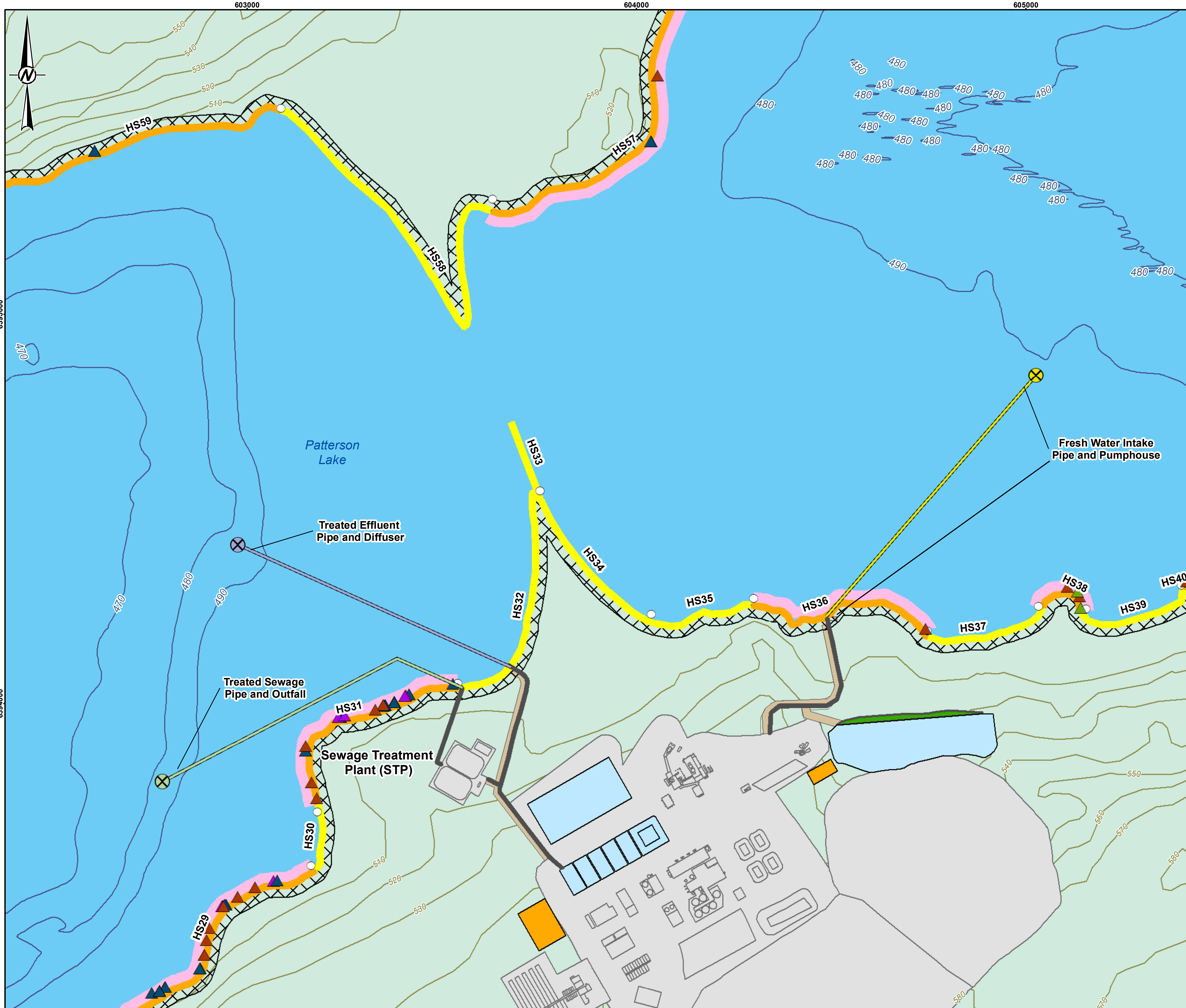
The release of suspended particulate matter during the proposed in-water construction and subsequent deposition of sediment on the lake bottom could locally alter substrate conditions and affect fish VC habitat suitability. Effects on fish habitat availability from settling of particulate matter may potentially occur in areas where high quality substrates are found (e.g., clean gravel, cobble, or boulder substrates that are relatively free of silt, organics, and debris). Based on the results of field surveys completed during the aquatic environment baseline study (Annex V.1), the pipes for the proposed fresh water intake and treated sewage outfall would intersect shoreline areas consisting of cobble and boulder substrates (Annex V.1; Figure 11.4-1). Limited and localized effects would be possible in these areas due to sediment release and subsequent deposition. However, meaningful effects from sediment deposition would be unlikely during the effluent diffuser pipe installation, which would intersect an area consisting primarily of sand substrate. Similarly, effects from sediment deposition are not expected in deeper areas of Patterson Lake where silt or organic substrates are more likely to occur.

In-water construction activities are expected to occur over short periods of one to two days (i.e., for each development). Consequently, the duration of potential effects would be short and limited to the immediate vicinity of the work area. Similar types of effects could occur during maintenance and removal activities related to the in-water developments. Construction of in-water developments and associated shoreline infrastructure would occur during the open-water season. Where possible, in-water work would be scheduled outside of the DFO restricted activity timing windows, which are: 1 September to 15 July for fall/winter spawning fish in northern Saskatchewan with lake trout present; and 1 May to 15 July for spring spawning fish in northern Saskatchewan without lake sturgeon (DFO 2013a). Any in-water work required outside of the restricted activity timing window would be specified in the Request for Review to be submitted to DFO for the Project; see effect pathway F-08: Loss or alteration of fish habitat. During onshore construction, runoff would be managed, and sediment and erosion controls would be implemented.

Project construction activities, such as land clearing, site preparation, excavation, and construction of facilities and infrastructure, would have the potential to accelerate erosion and runoff into surrounding waterbodies and watercourses by exposing terrestrial soils to wind, rain, and surface water runoff throughout Construction, Operations, and the Active Closure Stage. In general, Project footprint components and associated construction activities would be located at a distance from waterbodies and watercourses, which would avoid or minimize the potential for sediment transfer to the surface water environment. However, construction would occur near or directly adjacent to Patterson Lake in limited instances, including during construction of a new site road along the east shoreline of Patterson Lake South Arm and during installation of on-shore components of the site water system (e.g., construction of the fresh water intake pumphouse on the south shoreline of Patterson Lake – North Arm East Basin, new site roads for the proposed fresh water intake and treated effluent diffuser).

All construction activities would occur in accordance with the Environmental Protection Program, which would outline management practices that include standard erosion and sediment control measures. Soil erosion from site-clearing, excavation, and construction would be mitigated and managed through the use of standard erosion and sediment control best management practices. The Project footprint would be limited to the smallest practical area of land, and site clearing and activities that expose soils would be completed in the shortest timelines possible. Areas of vegetation clearing and soil disturbance would be minimized, and soil stockpiles would be located away (i.e., greater than 150 m) from any water feature, unless required for temporary storage. Appropriate site drainage would be established, and where feasible, natural drainage features would be preserved to minimize alteration to drainage conditions in the area and limit interaction between surface water and erodible soils. As part of the reclamation process, disturbed areas that are no longer required and where Project infrastructure has been removed, would be progressively reclaimed and revegetated to prevent erosion. Finally, erosion and sediment control measures would be checked on an ongoing basis to verify that control practices are functioning as intended.

Through the described mitigation, the release of sediment from in-water infrastructure construction, including maintenance and removal activities, is expected to result in short-term, localized, and minor changes to fish habitat quality in Patterson Lake. Additionally, implementation of sediment and erosion control best practices, both during Construction and or at other phases when ground disturbance would be required, are expected to effectively minimize the erosion of soils and associated transfer of sediment into nearby waterbodies. Therefore, this pathway is expected to have negligible effects on fish habitat availability and the survival and reproduction of VCs (i.e., lake trout, lake whitefish, walleye, and northern pike) and was not carried forward for further assessment.



LEGEND

- BATHYMETRY CONTOUR ELEVATION (10 m
- ELEVATION CONTOUR (10 m INTERVAL)
- WATERBODY
- WOODED
- INTAKE OR DISCHARGE PIPE
- CONTACT WATER CONTAINMENT
- PROJECT
- SITE ROAD
- TOPSOIL STORAGE
- WATER MANAGEMENT
- LAKE TROUT EGGS
- LAKE WHITEFISH EGGS
- NORTHERN PIKE EGGS
- WALLEYE EGGS
- EFFLUENT TREATED PIPE
- FRESH WATER INTAKE
- SEWAGE TREATED PIPE
- EFFLUENT TREATED PIPE
- FRESH WATER INTAKE PIPE
- SEWAGE TREATED
- GRAVEL/COBBLE/BOULDER
- SAND/GRAVEL SUBSTRATE
- MODERATE TO MOST SUSTAINABLE SPAWNING HABITAT LAKE WHITEFISH, LAKE TROUT AND
- 30m RIPARIAN BUFFER

0 0.3 0.6
1:10,000 KILOMETRES

NOTE(S)

HS = Habitat Section

Information on fish habitat conditions and egg search results were summarized from field data collected by Canada North Environmental Services (CanNorth 2021). Habitat sections were delineated based on physical habitat characteristics, as described in Section 2.8.2.4 of CanNorth 2021. Spawning habitat suitability ratings were defined for each habitat section based on known spawning habitat characteristics that have been described in literature, and where available, habitat suitability models developed for the species. Section 2.8.2.4 of CanNorth 2021 provides detailed information regarding assumptions used to used to develop the habitat suitability ratings, along with a list of references considered.

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.
3. BATHYMETRY CONTOURS DERIVED FROM DATA COLLECTED BY NEXGEN, 2016.

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

CONCEPTUAL LOCATIONS OF IN-WATER DEVELOPMENTS IN PATTERSON LAKE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	LJ	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	KM	2023-02-08	FIGURE 11.4-1	
REVIEW	KM	2023-02-08		

F-13: Project activities affecting water and sediment quality and aquatic health:

- Project activities and discharge (e.g., treated effluent and treated sewage discharge, runoff from the Project footprint, air and dust emissions, and runoff and seepage from the WRSAs) may cause changes to water and sediment quality during Construction, Operations, and Closure and adversely affect fish habitat availability, survival, and reproduction.

Effects on fish and lower trophic organisms, including phytoplankton, zooplankton, and benthic invertebrates, could potentially occur due to changes in water and sediment quality during the proposed 43-year period from initial Project Construction to the end of Closure. Sources of constituents to the aquatic receiving environment during Construction, Operations, and Closure of the Project include releases from the ETP and STP, runoff from the Project footprint, Project-related air and dust emissions, and seepage and runoff from the WRSAs. Changes to water and sediment quality can alter fish health and the suitability of fish habitat in affected waterbodies and watercourses, which could adversely affect the survival and reproduction of fish VC populations in the RSA or LSA.

The protection of water from Project effects is extremely important to Indigenous Groups and LPA communities (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; BNDN-JWG 2019, BRDN-JWG 2019a; MN-S-JWG 2019b; NexGen 2019). Indigenous Groups have expressed concerns regarding potential effects on water quality, and have indicated that they are already experiencing the adverse effects to water quality from industrial developments, including mineral exploration activities and the Cluff Lake Mine, which they believe has impacted the health of the land and resources (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; BNDN-JWG 2019; BRDN-JWG 2020; BRDN-JWG 2021a; BRDN-JWG 2021b; CRDN-JWG 2020; CRDN-JWG 2021; MN-S-JWG 2019a; MN-S-JWG 2019b).

During engagement for the Project, Indigenous Groups expressed concerns that Project activities and discharge could pollute Patterson Lake, and by extension, the Clearwater River watershed (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN). Patterson Lake is considered by Indigenous Groups to be an integral part of the Clearwater River system (TSD III: BRDN; TSD IV: MN-S; TSD V.2: CRDN), which has its headwaters to the north of the Project (Section 11.3.1, Fish Habitat). The CRDN raised concerns about contaminants entering the food chain within the Clearwater River watershed and adversely affecting fish health (TSD V.1: CRDN; TSD V.2: CRDN; CRDN-JWG 2020; CRDN-JWG 2021). Similar concerns were raised by the BNDN, BRDN, and MN-S related to the effects of water contamination from Project activities to fish populations and health, and in turn to human health (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; BNDN-JWG 2021a; BRDN-JWG 2019b; BRDN-JWG 2020; BRDN-JWG 2021b). Trappers from the 2021 trappers workshop and LPA community members also are concerned about the potential Project effects on water quality and fish in the area of the Project (NexGen 2019).

Potential Project effects on fish habitat availability, survival, and reproduction from changes in surface water quality are assessed below and incorporate the results from the EcoRA completed for the Project (TSD XXI). Potential Project effects on human health are assessed in the human health assessment (Section 15).

The release of constituents of toxicological concern (e.g., metals, radionuclides) to the aquatic receiving environment has the potential to affect the health of fish and lower trophic organisms if the constituent concentrations are at high enough levels to cause toxicological effects (e.g., effects on growth and survival). For fish and lower trophic organisms, contact with water and contaminant uptake from water as a result of feeding on other aquatic organisms represent the main paths of exposure to COPCs in the environment. Direct contact or uptake from sediment is also relevant for benthic invertebrates and bottom-feeding fish such as lake whitefish.

The YNLRO communicated the importance of mitigating and monitoring the potential effects of Project activities and discharge on the Patterson Lake receiving environment (YNLRO 2019). Environmental protection and monitoring plans developed for the Project (e.g., Environmental Protection Program, Environmental Monitoring Plan), which include adaptive management, are expected to reduce the loading of COPCs to the surface water environment and the potential for associated effects on water quality and the health of fish and lower trophic organisms. Biological monitoring of the aquatic receiving environment would occur as a component of the Environmental Monitoring Plan and in accordance with federal and provincial requirements to monitor and manage the potential effects of Project discharges on water and sediment quality and on the fish population and benthic invertebrate community in the vicinity of the Project (Section 11.7).

Design features and mitigation have been incorporated into the Project to reduce potential effects from proposed Project activities that can alter surface water quality (Section 5, Project Description). Non-contact water generated from undisturbed catchments adjacent to the Project footprint would be diverted around the area to reduce the total volume of contact water generated by the Project. Contact water would be collected, stored, and treated as necessary prior to release to the environment. The rate of discharge from the ETP would be managed by having adequate surface water storage capacity to allow for controlled release rates, as required. The YNLRO specifically noted the importance of properly treating and closely monitoring effluent prior to releasing it to the environment (YNLRO 2019). Regulated monitoring of treated discharges from the effluent and sewage treatment plants would be conducted to confirm water quality objectives are met for discharge, including adherence to the limits defined as per Schedule 4 of the MDMER. Potential seepages from the PAG WRSA would be limited during Operations through the use of a liner under the storage area and minimized after Closure by an engineered cover.

An evaluation of Project-related effects on surface water and sediment quality and resulting effects on aquatic health in the receiving environment is presented in the surface water quality assessment (Section 10) and in the EcoRA component of the ERA completed for the Project (TSD XXI). A summary of the results of these assessments and potential for resulting effects on fish VCs is provided below.

Predicted Changes to Surface Water Quality

Potential changes to surface water quality in the receiving environment were predicted via the development of a regional surface water quality model (RSWQM; Section 10.2.8.1.3) used to assess the expected magnitude, extent, and duration of Project effects in waterbodies along the Clearwater River mainstem (i.e., Broach Lake, Lake G, Lake H, Patterson Lake, Forrest Lake, Beet Lake, and Naomi Lake). A description of the source term inputs and COPCs considered in the RSWQM is provided in Section 10.2.8. Constituents of potential concern included metals and radionuclides. In addition to assessing potential Project effects, the RSWQM considered a sensitivity scenario that was representative of reasonable upper bound conditions (Section 10.2.8.1.3). This reasonable upper bound scenario was completed to provide a precautionary, more conservative bound in the surface water quality assessment.

Based on the RSWQM, the concentrations of metals and radionuclides defined as COPCs in the surface water quality assessment (Section 10.2.8) were predicted to increase relative to Base Case concentrations (i.e., existing conditions, as defined in Section 10.2.8) during the 43-year period that includes Construction, Operations, and Closure. The concentrations of metals and radionuclides were predicted to begin increasing in Patterson Lake once active discharge commences and were typically expected to reach peak concentrations at the end of Operations. Increases in the concentrations of COPCs were predicted in all downstream waterbodies in the LSA but would attenuate with increased distance downstream from Patterson Lake. The increase in COPC concentrations during the proposed Project lifespan would primarily be the result of the active ETP and STP discharges to Patterson Lake during Operations. The concentrations of radionuclides and certain metals were predicted to subsequently decrease following the cessation of Project discharges at Closure. A limited number of metal COPC concentrations were predicted to continue to increase after Closure due to delayed onset of acid generation and groundwater migration from the UGTMF; effects on fish VCs from these predicted increases after Closure and in the far future are assessed in Section 11.5.

Despite COPC metal and radionuclide concentrations increasing in the receiving environment, concentrations during the 43-year period from initial Project Construction to the end of Closure were predicted to remain below Project-specific water quality threshold values in both the Application Case and the reasonable upper bound scenario. Water quality threshold values defined for the Project are described in the surface water quality assessment (Section 10.2.8.2.1) and are based primarily on the Canadian Environmental Quality Guidelines for the Protection of Aquatic Life summary table (CCME 2021) and Saskatchewan's provincial water quality objectives (WSA 2015). These guidelines are intended to provide protection to fresh water life from anthropogenic (i.e., human-caused) stressors such as chemical inputs. These guidelines are based on current, scientifically defensible toxicological data and are meant to protect all forms of aquatic life and all aspects of aquatic life cycles, including the most sensitive life stage of the most sensitive species over the long term.

Estimated Health Risks to Aquatic Life

The EcoRA component of the ERA completed for the Project provides an evaluation of the estimated ecological health risks to aquatic receptors potentially affected by the proposed Project. Ecological health risks resulting from changes in surface water quality were examined for aquatic species or receptors, including phytoplankton, zooplankton, benthic invertebrates, northern pike, and lake whitefish. The environmental pathways model, IMPACT, was used to predict concentrations of COPCs identified for the EcoRA in environmental media and potential risks to ecological receptors (TSD XXI, Appendix A, IMPACT Model Report). Based on the screening process undertaken for the EcoRA (TSD XXI, Section 4.2.3, Screening for Constituents of Potential Concern in Aquatic Environment), chloride, sulphate, arsenic, cobalt, copper, uranium, and the radionuclides, uranium-238, uranium-234, thorium-230, radium-226, lead-210, and polonium-210 were selected as COPCs for further assessment within the EcoRA. Constituents selected as COPCs in the EcoRA were predicted to exceed screening criteria in the treated mine effluent or at the edge of the mixing zone, or they are constituents of interest from other uranium mining and milling operations. The above-described radionuclides were carried forward as COPCs for further assessment in the ERA due to public and regulatory interest in these constituents (TSD XXI, Section 4.1, Model Integration).

The EcoRA also included an evaluation of ecological health risks related to changes in sediment quality. Based on the EcoRA screening process, no COPCs in sediment were identified for further evaluation of potential risks for ecological health, and thus toxicity via direct contact with sediment was not considered further.

Exposures of aquatic organisms to radionuclide and non-radionuclide COPCs in surface waters were predicted and assessed. A radiation dose benchmark of 9.6 milligrays per day (mGy/d) was selected for the assessment of effects on aquatic biota, as recommended in the CSA N288.6-22 standard (UNSCEAR 2008; CSA Group 2022). For assessment of non-radiological COPCs, a toxicity reference value (TRV) is used. A TRV is a toxicological index associating specific effects with a level of exposure to a chemical. The ecological risk to aquatic organisms was then estimated by calculating a hazard quotient (HQ) that provides a quantitative estimate of overall risk to a receptor. The HQ was calculated as the ratio between an exposure (i.e., dose) estimate and TRV. An HQ of less than or equal to 1 suggests low risk to the ecological receptor because exposure estimates do not exceed levels known to cause adverse effects. If the HQ is greater than 1, adverse effects may be possible, and further assessment would be warranted.

The results of the EcoRA indicate that there are no exceedances of the 9.6 mGy/d radiation dose benchmark for aquatic biota in the LSA or RSA for the 43-year period that includes Construction, Operations, and Closure, for both Project effects in the Application Case and in the reasonable upper bound scenario. Similarly, HQs for all non-radiological COPCs (i.e., chloride, sulphate, arsenic, cobalt, copper, uranium) for aquatic receptors are less than 1 during all Project phases.

Effects on Lower Trophic Organisms and Fish Populations

Although the concentrations of COPCs are predicted to increase in waterbodies and watercourses during the Project lifespan, these changes are not expected to result in adverse effects on the health of fish and lower trophic organisms. As all HQs derived for aquatic receptors considered in the EcoRA were less than 1, and predicted radiological doses were well below the benchmark (i.e., 9.6 mGy/d), toxicological effects on aquatic populations or communities are not expected because exposure estimates to COPCs in water and sediment are below levels known to cause adverse effects. Additionally, concentrations of COPCs in the receiving environment (i.e., Patterson Lake outside of the RMZs for the ETP and STP, and in downstream waterbodies) are predicted to remain below water quality thresholds defined for the proposed Project to provide protection for aquatic life in the receiving environment. Therefore, effects on the survival and reproduction of fish VCs are not expected as a result of the predicted changes to water and sediment quality during Construction, Operations, and Closure.

Summary

Based on the results of the surface water quality assessment and EcoRA completed for the proposed Project, predicted COPC concentrations in the aquatic receiving environment would remain below water quality thresholds, and the estimated ecological health risks for radiological and non-radiological COPCs are less than respective screening values for all aquatic receptors assessed. Therefore, this pathway is expected to have negligible effects on fish habitat quality and the health, survival, and reproduction of fish VCs (i.e., lake trout, lake whitefish, walleye, and northern pike) and was not carried forward for further assessment.

F-14: Nutrient changes from Project activities:

- Project activities and discharge (e.g., treated effluent and treated sewage discharge, runoff from the Project footprint, and air and dust emissions) may change nutrient concentrations in the aquatic receiving environment and affect fish habitat availability, survival, and reproduction during Construction, Operations, and Closure.

The release of treated effluent and treated sewage from the ETP and STP, respectively, is anticipated to result in an increase in nutrient concentrations (e.g., nitrogen, phosphorus) in the receiving environment during the 43-year period from initial Construction to the end of Closure (Section 10.5.1.2.2). An increase in nutrient concentrations in Patterson Lake and downstream waterbodies may cause an increase in phytoplankton, which could alter the transfer of food energy through the aquatic food web and affect the food base for fish, ultimately resulting in changes to fish habitat quality and the survival and reproduction of fish VCs in the LSA and RSA.

Food webs represent feeding relationships within a community (Smith and Smith 2009) and the transfer of food energy up the food chain from its source in plants to herbivores, omnivores, and carnivores (Krebs 2009). In a simplified aquatic food web, energy and nutrients move from the phytoplankton at the bottom of the food chain to the zooplankton consuming them and then to carnivores or omnivores, which can include fish and certain zooplankton or benthic invertebrate taxa. The position of organisms in the food web is represented by trophic level. Phytoplankton are referred to as primary producers, or autotrophs, meaning they obtain nutrients and energy through photosynthesis. Zooplankton and benthic invertebrates that feed on phytoplankton are referred to as primary consumers. Secondary and tertiary consumers are represented by the omnivores and carnivores in the system (i.e., certain zooplankton or benthic invertebrate taxa, and fish) that feed on primary and secondary consumers.

Energy flow through the aquatic food web is strongly influenced by the concentration of nutrients such as nitrogen or phosphorus in the water (Wetzel 2001). Nutrients are essential for phytoplankton growth and therefore, the loading of nutrients to a waterbody can result in an increase in phytoplankton or what is referred to as primary productivity (Krebs 2009; Elser et al. 1990). This increase can result in an increase in food availability for consumer organisms such as zooplankton, benthic invertebrates, and fish (Carpenter et al. 1985). The assimilation and expenditure of energy by consumer organisms is referred to as secondary productivity. Productivity is often measured in terms of energy flow between trophic levels or biomass, a term used to refer to the weight of living organisms in an area (Krebs 2009). Changes in biomass can occur as a result of altered growth rates or reproductive output by individuals and populations.

During engagement for the Project, Indigenous Groups expressed concern that Project activities, including discharge, could result in pollution of Patterson Lake and the lakes and waterways to the south of the Project (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; BRDN-JWG 2020). Indigenous Groups commented on the clarity of the water in Patterson Lake and potential for changes (TSD II BNDN; TSD V.1: CRDN; McQueen et al. 1990). For example, the BNDN noted:

> Well, if it’s not as clear as it was back then . . . [there’s] probably [something] wrong. Because all these lakes here are just crystal-clear water . . . . If you start seeing algae and all that and just – something’s not right because these are all rock and sand lakes – sand bottom, rock. (TSD II: BNDN)

Water clarity can decrease with increased phytoplankton biomass resulting from nutrient increases. The clarity is typical of the oligotrophic lakes in the RSA. Lower clarity can be indicative of more productive lakes but may also be indicative of anthropogenic sources of nutrients.

The Environmental Protection Program and Environmental Monitoring Plan developed for the Project would reduce the load of COPCs, including nutrients such as phosphorus, to the surface water environment and the potential for corresponding effects on the productivity of aquatic organisms. Biological monitoring of the aquatic receiving environment would consider the potential for nutrient enrichment effects on fish and lower trophic organisms (Section 11.7). Effluent characterization for the ETP would include monitoring of phosphorus, as required under the MDMER. The Project design features and mitigations described in the preceding effect pathway (F-13) are also relevant to the management of phosphorus in the receiving environment and would be effective in reducing effects from nutrient loading to the surface water environment.

Effects on aquatic habitat and fish VCs from changes in nutrient concentrations were evaluated using quantitative and qualitative methods. The assessment included consideration of the results of the surface water quality assessment, which presents predictions for nutrient concentrations in the receiving environment during Project phases, review of scientific literature on the effects of nutrient enrichment, and trophic classification of aquatic ecosystems based on nutrient concentrations (CCME 2004). Trophic status is an accepted and widely used means of classifying waterbodies and describing waterbody processes based on the amount of biological productivity they sustain (Wetzel 2001; additional information about lake trophic status is provided in Section 11.2.6.1, Sampling Locations and Activities).

An evaluation of Project-related effects on nutrient concentrations in the receiving environment is presented in the surface water quality assessment (Section 10). A summary of these results and potential for corresponding effects on fish VCs is provided below.

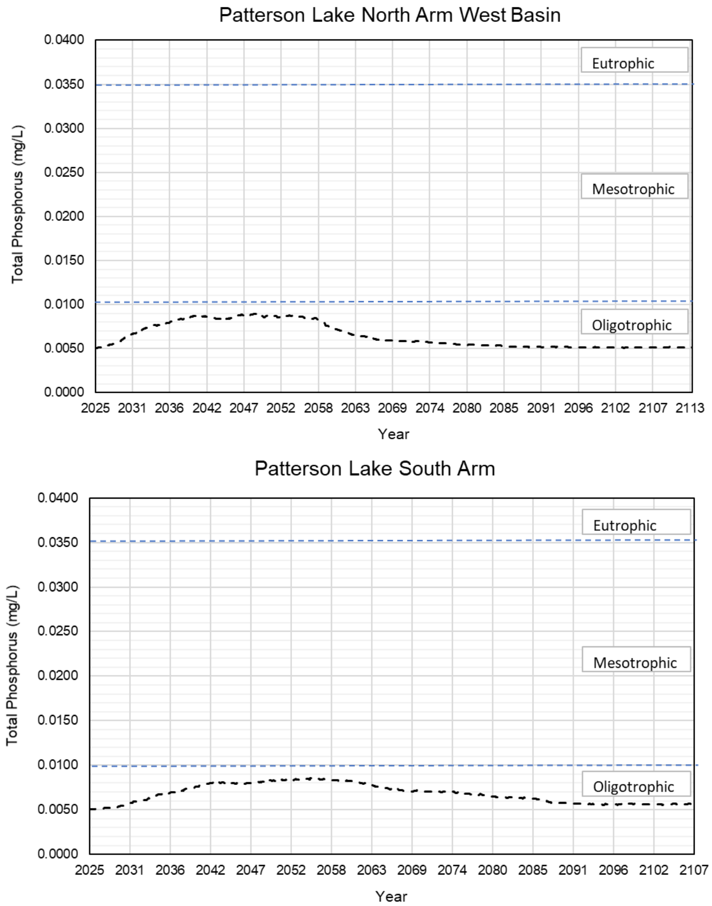
Predicted Total Phosphorus Concentrations

Water quality modelling was used to simulate nutrient concentrations in the receiving environment during Project phases. A summary of the approach used in the surface water quality assessment to model constituent concentrations in the receiving environment via development of a RSWQM (Section 10.2.8) is provided in the assessment of the preceding pathway (F-13). Nutrients defined as COPCs in the RSWQM included ammonia, nitrate, and TP. Patterson Lake is a phosphorus-limited waterbody (Annex V.1; Section 11.3.2), meaning that ecosystem productivity is limited by the amount of phosphorus present in the system compared to other nutrients such as nitrogen; therefore, the analysis of effects from changes in nutrient concentrations was based on predicted TP concentrations.

Based on the RSWQM results, concentrations of TP are predicted to increase relative to Base Case concentrations during the 43-year Project lifespan. The increase in TP begins during Construction when discharge of treated sewage effluent to Patterson Lake North Arm – West Basin commences. Increases in TP concentrations relative to baseline conditions (Table 11.3-1) are predicted in all downstream waterbodies in the LSA with concentrations attenuating with distance downstream from Patterson Lake. Peak concentrations of 0.009 mg/L are predicted in Patterson Lake North Arm – West Basin at the end of Operations (Section 10.5.1.2.2). Concentrations subsequently decrease following the cessation of Project discharges, with steady state conditions, non-distinguishable from Base Case conditions, occurring after Closure (Figure 11.4-2). The magnitude of the predicted increases in TP concentrations are greater in the reasonable upper bound scenario, with peak concentrations of 0.014 mg/L modelled in Patterson Lake North Arm – West Basin by the end of Operations.

The increase in TP during the Project lifespan is primarily the result of the active ETP and STP discharges to Patterson Lake, with treated sewage and effluent discharge from the ETP being the primary source of phosphorus.

Figure 11.4-2: Predicted Phosphorus Concentrations in Patterson Lake in the Application Case



Note: Blue dashed lines represent divisions between lake trophic status based on the CCME (2004) classification system. Based on this system, waterbodies can be classified as oligotrophic, mesotrophic, or eutrophic based on low (i.e., <0.01 mg/L), moderate (i.e., 0.01 mg/L to 0.035 mg/L), and high (i.e., >0.35 mg/L) concentrations of TP, respectively; black dashed line represents predicted TP concentration for the Project.
TP = total phosphorus; <= less than; >= greater than; CCME = Canadian Council of Ministers of the Environment.

Effects on Lake Trophic Status

The trophic status of Patterson Lake and waterbodies downstream in the LSA was evaluated based on existing and predicted concentrations of TP using the CCME (2004) classification system described in Section 11.2.6. Based on this system, waterbodies can be classified as oligotrophic, mesotrophic, or eutrophic based on low (i.e., less than 0.01 mg/L), moderate (i.e., 0.01 mg/L to 0.035 mg/L), and high (i.e., more than 0.35 mg/L) concentrations of TP, respectively (Section 11.2.6). The overall trophic classification of the LSA waterbodies was based on the maximum predicted concentration of TP during the 43-year Project lifespan to provide a conservative estimate of potential Project effects.

The results of the surface water quality baseline study (Annex V.1; Attachment 10A-1; Section 11.3.2) indicate that waterbodies in the LSA would generally be classified as oligotrophic (i.e., characterized by low productivity due to low nutrient concentrations; Section 11.2.6.1; Table 11.4-2). Baseline concentrations of TP during the open-water period were consistently measured at or below the analytical detection limit (DL) of 0.01 mg/L in the LSA waterbodies included in the RSWQM. The exception was Lake G, which is a small, shallow waterbody that discharges through a tributary stream into Patterson Lake North Arm – East Basin and was classified as mesotrophic based on measured TP concentrations ranging between 0.01 mg/L and 0.02 mg/L.

Throughout the proposed 43-year Project lifespan, Patterson Lake and downstream waterbodies are predicted to remain oligotrophic based on modelled concentrations of TP (Section 10; Table 11.4-2). Lake G would remain within the mesotrophic range. Model predictions, therefore, demonstrate that there would be no change in trophic status as a result of Project-related nutrient releases (Table 11.4-2). Under the most conservative conditions defined by the reasonable upper bound scenario, Patterson Lake North Arm – West Basin downstream to Forrest Lake – North Basin shifts trophic state from oligotrophic to mesotrophic towards the end of Operations but returns to oligotrophic status after Project discharges cease during Closure (Section 10.5.3.1.2). The likelihood that reasonable upper bound scenario conditions would be realized is low given the high level of conservatism considered in the modelling assumptions for this scenario (Section 10.2.8). For example, the uptake of additional bioavailable phosphorus, which would be immediate in a phosphorus-limited system, was assumed not to occur in the mass balance model. The model calculated TP concentrations as if they would accumulate additively, so the predicted concentrations presented here are likely overestimates of change.

Table 11.4-2: Modelled Concentrations of Total Phosphorus and Predicted Trophic Classification by Waterbody during Rook I Project Operations

Waterbodies	RSWQM Predictions – Operations			
	TP (mg/L)			Trophic Status
	Min.	Mean	Max.	
Broach Lake	0.005	0.005	0.005	Oligotrophic
Patterson Lake – North Arm West Basin	0.005	0.006	0.006	Oligotrophic
Patterson Lake – North Arm East Basin	0.005	0.008	0.009	Oligotrophic
Patterson Lake South Arm	0.005	0.007	0.009	Oligotrophic
Lake H	0.005	0.006	0.007	Oligotrophic
Lake G	0.010	0.012	0.013	Mesotrophic
Forrest Lake – North Basin	0.003	0.006	0.007	Oligotrophic
Forrest Lake – South Basin	0.005	0.005	0.005	Oligotrophic
Beet Lake	0.005	0.006	0.007	Oligotrophic
Naomi Lake	0.005	0.006	0.007	Oligotrophic

RSWQM = regional surface water quality model; TP = total phosphorus.

Effects on Lake Ecosystem Productivity

Phosphorus is generally the limiting nutrient for primary production in most Canadian Shield lakes (Schindler 1974; Elser et al. 1990; Power 1992; Dillon et al. 2004) because of its scarcity in bedrock and overburden in Canadian Shield watersheds and efficient retention by upland forests and wetlands (Allan et al. 1993; Devito et al. 1989 cited in Steedman et al. 2004). Therefore, loading of phosphorus to the surface water environment can result in effects on lake ecosystem productivity, wherein an increase in primary production may propagate up the food web and affect the productivity of secondary consumers, which include lower trophic organisms (i.e., phytoplankton, zooplankton, and benthic invertebrates) and fish (Power 1992; Dillon et. al. 2004).

In contrast to constituents that can elicit a toxicological response (e.g., metals) at a certain concentration, there is no given threshold or concentration of nutrients at which a nutrient enrichment response can be expected. Theoretically, any input of nutrients to an oligotrophic waterbody could result in some response, such as an increase in phytoplankton biomass. For example, nutrient-enhanced growth of phytoplankton can increase biomass available for zooplankton to feed upon, which in turn may increase food availability for fish species and invertebrate life stages that feed on zooplankton.

As outlined above, baseline concentrations of TP in most LSA waterbodies were consistently reported at or below the analytical DL of 0.01 mg/L (Table 11.4-2). Notably, the analytical DL used for TP during the baseline monitoring is also the trophic boundary between oligotrophic and mesotrophic conditions (0.01 mg/L; Section 11.2.6.1; Table 11.4-2). A reasonable approximation of baseline conditions can be estimated by multiplying the analytical DL by 0.5 (i.e., estimated baseline TP concentration of 0.005 mg/L). Replacement of non-detectable values with half the analytical DL is a widely used method of dealing with non-detectable data in water quality datasets (USEPA 2002). Based on the maximum predicted TP concentration generated by the RSWQM (i.e., 0.009 mg/L during Operations; Table 11.4-2) and assumed baseline concentration of approximately 0.005 mg/L, a maximum TP concentration increase of less than or equal to approximately 0.005 mg/L could be expected by the end of Operations when peak effects are expected.

Effects on Lower Trophic Organisms

With an increase in TP concentration of approximately 0.005 mg/L in Operations, it is expected that there may be a corresponding increase in primary productivity. In phosphorus-limited systems, such as Patterson Lake, phytoplankton communities can readily respond to even small increases in available phosphorus with increases in algal biomass; however, large shifts in community composition or excessive nuisance algal growth would not be expected at the predicted magnitude of effect (Wetzel 2001). The predicted magnitude of increase in phytoplankton biomass in Patterson Lake may be measurable in phytoplankton community metrics, but effects would be localized and are unlikely to be detectable in downstream waterbodies due to attenuation of TP concentrations with increasing distance downstream (Table 11.4-2). Additionally, available phosphorus inputs from the discharge into Patterson Lake would be readily captured and used by phytoplankton within Patterson Lake. The numerical predictions presented above for TP concentrations conservatively omit this process.

An increase in phytoplankton biomass may result in changes to energy flow up the food web, potentially resulting in an increase in secondary production in the zooplankton and benthic invertebrate communities. Studies have shown that nutrient enrichment can result in an increase in biomass of zooplankton and benthic invertebrates (LeBrasseur et al. 1978; Rasmussen and Kalff 1987; Welch et al. 1988; Hershey 1992; Jorgenson et al. 1992; Clarke et al. 1997). Conversely, other studies have reported no effects on biomass (Dinsmore 1999; Bergström et al. 2021). Proportional increases in zooplankton and benthic invertebrate biomass would be expected to be lower than that of phytoplankton because the energy transfer between trophic levels is inefficient (McCauley and Kalff 1981; Kalff 2002). Only about 10% of available energy is transferred between trophic levels (i.e., up the food chain) due to factors such as incomplete ingestion of food, energy used for respiration, and energy lost as waste (Krebs 2009). Given the low predicted magnitude of effect for TP concentrations in the receiving environment and that energy transfer between trophic levels is inefficient, increases in zooplankton and benthic invertebrate biomass would likely be within range of baseline values. If increases do occur, the responses would be negligible and spatially and temporally limited to the area and timeframe associated with peak effects (i.e., Patterson Lake North Arm – West Basin during late Operations from approximately 2040 to 2055). Similarly, measurable changes to zooplankton and benthic invertebrate community composition are unlikely at the anticipated level of effect. Overall, conditions are predicted to remain within the bounds of a healthy oligotrophic ecosystem.

Effects on Fish Populations

Studies have shown that nutrients, and in particular TP, can affect the rate of fish production in waterbodies (Morgan 1966; Colby et al. 1972; McQueen et al 1986; Plante and Downing 1993; Johnston et al. 1999). Potential effects of phosphorus loading on the productivity of fish populations can include changes in growth and reproduction rates, body size (i.e., length, weight, or condition factor that is a measure of the "fatness" of a fish), or abundance (Hyatt and Stockner 1985; Johnston et al. 1990).

Because Patterson Lake and downstream waterbodies are predicted to remain oligotrophic during the 43-year Project lifespan, and because oligotrophic waterbodies are characterized by low nutrient concentrations, low primary productivity, and depressed secondary production (Wetzel 2001), it is unlikely that there would be meaningful changes to the food base for fish, particularly for upper trophic level consumers such as lake trout, walleye, and northern pike. Predicted TP concentrations during the Project lifespan are expected to result in at most, negligible and non-measurable increases in the productivity of fish prey items, including zooplankton and benthic invertebrates. However, an increase in the productivity of forage fish species (e.g., lake whitefish) or life stages that feed primarily on lower trophic organisms (e.g., juvenile lake trout, walleye, and northern pike) is not expected as the energy transfer between trophic levels is inefficient. Similarly, no change in the productivity of upper trophic level consumers that are primarily piscivorous (e.g., adult lake trout, walleye, northern pike) is expected. Additionally, based on the surface water quality modelling results for TP, any increase in the food base that may occur would be largely restricted to Patterson Lake North Arm – West Basin, where peak TP concentrations are predicted to occur. While fish VCs may take advantage of the increased food base in that portion of the waterbody, Patterson Lake is a large waterbody and it is unlikely that the fish population would be meaningfully altered by the predicted small magnitude increases in primary productivity in a single basin of the lake.

Summary

Through the described mitigation, the loading of phosphorus from Project activities and discharge to Patterson Lake is predicted to result in a minimal increase in TP concentration in the aquatic receiving environment with no changes to lake trophic status expected for any of the waterbodies assessed. An increase in TP concentrations may result in minor changes to primary productivity and in potentially negligible and non-measurable effects on the productivity of lower trophic level consumers (e.g., zooplankton and benthic invertebrates). Effects on the productivity of fish, particularly piscivorous, upper trophic level consumers, are not expected. Therefore, this pathway is expected to have negligible effects on fish habitat quality and, survival and reproduction of fish VCs, and was not carried forward for further assessment.

F-07: Air and dust emissions affecting water quality:

- Air and dust emissions, including emissions of criteria air contaminants and fugitive dust, and subsequent deposition (e.g., particulate matter, metals, and radionuclides) may cause changes to surface water quality, which may adversely affect fish habitat availability, survival, and reproduction in local waterbodies and watercourses.

Air and dust emissions from the proposed Project, and the subsequent deposition of constituents (i.e., total suspended particulate [TSP], metals, and radionuclides) can change surface water quality, thereby affecting fish habitat quality and the health of fish and lower trophic organisms. Air and dust emissions that may affect surface water quality include criteria air contaminant emissions and fugitive dust emissions. Criteria air contaminants emissions include particulate matter in two categories (2.5 µm or less in diameter [$PM_{2.5}$] and 10 µm or less in diameter [PM_{10}]), TSP, sulphuric acid, sulphur dioxide, and nitrogen dioxides (Section 7), and would be released from the combustion of fossil fuels in large equipment, aircraft, trucks, vehicles, and power generation, as well as through the burning of non-hazardous waste materials. A detailed summary of Project emissions by source category is provided in Appendix 7A (Air Dispersion Modelling Report). Sources of fugitive dust include activities such as land clearing, site preparation, facility construction, site traffic, waste rock handling during Construction and Operations, and infrastructure removal during the Active Closure Stage (Appendix 7A). Particulate matter and dust from Project-related emissions may be deposited onto waterbodies and watercourses, which could change in-water pH and concentrations of TSS, metals, and radionuclides and adversely affect fish habitat availability, and the survival and reproduction of fish VCs.

Indigenous Groups are concerned about the potential effects of Project related air and dust emissions on the quality of water (TSD II: BNDN; TSD IV: MN-S). For example, MN-S members noted concerns of environmental heath risks from windblown dust dispersal and airborne contamination of water (TSD IV: MN-S). Specific concerns were expressed by Indigenous Groups related to the adverse effects of uranium dust on the environment, which is believed to travel hundreds of kilometres with the wind and affect the air, water, and vegetation (TSD II: BNDN; TSD IV: MN-S; MN-S-JWG 2019b).

The surface water quality assessment utilized a sensitivity scenario within the RSWQM to evaluate the effects of Project atmospheric deposition on waterbodies in the LSA during Construction, Operations, and Closure (Section 10). Results from the air quality dispersion model were used as inputs for the sensitivity scenario in the RSWQM and included estimates of aerial deposition of particulate matter (i.e., particulate matter less than 2.5 µm in diameter, particulate matter less than 10 µm in diameter, and TSP), dust, metals, and radionuclides to surface waters. In-water concentrations of metals and radionuclides were estimated from the aerial deposition modelling results.

The effects of atmospheric deposition were assessed for four waterbodies located in the LSA that are not directly connected to the Clearwater River: Lake C; Lake E; Unnamed Lake 1; and Unnamed Lake 2 (Figure 11.2-2). As these waterbodies are not located along the Clearwater River flow path, their water chemistry would not be affected by other Project-related mass inputs or contributions (e.g., treated effluent discharge). Therefore, these waterbodies can be used to evaluate potential air deposition effects in isolation of effects from other Project-related sources.

Results from the atmospheric deposition assessment indicated that effects from aerial deposition would result in minor, localized changes to COPC concentrations in Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2. The magnitude of effects was greatest in Unnamed Lake 2, which is attributed to the predominant downwind location of this lake relative to the proposed Project site. The COPCs with the greatest concentration increase relative to the Base Case were mercury, certain radionuclides (i.e., polonium-210, radium-226, thorium-230), and uranium. However, none of the COPCs evaluated were predicted to exceed water quality threshold values (Section 10). Therefore, toxicological effects on fish and lower trophic organisms are not expected to occur as a result of Project-related air emissions and dust deposition. Consequently, no change to the survival and reproduction of fish VCs is expected from Project-related air emissions and dust deposition.

The surface water quality assessment (Section 10) also quantitatively evaluated the potential Project-related changes in TSS resulting from fugitive dust deposition from the Project. A desktop analysis was performed to estimate the average annual increase in TSS in waterbodies due to the aerial deposition of TSP emitted from the Project (Appendix 10A). The air quality dispersion model results for Construction and Operations were used to estimate the total annual air deposition of TSP into each waterbody based on surface area. The predictions for Construction and Operation were used as these Project phases represented peak effects. The predicted increase in TSS concentration in Lake C, Lake E, Unnamed Lake 1, and Unnamed Lake 2 was less than 0.1 mg/L. This increase is well within the natural variability of TSS concentrations in LSA waterbodies (Section 10) and would not be measurable. Consequently, effects from dust deposition on fish habitat availability are predicted to be negligible.

Effects on water pH are not expected to occur in LSA waterbodies and watercourses as the potential for contribution by Project air emissions to acid deposition was determined by the air quality assessment to be below screening values used by ENV to determine if a facility's emissions would result in acid deposition levels that would warrant additional assessment (Appendix 7A, Section 7A2.1). Therefore, no measurable effects on surface water quality and fish habitat availability, survival, and reproduction are anticipated due to this potential effect mechanism.

Environmental protection and monitoring plans developed for the Project, which include adaptive management, are expected to limit the emissions of criteria air contaminants and fugitive dust and associated effects on surface water and fish habitat quality. Additionally, Project design features and mitigation have been incorporated into the Project to reduce potential effects from air emissions and dust deposition; these include the primary use of liquid natural gas for power generation, procurement criteria that require certain stationary and mobile equipment to meet applicable performance standards, use of emission control devices on combustion-based equipment and vehicles, and regular maintenance of equipment. Water and/or dust suppressants would be applied to the airstrip, site roads, and the existing access road as necessary. Speed limits would be enforced and are expected to reduce dust emissions from site roads. These measures would be developed in accordance with applicable provincial and federal environmental legal requirements and guidelines.

With implementation of best management practices and mitigation, effects on fish VC habitat quality from Project-related air emissions and dust deposition are expected to be localized and negligible in magnitude. No effects on the survival and reproduction of fish VCs are anticipated as a result of air emissions and dust deposition from the Project. Therefore, this pathway was classified as a secondary pathway and not carried forward for further assessment.

F-08: Loss or alteration of fish habitat:

- Physical loss or alteration of fish habitat in Patterson Lake from the Project footprint, including the fresh water intake, treated effluent diffuser, treated sewage outfall, may affect fish habitat availability.

The Project would require construction of water management infrastructure that would include components installed below the high water mark of Patterson Lake. Water management facilities that would have a physical footprint in Patterson Lake include a fresh water intake, treated effluent diffuser, treated sewage outfall, and associated pipelines. These structures would be located in Patterson Lake North Arm at the conceptual locations shown in Figure 11.4-1. The installation of these structures and their associated maintenance activities and removal (i.e., Construction, Operations, and Active Closure Stage) has the potential to adversely affect fish VC habitat availability in the LSA. These effects include the potential for loss or disturbance to riparian vegetation due to development of new site roads, shoreline infrastructure, and the physical footprints of the conveyance pipes for the fresh water intake, treated effluent diffuser, and treated sewage outfall.

Predicted effects on fish VCs were estimated for each component of the water management infrastructure with an in-water footprint based on available conceptual design information and review of baseline fish and fish habitat survey data for the shoreline of Patterson Lake in the vicinity of the proposed Project. Changes in available habitat area, including riparian zone habitat, were estimated in terms of the absolute (m^2) and relative

(%) values of lost or altered habitat. Absolute values were estimated based on the conceptual footprints of the developments (i.e., the fresh water intake, treated effluent diffuser, treated sewage outfall). Relative values were estimated based on the proportion of habitat lost relative to the surface area of Patterson Lake and its riparian zone. The surface area of Patterson Lake (38 km^2) was defined from the shoreline delineation using georeferenced satellite imagery. The evaluation of direct habitat loss also included consideration of fish habitats that are also wetlands, as assessed by the wetland ecosystems VC (refer to Figure 13.3-4 in Section 13.3.2.2 [Ecosystem Distribution]). Other wetland areas identified in Section 13.5.2 (Wetland Ecosystems) that may potentially be affected by the Project through direct loss or disturbance are not fish habitat (i.e., do not have open-water areas or surface connectivity with downstream fish habitats).

The riparian area for Patterson Lake was defined as all naturally vegetated areas within a 30 m buffer of the lake shoreline. The 30 m buffer zone criterion was assumed to represent a conservative approach for delineating a riparian zone width in terms of fish habitat and is consistent with scientific literature and recommendations outlined by Environment Canada (2013), as well as the approach taken for the vegetation component effects assessment (Section 13). Environment Canada guidelines recommend that water features be buffered by 30 m of naturally vegetated riparian areas on both sides (Environment Canada 2013). Within these buffers, vegetation communities function to maintain aquatic ecosystems by moderating temperature through shading, filtering sediments and nutrients, providing food through leaf litter / organic matter, and influencing the structure of watercourses and waterbodies through fallen woody material (Environment Canada 2013).

As part of the aquatic baseline program, CanNorth characterized the fish habitat conditions present along the Patterson Lake shoreline within the areas that would be affected by the proposed in-water developments (Annex V.1; Figure 11.4-1). This information was reviewed to understand potential changes to habitat quality and to identify potentially sensitive or unique habitats that may be affected by the in-water developments. Sensitive or unique habitats are areas that would be considered limiting or rare within Patterson Lake and therefore would be especially valuable to the sustainability of fish VC populations. Habitat sections were delineated based on physical characteristics, as described in Annex V.1 and summarized in Figure 11.4-1. The focus of the surveys was the shoreline area and littoral zone. Spawning habitat suitability ratings were defined for each habitat section based on known spawning habitat characteristics that have been described in literature, and where available, habitat suitability models that have been developed for the species. Annex V.1 provides detailed information regarding assumptions used to develop the habitat suitability ratings, along with a list of the references considered.

An evaluation of potential effects on fish VCs resulting from development of the fresh water intake, treated effluent diffuser, treated sewage outfall, and associated infrastructure in and immediately adjacent to Patterson Lake is provided below.

Fresh Water Intake

The Project would require a fresh water intake to meet process and potable water requirements. The fresh water intake would draw water from a single location in Patterson Lake at the conceptual location shown in Figure 11.4-1. Components of the conceptual system design that could affect fish habitat in Patterson Lake would include a fresh water intake pumphouse, intake pipe, and fresh water intake structure. Fresh water for the Project is water sourced directly from Patterson Lake that has been screened for sediment and organic materials at the intake location. A new site road would also be required to provide access to the lake shoreline. The fresh water intake pumphouse would be constructed adjacent to Patterson Lake and is estimated to consist of a 10 m by 20 m building (Figure 11.1-3). The intake pipe is assumed to consist of a 750 mm high density polyethylene

(HDPE) pipe, which would extend northeast from the fresh water intake pumphouse into Patterson Lake. The length of pipe installed in the lake would be approximately 740 m, with the remaining length (approximately 80 m) extending over land and intersecting the lake shoreline and riparian zone. The fresh water intake structure would consist of a stainless steel combined passive intake and fish screen affixed over an approximately 1.5 m by 12 m concrete pad installed on the lake bottom. The fresh water intake structure would be installed at a depth more than 3 m and less than 10 m. The intake components would be anchored to the lake bottom by the concrete pad and weights affixed along the pipe length.

Effort was made to site the in-water developments away from potentially sensitive fish habitats and to reduce associated riparian habitat loss. Three candidate locations for the fresh water intake were initially identified and evaluated in Patterson Lake North Arm – East Basin (Section 4.16.15, Fresh Water Supply – Location). The selected location (Figure 11.4-1) was chosen as the other candidate locations were too shallow when accounting for the estimated ice thickness (i.e., of 1.5 m) and intake structure clearance (i.e., 0.5 m) requirements. The fresh water intake pumphouse and the alignments for the intake pipe and new site road were routed through an existing disturbance area adjacent to Patterson Lake. Based on field surveys of the Patterson Lake shoreline area in the vicinity of the proposed fresh water intake site, the intake pipe would intersect a section of shoreline habitat that consists of approximately 50% boulder and 50% cobble substrates (Annex V.1). The habitat section intersected by the intake pipe was assessed as moderately suitable spawning habitat for lake whitefish and walleye, marginally suitable spawning habitat for lake trout, and not suitable for northern pike spawning (Annex V.1). The affected area may also provide nursery, rearing, and adult feeding habitat for VCs.

Based on the conceptual design criteria outlined above, the in-water footprint associated with the fresh water intake structure (i.e., pre-cast concrete pad of 1.5 m by 12 m) and HDPE conveyance pipe (i.e., 740 m by 750 mm diameter) is estimated to be 573 m^2, consisting of 18 m^2 for the concrete pad and 555 m^2 for the intake pipe. This proposed footprint area represents less than 0.002% of the total habitat area of Patterson Lake (i.e., 573 m^2 of the total Patterson Lake surface area of 38 km^2). Although the intake pipe would pass through an area identified as suitable spawning habitat for selected VCs, the fresh water intake structure and a portion of the conveyance pipe would be situated in deeper water (i.e., between 3 m and 10 m), which would be unsuitable as spawning habitat for the selected VCs based on the suitability ratings developed by CanNorth (Annex V.1). Lake whitefish and lake trout typically spawn in water less than 3 m deep (Annex V.1); therefore, the potential for interaction between the fresh water intake structure and spawning habitat and incubating eggs of these VCs is nil to low. Walleye typically spawn in water less than 1.5 m deep (Annex V.1); therefore, walleye spawning is unlikely to interact with the physical footprint of the fresh water intake infrastructure. Additionally, the habitat disturbed by the intake pipe and fresh water intake structure is not unique within Patterson Lake. Based on field surveys of Patterson Lake, 20 km of shoreline, representing 37% of the total Patterson Lake shoreline length of 54 km was assessed as being moderately to highly suitable spawning habitat for lake whitefish and lake trout; 21 km of shoreline, representing 37% of the total Patterson Lake shoreline length, was assessed as being moderately to highly suitable habitat for walleye spawning (Annex V.1). These results indicate that although some limited disturbance to habitats used for spawning and rearing may occur due to the physical footprint of the fresh water intake, when considered in the context of available habitat within Patterson Lake for fish VCs, meaningful effects on fish VCs are not expected to occur.

Based on review of georeferenced satellite imagery for the Patterson Lake shoreline area and 30 m riparian buffer overlaid with the footprint data, the new site road, intake pipe, and fresh water intake pumphouse can be constructed within an existing disturbance area. Therefore, no new disturbance within the 30 m riparian buffer would be required to construct and operate the fresh water intake system and new site road. Overall, the in-water and riparian habitat losses associated with the fresh water intake are small and would be expected to result in negligible and non-measurable effects on fish VCs.

Treated Effluent Diffuser

The Project would require treated effluent discharge infrastructure to be installed in Patterson Lake at the conceptual location shown in Figure 11.4-1. Infrastructure components that could affect fish habitat in Patterson Lake would include a pipeline and diffuser. A new site road would also be required to provide access to the lake shoreline. The discharge pipe would consist of a 400 mm HDPE pipe, which would extend from the outlet of the effluent monitoring ponds into Patterson Lake North Arm – West Basin (Figure 11.4-1). The pipeline would extend northwest approximately 750 m into the lake and discharge through a diffuser at a water depth of approximately 10 m. The discharge pipeline would intersect the lake shoreline and riparian zone along its alignment from the effluent monitoring ponds. The diffuser would consist of one vertical nozzle connected to the pipe, which would extend approximately 1 m above the lake bed and 0.65 m above the pipe. The diffuser would be affixed to a support structure (e.g., sled or pre-cast concrete pad; expected to be less than 5 m by 5 m in size) to provide stability for the submerged structure. The treated effluent diffuser components would be anchored to the lake bottom by weights affixed along the pipe length.

Six candidate locations for the diffuser were initially identified and evaluated in Patterson Lake – North Arm, including five options in the West Basin and one in the East Basin (Section 4.5-13, Treated Effluent Discharge Location). The selected location (Figure 11.4-1) was chosen because it was estimated to have favourable ambient currents for effluent mixing and because it avoided interaction with higher quality fish habitats that are present along the shoreline of Patterson Lake adjacent to the proposed Project (i.e., suitable spawning habitats for VCs; Figure 11.4-1). Based on field surveys of the Patterson Lake shoreline area in the vicinity of the proposed treated effluent diffuser site, the diffuser pipe would intersect a habitat section consisting of 95% sand and 5% organics (Annex V.1). The shoreline and nearshore area intersected by the diffuser pipe was assessed as not suitable spawning habitat for all four fish VCs. Based on the substrate and physical habitat conditions, the area would not provide high quality habitat for rearing, nursery, or adult feeding life stages. The physical habitat characteristics represented in the affected area are common in Patterson Lake, where the dominant substrate in the littoral zone consisted of sand in approximately half of the area surveyed (Annex V.1). The riparian zone at the selected location for the diffuser was forested to the bank with vegetation consisting of trees and shrubs.

Based on the conceptual design criteria outlined above, the in-water footprint associated with the diffuser structure (i.e., sled or concrete pad) and HDPE pipe (i.e., 750 m length of 400 mm diameter) is estimated to be 325 m^2, consisting of 25 m^2 for the support structure and 300 m^2 for the pipe. This proposed footprint area represents less than 0.009% of the total habitat area of Patterson Lake (i.e., 325 m^2 of the total Patterson Lake surface area of 38 km^2). Additionally, the discharge infrastructure would avoid high quality fish habitats identified during the aquatic environment baseline study (Figure 11.4-1). The riparian habitat loss associated with the treated effluent discharge system is conservatively estimated to be 192 m^2 and includes the alignment of the new site road and the on-land portion of discharge pipe alignment, which intersect with the 30 m riparian buffer. This area represents 0.01% of the total riparian habitat area associated with Patterson Lake (i.e., 16 km^2). Overall, the in-water and riparian habitat losses associated with the treated effluent discharge pipe and diffuser are very small and would be expected to result in no effects, or at most, negligible and non-measurable effects on fish VCs.

Treated Sewage Outfall

The Project would require a treated sewage outfall installed in Patterson Lake at the conceptual location shown in Figure 11.4-1. Components of the treated sewage system that could affect fish habitat in Patterson Lake would include an HDPE pipe and an outfall. At the current stage of the Project, design details for the treated sewage outfall are conceptual; however, the volume of treated sewage discharge expected to be generated for the site is small (i.e., 165 m^3/d) relative to the release water volume treated through the ETP and generated from the mine and process plant (i.e., 833 m^3/h). Therefore, it is anticipated that the pipe and outfall associated with treated sewage discharge would be smaller in size than the treated effluent discharge pipe and diffuser. Based on conceptual drawings, the pipe would extend from the STP into the Patterson Lake North Arm – West Basin (Figure 11.4-1) and would intersect the lake shoreline and riparian zone along its alignment. The pipe would extend approximately 200 m northwest into the lake before angling west-southwest and extending an additional 700 m into the lake (Figure 11.4-1) to a depth of approximately 10 m. Based on treated sewage discharge flow projections, it is anticipated that this water would discharge directly from the pipe outlet; however, the final outfall design may include an engineered structure at end-of-pipe to promote mixing, if required.

Two candidate locations for the treated sewage outfall were initially identified and evaluated in Patterson Lake – North Arm West Basin. The selected location was chosen to avoid interaction with the fresh water intake and the RMZ associated with the treated effluent discharge pipe and diffuser. Based on field surveys of the Patterson Lake shoreline area in the vicinity of the proposed treated effluent diffuser site, the treated sewage outfall pipe would intersect a habitat section consisting of 80% cobble and 20% boulder (Annex V.1). The habitat section intersected by the pipe was assessed as moderately suitable spawning habitat for lake whitefish, walleye, and lake trout and not suitable for northern pike spawning (Annex V.1). The affected area may also provide nursery, rearing, and adult feeding habitat for fish VCs. However, as described above for the fresh water intake pipe, the treated sewage outfall and a portion of the associated pipeline would be situated in deeper water, which would be unsuitable as spawning habitat for the selected VCs based on the suitability ratings developed by CanNorth (Annex V.1). Additionally, the habitat disturbed by the discharge pipe is not unique due to the same considerations as noted above for the fresh water intake.

Based on the conceptual design details for the treated sewage outfall, it is anticipated that the in-water footprint associated with the treated sewage discharge would be limited to the conveyance pipe (i.e., 900 m of pipe, expected to be 400 mm or less in diameter). Based on these estimates, the in-water footprint associated with the treated sewage discharge is expected to be approximately 360 m^2, representing less than 0.001% of the total habitat area of Patterson Lake (i.e., 360 m^2 of the total Patterson Lake surface area of 38 km^2). The riparian habitat loss within the 30 m buffer zone is conservatively estimated to be 127 m^2, which includes the conveyance pipe buffered by 2 m on either side. This area represents 0.008% of the total riparian habitat area associated with Patterson Lake (i.e., 127 m^2 of the total 1.6 km^2 riparian area of Patterson Lake). Overall, the in-water and riparian habitat losses associated with the treated sewage discharge are very small and would be expected to result in no effects, or at most, negligible and non-measurable effects on fish VCs.

Summary

Development of water management infrastructure in Patterson Lake would result in a limited amount of physical habitat loss for fish VCs. The total estimated in-water footprint associated with these developments is approximately 1,258 m^2, which represents 0.003% of the surface area of Patterson Lake (i.e., 1,258 m^2 of the total Patterson Lake surface area of 38 km^2). Approximately 1,215 m^2 or 97% of the total estimated in-water footprint for these developments is associated with the conveyance pipes for the structures. The estimated loss of riparian habitat associated with these developments is 319 m^2, representing 0.02% of available riparian habitat for Patterson Lake (i.e., 319 m^2 of the total 1.6 km^2 riparian area of Patterson Lake). Overall, the amount of change to in-water and riparian habitat would be small and localized. Additionally, the developments have been sited to avoid high quality fish habitats, as much as possible. The pipeline associated with the treated effluent discharge pipe and diffuser would pass through an area considered to have relatively low habitat quality for spawning and for use by other life stages of fish as rearing, nursery, or feeding habitat. The fresh water intake and treated sewage outfall pipes would pass through areas assessed as suitable spawning habitat for selected VCs. However, none of the habitats affected by these developments are unique within Patterson Lake, meaning that the infrastructure would not disturb sensitive areas that are vital to the sustainability of fish populations in the LSA or RSA.

Although some limited changes in habitat availability may occur due to these developments, the proposed works are not expected to meaningfully affect VC fish populations (i.e., through effects on growth, survival, or reproduction) or associated fisheries productivity. Changes in habitat distribution are likewise not expected, as these developments would not affect the movements of fish or connectivity of habitats in Patterson Lake. Overall, effects on fish VC populations are predicted to be negligible.

To the extent possible, the proposed in-water developments have been designed such that the structures and related activities minimize adverse effects on fish and fish habitat and avoid a harmful alteration, disruption, or destruction of fish habitat, as defined by the federal *Fisheries Act*. However, the developments would require work below the high water mark in Patterson Lake and would result in limited physical habitat loss or alteration. A Request for Review would be submitted to DFO for the Project to determine if an authorization under the *Fisheries Act* would be required to permit the proposed developments. If DFO determines that residual harmful effects to fish and fish habitat cannot be avoided or mitigated, NexGen would submit an application for a *Fisheries Act* Authorization for the relevant component(s) of the water management infrastructure. NexGen would develop an offsetting plan and implement offsetting measures, if required, to counterbalance the harmful alteration, disruption, or destruction of fish habitat with the goal of protecting and conserving fish and fish habitat. The offsetting plan would be developed in consultation with DFO and with engagement of the Indigenous and local communities, and ultimately, authorized by DFO. The offsetting plan, if required, would be developed during the permitting phase of the Project and would be submitted as part of an Application for Authorization under the *Fisheries Act*.

Through the use of appropriate design, mitigation, and management practices, effects from installation of in-water developments are expected to have negligible effects on fish VCs. Overall, the physical habitat loss associated with these structures is predicted to result in a small change to habitat availability for fish VCs in Patterson Lake and no change to distribution relative to existing conditions. If required by DFO, fish habitat lost or altered because of the developments would be offset with habitat created, restored, or enhanced. Therefore, this pathway was classified as a secondary pathway and not carried forward for further assessment.

F-09: Disturbance during in-water construction:

- In-water construction and related activities for the fresh water intake, treated effluent diffuser, treated sewage outfall can cause injury or mortality to fish, including fish eggs, and disturb fish habitats in Patterson Lake, which may adversely affect fish habitat availability, survival, and reproduction.

In-water construction activities related to the Project's proposed fresh water intake, treated effluent diffuser, and treated sewage outfall, as well as the associated pipelines, have the potential to cause damage or disturbance to fish habitats in Patterson Lake, including spawning substrates, incubating eggs, and the early life stages of fish (e.g., fry, alevin). In-water construction activities could also disturb spawning activity and spawning fish, which could affect fish VC reproduction success. The installation of these structures and the associated maintenance and removal activities would require work below the high water mark of Patterson Lake, a known fish-bearing waterbody. During in-water construction activities, there is potential for physical injury or mortality of fish to occur, which could affect the survival of fish VCs, including fish eggs, in Patterson Lake.

A summary of the conceptual locations (Figure 11.4-1) and design details for the proposed water management infrastructure developments in Patterson Lake is provided in the assessment of the pathway, F-08: Loss or alteration of fish habitat. In-water components of the water management infrastructure have been designed to minimize the potential for adverse effects on the aquatic environment. The construction methods that would be employed to install the fresh water intake, treated effluent diffuser, treated sewage outfall and associated pipelines would be relatively unobtrusive in terms of the potential to cause injury or mortality of fish or to disturb fish habitats. The structures would be assembled on shore, where practical, and floated into position in Patterson Lake and then submerged and anchored on the lake bottom. The installation activities would not require excavation or operation of heavy equipment in Patterson Lake. Additionally, activities that are associated with a greater risk of potential effects on fish and fish habitat (DFO 2019b), such as dewatering of in-water work areas, fish rescue activities, and the use of intake pumps that can cause impingement or entrainment of fish and eggs, are not required.

The sections of HDPE pipe that would be used for the in-water developments would be fused together on shore and incrementally moved out into Patterson Lake, with the pipelines filled with air and ballast collars attached. The assembled pipes would be floated out to the preferred location and then submerged in place and anchored to the lake bottom using weights affixed along the pipe length. The fresh water intake structure would consist of a stainless steel intake affixed to a concrete pad, which would be floated out into the lake and submerged at the preferred location. The stainless steel intake would either be attached to the concrete pad on shore or by a dive team once the pipe and concrete pad were installed in the lake. Similarly, the vertical nozzle for the diffuser and discharge structure for the treated sewage outfall would be attached to the respective pipes on shore or by a dive team once the pipes were submerged in the lake. Divers may also be used to adjust alignment of in-water developments during installation or maintenance activities.

The locations of in-water developments were selected to avoid high quality fish habitats, where possible. A description of the fish habitat conditions documented in the vicinity of the proposed locations for the fresh water intake, treated effluent diffuser, and treated sewage outfall is provided in the assessment of the pathway, F-08. The treated effluent discharge pipe and diffuser would intersect in an area assessed as having low habitat quality for spawning (Annex V.1). The fresh water intake and treated sewage outfall locations would intersect areas assessed by CanNorth (Annex V.1) as suitable spawning habitat for selected VCs and where spawning activity has been documented (Section 11.4.2; Figure 11.4-1). However, as outlined for the pathway F-08, the affected habitats are common in Patterson Lake. Therefore, although some disturbance to fish habitats may occur due to in-water construction, the activities would not affect sensitive or unique habitats that are vital to the sustainability of VC populations.

All construction activities would occur in accordance with the Environmental Protection Program, which would outline management practices for in-water construction. Where possible, in-water work would be scheduled outside of the DFO restricted activity timing windows, which are: 1 September to 15 July for fall/winter spawning fish in northern Saskatchewan with lake trout present; and 1 May to 15 July for spring spawning fish in northern Saskatchewan without lake sturgeon (DFO 2013a). Construction practices and mitigation measures would follow DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2019b) to minimize adverse effects on aquatic resources.

Despite the described mitigation and lower level of risk associated with the construction methods that would be employed to install the fresh water intake, treated effluent diffuser, treated sewage outfall, and associated pipelines, limited disturbance to fish habitats and fish VCs may occur during in-water construction related to these developments. In-water construction activities are expected to occur over a period of one to two days for each development. Consequently, the duration of potential effects would be short and limited to the immediate vicinity of the work area. Similar types of effects could occur during maintenance activities for the developments and during removal.

With implementation of best management practices and mitigation, effects on fish VC survival and reproduction from in-water construction and related activities in Patterson Lake are expected to be of short duration and negligible in magnitude. Therefore, this pathway was classified as a secondary pathway and not carried forward for further assessment.

F-10: Impingement and entrainment of fish in the fresh water intake:

- Impingement and entrainment of fish in the fresh water intake may cause injury or mortality to fish and affect the survival of fish.

Water withdrawals from a fish-bearing waterbody have the potential to cause impingement and entrainment of fish that could potentially result in injury or mortality to fish VCs. Impingement occurs when a fish becomes trapped against the intake screen that prevents debris from entering the intake and the fish is unable to free itself. Entrainment occurs when a fish is drawn into a water intake, where mechanical stress can cause injury or mortality.

Water withdrawals from Patterson Lake would be required during Project Construction, Operations, and the Active Closure Stage to meet Project fresh water requirements. The fresh water intake for the Project would be located north of the proposed Project footprint in the Patterson Lake North Arm – East Basin (Figure 11.4-1). The intake system would consist of the fresh water intake pumphouse, intake pipe, and fresh water intake structure. The fresh water intake pumphouse would be fitted with turbine pumps that would supply water to the Project site on demand. As Patterson Lake is a fish-bearing waterbody, fish would be at risk of impingement or entrainment in the intake. Based on the biology and life history requirements of VC fish species (Section 11.3.6) and information regarding fish species distribution in the LSA (Section 11.3.4), there is potential for adults and juveniles of all four fish species considered as VCs to be present in the vicinity of the fresh water intake.

To minimize potential harm to fish, the fresh water intake structure would be fitted with a fish screen designed in accordance with DFO's *Fresh Water Intake End-of-Pipe Fish Screen Guideline* (DFO 1995). The DFO (1995) guidelines for fish screens on fresh water intake pipes would be followed in design, installation, and maintenance of fish screens on the Project fresh water intake. Several studies demonstrate the effectiveness of fish screens in preventing impingement and entrainment of fish at intake pipes with maximum approach velocities suitable to the species present in Patterson Lake (Katopodis 1994; Savitz et al. 1998; Peake 2004; Boys et al. 2013).

Including a properly designed fish screen in the fresh water intake design would limit the screen mesh pore size such that fish greater than a certain size would be physically unable to pass through. Additionally, the screened-in area would be designed to be large enough that the approach velocity of water into the intake would be sufficiently low to enable fish to swim away and avoid the screen. The appropriate screen mesh pore size and screen opening size for the planned pumping rates would be determined to prevent or minimize the potential for fish to enter the intake during pumping. The intake screen would be designed to accommodate nearly uniform and low-flow velocity across the entire screen surface, reducing the intake velocity to a maximum of 0.15 m/s to allow for juvenile fish to swim away. The intake screen mesh size and dimensions would be influenced by the species found in Patterson Lake, as well as the swimming abilities of species likely to be present at the fresh water intake location.

To further limit the occurrence of impingement and entrainment of fish in the intake pipe, the fresh water intake structure would be located away from identified spawning habitats and locations where incubating eggs have been documented. The fish habitat conditions present along the Patterson Lake shoreline in the vicinity of the fresh water intake were characterized in Annex V.1. The fresh water intake structure and fish screen would be situated in deeper water (i.e., between 3 m and 10 m; Figure 11.4-1) that would be considered unsuitable as spawning habitat for the selected VCs, based on the suitability ratings developed by CanNorth.

Designing and screening the fresh water intake structure in accordance with applicable DFO (1995) guidelines and locating the structure away from high quality fish habitats, including identified spawning habitats along the Patterson Lake shoreline adjacent to the proposed Project site (Figure 11.4-1), would reduce the potential for fish injury or mortality resulting from impingement or entrainment such that effects on VCs fish populations would be negligible. Any impingement or entrainment of small or juvenile fish would be limited to localized areas around the intake pump.

With proper design, installation, and maintenance, injury and mortality of fish due to impingement on the intake screen or entrainment into the fresh water intake is anticipated to result in negligible residual effects on fish VCs. Therefore, this pathway was classified as a secondary pathway and not carried forward for further assessment.

F-11: Habitat disturbance from treated effluent diffuser:

- The area of water turbulence around the treated effluent diffuser may affect local fish habitat availability in Patterson Lake.

Turbulence from a discharge can adversely affect fish habitat in terms of quantity where the turbulence in the water column causes fish to avoid the area, or quality due to the mobilization of lake bed material and sediments into the water column and redistribution of sediments on the lake bottom in the vicinity of the discharge. The velocity of pumped treated effluent discharge entering Patterson Lake during Operations would be reduced by the use of an engineered, submerged diffuser (TSD XXI). The discharge pipe would extend 750 m from the shoreline into Patterson Lake and discharge treated effluent through a diffuser at a water depth of approximately 10 m; the conceptual location is shown in Figure 11.4-1. The treated effluent would be discharged into Patterson Lake in batches released during Construction, Operations, and the Active Closure Stage.

To avoid adverse effects on fish habitat, the diffuser would be located in an area of Patterson Lake that avoids high quality fish habitats (e.g., documented spawning and nursery areas, or unique habitats; WSA 2015). Based on field surveys of the Patterson Lake shoreline area in the vicinity of the proposed treated effluent diffuser site, the diffuser would intersect a section of shoreline assessed as consisting of 95% sand and 5% organics (Annex V.1). A lake bed substrate sample collected at the discharge location indicated that the substrate consisted of medium- to fine-grained sand (TSD XXI). The sand substrate present in the affected area is common throughout Patterson Lake (Annex V.1) and generally would be considered low quality habitat for fish VCs. The area was noted to not be suitable spawning habitat for large-bodied fish, including lake trout, walleye, lake whitefish, and northern pike. Additionally, no eggs of any fish species, including VCs, were found in the area during the baseline surveys (Annex V.1; Figure 11.4-1).

To control the flow velocities and reduce stress on the surrounding lake bed, the diffuser would be placed at a depth of 10 m and the nozzle would be elevated 1 m above the lake bed (TSD XXI). This design would maximize dispersion and attenuation of the discharge from the diffuser. The design is also expected to avoid any potential disturbance or entrainment of the lake bed substrate and associated fish habitat. The diffuser would be inspected upon completion of the installation activities and on a regular basis during Operations to confirm that it is functioning as designed and that disturbance to the lake bottom does not occur. Therefore, effects on fish habitat due to sediment entrainment are not expected (TSD XXI).

Operation of the diffuser in Patterson Lake would create an area of increased turbulence and noticeable velocity in the water column. It is expected that fish would avoid this area upon sensing the increased water turbulence. The area of increased turbulence would extend vertically from the discharge pipe to the water surface, with a limited amount of lateral disturbance also expected. The velocity and turbulence of the water would be greatest at the centreline, closest to the diffuser pipe. Overall, the area of disturbance would be small and limited to the immediate area of the discharge location.

As a result of the design and location of the diffuser and the described mitigation measures, effects on fish habitat availability due to water turbulence from the treated effluent diffuser during Construction, Operations, and the Active Closure Stage are expected to be negligible. Therefore, this pathway was classified as a secondary pathway and not carried forward for further assessment.

F-12: Public access affecting survival:

- Changes in public access to fishing areas on the Clearwater River and in Patterson Lake, and increased density of people (e.g., Project staff and contractors) in the area, may affect the survival of fish.

Project-related changes to roads and associated access conditions can alter public access to fishing areas on the Clearwater River and in Patterson Lake and affect the survival of fish VCs.

Patterson Lake and the Clearwater River provide attractive opportunities for recreational fishing in the region. Fish species that are targeted by fishers (i.e., anglers) in the area include all four VC species (i.e., lake trout, walleye, northern pike, lake whitefish) and other large-bodied species (i.e., Arctic grayling, burbot, yellow perch) (Government of Saskatchewan 2021). Sport fishing in Saskatchewan is regulated by The Fisheries Regulations under *The Fisheries (Saskatchewan) Act, 2020.* All recreational anglers are required to have an angling licence from ENV and follow the regulations outlined in the Anglers Guide (Government of Saskatchewan 2021). Waterbodies and watercourses in the LSA and RSA fall within the Northern Zone management area for angling regulation in Saskatchewan. Season and catch limits and catch-and-release rules are in force in the province and restrict individual angler harvest or activity. The “general” limits defined in the regulations are applied to Patterson Lake, the Clearwater River, and other waterbodies and watercourses in the LSA and RSA. These limits include harvest restrictions for the four fish VCs. Potential changes in angler pressure and fish harvest in the province would continue to be managed by ENV, which is the government agency responsible for managing fisheries resources in the province.

During engagement for the Project, Indigenous Groups expressed concerns about potential effects of the Project on access and fishing opportunities. The potential for disruption to, or diminution of, resource use opportunities, including fishing, is a serious concern for communities (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN). Indigenous Groups expressed concerns about Project-related changes in access, including an increase in traffic and non-Indigenous resource users in the area of the Project, which could affect the availability of fish and fishing opportunities.

> I think even without the mine being there it's, you know, there's still some – a lot of exploration around that area at [Highway] 955. I think it's going to affect that area. And it's not only that area, but it's even in around closer to – closer to our community because of, because of traffic . . . More trucks. More, you know, more activity, more people. More people coming into our immediate area – our immediate hunting area, our immediate fishing area, our immediate, you know, traditional territory around our community. It's quiet now, but there's always people who look for places to fish, to set up camp, to lease out land to build cabins and – there's always that potential for a lot of other things. (TSD II: BNDN)

The Project would not include the development of new public roads. Access to the Project site would be provided by an existing access road from Highway 955 (Figure 11.2-3). Upgrades to this access road, including widening of the road surface, are planned to support increased traffic volume and heavy vehicle/equipment use associated with the Project. Existing fishing opportunities along the highway and road are limited, with the only road access to a fish-bearing waterbody or watercourse being at the existing bridge crossing of the Clearwater River downstream of the Patterson Lake outlet. Upgrades to the existing access road are not expected to result in measurable changes to existing fishing pressure at this location. However, the increase in use of the road due to an influx of people and traffic accessing the Project site, particularly during Construction and Operations, may result in greater use of the bridge crossing and associated river access for recreational fishing purposes.

Development of the Project would result in an increase in the density of people in the area due to employees and contractors during Construction, Operations, and the Active Closure Stage. New roads would also be developed on the Project site, which would improve access to Patterson Lake for employees and contractors who may wish to fish recreationally during their time off shift while on site. The increase in density of people around the area of the Project, combined with the development of new site roads that improve access to Patterson Lake, could increase recreational angling in the area and, therefore, increase rates of fish injury or mortality. The survival of fish VCs may be adversely affected due to an increase in harvesting of fish, or as a result of incidental injuries or mortality related to catch-and-release fishing.

NexGen is exploring the possibility of implementing a policy that would prohibit or restrict fishing by employees and contractors on the Project site and along the existing access road while on rotation or residing in the camp. As NexGen plans to prioritize employment from local communities where possible, engagement with these communities would be undertaken to gather feedback on whether a no fishing policy is a desired mitigation to reduce effects on harvested fish populations from increased fishing pressure. However, for the purpose of the effects assessment, and to provide a conservative evaluation of potential effects on fish VCs, it was assumed that employees and contractors would be permitted to fish recreationally during their time off while on site, as well as along the existing access road.

New and existing roads on the Project site that would provide access to Patterson Lake include the main road from the gatehouse that runs adjacent to the east shoreline of Patterson Lake and roads accessing the Patterson Lake shoreline at the fresh water intake and treated effluent diffuser locations (Figure 11.4-1). These roads would not be accessible to the public during Construction, Operations, and the Active Closure Stage, but potentially may be used by employees and contractors to access Patterson Lake to fish recreationally. As a result, Patterson Lake could experience an increase in fishing pressure as a result of recreational angling by employees and contractors.

The Preliminary Decommissioning and Reclamation Plan assumes that site roads would be decommissioned (e.g., regraded, scarified) and reclaimed (e.g., revegetated) during the Active Closure Stage, which would discourage long-term use of site roads by the public during post-closure. However, the Preliminary Decommissioning and Reclamation Plan is subject to change and further refinement through the lifespan of the Project and would consider the results of additional public and community engagement on closure planning for site roads. If site roads were to remain in place after Closure, these roads could improve public access to Patterson Lake at the described locations and potentially allow increased fishing pressure.

Mitigation would be implemented to reduce the potential for effects on fish VCs from an increase in recreational fishing pressure. The Project site entrance would be gated at the gatehouse to discourage public access. During Construction, contractors and employees would be transported by bus to site from La Loche until the on-site airstrip is completed, after which employees would be transported to and from site by aircraft. These transportation practices would reduce the amount of personal vehicles and traffic in the area of the Project and limit the opportunity for employees to fish along the access road. Although not a Project mitigation measure, it is expected that ENV would continue to manage sport fishing in Patterson Lake and the Clearwater River through the use of harvest restrictions, as well as the implementation of other regulations as required (e.g., catch-and-release).

With effective implementation of mitigation and continued management by ENV, changes to harvest of fish in the Clearwater River and Patterson Lake and effects on fish habitat quality are anticipated to be minor, with a negligible residual effect on the survival of fish VCs (i.e., lake trout, lake whitefish, northern pike, walleye). Therefore, this pathway was classified as a secondary pathway and not carried forward for further assessment.

11.4.3 Primary Pathways

The following Project interaction was predicted to be a primary pathway to fish and fish habitat VCs and was advanced for further assessment of residual effects (Section 11.5).

F-01: Changes in surface water quality from WRSAs and UGTMF after Closure:

- Runoff and seepage from the WRSAs and groundwater flow from the UGTMF may alter surface water quality in Patterson Lake after Closure and adversely affect fish habitat availability, survival, and reproduction.

11.5 Residual Effects Analysis

Section 11.5 assesses the predicted changes to fish VCs in the receiving environment due to changes in surface water quality and sediment quality from the primary pathway identified in Section 11.4.3, Primary Pathways. This primary pathway addresses the potential effects from altered surface water quality after Closure and in the far future projection. Effects from changes to surface water quality during the Project lifespan are evaluated in Section 11.4.1 and Section 11.4.2.

Potential effects on fish and lower trophic organisms, including phytoplankton, zooplankton, and benthic invertebrates, may occur due to changes in water and sediment quality after Closure and in the far future. The primary source of loading for metals in the far future would be the seepage load through the groundwater flow path from stored mine waste on the Project footprint. Changes to water and sediment quality in the far future could alter the health of fish and lower trophic organisms and the subsequent suitability of fish habitat in affected waterbodies and watercourses; these changes could adversely affect the survival and reproduction of fish VC populations in the RSA or LSA.

During engagement for the Project, Indigenous Groups expressed concern that Project activities could pollute Patterson Lake, and by extension, the Clearwater River watershed (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN). Indigenous Groups raised concerns about potential toxins entering the food chain through water and affecting fish (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN). Specific concerns were expressed by the BNDN regarding the potential for contamination of groundwater and the release of mine-affected water to the environment (TSD II: BNDN). The BNDN and CRDN stated concern of potential for increased incidences of diseased or unhealthy fish and decreased health of fish populations due to water contamination from Project activities (TSD II: BNDN; TSD V.2: CRDN). The BNDN also commented about the potential for changes in sediment quality and effects on bottom-feeding fish species such as lake whitefish (TSD II: BNDN).

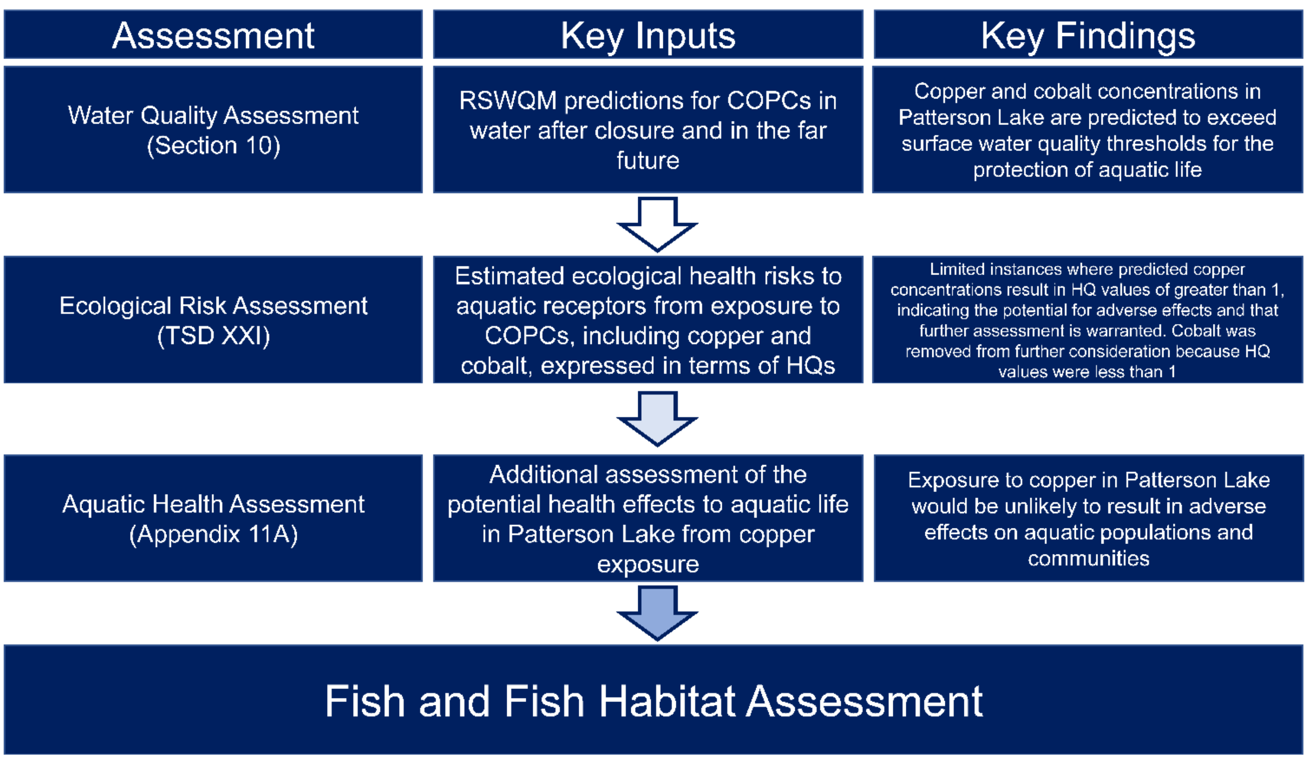
Infiltration and seepage from the Project footprint to the groundwater regime in the far future were predicted through groundwater flow and solute transport modelling to invoke a long-term period of extremely slow migration of COPC metals from the underground mine workings, UGTMF, and WRSAs to the Patterson Lake receiving environment. This migration was predicted to result in incremental mass loadings to Patterson Lake North Arm – West Basin in the far future for a subset of COPC metals. Additional description of the potential mine sources and hydrogeological processes that would be expected to contribute to changes to the groundwater regime, and ultimately surface water quality in the receiving environment after Closure, is provided in the groundwater and surface water quality assessments (Section 8 and Section 10).

The mechanisms by which fish VCs and lower trophic organisms could be affected by exposure to COPCs in the water column or in sediment could either be direct or indirect. Direct mechanisms involve a direct influence on a receptor; for example, direct toxicity to fish and aquatic life could occur as a result of an elevated concentration of potential toxicant (e.g., metal or radionuclide) acting directly at the sites of toxic action, resulting in adverse biological effects (Rand 1995). Indirect mechanisms involve adverse effects or toxicity that results from the agent acting on and producing changes in the physical or biological environment external to the VC (Rand 1995). In aquatic ecosystems, indirect mechanisms often include several levels of the food web. For example, mine-related sources of constituents to the surface water environment may result in a toxicological effect on lower trophic level organisms, which may cause changes in the food base for fish and affect the productivity of higher trophic level organisms such as fish.

11.5.1 Approach

Information from the surface water quality and aquatic health assessments as well as the EcoRA completed for the Project formed the basis of the residual effects analysis for fish and fish habitat. A summary of the methods used by these assessments to predict potential changes in water chemistry and estimate the resulting health effects on aquatic biota for the far future is provided in Sections 11.5.1.1 to 11.5.1.3. Additional details can be found in Section 10, TSD XXI, and Appendix 11A, Aquatic Health Assessment of the Potential for Adverse Effects of Predicted Far-Future Copper Concentrations in Patterson Lake. Information from these assessments was then used to predict potential changes to habitat availability, survival, and reproduction of fish VC populations in the LSA and RSA (Section 11.5.1.5, Assessing Effects on Lake Trout, Lake Whitefish, Walleye, and Northern Pike). A simplified schematic summarizing the key information sources considered in the fish and fish habitat residual effects assessment is provided in Figure 11.5-1.

Figure 11.5-1: Summary of Key Information Sources Considered in the Fish and Fish Habitat Residual Effects Assessment



COPC = constituent of potential concern; HQ = hazard quotient; RSWQM = regional surface water quality model; TSD = technical support document.

11.5.1.1 Summary of Surface Water Quality Assessment Methods

Potential changes to surface water quality in the receiving environment were predicted through the development of an RSWQM (Section 10.2.8.1.2). The purpose of the RSWQM was to assess the expected magnitude, extent, and duration of Project effects in the downstream receiving environment, on a lake-wide scale, or for individually defined basins within a waterbody. To predict effects in the far future, the RSWQM considered an Application Case and an RFD Case. Source term inputs considered in the RSWQM Application Case included inputs from the Project site-wide water balance model and the groundwater solute transport model. A sensitivity scenario was considered within the Application Case that was representative of reasonable upper bound conditions (Section 10.2.8.1.2). This reasonable upper bound scenario was completed to provide a precautionary, more conservative bound in the surface water quality assessment.

The RFD Case considered inputs from the Fission Patterson Lake South Property, in addition to the Project inputs in the Application Case and included mass loading associated with site runoff from an above-ground tailings management facility and covered waste rock storage facility as outlined in the Fission (2019) prefeasibility study. The potential for inputs related to long-term solute transport associated with Fission Patterson Lake South Property were not considered, as it is not currently known whether there is any potential for mass transport via groundwater to Patterson Lake from this potential development.

Additionally, a sensitivity scenario was considered within the RFD Case that evaluated the effects of future climate change based on hydrological processes (e.g., increased precipitation and evaporation; Sections 9.2.7 and 10.2.8.1.2). Site-specific future climate projections were developed for the Project through analysis of available projections from a multi-model ensemble (Section 9.8.2, Model Predictions). The multi-model ensemble consists of available regional scale projections from several climate models representing different future climate scenarios (e.g., level of greenhouse gas emissions). The period from 2041 to 2070 presents a conservative estimate in terms of climate change during the Project timeline. The mean changes of projections for 2041 to 2070 relative to the period from 1981 to 2010 were applied to the historical climate record compiled for the Project. Adjusting the historical climate record based on this approach accounts for changes due to climate change, incorporates seasonality, and maintains the integrity of climate cycles that may continue as the climate changes (Appendix 9A, Appendix 10A, and Appendix 22A, Climate Change Dataset Summary Report).

The modelling of the tailings-affected groundwater migration by the groundwater solute transport model demonstrated that the time for groundwater to reach surface water spans a very large temporal scale extending hundreds of thousands of years into the future (Section 8, Hydrogeology). However, computational limits with the RSWQM precluded the use of such a large temporal scale as demonstrated in the solute transport model. To address this limitation, loadings from the groundwater solute transport model were effectively fast-tracked to allow for a shorter modelling timeframe that considered maximum effects on surface water quality. The far-future modelling period considered in the RSWQM extends 357 years after Closure and includes two time periods: an initial 157-year period that includes the natural hydrological and hydrogeological processes from the site following Closure; and a subsequent 200-year period that includes the natural hydrological and hydrogeological processes that account for maximum mass loadings associated with solute transport by groundwater, as predicted by the groundwater model. As the RSWQM modelled conditions for the far future were effectively fast-tracked, these “years” do not correspond to actual future years. Thus, any mention of a specific year in this residual effects analysis refers only to a point in the far future that represents reasonable worst-case conditions.

Surface water quality predictions generated for the far future were developed using a conservative approach and assumptions. Conservative assumptions were applied when calculating the loading rates of COPCs associated with the groundwater solute transfer inputs (Section 8 and Section 9); these assumptions include limited control of the source material from the WRSAs and UGTMF and maximum potential for contamination and infiltration.

Surface water quality predictions were compared to water quality thresholds (Section 10.2.8.3.1), which are Project-specific water quality guidelines applied to the aquatic receiving environment. These guidelines are primarily based on the CCME (CCME 2021) and Saskatchewan provincial water quality objectives (WSA 2015) and are intended to provide protection to fresh water life from anthropogenic stressors such as chemical inputs.

11.5.1.2 Summary of Ecological Risk Assessment Methods

The EcoRA component of the ERA completed for the Project provides an evaluation of the estimated ecological health risks to aquatic receptors potentially affected by the Project. Ecological health risks resulting from changes in surface water quality were examined in the EcoRA for aquatic species or receptors, including phytoplankton, zooplankton, benthic invertebrates, and predator fish and forage fish, which were represented in the EcoRA by northern pike and lake whitefish, respectively.

Potential chemical stressors in the environment were selected as COPCs for further evaluation in the EcoRA. For the far future, constituents were included as COPCs if predicted maximum water quality concentrations exceeded water quality objectives after the addition of groundwater solute loadings. The environmental pathways model, IMPACT, was used to predict concentrations of COPCs in environmental media and the resulting risks to ecological receptors. The conservative assumptions applied in the development of these models (Section 10; Appendix 10A; Section 8; TSD XIV, Groundwater Flow and Solute Transport Modelling Report) were carried forward into the IMPACT model assumptions.

For fish and lower trophic organisms, contact with water and contaminant uptake from water via bioaccumulation (i.e., feeding on other aquatic organisms) represents the main pathway of exposure to COPCs. Direct contact or uptake from sediment was also considered for benthic invertebrates and bottom-feeding fish (i.e., lake whitefish). Bioaccumulation factors based on surface water concentrations were used in the EcoRA to estimate COPC concentrations in invertebrate and fish tissue based on ambient media concentrations. The radiological dose and non-radiological risk were characterized for each receptor at downstream waterbodies in the LSA. A radiation dose benchmark of 9.6 mGy/d (UNSCEAR 2008) was selected for the assessment of effects on aquatic biota (CSA Group 2022). For non-radiological COPCs, chronic dose-based TRVs were used. The TRVs were derived based on chronic effects levels that represent measurable and statistically meaningful exposure or dose levels affecting only 20% of the organisms tested (i.e., 20% effect concentrations values). This level of effect was preferred because 20% is near the level at which effects become statistically discernible or measurable in both laboratory and field studies.

For radiological COPCs, the ecological risk was assessed through comparison with the dose benchmark identified above. For non-radiological COPCs, the ecological risk to aquatic organisms was estimated by calculating an HQ that provides a quantitative estimate of overall risk to a receptor. Hazard quotients were calculated by dividing the exposure value by the TRV for a given COPC, and the resulting HQ value is compared to a benchmark HQ value of 1. An HQ value greater than 1 would indicate the potential for adverse effects and further assessment would be warranted. An HQ that is less than or equal to 1 suggests that adverse effects on an ecological receptor are unlikely because exposure estimates do not exceed levels known to cause adverse effects.

11.5.1.3 Summary of Aquatic Health Assessment Methods

The EcoRA identified limited instances where predicted copper concentrations in the far future resulted in HQ values of greater than 1, indicating the potential for adverse effects (Section 11.5.2). Therefore, an aquatic health assessment was undertaken to further evaluate the potential effects of exposure of aquatic biota in Patterson Lake to elevated copper concentrations (Appendix 11A). Other COPCs considered in the EcoRA

(Section 11.5.1.2) were not carried forward into the aquatic health assessment because their estimated HQ values were less than 1.

The aquatic health assessment specifically focused on characterizing the potential health effects from copper exposure for the limited instances where concentrations in Patterson Lake were predicted to exceed the minimum fresh water copper TRV used in the EcoRA (i.e., instances where HQs were greater than 1). In the EcoRA, the minimum receptor-specific TRV used for copper was 0.002 mg/L, which corresponds to the CCME's and Province of Saskatchewan's default water quality guideline for the protection of aquatic life (CCME 2021; WSA 2015).

Effects from copper exposure were described in the aquatic health assessment using Environment and Climate Change Canada's recently developed copper biotic ligand model (BLM; ECCC 2021) combined with a multiple linear regression (MLR)-based approach developed by Brix et al. (2017, 2021). These tools predict the bioavailability of copper, and hence the toxicity, based on ambient water chemistry conditions. These tools allow the assessment of the potential for toxicity on aquatic biota by evaluating the predicted copper concentrations in consideration of predicted exposure and toxicity modifying factors. Exposure and toxicity-modifying factors are ambient surface water quality conditions that can affect copper bioavailability and toxicity, such as water hardness and the concentrations of certain ions. Additional explanation and rationale for the approach is provided in the aquatic health assessment (Appendix 11A).

The BLM and MLR approaches were used to evaluate how predicted copper concentrations might adversely affect all forms of aquatic life in Patterson Lake, including phytoplankton, zooplankton, benthic invertebrates, and fish. Effects were evaluated in relation to predicted "no effect" and "low effect" thresholds for copper toxicity in Patterson Lake. No effect thresholds were derived based on the results of the copper BLM, and low effect thresholds were derived based on the results of the MLR model. Detailed information regarding the derivation of these thresholds is provided in the aquatic health assessment (Appendix 11A).

As the BLM and MLR models estimate toxicity based on predicted ambient water chemistry conditions, the resulting no effect and low effect thresholds vary depending on the predicted far future conditions (i.e., assessment case [i.e., Application Case, RFD Case], modelled time step, and Patterson Lake basin [i.e., North Arm – West Basin, South Arm]). Figures illustrating the no effect and low effect thresholds derived by the BLM and MLR for the far future water quality predictions are presented in Appendix 11A and in Sections 11.5.2.3 and 11.5.3.3.

11.5.1.4 Summary of Threshold Values Applied for Copper

A summary of the threshold values applied for copper in the surface water quality assessment, EcoRA, and aquatic health assessment is provided in Table 11.5-1. This information is provided for reference purposes and to summarize the water quality benchmarks and exposure threshold values considered for copper in the fish and fish habitat assessment. Details regarding the derivation of these threshold values are provided in the respective technical sections (Section 10; TSD XXI; and Appendix 11A).

Table 11.5-1: Summary of Water Quality and Exposure Threshold Values Applied for Copper in the Surface Water Quality Assessment, Ecological Risk Assessment, and Aquatic Health Assessment of the Potential for Adverse Effects of Predicted Far-Future Copper Concentrations in Patterson Lake

Assessment	Threshold/Guideline	Source/Derivation	Value
Surface Water Quality Assessment (Section 10.2.8.3, Development of Thresholds)	Project-Specific Water Quality Threshold	Canadian Council of Ministers of the Environment (CCME) Guidelines - Long-term Chronic (CCME 2021) guideline	Copper in water = 0.002 mg/L
Ecological Risk Assessment (TSD XXI Section 6.0)	Lowest Receptor Specific Toxicity Reference Value (TRV)	Estimated 20% effect concentrations (i.e., EC_{20} values; concentrations at which only 20% of the test organisms respond). This level of effect was used because 20% is near the level at which effects become statistically discernible or measurable in both laboratory and field studies. EC_{20} values were obtained from the United States Environmental Protection Agency ECOTOXicology database (lake whitefish) or from CCME (zooplankton and benthic invertebrates)	Zooplankton TRV = 0.002 mg/L Benthic invertebrates TRV = 0.002 mg/L Lake whitefish TRV = 0.002 mg/L
	Hazard Quotients (HQs)	HQs provide a quantitative estimate of overall risk to a receptor. HQs were calculated by dividing the exposure value by the TRV, and the resulting HQ value is compared to a benchmark HQ value of 1. An HQ value greater than 1 would indicate the potential for adverse effects and further assessment would be warranted	Benchmark = 1
Aquatic Health Assessment of the Potential for Adverse Effects of Predicted Far-Future Copper Concentrations in Patterson Lake (Appendix 11A)	No Effect Threshold Values	Environment and Climate Change Canada (ECCC) copper biotic ligand model (BLM; ECCC 2021). No effect thresholds are concentrations of copper at which health effects on aquatic life would not be expected to occur (ECCC 2021)	Variable based on predicted ambient water quality conditions (Figure 11.5-2 and Figure 11.5-5)
	Low Effect Threshold Values	Multiple linear regression-based approach developed by Brix et al. (2017, 2021). Low effect thresholds are concentrations at which only 20% to 25% of organisms may be affected. This level of effect is consistent with relevant guidance for a permissible level of effect (Suter et al. 1995) and for providing protection against unacceptable adverse effects (Mebane 2010). A difference of less than or equal to 20% in response to a test is widely considered to be within the range of natural variability often observed in the field among normal, unexposed populations	Variable based on predicted ambient water quality conditions (Figure 11.5-2 and Figure 11.5-5)

CCME = Canadian Council of Ministers of the Environment; TRV = toxicity reference value; HQ = hazard quotient.

11.5.1.5 Assessing Effects on Lake Trout, Lake Whitefish, Walleye, and Northern Pike

Predicted effects on fish VCs from changes to surface water quality are described for the far-future projection that considers the long-term, slow migration of hydrogeological mass load inputs from certain areas of the Project site following Closure. The approach used to characterize potential effects on fish VCs and associated measurement indicators was quantitative where possibly; however, the approach was primarily qualitative. Changes in measurement indicators for fish VCs were estimated relative to the Base Case to describe the following residual effects:

- **Habitat availability:** Changes in the habitat availability measurement indicator were estimated by examining potential changes to habitat quantity or quality, as well as the use of potentially affected habitat(s) by fish VCs.

  The primary mechanism that could alter fish habitat availability after Closure and in the far future is the potential for effects on the food base for fish. This mechanism could occur as a result of exposure of lower trophic organisms and forage fish, which are important prey items for fish VCs, to COPCs in water or sediment. Effects on the available food supply for fish were assessed qualitatively based on the results of the EcoRA and aquatic health assessment completed for the Project, which provided quantitative predictions regarding the potential for effects on the health of lower trophic organisms, including phytoplankton, zooplankton, benthic invertebrates, and forage fish (represented by lake whitefish in the EcoRA). Also considered in the evaluation of the habitat availability measurement indicator was the potential for effects on the viability and suitability of the affected habitat for use by fish VCs. For example, if changes to the available food supply for fish occurred, the evaluation considered how these changes might affect fish use of the affected habitat.
- **Habitat distribution:** Changes in habitat distribution were estimated by qualitatively examining potential changes in the arrangement and spatial distribution of habitats in the LSA and RSA. Predictions for habitat distribution considered the potential for changes in habitat availability and whether changes to habitat quality could result in corresponding effects on the ability of fish to move between habitats to carry out their life processes.
- **Survival and reproduction:** Changes in survival and reproduction were estimated by considering the potential for direct effects from exposure to COPCs in water or sediment (e.g., direct toxicity as a result of exposure to an elevated concentration of potential toxicant) and the potential for indirect effects from changes in habitat (e.g., effects from a change in available food supply). Predicted changes in survival and reproduction were then summarized qualitatively in consideration of both potential effect mechanisms.

Potential direct effects on the survival and reproduction of fish VCs were assessed based on the results of the EcoRA component of the ERA and aquatic health assessment completed for the Project, which provided quantitative predictions regarding the potential health risks to fish. The EcoRA provided an assessment of the potential health risks for a defined list of aquatic receptors, of which two (i.e., lake whitefish, northern pike) are VCs in the fish and fish habitat assessment. The results of the EcoRA can also be used to interpret potential direct effects on lake trout and walleye, which are the other two fish VCs considered in the fish and fish habitat assessment. Toxicity reference values used in the EcoRA for fish receptors were derived for two broad functional categories: forage fish and predator fish. These TRVs are not specific to individual VCs. Therefore, the estimated health risks identified for northern pike, a predator species, can be used as a surrogate to predict effects on lake trout and walleye, which are also primarily piscivorous. Potential direct effects on all forms of aquatic life, including the four fish VCs, were considered in the aquatic health assessment (Appendix 11A).

Potential indirect effects on the survival and reproduction of fish VCs were assessed qualitatively based on the results for habitat availability. Therefore, the assessment considered the potential for effects on the lower trophic food base for fish to propagate up the food web and affect the survival and reproduction of fish VCs.

The effects of future climate change on fish and fish habitat were considered in the RFD Case through the inclusion of a climate change scenario in the hydrological data inputs to the RSWQM (Section 11.5.1.1). These inputs were considered in the EcoRA, the aquatic health assessment, and ultimately in the residual effects analysis for fish VCs.

11.5.2 Application Case

This subsection presents the results of the residual effects analysis for fish and fish habitat for the Application Case. A summary of the results of the predicted changes to surface water quality and resulting health effects on aquatic biota in the Application Case for the far-future projection is provided in Sections 11.5.2.1 to 11.5.2.3. Additional details and results can be found in Section 10, TSD XXI, and Appendix 11A. Predicted effects on fish VC populations in the LSA and RSA resulting from changes to habitat availability, survival, and reproduction in the Application Case are described in Section 11.5.2.4, Effects on Lake Trout, Lake Whitefish, Walleye, and Northern Pike.

Mitigation measures have been incorporated into the Project (Table 11.4-1), where feasible, to limit potential effects on fish VCs from Project components or activities that could alter surface water quality after Closure and in the far future. As part of the Project design, source control would be applied to the WRSAs and UGTMF to reduce and control infiltration, runoff, and seepage to limit the potential mass loading from these facilities to groundwater and surface water. Source control with respect to the PAG WRSA includes incorporating a physical liner under the storage area and providing a form of cover that enhances runoff, limits infiltration, and reduces oxygen ingress to the waste rock. Water quality of runoff from the PAG and NPAG would be managed by the final design and closure plans of the two storage areas, in accordance with the Mine Waste Management Plan. Source control with respect to the UGTMF would include the design, maintenance, and monitoring of a mine dewatering system to control the flow of groundwater inflow, applying a binder to reduce permeability in backfill and tailings, and engineering tailings geochemistry such that the release of mass is controlled. Further details about how the water quality from these areas would be managed can be found in Section 5, Project Description and Section 10.

11.5.2.1 Summary of Predicted Changes to Surface Water Quality

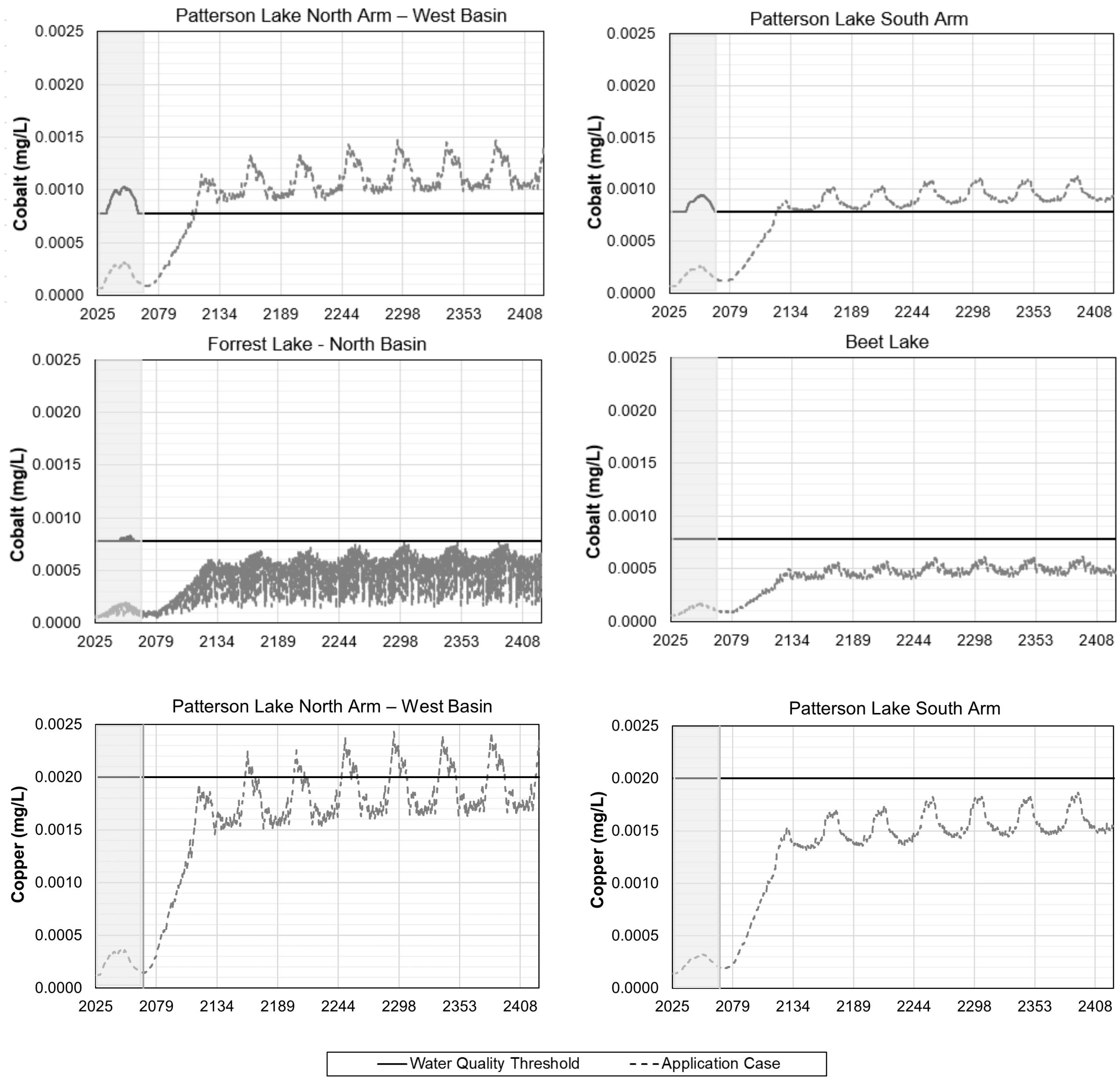
A summary of predicted changes to surface water quality is presented to provide an understanding of water chemistry conditions in the receiving environment in the far future. The results summary is focused on predicted changes in potential toxicants (i.e., metals and radionuclides) that could affect the health of fish and lower trophic organisms after Closure and in the far future.

In the far future, COPC metals (i.e., aluminum, cobalt, copper, iron, manganese, molybdenum, nickel, selenium, uranium, and zinc) were predicted to increase in the receiving environment due to slow migration from the UGTMF and PAG WRSA. The concentrations of these COPCs were predicted to increase during the far future compared to during the Project lifespan and the Base Case. The concentrations of these metals were predicted to increase after Closure because of an influx of mass loading from groundwater and peak after the maximum groundwater loadings are applied to the RSWQM. Note that the peaks represent a fast-tracked timeline as described in Section 11.5.1.1. As outlined in Section 10.5.1.2.3, predicted metal COPC concentrations are influenced by climate, where concentrations are generally higher during dry years and lower during wet years. Overall, the magnitude of metal COPC concentration increases were predicted to be greater in the reasonable upper bound scenario compared to the Application Case.

Although increases were noted for these COPCs in the Application Case and reasonable upper bound scenario, only cobalt and copper were predicted to exceed surface water quality thresholds. Cobalt exceedances were predicted in Patterson Lake North Arm – West Basin and Patterson Lake South Arm in the Application Case (Figure 11.5-2) and Patterson Lake North Arm – West Basin, Patterson Lake South Arm, Forrest Lake – North Basin, and Beet Lake in the reasonable upper bound scenario. Copper exceedances were limited to Patterson Lake North Arm – West Basin for both the Application Case (Figure 11.5-2) and reasonable upper bound scenario. The extent and magnitude of the cobalt and copper exceedances were predicted to be greater in the reasonable upper bound scenario compared to the Application Case (Figure 10.5-13 and Figure 10.5-14). These results for cobalt and copper were carried forward to the EcoRA, which evaluated risks to aquatic receptors and is summarized in Section 11.5.3.2, Summary of Ecological Risk Assessment Results.

In the Application Case, concentrations of radionuclides in the receiving environment are predicted to decline after Closure, eventually reaching steady-state conditions. Concentrations of radionuclides defined as COPCs (i.e., lead-210, polonium-210, radium-226, and thorium-230) are predicted to remain below water quality threshold values in all waterbodies in the far future.

Figure 11.5-2: Cobalt and Copper Concentrations Predicted by the Regional Surface Water Quality Model, Application Case



Note: The shaded area of the plot is representative of the lifespan of the Project, and the unshaded area is representative of the far-future projection.

11.5.2.2 Summary of Ecological Risk Assessment Results

The EcoRA evaluated and presented the estimated risks to aquatic receptors due to releases from the Project to Patterson Lake in the far future once groundwater solute would reach the Patterson Lake North Arm – West Basin. Based on the COPC screening process undertaken for the EcoRA, chloride, sulphate, arsenic, cobalt, copper, uranium, and the radionuclides, uranium-238, uranium-234, thorium-230, radium-226, lead-210, polonium-210 were selected as COPCs for surface water. Based on the EcoRA screening process, no COPCs in sediment were identified for further evaluation of potential risks for ecological health, and thus toxicity via direct contact with sediment was not considered further.

Estimated HQs for the far future were predicted to be below the benchmark of 1 for all COPCs, except for copper in the Application Case and reasonable upper bound scenario. Although cobalt concentrations were predicted to exceed surface water quality guidelines (Section 11.5.2.1), estimated HQs for cobalt were less than 1 in all assessment cases and for all aquatic receptors; therefore, cobalt was not considered further. The maximum HQ for copper was predicted to exceed 1 in Patterson Lake North Arm – West Basin for benthic invertebrates, zooplankton, and forage fish (represented by lake whitefish in the EcoRA) in the far future for the Application Case and the reasonable upper bound scenario. Additionally, the estimated HQ for copper was predicted to exceed 1 in Patterson Lake South Arm for the same three receptors in the far future in the reasonable upper bound scenario. All other modelled waterbodies in the receiving environment had predicted HQs below 1 for the Application Case and reasonable upper bound scenario. There were no predicted exceedances of the 9.6 mGy/d radiation dose benchmark for aquatic biota (UNSCEAR 2008; CSA Group 2022) for the far future.

The results of the EcoRA indicated that direct toxicity from exposure to elevated copper concentrations cannot be ruled out for a subset of aquatic receptors. However, an HQ that is slightly above 1 is not indicative of impending risk to aquatic biota, but rather, that the potential for adverse effects may be increased and that additional investigation is warranted. In the Application Case, the maximum estimated HQs for copper were predicted to slightly exceed the benchmark of 1 and remained below 1.4 in all instances where exceedances occur. A slight exceedance of the benchmark value of 1 indicated that the exposure concentration (i.e., maximum copper concentration in Patterson Lake North Arm – West Basin) only slightly exceeded the reference concentration (i.e., TRV). While the HQ cannot be translated to a probability that adverse health effects would occur and is not directly proportional to risk, a lower HQ would generally have a lower magnitude of effect than a high HQ (e.g., HQ value greater than 10).

The fresh water copper TRV used in the EcoRA for lake whitefish, zooplankton, and benthic invertebrates was based on the CCME's default water quality guideline of 0.002 mg/L (CCME 2021). The CCME water quality guideline is a conservative benchmark below which adverse effects for most aquatic biota are not expected to occur. The EcoRA concluded that effects from copper exposure, if evident, would be limited to exposed individuals of the most sensitive taxa, which included fresh water snails and clams, and water fleas. The most sensitive endpoints for chronic exposure to copper include growth for benthic invertebrates, reproduction for zooplankton, and growth and reproduction for fish (ECCC 2021).

Exceedances of the HQ benchmark value of 1 were predicted to be spatially limited to Patterson Lake North Arm – West Basin in the Application Case and were predicted to extend as far downstream as Patterson Lake South Arm in the reasonable upper bound scenario. Population-level effects on forage fish (e.g., lake whitefish), zooplankton, and benthic invertebrates were not predicted to occur due to the limited magnitude of effect and spatial extent of predicted effects in the LSA.

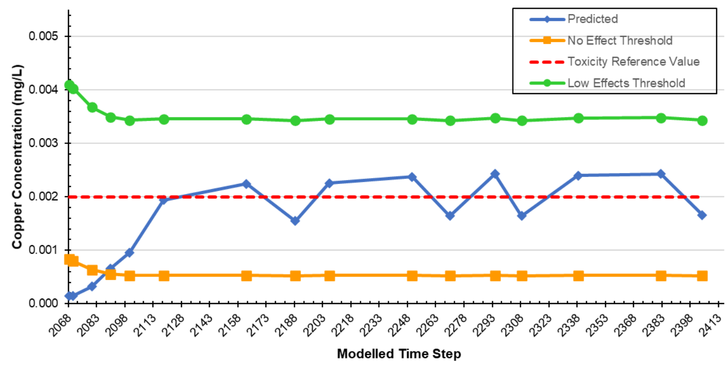
11.5.2.3 Summary of Aquatic Health Assessment Results

An aquatic health assessment was undertaken to further evaluate the potential effects of exposure of aquatic biota in Patterson Lake to elevated copper concentrations (Appendix 11A), focusing on the limited instances where concentrations exceed the minimum receptor-specific TRV of 0.002 mg/L. In the Application Case, copper concentrations in Patterson Lake North Arm – West Basin were predicted to consistently exceed the no effect threshold predicted by the BLM beginning after Closure but would remain below the low effect threshold predicted by the MLR over the modelling timeframe (Figure 11.5-3). Although effects on aquatic life cannot be ruled out for this period, the aquatic health assessment concluded that at the predicted magnitude of effect, exposure to copper in Patterson Lake would be unlikely to result in adverse effects on aquatic populations and communities. If effects occurred, the predicted magnitude would be within the range of background variability and thus unlikely to be measurable (Appendix 11A).

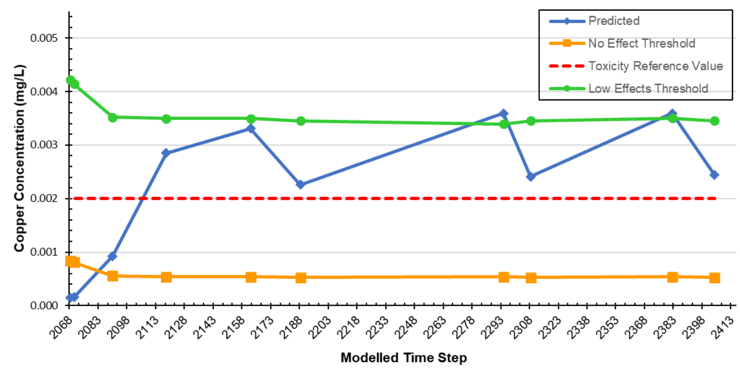
Under the more conservative assumptions considered in the reasonable upper bound scenario, predicted copper concentrations in Patterson Lake North Arm – West Basin would exceed the no effect threshold beginning after Closure but would largely remain below the low effect threshold over the modelling timeframe (Figure 11.5-2). However, concentrations were predicted to occasionally fluctuate above the low effect threshold during periods of dry climate conditions (Appendix 11A). Predicted concentrations above the low effect threshold may result in potential adverse effects on sensitive aquatic receptors. Therefore, a review of the potential magnitude of effects on sensitive species was undertaken. The results of this analysis indicated that adverse effects on aquatic biota are unlikely to occur because predicted copper concentrations are lower than the lowest low effect concentration for the most sensitive species.

Figure 11.5-3: Predicted Copper Concentrations relative to No Effect and Low Effect Thresholds derived by the Biotic Ligand Model and Multiple Linear Regression Model, Patterson Lake North Arm – West Basin and South Arm, Application Case and Reasonable Upper Bound Scenario

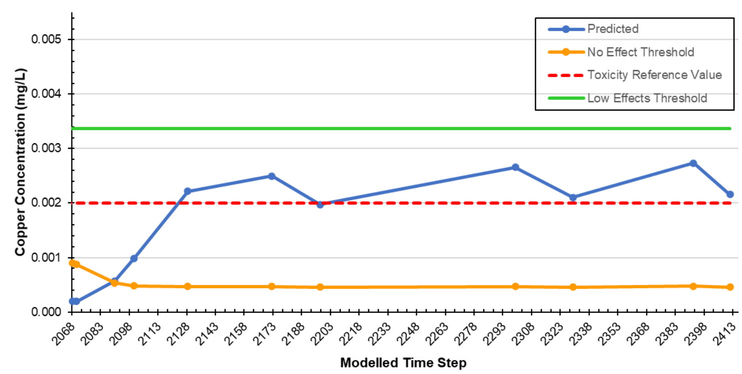
Patterson Lake North Arm – West Basin: Application Case



Patterson Lake North Arm – West Basin: Application Case, Reasonable Upper Bound Scenario



Patterson Lake South Arm: Application Case, Reasonable Upper Bound Scenario



Source: Appendix 11A.

11.5.2.4 Effects on Lake Trout, Lake Whitefish, Walleye, and Northern Pike

The evaluation of effects on fish VCs follows directly from the predictions generated from the surface water quality assessment, aquatic health assessment, and the EcoRA, and therefore incorporates a similar level of conservatism to these assessments. Residual effects on fish VCs were assessed in terms of the measurement indicators defined in Section 11.2.2.2 (i.e., habitat availability, habitat distribution, and survival and reproduction). Changes in measurement indicators for fish VCs relative to the Base Case were assessed according to the approach described in Section 11.5.1.4.

11.5.2.4.1 Effects on Habitat Availability

The residual effects assessment for fish VCs indicated limited potential for changes in habitat availability due to exposure to predicted copper concentrations in Patterson Lake North Arm – West Basin after Closure and in the far future. Changes to health of lower trophic level communities (e.g., plankton, benthic invertebrates) and forage fish (e.g., lake whitefish) due to exposure to copper could alter the available food supply for fish, and consequently the quality of available habitat for fish VCs in Patterson Lake. Zooplankton are an important food source for pelagic fish; therefore, direct toxicological effects on zooplankton could alter habitat quality for pelagic fish (e.g., lake trout and walleye). Similarly, benthic invertebrates exposed directly to potential toxicants in water or sediment are a key food supply for fish feeding on the lake bottom; therefore, direct toxicological effects on benthic invertebrates could alter habitat quality for bottom-feeding fish (e.g., lake whitefish). Forage fish, including lake whitefish, are an important food source for piscivorous fish; therefore, direct toxicological effects on forage fish could adversely affect habitat quality for upper trophic level consumers such as lake trout, walleye, and northern pike.

The results of the EcoRA component of the ERA and the aquatic health assessment completed for the proposed Project indicated that exposure to predicted copper concentrations in the Application Case and reasonable upper bound scenario would be unlikely to result in adverse effects on lower trophic level organisms and forage fish species that form the food base for fish. In the EcoRA, estimated HQs for copper for zooplankton, benthic invertebrates, and forage fish (represented by lake whitefish) were slightly greater than 1, indicating that toxicological effects could not be ruled out for these receptors. Each of these receptors may be targeted as prey by fish VCs in Patterson Lake. However, at the predicted level of exposure, effects would be limited to individual taxa or species that may be sensitive to elevated copper concentrations. The aquatic health assessment results supported these findings and indicated that any potential changes to the lower trophic food base for fish would be minimal and within the range of variability observed in unexposed populations. This assessment is based on the prediction that copper concentrations in the Application Case would remain below the low effect threshold, which as outlined in Section 11.5.1.3 and Appendix 11A, is considered to be a level of effect below which changes in aquatic populations would not be measurable.

Based on the results of the EcoRA and aquatic health assessment, there is some limited potential that a decrease in the abundance and/or biomass of certain prey items for fish VCs could occur. However, both the EcoRA and aquatic health assessment concluded that population and/or community level effects on lower trophic organisms and forage fish are not predicted to occur; therefore, broadscale changes to the food base for fish VCs are not expected at the predicted magnitude of effect. If small changes to the availability of selected prey items occurred, these effects would not be expected to measurably alter fish habitat use of affected areas in Patterson Lake, as overall prey availability would not be expected to be affected. Therefore, no adverse effects on the viability and suitability of habitats for use by fish VCs are predicted to occur.

Based on the results of the EcoRA and aquatic health assessment, and given the conservatism applied to the surface water quality modelling assumptions for copper in the far future, predicted effects on fish VC habitat availability in the Application Case are considered to be negative in direction and negligible in magnitude (i.e., within the range of background variability and unlikely to be measurable); however, it is conservatively considered possible that low magnitude effects may occur. Therefore, the predicted magnitude of effects on fish VCs due to changes in habitat availability in the Application Case was assessed as being negligible to low.

Exposure of lower trophic level prey and forage fish species to maximum copper concentrations would be limited spatially to Patterson Lake North Arm – West Basin for the Application Case. In the reasonable upper bound scenario, effects may extend into Patterson Lake South Arm. However, the likelihood that reasonable upper bound conditions would be realized is low given the high level of conservatism considered in the modelling for this scenario. The frequency of potential effects on fish VC habitat availability is also limited. As shown in Figure 11.5-2, copper concentrations in the Application Case in the far future are influenced by climate where concentrations are generally higher during dry years and lower during wet years. Thus, exposure to maximum copper concentrations would occur only during dry climate years when there is a lower natural runoff to the lake. However, effects on fish habitat availability could potentially occur continuously during periods when predicted concentrations exceed reference values (i.e., TRVs, no effects or low effects thresholds).

The summary of potential residual effects on fish VC habitat availability considered the implementation of mitigation outlined in Section 11.4 and 11.5.2, Application Case, which is expected to reduce the magnitude and duration of residual effects on surface water quality, aquatic health, and ultimately fish habitat availability. However, notably, the assumptions of the groundwater solute transport modelling, which provided information for development of the RSWQM, and subsequently the fish and fish habitat effects analysis, assumed only limited mitigation associated with the WRSAs and the UGTMF (Section 10.6.1.4); as a result, predicted effects on fish VCs from changes in habitat availability may be overestimated. Additional discussion related to uncertainty associated with the groundwater and surface water quality modelling is provided in Section 11.6.

In consideration of all assessment factors, the predicted effects to habitat availability are considered to be possible, meaning that the changes may occur but are not likely.

11.5.2.4.2 Effects on Habitat Distribution

No adverse effects on habitat distribution in the LSA and RSA are predicted to occur as a result of predicted changes to surface water quality in the aquatic receiving environment after Closure and in the far future. While there is some potential that exposure to copper could result in negligible to low magnitude effects on the available food supply for fish, no change in the viability of habitats for use by fish in Patterson Lake is expected at the predicted magnitude of effect. Therefore, fish would be able to continue using the habitats present, and move between habitats, to carry out their life processes (e.g., spawning, rearing, overwintering), and no effects on habitat arrangement or the spatial distribution and movement of fish in Patterson Lake are expected to occur.

11.5.2.4.3 Effects on Survival and Reproduction

Effects on the survival and reproduction of fish VCs could directly occur as a result of exposure to copper in the water column or indirectly due to changes in habitat availability resulting from potential effects on the lower trophic food base for fish, as described in Section 11.5.2.4.1, Effects on Habitat Availability. Potential effects on fish VCs that may occur due to these mechanisms are discussed below. The effects associated with both mechanisms (i.e., direct exposure and changes in habitat availability) were then considered when describing the resulting residual effects on the survival and reproduction of fish VCs.

The results of the EcoRA component of the ERA and the aquatic health assessment completed for the Project indicate that effects on the health, and therefore survival and reproduction, of fish are unlikely to occur in the Application Case and reasonable upper bound scenario. Based on the results of the EcoRA, direct toxicological effects on predator fish (represented by northern pike) are not expected to occur, as the estimated HQ for copper for predator fish was below 1 for both the Application Case and reasonable upper bound scenario. Therefore, no changes to the survival and reproduction of predator VCs, including lake trout, walleye, and northern pike, are expected due to exposure to copper in the water column.

The EcoRA concluded that direct toxicological effects on forage fish (represented by lake whitefish in the EcoRA) could not be ruled out based on an estimated HQ of slightly greater than 1. However, if effects were to occur, the predicted magnitude would be limited by the minimal exceedance of the copper TRV. Overall, the results of the aquatic health assessment supported these conclusions and indicated that any potential health effects on aquatic biota, including fish VCs, would be minimal and would be within the range of variability observed in unexposed populations. Both the EcoRA and aquatic health assessment results indicated that population-level effects are not expected to occur. Large-bodied fish such as lake whitefish are mobile and can move around among basins within Patterson Lake, or to nearby waterbodies; therefore, it is unlikely that individuals would be exposed to the maximum copper concentration for extended periods.

The growth and productivity of fish is strongly influenced by the available food supply. As described in Section 11.5.2.4.1, changes to the health of lower trophic level organisms and forage fish due to exposure to copper in the water column could result in limited effects on the food base for fish in Patterson Lake North Arm – West Basin. These potential changes could propagate up the food web and adversely affect the survival and reproduction of fish VCs. The potential effects of a reduction or change in the quality or quantity of available prey for fish can include changes in growth, body size, reproductive output, or population size. The type and magnitude of effect is dependent of several factors including the complexity of feeding interactions, the preferred diet of the affected fish species, and the existing density of affected fish populations.

Because effects on habitat availability resulting from changes to the food base for fish are predicted to be negligible, or at most low in magnitude, and because any realized changes would be limited by the limited spatial extent of elevated copper concentrations, it is unlikely that there would be meaningful changes to the survival and reproduction of fish VC populations due to changes in available food supply. Some limited effects on the food base for fish are possible due to the potential for a slight reduction in the availability or biomass of individual prey items (e.g., taxa or species that may be sensitive to elevated copper concentrations); however, corresponding effects on the productivity of forage fish species such as lake whitefish, and piscivorous species such as lake trout, walleye, and northern pike, are unlikely to occur as the transfer of energy between trophic levels is inefficient. Only about 10% of available energy typically is transferred between trophic levels due to factors such as incomplete ingestion of food, energy used for respiration, and energy lost as waste (excreted) (Krebs 2009). Therefore, only limited effects on fish VC survival and reproduction are possible due to changes to food supply, and it is unlikely that these changes would be measurable at the predicted copper concentrations for both the Application Case and the reasonable upper bound scenario.

Based on the results of the EcoRA and aquatic health assessment, and given the conservatism applied to the surface water quality modelling assumptions for copper in the far future, predicted effects on fish VCs due to changes in survival and reproduction in the Application Case are considered to be negative in direction and negligible in magnitude (i.e., within the range of background variability and unlikely to be measurable); however, it is conservatively considered possible that low magnitude effects may occur. Therefore, the predicted magnitude of effects on fish VC survival and reproduction due to potential direct effects resulting from to exposure to copper in the water column, and indirect effects related to changes in habitat availability, was assessed as negligible to low.

Exposure of fish VCs to maximum copper concentrations and predicted changes in habitat availability would be limited spatially to Patterson Lake North Arm – West Basin for the Application Case and may extend into Patterson Lake South Arm in the reasonable upper bound scenario. However, as fish VCs can move around, the geographic extent of effects on survival and reproduction was assessed as local. The frequency of potential effects on fish VC survival and reproduction would be limited to dry climate years when there is a lower natural runoff to the lake. However, effects could potentially occur continuously during periods when predicted concentrations exceed reference values (i.e., TRVs, no effects or low effects thresholds).

In consideration of all assessment factors, the predicted effects to survival and reproduction are considered to be possible, meaning that the predicted changes may occur but are not likely.

11.5.3 Reasonably Foreseeable Development Case

This subsection presents the results of the residual effects analysis for fish and fish habitat for the RFD Case. A summary of the results of the predicted changes to surface water quality and resulting health effects on aquatic biota in the RFD Case for the far future is provided in Section 11.5.3.1 to Section 11.5.3.3. Details can be found in Section 10, TSD XXI, and Appendix 11A. Predicted effects on fish VC populations in the RSA resulting from changes to habitat availability, survival, and reproduction in the RFD Case are described in Section 11.5.3.4, Effects on Lake Trout, Lake Whitefish, Walleye, and Northern Pike.

Mitigation measures incorporated into the Project, as described for the Application Case (Table 11.4-1 and Section 11.5.2.1, Summary of Predicted Changes to Surface Water Quality), are expected to also limit the potential for effects on fish VCs due to the cumulative effects of the Project and Fission Patterson Lake South Property. Information on specific mitigation measures that would be implemented for the Fission Patterson Lake South Property to avoid or reduce effects on surface water quality was unavailable; however, it was assumed that similar types of measures that are being employed for the Project would be implemented for the Fission Patterson Lake South Property.

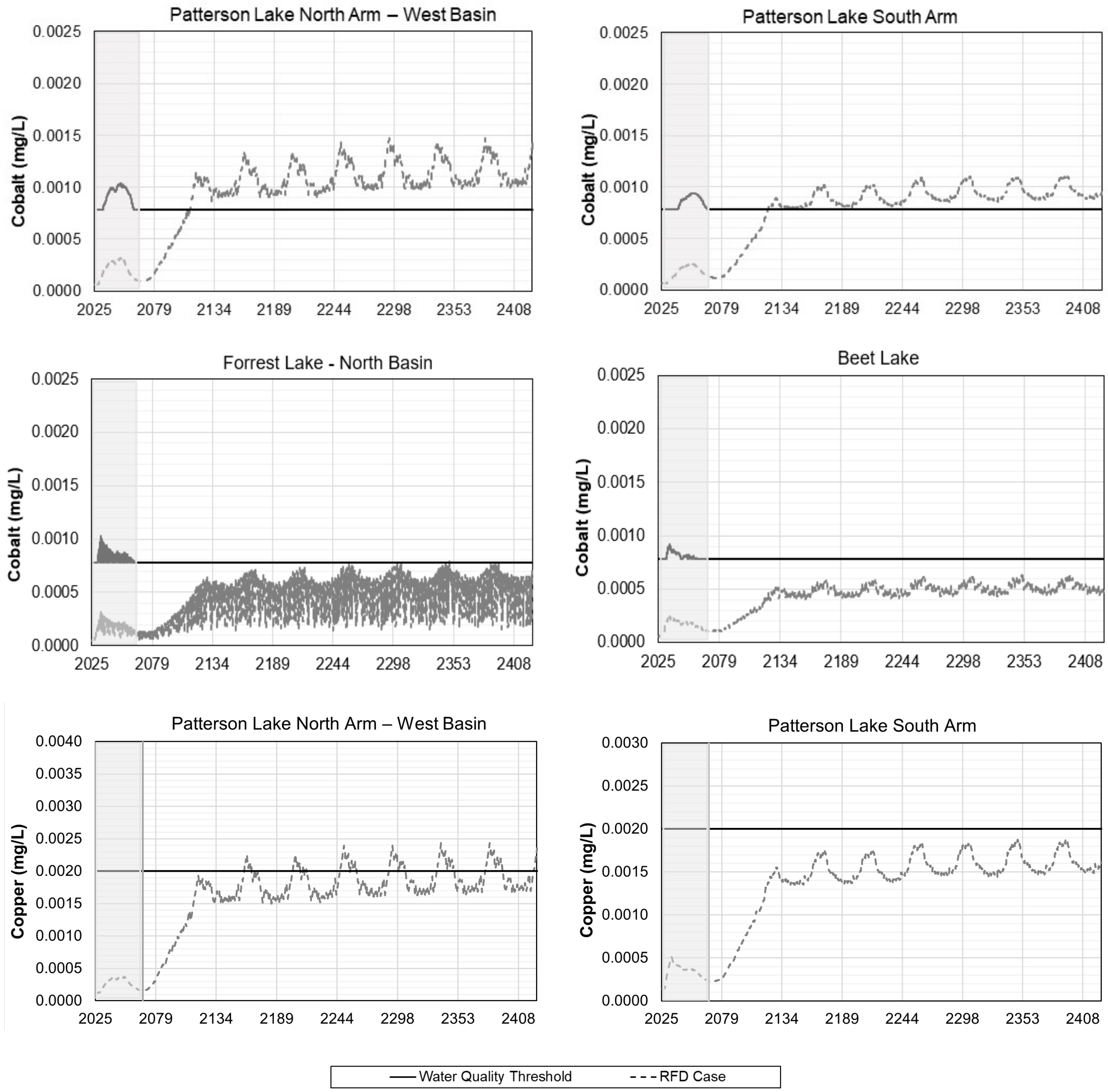
11.5.3.1 Summary of Predicted Changes to Surface Water Quality

The general influence of the RFD Case on surface water quality in the far future projection would represent a very slight increase in the concentrations of metal COPCs in Patterson Lake compared to the Application Case. Similar to the Application Case, concentrations of metal COPCs were predicted to increase in the far future compared to during the Project lifespan and Base Case. The primary loading source for metals in the far future is from groundwater influenced by loadings generated by seepage from the WRSAs and the UGTMF. However, despite the primary contribution of COPC metals being from loading to groundwater from the Project, COPC metals concentrations are slightly elevated compared to the Application Case because of the additional metal mass loadings to Patterson Lake contributed by the Fission Patterson Lake South Property site runoff from the above-ground tailings management facility and covered waste rock storage facility. Overall, concentration trends in the far future remain very similar to the concentrations and trends predicted for the Application Case. Similar to the Application Case, all metal COPC concentrations in the RFD Case were predicted to remain below thresholds in all waterbodies in the LSA during the far future, with exception of cobalt and copper. Cobalt was predicted to exceed water quality thresholds during the modelled far future period in Patterson Lake North Arm – West Basin and Patterson Lake South Arm (Figure 11.5-4). Cobalt exceedances are limited to Patterson Lake with the maximum monthly concentrations in Forrest Lake – North Basin (i.e., 0.00077 mg/L) predicted to be below the Project threshold. Copper exceedances are predicted periodically in Patterson Lake North Arm – West Basin only (Figure 11.5-4).

In the RFD Case, radionuclide concentrations were predicted to be slightly greater compared to the Application Case due to the loading of these constituents from the Fission Patterson Lake South Property. Radionuclides defined as COPCs were predicted to remain below water quality thresholds in all waterbodies in the LSA in the far future.

The results of the climate change sensitivity scenario completed for the RFD Case indicate that the effects of climate change on COPC concentrations were minor overall. Climate change is generally expected to result in wetter and warmer conditions in the RSA in the far future projection (Section 9.4). In general, the influence of these changes is an increase in water levels and flows in the RSA. However, variability of water levels and flows would also increase, which results in some COPCs having slightly higher concentrations and others having slightly lower concentrations (Section 10.5.2.1.6). For copper and cobalt, which were predicted to exceed water quality threshold values in the RFD Case, there is some minor variability between trends for the RFD Case and RFD plus climate change sensitivity scenario (Section 10, Figure 10.5-17); however, climate change is not predicted to result in a meaningful increase in the concentrations of these COPCs over the modelling timeframe, nor is it expected to alter the frequency or magnitude of the threshold exceedances.

Figure 11.5-4: Cobalt and Copper Concentrations Predicted by the Regional Surface Water Quality Model, Reasonably Foreseeable Development Case



Note: The shaded area of the plot is representative of the lifespan of the Project, and the unshaded area is representative of the far-future projection.
RFD = reasonably foreseeable development.

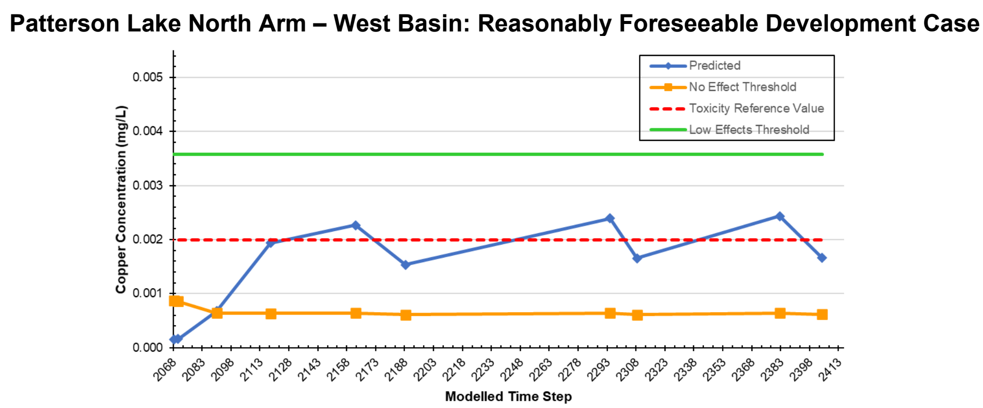
11.5.3.2 Summary of Ecological Risk Assessment Results

The EcoRA component of the ERA presents the estimated risks to aquatic receptors due to releases from the Project and the Fission Patterson Lake South Property to Patterson Lake in the far future. The list of COPCs considered in the RFD Case was the same as that evaluated in the Application Case. Similar to the Application Case, the estimated HQs in the RFD Case were predicted to be below 1 for all COPCs, except for copper. The results for the RFD Case are very similar to the far future in the Application Case, where the maximum HQ for copper was predicted to exceed 1 in Patterson Lake North Arm – West Basin for benthic invertebrates, zooplankton, and forage fish (represented by lake whitefish). There were no predicted exceedances of the 9.6 mGy/d radiation dose benchmark (UNSCEAR 2008; CSA Group 2022) for aquatic biota in the RFD Case.

11.5.3.3 Summary of Aquatic Health Assessment Results

The BLM and MLR model results for the RFD Case produced similar results to the Application Case. Copper concentrations in Patterson Lake North Arm – West Basin were predicted to consistently exceed the no effect threshold beginning after Closure but would remain below the low effect threshold for duration of the far future modelling timeframe (Figure 11.5-5). Predicted effects on the health of aquatic biota were the same as those described for the Application Case. Exposure of aquatic biota to predicted copper concentrations in Patterson Lake was assessed as unlikely to result in adverse effects on aquatic populations and communities. If effects occurred, the predicted magnitude would be within the range of background variability and thus unlikely to be measurable.

Figure 11.5-5: Predicted Copper Concentrations relative to No Effect and Low Effect Thresholds derived by the Biotic Ligand Model and Multiple Linear Regression Model, Patterson Lake North Arm – West Basin, Reasonably Forseeable Development Case



Source: Appendix 11A.

11.5.3.4 Effects on Lake Trout, Lake Whitefish, Walleye, and Northern Pike

As described for the Application Case (Section 11.5.2.2, Summary of Ecological Risk Assessment Results), the evaluation of effects on fish VCs follows directly from the predictions generated from the surface water quality assessment, aquatic health assessment, and the EcoRA. Therefore, the RFD Case assessment for fish and fish habitat incorporates a similar level of conservatism to that considered by these assessments. Uncertainty associated with the effects predictions related to the surface water quality assessment was carried forward into the RFD Case assessment for fish and fish habitat.

Overall, predicted effects on surface water quality, aquatic health, and ultimately the four fish VCs in the RFD Case were similar to the Application Case predictions. The main reason is that the additional metal mass loadings to Patterson Lake contributed by the Fission Patterson Lake South Property are minor overall compared to the inputs associated with the Project, which for the far future were largely associated with long-term solute transport from the WRSAs and UGTMF. The main influence of the Fission Patterson Lake South Property in the RFD Case is a slight increase in COPC concentrations, including copper concentrations, in the receiving environment. However, the inclusion of the Fission Patterson Lake South Property in the RFD Case does not result in meaningful changes to the effects predictions for fish VCs as outlined for the Application Case because mass loading from long-term solute transport from the Project is the main driver of the predicted effects on surface water quality and fish VCs.

The effects of future climate change were considered in the RFD Case through the inclusion of a climate change sensitivity scenario in the hydrological data inputs to the RSWQM. These inputs were thus carried through the EcoRA, the aquatic health assessment, and finally to the residual effects analysis for fish VCs. Results from the RFD plus climate change sensitivity scenario indicated that climate change effects on surface water quality within the LSA based on hydrological projections would be minor (Section 11.5.3.1). These minor changes in hydrologic conditions did not result in changes to COPC concentrations that ultimately changed the predicted effects for fish VCs from exposure to elevated copper concentrations in Patterson Lake after Closure of the Project and in the far future.

11.5.3.4.1 Effects on Habitat Availability

The results of the RFD Case assessment for effects on fish VC habitat availability are the same as those presented for the Application Case. Overall, negligible, or at most low magnitude effects on habitat availability are predicted to occur, resulting from the potential for effects on the health of lower trophic level communities and forage fish (e.g., lake whitefish) that form the food base for fish. The predicted geographic extent, duration, reversibility, frequency, and probability of occurrence of residual effects are the same as described for the Application Case.

11.5.3.4.2 Effects on Habitat Distribution

The results of the RFD Case assessment for effects on habitat distribution are the same as those presented for the Application Case. Overall, no adverse effects on habitat distribution in the RSA are predicted to occur as a result of changes to surface water quality in the aquatic receiving environment after Closure and in the far future. The predicted geographic extent, duration, reversibility, frequency, and probability of occurrence of residual effects are the same as described for the Application Case.

11.5.3.4.3 Effects on Survival and Reproduction

The results of the RFD Case assessment for effects on fish VC survival and reproduction are the same as those presented for the Application Case. Overall, negligible, or at most low magnitude effects on survival and reproduction are predicted to occur due to potential direct effects resulting from exposure of fish VCs to copper in the water column and changes in habitat availability. The predicted geographic extent, duration, reversibility, frequency, and probability of occurrence of residual effects is the same as described for the Application Case.

11.5.4 Residual Effects Classification and Determination of Significance

11.5.4.1 Classification Summary

Residual effects were classified for the Application Case and the RFD Case (Table 11.5-2). The residual effects classification for fish and fish habitat is focused on the far future projection that considers the long-term, slow migration of hydrogeological mass load inputs from certain areas of the site following Closure (i.e., WRSAs and the UGTMF).

Residual effects on fish VCs due to exposure to elevated copper concentrations in Patterson Lake in the far future are predicted to occur as a result of potential changes in habitat availability and survival and reproduction. No residual adverse effects on habitat distribution are expected; therefore, residual effects were classified for the habitat availability and survival and reproduction measurement indicators only.

For the Application Case, which considered a reasonable upper bound scenario, the residual effects classification was based on the Application Case predictions and not the predicted reasonable upper bound conditions. The reasonable upper bound scenario incorporated a high level of conservatism that was intended to provide a precautionary, more conservative bound for the assessment. The Application Case presents a more realistic yet reasonably conservative representation of the potential Project-related effects on fish VCs from changes in surface water quality after Closure and in the far future, and was, therefore, the focus of the residual effects classification.

Effects of future climate change were considered in the RFD case. As outlined in Section and 10.2.8.1.2 and Section 11.5.1.1, a sensitivity scenario was considered within the RFD Case for the RSWQM, which evaluated the effects of future climate change based on hydrological processes. These inputs were then carried through to the residual effects analysis for fish VCs. The classification of effects for the RFD Case under the climate change scenario is consistent with the classification for the RFD Case. Results from the RFD plus climate change sensitivity scenario indicated that climate change effects on surface water quality within the LSA based on hydrological projections would be minor and did not result in changes to COPC concentrations that ultimately changed the effects classification for fish VCs.

The residual effects classification considered the implementation of mitigation outlined in Section 11.4 to reduce the magnitude of residual effects on surface water quality, aquatic health, and consequently, fish VCs. Effective implementation of mitigation outlined in Section 11.4 would be expected to reduce the magnitude and duration of residual effects on fish VCs.

Residual effects on fish VCs are summarized according to direction, magnitude, geographic extent, duration/reversibility, frequency, and probability of occurrence following the methods described in Section 11.2.8, Residual Effects Analysis.

Table 11.5-2: Classification of Residual Effects on Lake Trout, Lake Whitefish, Walleye, and Northern Pike Measurement Indicators for the Application Case and Reasonably Foreseeable Development Case in the Far Future

Measurement Indicator	Criterion	Rating / Effect Size	
		Application Case	RFD Case
Habitat availability	Direction	Negative	Negative
	Magnitude	Negligible to low: due to the potential for limited changes to the food base for fish resulting from exposure to elevated copper concentrations in the far future projection	Negligible to low: due to the potential for limited changes to the food base for fish resulting from exposure to elevated copper concentrations in the far future projection
	Geographic extent	Local: restricted to Patterson Lake North Arm – West Basin where peak copper concentrations are predicted to occur	Local: restricted to Patterson Lake North Arm – West Basin where peak copper concentrations are predicted to occur
	Duration	Permanent	Permanent
	Reversibility	Irreversible: not reversible before end of modelling timeframe	Irreversible: not reversible before end of modelling timeframe
	Frequency	Periodic: fluctuating with climate	Periodic: fluctuating with climate
	Probability of occurrence	Possible	Possible
Survival and reproduction	Direction	Negative	Negative
	Magnitude	Negligible to low: due the potential for direct toxicological effects (lake whitefish) and/or due to predicted changes in habitat availability (i.e., food base; all VCs)	Negligible to low: due the potential for direct toxicological effects (lake whitefish) and/or due to predicted changes in habitat availability (i.e., food base; all VCs)
	Geographic extent	Local: exposure of fish VCs to peak copper concentrations and changes in habitat availability would be restricted to Patterson Lake North Arm – West Basin. However, as fish VCs can move around, the geographic extent of effects on survival and reproduction was assessed as local	Local: exposure of fish VCs to peak copper concentrations and changes in habitat availability would be restricted to Patterson Lake North Arm – West Basin. However, as fish VCs can move around, the geographic extent of effects on survival and reproduction was assessed as local
	Duration	Permanent	Permanent
	Reversibility	Irreversible: not reversible before end of modelling timeframe	Irreversible: not reversible before end of modelling timeframe
	Frequency	Periodic: fluctuating with climate	Periodic: fluctuating with climate
	Probability of occurrence	Possible	Possible

VC = valued component; RFD = reasonably foreseeable development.

11.5.4.2 Significance Determination

Fish VC populations are considered to have ecological resilience and adaptive capacity to changes in habitat availability and survival and reproduction in the Base Case. Each of the fish VCs included in the fish and fish habitat assessment are common in Saskatchewan (SKCDC 2021b) and occur throughout the LSA and RSA (Section 11.3.6; Annex V.1). In particular, lake whitefish, walleye, and northern pike were found to be abundant and widely distributed throughout the LSA and RSA based on the results of the aquatic environment baseline study (Annex V.1). Lake trout were somewhat less common in the LSA and RSA but were present in the larger, deeper lakes in the LSA and RSA. Suitable habitat for spawning, nursery, rearing, feeding, and overwintering was readily available for all four VCs in the LSA and RSA. The results of baseline studies completed in Patterson Lake, the Clearwater River, and downstream waterbodies along the Clearwater River flow path indicate the presence of relatively undisturbed conditions (Annex V.1). This finding is based on the relatively dilute nature of waterbodies and watercourses in the LSA and RSA (i.e., the incidence of low concentrations of metals and major ions) and the occurrence of oligotrophic conditions (Annex V.1). Existing pressures on fish VC populations include effects from recreational and subsistence fishing. However, overall, the evidence indicates that fish VC populations in the RSA are self sustaining and ecologically effective in the Base Case.

Application Case

In the Application Case, changes to habitat availability and the survival and reproduction of fish VCs as a result of the Project are predicted to be negative in direction and negligible to low in magnitude. These effects are predicted to occur due to changes in surface water quality in Patterson Lake in the far future. The primary source of loading for COPCs in the far future would be the seepage load through the groundwater flow path from the Project footprint. In particular, predicted copper concentrations in the far future would have the potential to affect fish VC habitat availability, survival, and reproduction.

Effects on fish habitat availability could occur due to the potential for changes to the food base for fish. However, at the predicted copper concentrations, any changes to the food base that may be realized would be limited to a potential decrease in abundance and/or biomass of selected prey items for fish VCs (i.e., species or taxa that may be sensitive to elevated copper concentrations). This decrease would not be expected to meaningfully change the available food supply for fish or adversely affect the suitability of the affected habitat for use by fish VCs. Any changes in habitat quality would be unlikely to be measurable.

Effects on survival and reproduction could occur directly as a result of exposure to copper in the water column, or indirectly, as a result of changes in habitat. Based on the results of the EcoRA and aquatic health assessment completed for the Project, effects on the health of fish due to direct exposure to copper in the water column are not expected for predator fish (e.g., lake trout, walleye, northern pike) and are unlikely for forage fish (e.g., lake whitefish). Changes in habitat quality are considered unlikely to measurably affect the survival and reproduction of fish VCs. Effects on fish VC habitat availability and survival and reproduction were determined to be local in geographic extent since exposure of aquatic organisms to maximum copper concentrations would be spatially limited to the Patterson Lake North Arm – West Basin. The predicted effects are not reversible before the end of the modelling timeframe and are therefore considered to be permanent. The frequency of effects is anticipated to be periodic, as exposure of aquatic organisms to maximum copper concentrations would occur only during limited periods (i.e., dry climate years when there is a lower natural runoff to the lake). The likelihood for the effects occurring is expected to be possible. This likelihood is based on the conservative assumptions and moderate to high degree of uncertainty associated with the groundwater solute transfer inputs to the RSWQM in the far future.

Reasonably Foreseeable Development Case

The predicted effects in the RFD Case are very similar to the Application Case. The main influence of the Fission Patterson Lake South Property in the RFD Case would be a slight increase in COPC concentrations in the receiving environment, including for copper, compared to the Application Case. However, the inclusion of the Fission Patterson Lake South Property in the RFD Case does not result in any meaningful changes to the effects predictions for fish VCs, as outlined for the Application Case, because mass loading from long-term solute transport from the Project is the main driver of the predicted effects on surface water quality and fish VCs.

The effects of future climate change were considered in the RFD Case through the inclusion of a climate change scenario in the hydrological data inputs to the RSWQM, which was then carried through to the residual effects analysis for fish VCs. Overall, the effects of climate change on surface water quality were minor and did not result in changes to COPC concentrations that ultimately changed the predicted effects on fish VCs for the Application Case due to exposure to elevated copper concentrations after Closure of the Project and in the far future.

Overall Significance

Overall, the results of the residual effects analysis for fish and fish habitat indicate that the incremental effects from the Project would not have a significant adverse effect on the maintenance of self-sustaining and ecologically effective fish populations in the RSA; effects to fish and fish habitat VCs are predicted to be not significant. Although changes to fish VC habitat availability and survival and reproduction are possible, the predicted effects would be within the resilience and adaptability limits for the four fish VCs (i.e., lake trout, lake whitefish, walleye, northern pike). Similarly, the incremental cumulative effects from the Fission Patterson Lake South Property in the RFD Case and with the addition of climate change would be not significant.

11.5.5 Effects on Biodiversity

Aquatic biodiversity encompasses the variety of fish and aquatic species present in an area, as well as the ecosystem complexes to which they contribute. Biodiversity includes all levels of organization, including diversity within species (i.e., genetic diversity), among species (i.e., richness), and of ecosystems (Canadian Biodiversity Strategy 1995, 2020).

The aquatic environment baseline study (Annex V.1) describes the aquatic ecosystems, habitats, and taxa present throughout the LSA and RSA so that they may be adequately managed to prevent a loss of biodiversity. This baseline study included identification of fish and lower trophic level communities, including phytoplankton, zooplankton, and benthic invertebrates. The LSA and RSA defined for the fish and fish habitat assessment contain both riverine (i.e., in river or watercourse) and lacustrine (i.e., waterbody) ecosystems, which provide fish habitat and support a variety of fish and aquatic species. These study areas include several large waterbodies, the Clearwater River, and numerous tributaries and smaller waterbodies. The larger waterbodies provide fish habitat year-round, including spawning, rearing, feeding, and overwintering habitat. Smaller waterbodies and tributary habitats provide suitable habitat for spawning, rearing, and feeding for portions of the year but may not provide overwintering habitat since DO levels in shallow lakes can be limiting and tributary habitats may freeze to bottom. Spring and fall spawning habitats are available for a variety of fish species.

In total, 17 fish species were identified in the LSA and RSA. Each of these species is common in northern Saskatchewan and native to the area. Consistent with the recommendations of Environment Canada (2012), the characterization of lower trophic level diversity occurred at the level of family. In total, 27 phytoplankton families, 13 zooplankton families, and 16 benthic invertebrate families were identified in the LSA and RSA through baseline sampling for the Project. When compared with the biological diversity represented by fish communities, lower trophic level organisms represent high levels of diversity within the local aquatic environment.

The genetic diversity of fish populations in the Project LSA and RSA is expected to be healthy. This finding is based on the relative absence of major existing developments, or disturbances in the LSA and RSA that might threaten the maintenance of diversity within a species. For example, there are no known barriers to fish movement identified in the LSA and RSA that might subdivide fish species into isolated or semi-isolated populations with little genetic differentiation (Parkinson et al. 1999). Existing effects on genetic diversity are likely to include limited effects from the harvesting of fish for recreational and subsistence purposes, which may limit genetic diversity to some degree by removing individuals, and therefore genetic information, from populations.

Potential Project-related effects on aquatic biodiversity were evaluated based on the assessment completed for the fish VCs, which were selected, in part, because they are strong ecological indicators of broader species assemblages and ecosystems (Section 11.2.2.1, Valued Components). For example, effects on lake whitefish are representative of effects on forage fish assemblages that support a variety of piscivorous fish species. Additionally, the effects assessment for fish VCs considered the potential for changes to lower trophic level organisms, including phytoplankton, zooplankton, and benthic invertebrates, which are an important component of the aquatic food web and provide the food base for fish. The assessment of the selected VCs also considered the potential for effects on the key elements comprising aquatic biodiversity (i.e., genetic, species, and ecosystem diversity) through the evaluation of changes in measurement indicators defined for VCs. For example, changes to species diversity were considered in the assessment of the survival and reproduction measurement indicator.

The primary mechanism by which the Project could affect aquatic biodiversity in the LSA and RSA would be through alteration of surface water quality in Patterson Lake after Closure and in the far future and the potential for corresponding effects on aquatic health and fish habitat quality (Section 11.5.2). The primary source of loading for COPCs in the far future is predicted to be from the seepage load through the groundwater flow path from selected areas of the Project footprint (i.e., WRSAs, UGTMF). In particular, exposure to elevated copper concentrations in Patterson Lake North Arm – West Basin has the potential to affect the health of fish and aquatic organisms. Aquatic species diversity could therefore be affected as a result of direct exposure of fish and aquatic organisms to elevated concentrations of copper in water or sediments.

The results of the EcoRA and aquatic health assessment completed for the proposed Project indicated that exposure to predicted copper concentrations in the far future would be unlikely to result in residual adverse effects on aquatic species diversity in the LSA and RSA for both the Application Case and the RFD Case (TSD XXI; Appendix 11A; Section 11.5.2 and Section 11.5.3). The results of these assessments indicate that any potential effects from copper exposure would be limited to individual taxa or species that may be sensitive to elevated copper concentrations. Population-level effects are not expected to occur based on the predicted level of exposure and limited spatial extent of elevated copper concentrations (i.e., Patterson Lake North Arm – West Basin). Overall, there would be limited potential for effects on aquatic species diversity locally in Patterson Lake South Arm – West Basin; however, changes to species diversity at the lake-wide scale, or the scale of the LSA and RSA are not anticipated. Additionally, at most, negligible effects on genetic diversity would be expected at the predicted magnitude of effect due to the limited potential for losses of individuals and, therefore genetic material, from aquatic populations.

Effects on ecosystem diversity are considered unlikely to occur as a result of the Project, for both the Application Case and the RFD Case. Limited and localized effects on fish habitat quality would be possible in Patterson Lake North Arm – West Basin due to the limited potential for health effects on lower trophic level organisms and on forage fish species that form the food base for fish (Section 11.5.2.4). However, no adverse effects on the viability of habitats for use by fish VCs or on the functionality of affected habitats are predicted to occur. Therefore, there would be no resulting loss of habitat that could contribute to an overall loss of ecosystem diversity. Additionally, based on the results of the EcoRA and aquatic health assessment, exposure to copper in Patterson Lake would be unlikely to result in adverse effects on aquatic communities, which in combination with abiotic factors (e.g., water quality) form an important component of the overall aquatic ecosystem.

Water pollution is only one of many potential threats to aquatic biodiversity in Canada (Canadian Biodiversity Strategy 1995, 2020). Other factors that could adversely affect aquatic biodiversity, and that were considered in the analysis of potential Project-related effects on fish and fish habitat, include the potential for direct habitat loss, including changes in riparian vegetation, habitat fragmentation, sediment release, and effects from increased fishing pressure. Each of these factors was considered in the evaluation of the potential pathways of effects on fish and fish habitat in Section 11.4. However, with implementation of best management practices and mitigation, the effects of these potential factors on fish VCs and aquatic biodiversity are expected to be negligible in magnitude.

Overall, the predicted effects of the Project and RFDs on aquatic biodiversity were considered to be negligible. As exposure of aquatic biota to elevated copper concentrations would be restricted to Patterson Lake North Arm – West Basin, the geographic extent of effects was considered local. The duration and reversibility of the predicted effects would be permanent and not reversible. The probability of occurrence was characterized as possible, meaning that effects are unlikely, but may occur.

11.6 Prediction Confidence and Uncertainty

Scientific inference is associated with uncertainty, and prediction confidence (i.e., the level of confidence in assessment results) depends on the level of uncertainty and the way this uncertainty is addressed. Primary factors affecting confidence in the predictions made in the fish and fish habitat assessment include:

- availability and accuracy of baseline data;
- level of understanding of baseline fish and fish habitat conditions, range of natural variation, and the resilience of fish VCs to disturbance;
- accuracy and certainty of water balance modelling inputs and results;
- accuracy and certainty of environmental modelling inputs and results for intermediate components and technical support documents (i.e., air quality, hydrogeology, hydrology, surface water quality, EcoRA, aquatic health), which provided the basis for assessing effects on fish and fish habitat;
- understanding of Project-related effects on complex ecosystems that contain interactions across different scales of time and space (e.g., exactly how the Project would influence fish VCs);
- level of understanding of the cumulative drivers of change in measurement indicators and associated effects on fish VCs, including uncertainty related to climate change projections with respect to future hydrologic and surface water quality conditions, and the associated responses of fish VCs; and
- level of certainty associated with the effectiveness of proposed mitigations, where applicable.

Uncertainty was managed by:

- reviewing baseline studies and other relevant information related to existing fish and fish habitat conditions in the LSA and RSA;
- completing quality assurance and quality control of baseline data;
- applying conservative assumptions regarding the footprint area and related Project activities that may cause disturbance or direct fish habitat loss to increase confidence that the effects were not underestimated;
- applying conservative assumptions regarding the potential for effects from changes to surface water quantity and quality to increase confidence that the effects were not underestimated; and
- comparing assessment results to relevant published scientific literature.

Prediction confidence and uncertainty with respect to predictions related to hydrogeology, surface water quality, and the EcoRA, and aquatic health are described in Sections 8.6, 9.6, 10.6, TSD XXI, and Appendix 11A.

Overall, there is a moderate to high degree of confidence in the predictions related to the changes to fish VCs during the Project lifespan (i.e., effects occurring during Construction, Operations, and Closure). Mitigation measures and best management practices would be implemented to reduce effects on the aquatic ecosystem and fish VCs. There is a high degree of confidence associated with the predicted changes in fish habitat availability associated with the development of water management infrastructure (i.e., fresh water intake, treated effluent diffuser, treated sewage outfall) in Patterson Lake. The estimated physical footprint of these structures is generally well understood and is based on conceptual design information and previous experience with similar types of developments for mining developments in northern Canada. There is also a good understanding of the existing fish habitat conditions in the immediate vicinity of the affected areas in Patterson Lake, where intensive surveys were completed during the aquatic environment baseline study (Annex V.1). Additionally, conservative assumptions were used when estimating the potential loss or disturbance to riparian vegetation (e.g., use of a conservative 30 m buffer). Overall, it is unlikely that effects associated with this Project interaction are underestimated.

There is a moderate to high degree of confidence in the predicted changes in fish VC habitat availability and distribution resulting from changes to surface water hydrology. As with any predictions of future conditions, the hydrologic predictions made in Section 9.6 (Residual Effects Analysis) embody some degree of uncertainty, which was carried forward into the fish and fish habitat assessment. Sources of uncertainty associated with the hydrologic modelling included assumptions related to initial conditions and variability in current climate data, particularly rainfall, wind speed, and humidity (Section 9.6). Uncertainty in model input data was mitigated using various methods, including calibrating the regional hydrology model using baseline hydrometric data and validating the model against long-term regional data. These approaches demonstrated that the model generated realistic predictions. Conservative approaches were used when describing effects; for example, the summary of potential effects on hydrometric measurement indicators focused on the Project phases and locations where peak effects were expected to occur. Consequently, uncertainty was addressed in a manner that increased the level of confidence that residual effects on hydrometric conditions and, therefore fish habitat, were conservatively predicted (Section 9.6).

The level of certainty associated with the predicted effects on fish VC habitat availability, survival, and reproduction due to changes in surface water quality during the Project lifespan, was moderate to high. Sources of uncertainty for the surface water quality modelling used to support the assessment of effects on fish and fish habitat included adequacy of baseline data and uncertainties related to the air quality dispersion model, the groundwater solute transport model, and the site-wide water balance model, which were used as inputs to the RSWQM (Section 10.6). Baseline water quality data were considered adequate but were subject to limitations related to the list of constituents and detection limits. For example, the elevated detection limit used for TP during the baseline monitoring period limited the sensitivity of the effects analysis for fish and fish habitat to predict the potential changes to biological productivity in Patterson Lake with a high level of accuracy; however, given that no changes to lake trophic status were predicted to occur due to Project discharges and activities, it is likely that residual effects on fish VCs related to nutrient inputs were conservatively predicted. Inputs to the RSWQM were developed based on conservative assumptions, as described in Section 10.6. Consequently, uncertainty was addressed in a manner that increased the level of confidence that the assessed residual effects on surface water quality in the receiving environment, and therefore fish VCs, did not underestimate potential effects from Project interactions.

Uncertainty associated with the results of the EcoRA component of the ERA completed for the Project also influenced the level of confidence in the effects predictions for fish VCs due to changes in surface water quality during the Project lifespan. Sources of uncertainty associated with the EcoRA included uncertainties related to the exposure of ecological receptors to maximum COPC concentrations and limitations associated with the estimation of ecotoxicological effect levels for COPCs (i.e., TRVs). The measures taken to address uncertainties in the EcoRA are described in TSD XXI and are anticipated to produce conservative exposure estimates, TRVs, and resulting risk estimates for ecological receptors. In general, measures used to address uncertainties are expected to cause an overestimation, and not an underestimation, of risk due to the conservative approaches employed in the EcoRA. Therefore, the resulting predictions for fish VCs due to exposure to COPC in surface waters are also considered conservative.

Monitoring of water and sediment quality, fish, and benthic invertebrates in the receiving environment would be used throughout the Project lifespan to address residual uncertainty by evaluating the responses of aquatic organisms to Project discharges against the predicted effects in the EIS (Section 11.7). Adaptive management would be incorporated into the design of monitoring programs and would identify management actions that could be used to reverse or reduce unacceptable adverse effects on aquatic ecosystem components.

Overall, the degree of confidence in the predictions related to the changes to fish VCs from changes to water quality after Closure and in the far future was lower than for the Project lifespan; however, conservatism considered in the assessments completed for intermediate components and TSDs that provided the basis for the assessment of effects on fish and fish habitat improved the overall level of confidence that effects are not underestimated. Inputs from the groundwater solute transport model are the primary source of uncertainty associated with the predicted effects on surface water quality, aquatic health, and consequently fish VCs. The inputs from the groundwater solute transport model were considered to be conservative as the source terms used in the model were derived in a conservative manner.

The assumptions in the groundwater solute transfer model include limited source control associated with the WRSAs and the UGTMF, which means that all infiltration and seepages through and from these facilities generate mass via contact with waste rock and ore tailings and carry them to the groundwater. Of these sources, the PAG WRSA was identified as being the main source that could lead to copper guideline exceedances in Patterson Lake in the far future. Despite this process being slow, the incremental mass eventually reaches Patterson Lake and propagates downstream through the waterbodies in the LSA. Further, the geochemical source terms associated with the waste rock that are assigned to the seepage and infiltration as they migrate to the groundwater in the far future period are conservative, assuming that all contact material is consistent with PAG material sources, which are assumed to be the prominent waste rock condition in the far future, conservatively assuming no source depletion over time.

As part of the Project design, source control would be applied to the WRSAs and UGTMF to reduce and control infiltration and seepage to reduce the potential mass loading from these facilities to the groundwater. Source control with respect to the PAG WRSA includes incorporating a physical liner under the storage area, reducing oxygen ingress to the waste rock, and providing a form of cover that enhances runoff and limits infiltration. Additionally, monitoring seepages and runoff quality at the PAG and NPAG WRSAs during and after Operations, and incorporating adaptive management would be expected to result in notable reductions in the mass loading carried into the far future surface water quality assessment. Adaptive management would be used to refine source terms, reduce uncertainty, and adapt the level of mitigation in response to operational datasets. Source control with respect to the UGTMF includes the design, maintenance, and monitoring of a mine dewatering system to control the flow of groundwater inflow, applying a binder to reduce permeability in backfill and tailings, and engineering tailings geochemistry such that the release of mass is controlled. Additionally, monitoring the UGTMF during and after Operations, and incorporating adaptive management would be expected to result in notable reductions in the mass loading carried into the far future surface water quality assessment.

The groundwater solute transport applied a number of sensitivity analyses to address uncertainty. Please refer to Section 8.6 for a full explanation.

The conservatism and sources of uncertainty previously described for the EcoRA and those associated with the aquatic health assessment (Appendix 11A) also influence the level of confidence in the predictions for fish VCs due to changes in surface water quality in the far future. As with all models, the BLM and MLR models used in the aquatic health assessment have limitations based on their assumptions and data inputs. Model limitations were mainly related to uncertainty associated with measured and predicted water quality used as inputs. Overall, uncertainties in the aquatic health assessment were considered to have low influence on the interpretation or use of the results for the purpose of evaluating the potential for adverse effects on aquatic health due to predicted copper concentrations. Overall, it is unlikely that potential health effects on aquatic biota have been underpredicted.

Overall, the level of confidence associated with the predictions related to the changes to fish VCs during the Project lifespan (i.e., effects occurring during Construction, Operations, and Closure) is moderate to high, whereas the level of confidence in the predicted effects on fish VCs after closure and in the far future are lower overall. The assessment applied a precautionary approach to address uncertainty by identifying the greatest magnitude, duration, and geographic extent of potential adverse effects when a range of possible outcomes was possible. Consequently, the predicted effects incorporate a high degree of conservatism and are unlikely to be underestimated.

11.7 Monitoring, Follow-Up, and Adaptive Management

Monitoring programs are proposed to address the uncertainties associated with the effect predictions and the performance of environmental design features and mitigation related to the proposed Project. In general, monitoring is used to verify the effects predictions, to identify any unanticipated effects, and implement adaptive management to limit these effects. This subsection presents a summary of the identified monitoring and follow-up activities proposed to monitor for potential Project effects in the receiving environment. Specifically, monitoring programs would be used to:

- Monitor for changes to fish and fish habitat, including lower trophic level community conditions (e.g., benthic invertebrates), in the receiving environment as a result of Project activities.
- Verify the predictions of the EIS and confirm that the aquatic ecosystem in the receiving environment is protected.
- Evaluate the effectiveness of mitigation measures and modify or enhance as necessary through monitoring and developing updated mitigation, if needed.
- Identify unanticipated negative effects, estimate spatial extent of effects, and support the implementation of adaptive management measures to address previously unanticipated adverse environmental effects.
- If applicable, monitor and evaluate the success of any fish habitat offsetting measures constructed for the Project.
- Contribute to the overall continual improvement of the Project.

The Environmental Monitoring Plan would be implemented to mitigate effects on fish and fish habitat and apply adaptive management where necessary. Monitoring results would be used to adjust or adapt mitigation measures or reclamation approaches used to limit Project effects on fish. In the context of REGDOC-2.9.2 (CNSC 2021b), adaptive management is a planned and systematic process for continuously improving environmental management practices by learning more about the outcomes where such information could improve site-specific understandings and possibly reduce the level of conservatism initially used to compensate for the lack of complete understanding of the interaction. Adaptive management provides flexibility to identify and implement new mitigation measures or to modify existing ones during the life of a project. It may include increased monitoring, changes in monitoring plans, or additional mitigation. In addition, special studies, which are studies proposed with the intent to supplement the primary monitoring programs, address potential data gaps, and support future monitoring, may be considered.

With regards to the specific issue of copper loading from the PAG WRSA to Patterson Lake in the far future, NexGen is developing an adaptive management plan to reduce uncertainty and manage risks related to this pathway.

The Environmental Monitoring Plan would be developed in accordance with the Metal and Diamond Mining Effluent Regulations (MDMER) for metal and diamond mining environmental effects monitoring (EEM), the federal *Fisheries Act*, the CNSC operating licence, and the ENV operating licence requirements.

The key components of the aquatic ecology environmental monitoring program are expected to include water and sediment quality, benthic invertebrates, and fish. Monitoring for water and sediment quality is addressed in detail in Section 10.7. Monitoring would be carried out in accordance with the MDMER and requirements of EEM (Environment Canada 2012) and with conditions identified through the licencing processes. The MDMER prescribes that EEM studies be performed to evaluate the potential effects of treated effluent release in the aquatic receiving environment. Environmental effects monitoring studies are designed to detect and measure changes in aquatic ecosystems and may include biological monitoring studies to determine if mine effluent is affecting fish, fish habitat, or the use of fisheries resources (Environment Canada 2012). Effects are assessed using regular cyclical monitoring and interpretation phases designed to evaluate changes in the receiving environment using standardized methods.

The monitoring program for water and sediment quality, benthic invertebrates, and fish would be designed to integrate the requirements of an EEM biological monitoring study (Environment Canada 2012). The MDMER identify triggers for biological monitoring based on effluent concentration in the receiving environment. Based on predictions for effluent dilution in the receiving environment, monitoring for benthic invertebrates and fish under EEM is expected to be initiated during Construction and continue on a cyclical basis during Operations.

Monitoring stations for benthic invertebrates and fish would be strategically located within the LSA, and specifically in Patterson Lake, to capture any potential effects in receiving waters as well as in reference waters. These stations would be identified under guidance of MDMER, ENV, and CNSC within the licensing process, and would be co-located with water and sediment quality sampling stations. The final study design for the Environmental Monitoring Plan and EEM would be determined through the permitting process and detailed planning, which would include consultation and engagement with regulatory agencies and local Indigenous communities.

Monitoring and sampling techniques and analysis procedures would be consistent with methods used during the baseline survey period to the extent possible. The field and laboratory processes would include the implementation of quality assurance / quality control measures for data acquisition, water and biota sampling, and analysis and reporting.

Along with the regular cyclical monitoring identified in the Environmental Monitoring Plan, additional monitoring may be required in accordance with the MDMER as part of an EEM program. The metal mining EEM program is an iterative system of monitoring and interpretation phases that is used to assess the effectiveness of environmental management measures by evaluating the effects of effluents on aquatic ecosystems. The EEM protocol has been designed to provide confirmation that a change or effect on the environment has or may occur prior to expending additional resources on additional monitoring and assessment and would be an overlay to the proposed protocol in the Environmental Monitoring Plan. If effects are confirmed in the receiving environment, a study investigating the potential cause of the observed effects may be required as part of the EEM protocol (Environment Canada 2012).

It is possible that a *Fisheries Act* Authorization may be required to permit component(s) of the site water management infrastructure proposed to be installed in Patterson Lake and that fish habitat offsetting may be required to counterbalance any residual adverse effects of these developments on fish habitat. If required, NexGen would develop an offsetting plan that would include a description of the monitoring measures that would be implemented to assess the effectiveness of the selected offsetting measures. The purpose of monitoring would be to determine if the selected measures are successful in meeting their objectives (DFO 2020). Details of the monitoring program, if required, would be developed in consultation with DFO and local Indigenous communities as a component of the *Fisheries Act* Authorization Application, which would be prepared during the permitting phase of the Project.

In compliance with MDMER, the federal *Fisheries Act,* the CNSC operating licence, and the ENV operating licence requirements, results of biological monitoring in the receiving environment would be reported in EEM reports on a schedule determined based on the monitoring phase for the Project.

In addition, Environmental Committees (i.e., one per primary Indigenous Group) composed of two NexGen and two Indigenous Group representatives would be established to act in an oversight manner to monitor the environmental performance of the Project and verify the parties are implementing the regulatory and environmental commitments made in respect of the Project.

Indigenous Groups have made recommendations related to mitigating the effects of the Project on the environment, including community-led long-term environmental testing and monitoring during Construction and Operations of the proposed Project (TSD IV: MN-S; TSD V.2: CRDN; TSD VI: YNLR). NexGen has committed to provide funding for the life of the Project for a full-time independent Indigenous Monitor chosen by each primary Indigenous Group; this Indigenous Monitor would have access to conduct environmental sampling for the Project, subject to the Indigenous Monitor complying with appropriate health and safety and other reasonable site-specific policies. The Indigenous Monitor would report openly and without restriction to the Environment Committee and Indigenous Group members on the performance of the Project. The Indigenous Monitor would also provide regular reports to the Environmental Committee.

11.8 Key Findings

The objectives of Section 11 were to provide a detailed and comprehensive assessment of all potential Project-specific effects and cumulative effects with RFDs on fish and fish habitat. Fish form an important role in the function of the aquatic food web and are an important resource culturally, economically, and traditionally to local Indigenous communities. During engagement for the Project, Indigenous community members spoke of the importance of fishing for subsistence, survival, and livelihood, and highlighted fishing as an important aspect of community and cultural life. Patterson Lake is highly valued by community members, in terms of both its historical and its current value and is considered of paramount importance to community members. Effects on fish and fish habitat were assessed for four VCs, lake trout, lake whitefish, walleye, and northern pike, which were informed by engagement with Indigenous communities.

This section meets the Terms of Reference for the Project submitted to the ENV and the Canadian Nuclear CNSC Generic Guidelines for the Preparation of an EIS Pursuant to CEAA 2012 (Appendix 1A) by providing a detailed and comprehensive assessment of potential Project-specific effects, and cumulative effects from the Project and other developments on fish and fish habitat.

A summary of key findings for fish and fish habitat section is provided as follows:

- Development of the physical Project footprint and activities related to the management of surface water on site were predicted in the hydrology assessment (Section 9) to result in limited changes to surface hydrology during Construction, Operations, and Closure. Small but undetectable increases in natural lake levels and watercourse flow rates were predicted to occur, with the largest increases expected in Patterson Lake and the Clearwater River downstream of Patterson Lake. Given the predicted magnitude of effects on hydrometric conditions, the predicted increases in natural lake levels and watercourse flow rates are expected to result in negligible and non-measurable residual effects on fish habitat availability and distribution in the LSA.
- Sediment release during in-water construction and from runoff due to ground disturbance may result in increased TSS and turbidity in Patterson Lake. These activities could result in short-term, localized, and minor changes to surface water quality in Patterson Lake. Implementation of sediment and erosion control best practices for both Construction and any other Project lifespan activities requiring ground disturbance are expected to effectively minimize the potential erosion of soils and associated transfer of sediment into nearby waterbodies. Overall, sediment release is expected to have negligible effects on fish habitat availability and the survival and reproduction of fish VCs.
- Project activities and discharges are predicted in the surface water quality assessment (Section 10) to result in an increase in the concentrations of metals and radionuclides in the downstream receiving environment during Construction, Operations, and Closure. However, concentrations were predicted to remain below Project-specific water quality threshold values. Exposures of aquatic organisms to COPCs in surface waters were predicted and assessed based on the results of the EcoRA (TSD XXI). Hazard quotients derived for aquatic receptors considered in the EcoRA were estimated to be less than the benchmark (i.e., HQ) of one, indicating that toxicological effects on aquatic populations or communities are not expected to occur during the Project lifespan, as exposure estimates to COPCs in water and sediment are below levels known to cause adverse effects. Therefore, negligible residual effects on the survival and reproduction of fish VCs were predicted as a result of the anticipated changes to water quality during the Project lifespan.

- The release of treated effluent and treated sewage from the ETP and STP, respectively, is anticipated to result in a minimal increase in nutrient concentrations in the receiving environment during Construction, Operations, and Closure. However, no changes to the trophic status of affected waterbodies are expected; Patterson Lake and downstream waterbodies are predicted to remain oligotrophic based on modelled concentrations of TP. The minimal increase in TP concentrations may result in limited changes to the productivity of phytoplankton, and potentially negligible and non-measurable effects on the productivity of zooplankton and benthic invertebrates. Effects on the productivity of fish, particularly piscivorous, upper trophic level consumers, are not expected. Overall, negligible residual effects on fish habitat quality and potentially, survival and reproduction of fish VCs, were predicted from changes in nutrient concentrations.
- Development of water management infrastructure components in Patterson Lake, including a fresh water intake, treated effluent diffuser, treated sewage outfall, and associated pipelines would result in a limited loss of fish habitat along the shoreline of the lake, adjacent to the proposed Project site. These developments have been designed to limit the in-water footprint in Patterson Lake and have been sited to avoid high quality fish habitats as much as possible. The total estimated in-water footprint associated with these developments is approximately 1,258 m^2, which represents 0.003% of the surface area of Patterson Lake (i.e.,38 km^2). The large majority (i.e., greater than 97%) of this footprint is associated with the conveyance pipes for the three structures. Overall, the physical habitat loss associated with these structures is predicted to result in a negligible change to habitat availability for fish VCs in Patterson Lake and no change to habitat distribution relative to existing conditions. If required, NexGen would submit a *Fisheries Act* Authorization application and an offsetting plan for the relevant component(s) of the water management infrastructure during the permitting phase of the Project.
- Effects on fish VCs could occur directly as a result of exposure to copper in the water column from runoff and seepage from the WRSFs and UGTMF in the far future. This could indirectly cause changes in habitat resulting from potential effects on the lower trophic food base for fish. The results of the EcoRA and aquatic health assessment (TSD XXI; Appendix 11A) completed for the Project indicated that effects on the health of fish due to direct exposure to copper in the water column, and therefore survival and reproduction, are not expected for predator fish (e.g., lake trout, walleye, northern pike) and are unlikely for forage fish (e.g., lake whitefish). Limited effects on the available food supply for fish are possible due to exposure of lower trophic level organisms (e.g., zooplankton and benthic invertebrates) and forage fish species to predicted copper concentrations; however, broadscale changes to the fish food base are not expected to occur. Any changes in habitat quality are considered unlikely to measurably affect the survival and reproduction of fish VCs.
- Overall, the predicted effects on fish habitat availability and survival and reproduction are expected to be negligible to low in magnitude and likely not distinguishable from natural background variability. Exposure of aquatic biota to maximum copper concentrations would be limited spatially to the North Arm – West Basin of Patterson Lake and temporally limited to dry climate years when there is a lower natural runoff to the lake. The predicted effects are considered possible, meaning that the changes may occur but are not likely permanent in duration and are irreversible. The effects of the Fission Patterson South Property on surface water quality during the far future are not expected to result in any changes to these effects predictions for fish VCs.

- The effects of future climate change on fish VCs were considered through the inclusion of a climate change scenario in the hydrological data inputs to the RSWQM, which was then carried through to the residual effects analysis for fish VCs. The effects of future climate change on the concentrations of COPCs defined in the surface water quality assessment, far future projection, were minor. Overall, based on the results of environmental modelling, climate change is not expected to meaningfully change the predicted effects defined for fish VCs in the RFD Case.

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Appendix 11A Aquatic Health Assessment of the Potential for Adverse Effects of Predicted Far-Future Copper Concentrations in Patterson Lake

Abbreviations and Units of Measure

Abbreviation	Definition
BLM	biotic ligand model
CCME	Canadian Council of Ministers of the Environment
COPC	constituent of potential concern
DOC	dissolved organic carbon
EC_{20}	20% effect concentration
EC_{25}	25% effect concentration
ECCC	Environment and Climate Change Canada
ETMF	exposure and toxicity modifying factor
FEQG	federal environmental quality guideline
HC_5	hazard concentration at 5%
HQ	hazard quotient
IC	inhibition concentration
LOEC	lowest observed effect concentration
MATC	maximum acceptable toxicant concentration
MLR	multiple linear regression
NexGen	NexGen Energy Ltd.
pH	potential of hydrogen; measure of the acidity or alkalinity of a solution on a scale of 0 to 14
Project	Rook I Project
RFD	reasonably foreseeable development
RSWQM	regional surface water quality model
SSD	species sensitivity distribution
TRV	toxicity reference value
USEPA	United States Environmental Protection Agency

Unit	Definition
%	percent
°C	degrees Celsius
µg/L	micrograms per litre
km	kilometre
mg/L	milligrams per litre

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11A1 INTRODUCTION

The Rook I Project (Project) is a proposed new uranium mining and milling operation that is 100% owned by NexGen Energy Ltd. (NexGen). The Project would be located in northwestern Saskatchewan, approximately 40 km east of the Saskatchewan-Alberta border, 130 km north of the Northern Village of La Loche, and 640 km northwest of the city of Saskatoon. The Project would reside within Treaty 8 territory and within the Métis Homeland. At a regional scale, the Project would be situated within the southern Athabasca Basin adjacent to Patterson Lake and along the upper Clearwater River system (Figure 11A-1). The Project would include underground and surface facilities to support the extraction and processing of uranium ore from the Arrow deposit, a land-based, basement-hosted, high-grade uranium deposit.

This appendix presents the results of an aquatic health assessment completed in support of the Project's Environmental Impact Statement (EIS). An aquatic health assessment was undertaken to evaluate the potential effects of exposure of fish and other aquatic organisms to elevated copper concentrations, which are predicted in the aquatic receiving environment after Decommissioning and Reclamation (i.e., Closure) of the Project and in the far future. The primary source of loading for copper in the far future is the slow migration of hydrogeological mass load inputs from the waste rock storage areas and to a lesser extent, the underground tailings management facility.

The results of the surface water quality assessment (EIS Section 10, Surface Water Quality and Sediment Quality) and ecological risk assessment (TSD XXI, Environmental Risk Assessment) completed for the Project indicated that copper concentrations in Patterson Lake in the far future were predicted to be above thresholds representing concentrations below which no effects on aquatic life would be expected. The results of the surface water quality assessment indicated that copper concentrations in the water column were predicted to exceed generic water quality guidelines for the protection of aquatic life (0.002 mg/L; CCME 2021; WSA 2015). Concentrations of copper were also predicted to exceed the minimum fresh water copper toxicity reference value (TRV) used in the ecological risk assessment (0.002 mg/L; CCME 2021). The guidelines used in these assessments represent threshold concentrations below which no effects are likely, and above which effects are possible. More specific thresholds based on site-specific conditions and ecology were derived herein. This additional assessment was undertaken to further describe the potential effects from copper exposure on the health of fish and aquatic life.

LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- FLOW DIRECTION
- LAKE BASIN DIVISION
- SECONDARY HIGHWAY
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED AREA
- PROPOSED PROJECT FOOTPRINT
- FISSION PATTERSON LAKE SOUTH PROPERTY FOOTPRINT

0 3 6

1:88,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
2. FISSION (FISSION URANIUM CORP.) OBTAINED FROM 2019 TECHNICAL REPORT ON THE PRE-FEASIBILITY STUDY OF THE PATTERSON LAKE SOUTH PROPERTY USING UNDERGROUND MINING METHODS.
3. 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

LOCATION OF PATTERSON LAKE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3106 - 3
DESIGN	LJ	2021-05-17	SCALE AS SHOWN	REV. 0
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CHECK	KM	2023-02-08		
REVIEW	KM	2023-02-08		

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11A1.1 Background

11A1.1.1 Predicted Effects on Surface Water Quality

Potential effects on surface water quality were predicted through the development of a regional surface water quality model (RSWQM) used to assess the expected magnitude, extent, and duration of Project effects in the downstream receiving environment. The RSWQM considered an Application Case and a Reasonably Foreseeable Development (RFD) Case. Source term inputs considered in the RSWQM Application Case included inputs from the Project site-wide water balance model and the groundwater solute transport model. Model simulations were completed for all Project phases, although this aquatic health assessment focuses only on far-future results because concentrations were predicted to remain below generic thresholds in the receiving environment during the Project lifespan (i.e., Construction, Operations, Closure). A sensitivity scenario was also considered, which was representative of reasonable upper bound conditions (EIS Section 10.2.8.1.2, Near-Field Water Quality Model). This reasonable upper bound scenario was completed for the Application Case to provide a precautionary, more conservative upper bound in the surface water quality assessment, and addressed uncertainty associated with the model outputs.

Infiltration and seepages from the Project footprint to groundwater in the far future were predicted through groundwater flow and solute transport modelling to predict migration of metals from the underground mine workings, underground tailings management facility, and waste rock storage areas to Patterson Lake. The modelling of the tailings-affected groundwater migration by the groundwater solute transport model demonstrated that the time for groundwater to reach surface water spans a very large temporal scale extending hundreds of thousands of years into the future (EIS Section 8, Hydrogeology). However, computational limits with the RSWQM precluded the use of such a large temporal scale as demonstrated in the solute transport model. To address this limitation, loadings from the groundwater solute transport model were effectively fast-tracked to allow for a shorter modelling timeframe that considered maximum effects on surface water quality. The far-future modelling period considered in the RSWQM extends 357 years after Closure and includes two time periods: an initial 157-year period that includes the natural hydrological and hydrogeological processes from the site following Closure; and a subsequent 200-year period that includes the natural hydrological and hydrogeological processes that account for maximum mass loadings associated with solute transport by groundwater, as predicted by the groundwater model. As the RSWQM modelled conditions for the far future were effectively fast-tracked, these “years” do not correspond to actual future years. Thus, any mention of a specific year in this appendix refers only to a point in the far future that represents reasonable worst-case conditions.

The RSWQM predicted incremental mass loadings to Patterson Lake North Arm – West Basin in the far future for a group of metals that were predicted to increase in the receiving environment. Overall, the magnitude of constituent of potential concern (COPC) concentration increases is greater in the reasonable upper bound scenario of the Application Case and in the RFD Case compared to the Application Case. In particular, the concentration of copper was predicted to exceed water quality thresholds for the protection of aquatic life (EIS Section 10, Surface Water Quality and Sediment Quality). As indicated above, increases in concentrations of other COPCs were not predicted to result in potential effects on aquatic biota.

11A1.1.2 Overview of the Results of the Ecological Risk Assessment

Ecological health risks resulting from changes in surface water quality were examined in the ecological risk assessment (TSD XXI) for aquatic species or receptors, including phytoplankton, zooplankton, benthic invertebrates, predator fish species (represented by northern pike), and forage fish species (represented by lake whitefish). The IMPACT environmental pathways model was used to predict transport of COPCs through the environment, their concentrations in environmental media, and potential risks to ecological receptors. Exposures of aquatic organisms to COPCs in surface waters were predicted and assessed. Toxicity reference values were used to assess the potential for effects. The ecological risk to aquatic organisms was then estimated by calculating hazard quotients (HQs) that provide a quantitative estimate of overall risk to a receptor.

The HQ was calculated as the ratio between the exposure estimate and the TRV. An HQ of less than or equal to one suggests low risk to the ecological receptor because exposure estimates do not exceed levels known to cause adverse effects. If the HQ is greater than one, toxicological effects may be possible.

For the far-future projection (i.e., after mine Closure, more than 100 years into the future), copper concentrations in Patterson Lake are predicted to intermittently exceed the minimum receptor-specific TRV of 0.002 mg/L, resulting in HQ values greater than one (TSD XXI). Copper concentrations were predicted to exceed the TRV in Patterson Lake North Arm – West Basin in the Application Case and the RFD Case, as well as in the reasonable upper bound scenario for the Application Case. In Patterson Lake South Arm, copper was predicted to exceed the TRV only in the reasonable upper bound scenario.

11A1.2 Scope of the Aquatic Health Assessment

The aquatic health assessment evaluated the scenarios that had predicted copper concentrations greater than TRVs in the environmental risk assessment (TSD XXI). Thus, out of the six scenarios evaluated by the environmental risk assessment, four scenarios were carried forward for further evaluation in the aquatic health assessment (Table 11A-1).

Table 11A-1: Selection of Scenarios Retained for Further Evaluation in the Aquatic Health Assessment

Patterson Lake Area	Assessment Case	HQ[a]	Retained in Aquatic Health Assessment[b]
North Arm – West Basin	Application Case	>1	Yes
North Arm – West Basin	Application Case, reasonable upper bound scenario	>1	Yes
North Arm – West Basin	RFD Case	>1	Yes
South Arm	Application Case	<1	No
South Arm	Application Case, reasonable upper bound scenario	>1	Yes
South Arm	RFD	<1	No

a) HQ is the predicted concentration divided by the TRV of 0.002 mg/L. A HQ of less than or equal to one indicates low risk to aquatic health because predicted concentrations are below levels known to cause adverse effects.
b) Model scenarios that resulted in HQs greater than 1 were retained for further evaluation.
RFD = reasonably foreseeable development; HQ = hazard quotient; < = less than; > = greater than; TRV = toxicity reference value.

Predicted effects on aquatic health due to copper exposure were described for the far future using an approach based on the biotic ligand model (BLM) and a multiple linear regression (MLR) model. The BLM is a tool that predicts the bioavailability of copper based on water chemistry and relates it to copper toxicity. The MLR model is an alternative to the BLM, based on the same principles of using water chemistry to predict copper toxicity. The use of these approaches allows for the assessment of the potential for toxicity on fish, invertebrates, and aquatic plants by evaluating the predicted copper concentrations in consideration of predicted exposure and toxicity modifying factors (ETMFs). The ETMFs are ambient water quality conditions that can affect copper bioavailability and toxicity, such as hardness and concentrations of certain ions. This information was used to support the assessment of effects on fish and fish habitat (EIS Section 11, Fish and Fish Habitat), including the potential for direct toxicological effects on the survival and reproduction of fish, as well as indirect effects that can result through reduction of, or changes to, the food base for fish.

Toxicological effects on aquatic biota were not predicted to occur due to exposure to other COPCs or during Project phases (i.e., Construction, Operations, Closure), and thus, these other COPCs and Project phases were not considered in the aquatic health assessment.

11A2 METHODS

11A2.1 Assessing Copper Toxicity

11A2.1.1 Chemical Form and Bioavailability

Copper can be toxic to aquatic life, but at low concentrations, it is an essential nutrient for both aquatic plants and animals (Grosell 2012). In natural waters, the divalent cupric ion is highly reactive, forming complexes and precipitates with organic and inorganic constituents and suspended solids in the water column (USEPA 1985). As a result, water quality characteristics can substantially affect the toxicity and bioavailability of copper to aquatic life. Bioavailability is a measure of the rate and extent to which a toxicant, like a metal, reaches the site of toxic action (Adams et al. 2019). Generally, a decrease in copper toxicity is observed as water hardness increases because hardness in natural waters is controlled by the presence of divalent calcium and magnesium ions that compete with metal cations for binding sites on the gills of aquatic organisms (ICME 1995).

11A2.1.2 Current Water Quality Guidelines

In developing their water quality criteria for copper, the United States Environmental Protection Agency (USEPA) recognized the relationship between copper toxicity and hardness, and developed a regression equation to incorporate hardness into the calculation of acute and chronic copper criteria (USEPA 1985). The Canadian Council of Ministers of the Environment (CCME) adopted the USEPA's revised hardness-based chronic copper criteria as a federal water quality guideline for the protection of aquatic life (CCREM 1987). However, hardness typically co-varies with pH and alkalinity, which means that the influence of hardness cannot easily be separated from the toxicity-modifying effects of pH and alkalinity. The hardness-based equation works best when the water of interest has similar combinations of pH, alkalinity, and hardness to those represented in the dataset used to develop the hardness-based criteria. Outside of this range of conditions, the hardness-based equation may not be as effective at predicting the toxicity of copper. Another issue with the hardness-based equation is that hardness is a surrogate for calcium and magnesium ion concentrations, which can exert different influences on copper bioavailability; therefore, toxicity may be more effectively modelled by considering calcium and magnesium as separate toxicity-modifying factors (Paquin et al. 2002).

Since the development of hardness-based criteria, an improved understanding of ETMFs and copper toxicity has led to the development of copper BLMs. The BLM explicitly considers the influence of multiple water chemistry parameters on copper bioavailability and toxicity. The USEPA considers the BLM to represent the best available method to predict copper toxicity and recommends it as the basis for developing site-specific fresh water, water quality criteria for copper in the United States (USEPA 2007). However, the USEPA copper BLM uses a toxicity database of acute lethality (i.e., 50% lethal concentration[1]) data and derives a chronic criterion by applying an acute-to-chronic ratio. In Canada, chronic water quality guidelines are preferentially derived using chronic toxicity data. Thus, Environment and Climate Change Canada (ECCC) recently published a federal environmental quality guideline (FEQG) for dissolved copper based on a BLM using chronic toxicity data that were selected according to the CCME (2007) guidance for the derivation of water quality guidelines (ECCC 2021a).

11A2.1.3 Biotic Ligand Model Overview

The BLM is based on the understanding that copper accumulation at the physiologically active site in the biological organism, referred to as the biotic ligand, elicits a toxic action within that organism. It is assumed that the dissolved copper concentration that elicits this toxic response is always associated with a fixed, critical level of metal accumulation at the biotic ligand; thus, copper toxicity can be predicted based on the water chemistry that produces that dissolved copper concentration (ECCC 2021a). This fixed level of metal-biotic ligand accumulation is constant and species-specific, regardless of the chemical characteristics of the water. The critical accumulation values can be based on any measure of biological impairment including survival, growth, or reproduction. The BLM uses binding constants (e.g., copper-pH, copper-calcium, copper-magnesium, copper-dissolved organic carbon [DOC]) to predict the concentration of dissolved copper based on the water chemistry. Any changes in water chemistry that would affect the dissolved copper concentration would also change the bioavailability and hence the toxicity of copper. Dissolved copper is generally considered to be the most bioavailable form of copper (ECCC 2021a).

The approach and development of the ECCC BLM is similar to that of the USEPA BLM, which was issued in 2007. For example, the ECCC BLM also uses a single set of parameters for all aquatic organisms; that is, the binding constants do not change for different organisms. This allows the BLM to apply a consistent mechanistic framework to metal bioavailability for organisms (ECCC 2021a). Like the USEPA BLM, the ECCC BLM is also used to normalize the available toxicity data to a consistent set of exposure conditions. These normalized data are then used to develop a species sensitivity distribution (SSD), which relates copper concentrations to toxicity endpoints observed in multiple species. The fifth percentile of the normalized SSD is determined and is used to set the criteria referred to as the hazard concentration at 5% (HC_5). The HC_5 represents the concentration of copper predicted to cause effects in the most sensitive 5% of species on the SSD.

The ECCC (2021a) followed the CCME (2007) protocol in the selection of chronic toxicity data for use in the toxicity database. The ECCC (2021a) selected EC_{10}[2] (i.e., effect concentration that results in 10% adverse effect), IC_{10} (i.e., inhibition concentration that results in 10% adverse effect) maximum acceptable toxicant concentration (MATC[3]), and no observed effect concentration from studies with fish, invertebrates, and plants.

[1] The 50% lethal concentration is the concentration of a test material at which 50% of exposed test organisms die in a laboratory toxicity test.

[2] The ECx is the concentration of a test material that is estimated to cause an effect of x% magnitude to test organisms. The ECx describes quantal effects (i.e., effect can be one thing or the other, such as dead/alive or normal/abnormal). ICx is the concentration of a test material that is estimated to cause a x% impairment in a quantitative biological function (e.g., size) in exposed test organisms compared to a control group. For example, an IC10 for weight would be the concentration at which weight is 10% than that observed in control test organisms. Both the ECx and ICx are estimated by linear regression or interpolation from the concentration-response curve.

[3] MATC is the geometric mean of the no observed effect concentration and LOEC. The no observed effect concentration is the concentration of a test material identified by hypothesis testing to have no significant difference from control in terms of an effect on exposed test organisms. The LOEC is the lowest concentration that is statistically different from control.

The ECCC BLM involves three steps, the details of which can be found in ECCC (2021a). A brief summary is provided below:

1. The critical copper accumulation levels are calculated, based on the exposure conditions in the original laboratory toxicity test that generated the chronic toxicity value. These exposure conditions include values for temperature, pH, DOC, alkalinity, calcium, magnesium, sodium, potassium, sulphate, and chloride. Two model parameters are used: one for fish and invertebrates and one for plants.
2. Toxicity data are normalized to the site conditions or water chemistry of interest.
3. Normalized data are used to develop an SSD. The species mean values (i.e., geometric mean of compiled chronic endpoints) are ranked and a distribution is fit to the data (i.e., log-normal, log-logistic, log-gumbel, log-extreme); the fifth percentile is calculated from this distribution (i.e., the HC_5). This HC_5 is selected as the FEQG.

The output of the ECCC BLM includes SSDs for each set of exposure conditions, the distribution used to fit the data, and the resulting HC_5 with 95% confidence intervals. From this information, the most sensitive species and the relative ranking of all species can be identified.

As with all federal water quality guidelines derived using CCME (2007), the FEQG is intended to be protective of all forms of aquatic life (i.e., all species and life stages) for indefinite exposure periods. Thus, there is high confidence that predicted copper concentrations below the FEQG would not adversely affect aquatic life. However, exceedances of the FEQG do not necessarily mean that there would be adverse effects. Given that the toxicity database is based on no effect concentrations, the FEQG could be considered as a no effect threshold and was applied as such in this aquatic health assessment.

For the aquatic health assessment, it was necessary to evaluate the extent and magnitude of adverse effects on aquatic receptors when predicted copper concentrations occur above this no effect threshold. To do this, a low effects threshold was derived using the MLR model of Brix et al. (2021).

11A2.1.4 Multiple Linear Regression Model Overview

The MLR model is based on the same principles of the BLM of predicting copper toxicity under various water chemistry conditions. It can be simpler to use than the BLM because it requires fewer water chemistry inputs and can be calculated in an Excel spreadsheet. A key difference between the MLR model and the ECCC BLM is that of the underlying toxicity dataset; the MLR model developed by Brix et al. (2021) uses low level effects concentrations whereas the ECCC BLM uses no effect concentrations. This difference is useful for this aquatic health assessment because both no effect and low effects thresholds can be derived using the same set of exposure conditions. In addition, both models produce SSDs, which allow for an evaluation of what species are most sensitive and the magnitude of the potential adverse effects at a particular predicted copper concentration.

To develop the MLR model, Brix et al. (2017) first identified the ETMFs that influence copper bioavailability the most, starting with the list of ETMFs that are considered as part of the BLM. Based on their evaluation, pH, DOC, and hardness were selected for use in deriving a MLR model. Using the same methodology that USEPA used to derive the hardness-based copper regression equation, Brix et al. (2021) developed a regression equation that incorporated all three ETMFs. Relationships between toxicity and hardness or DOC tend to be linear, whereas a linear relationship between toxicity and pH is observed when toxicity is transformed (Brix et al. 2017). Thus, toxicity, hardness, and DOC were log transformed, but pH was not transformed in the final model. The statistical methods to develop and select the best-fitting model are provided by Brix et al. (2017, 2021).

Similar to the BLM, the MLR model normalizes toxicity data to a consistent set of exposure conditions, specifically those for pH, DOC, and hardness. The MLR model uses a database of toxicological data compiled by the USEPA (2007) and subsequently updated by Brix et al. (2017) to include more recent studies that meet USEPA (1985) test acceptability guidelines. The data compilation also considered the chronic toxicity dataset compiled by ECCC (2021a). The MLR model database includes chronic toxicity data for 26 fish, amphibian, and invertebrate species. The chronic endpoints include EC_{20} (20% effect concentration), EC_{25} (25% effect concentration), MATC, and lowest observed effect concentration (LOEC). The CCME (2007) considers these endpoints to represent low effects thresholds. Low level adverse effects may occur to sensitive species in long-term exposures if predicted copper concentrations are at or above low effects thresholds.

Table S5 in the supplemental information provided by Brix et al. (2021) provides the chronic copper SSDs based on moderately hard water (i.e., pH 7.5, DOC of 0.5 mg/L, hardness of 85 mg/L). Specifically, the individual normalized toxicity values and the species mean values based on this set of exposure conditions were calculated based on the MLR equation provided in the spreadsheet. By changing the water chemistry values used to normalize the data, the spreadsheet can provide a revised list of species mean values based on a new set of exposure conditions. For the aquatic health assessment, a log-normal distribution was fitted to the species means values because this distribution was consistently selected in the ECCC BLM for the same modelling scenario. The fifth percentile of the fitted log-normal distribution was selected as the low effects threshold.

11A2.2 Model Input Requirements

11A2.2.1 Biotic Ligand Model

The BLM Windows Interface, Environment and Climate Change Canada FEQG Chronic Cu BLM Version 1.2, (ECCC 2021b) was used to derive the no effect thresholds. The water quality parameters necessary to run the BLM are:

- physical parameters (i.e., water temperature, and pH);
- DOC and proportion of humic acid[4];
- major cations (i.e., calcium, magnesium, sodium, and potassium);
- major anions (i.e., sulphate, and chloride); and
- total alkalinity.

In general, the proportion of humic acid is not measured in water quality assessments; this is recognized by ECCC (2021c) and is not considered a deterrent to running the BLM. As recommended by the BLM User Guide (ECCC 2021c), the humic acid proportion of DOC was assumed to be 10%.

[4] Humic acid is the organic acid obtained from humic material and can complex with metals differently from other organic acids like fulvic acid. The ECCC (2021c) notes that characterizing dissolved organic matter content beyond measuring DOC concentrations is not a critical factor in the predictability of the BLM.

The copper BLM was developed and calibrated under a range of water quality parameters that reflect typical conditions in the toxicity tests selected to support BLM development. If any input value is outside the prescribed range, then the BLM substituted the lower or upper bound for that input parameter before normalizing the data. This substitution was applied for temperature because average baseline temperature in Patterson Lake was less than the lower bound prescribed value of 8.5°C. However, ECCC (2021c) notes that temperature effects on copper toxicity are relatively minor and the application of temperature input values outside the range is not a concern.

11A2.2.2 Multiple Linear Regression Model

The MLR model requires three parameters: pH, DOC, and hardness. No calibration ranges were noted by Brix et al. (2021) but it is assumed that these ranges would be similar to those of the ECCC BLM, as the underlying toxicity dataset is similar.

11A2.3 Receiving Environment Chemistry Inputs

To run the BLM and MLR models, it was necessary to use a combination of measured laboratory and field data, as well as modelled data. Modelled data were available for calcium, magnesium, sodium, and sulphate (Attachment 10A-2, Regional Surface Water Quality Model Results). Hardness for the MLR model was calculated from predicted calcium and magnesium concentrations. Measured data for pH, DOC, alkalinity, and potassium were obtained from the baseline dataset (i.e., measured in Patterson Lake between 2015 and 2020). Average values for these parameters were used in the models. Average values were selected as representative of typical future conditions. As noted in Section 11A2.2.1, Biotic Ligand Model, the lower bound of the prescribed range for temperature was used in the BLM.

Table 11A-2 summarizes the input values used in the BLM and the MLR models. Multiple BLM runs were performed, each reflecting different water quality scenarios predicted by the three water quality models at different time steps in the far future. Values used in BLM runs for water quality parameters with model predictions (i.e., calcium, magnesium, sodium, sulphate) varied depending on model data for each timepoint. Water quality parameters for which average baseline values were used (i.e., pH, DOC, alkalinity, potassium) in the BLM remained the same across all BLM runs on a given area of Patterson Lake. For the MLR model, only hardness varied among model runs as average baseline pH and DOC were used for all modelling scenarios.

Table 11A-2: Patterson Lake Water Quality Data Used in Biotic Ligand Model and Multiple Linear Regression Models

Parameter	Source	Values Used for North Arm – West Basin	Values Used for South Arm	Model Parameters Used in
Temperature (°C)	Baseline[(a)]	6.9[(b)]	7.5[(b)]	BLM
pH	Baseline[(a)]	6.95	6.89	BLM and MLR
DOC (mg/L)	Baseline[(a)]	2.3	2.2	BLM and MLR
Alkalinity (mg/L as $CaCO_3$)	Baseline[(a)]	29	31	BLM
Potassium (mg/L)	Baseline[(c)]	0.55	0.57	BLM
Humic acids (%)	ECCC 2021c[(d)]	10	10	BLM
Calcium (mg/L)	Predicted[(e)]	3.37-10.3	3.89-16.6	BLM
Magnesium (mg/L)	Predicted[(e)]	1.14-1.97	1.35-2.78	BLM
Sodium (mg/L)	Predicted[(e)]	1.44-10.6	1.61-18.9	BLM
Sulphate (mg/L)	Predicted[(e)]	2.37-29.5	2.88-52.1	BLM
Chloride (mg/L)	Predicted[(e)]	0.747-22.4	0.943-40.5	BLM
Hardness (mg/L)	Predicted[(f)]	13.2-33.6	15.3-53.0	MLR

Note: Minimum and maximum values are provided for parameters with a range of values produced by model predictions.
a) Average baseline water quality as measured between 2015 and 2020.
b) Temperature was below lower bound of prescribed range of 8.5°C; therefore, lower bound was substituted in the BLM run.
c) Average baseline water quality as measured between 2018 and 2020 (not available for earlier years).
d) Recommended value from ECCC in absence of chemical characterization (ECCC 2021c).
e) Model predicted value from the Application Case, RFD Case, or reasonable upper bound scenario (sensitivity scenario for the Application Case).
f) Hardness was calculated from predicted calcium and magnesium concentrations.
$CaCO_3$ = calcium carbonate; BLM = biotic ligand model; DOC = dissolved organic carbon; MLR = multiple linear regression; RFD = reasonably foreseeable development; ECCC = Environment and Climate Change Canada.

11A2.4 Modelling Scenarios

The water quality model yielded monthly time steps for each assessment case during the far-future modelling period. Time steps were chosen to capture representative scenarios within each assessment case with regards to predicted copper concentrations. This included time steps at the modelled start of the period immediately following Closure (i.e., 2068), during the modelled period when copper concentrations are predicted to increase in Patterson Lake (i.e., 2068 to 2100), and during the period when predicted copper concentrations appear to stabilize and only fluctuate with climatic conditions (i.e., peaks occurring during dry periods, troughs during wet periods; 2100 to 2425). It should be noted that the years listed do not correspond to actual future years as stated in Section 11A1.1.1, Predicted Effects on Surface Water Quality, as the far-future modelling timeframe condensed thousands of years into 357 years. Thus, any mention of a specific year in this assessment only refers to some point in the far future, which is relatively closer or farther away from another point in the far future (e.g., 2068 immediately follows Closure, so 2100 is relatively closer to the start of the post-closure timeframe than 2400).

For the BLM, a total of 47 modelling scenarios were run through the BLM: 16 time steps from the Patterson Lake North Arm – West Basin Application Case, 10 time steps from the Patterson Lake North Arm – West Basin reasonable upper bound scenario, 10 time steps from the Patterson Lake North Arm – West Basin RFD Case, and 11 time steps from the Patterson Lake South Arm reasonable upper bound scenario (Attachment 11A-1, Patterson Lake Water Quality Data Used in the Biotic Ligand Model and Multiple Linear Regression Analyses).

For the MLR model, fewer modelling scenarios were run because of the similarity in predicted hardness, which was the only parameter that varied among scenarios (i.e., average baseline pH and DOC were used for all runs). A total of 31 modelling scenarios were run through the MLR model: 16 time steps from the Patterson Lake North Arm – West Basin Application Case, 10 time steps from the Patterson Lake North Arm – West Basin reasonable upper bound scenario, 2 time steps from the Patterson Lake North Arm – West Basin RFD Case, and 3 time steps from the Patterson Lake South Arm reasonable upper bound scenario (Attachment 11A-1).

11A3 RESULTS

Copper toxicity in Patterson Lake was modelled using both BLM and MLR approaches to evaluate how predicted copper concentrations above the TRV might adversely affect aquatic life. The results were interpreted as follows:

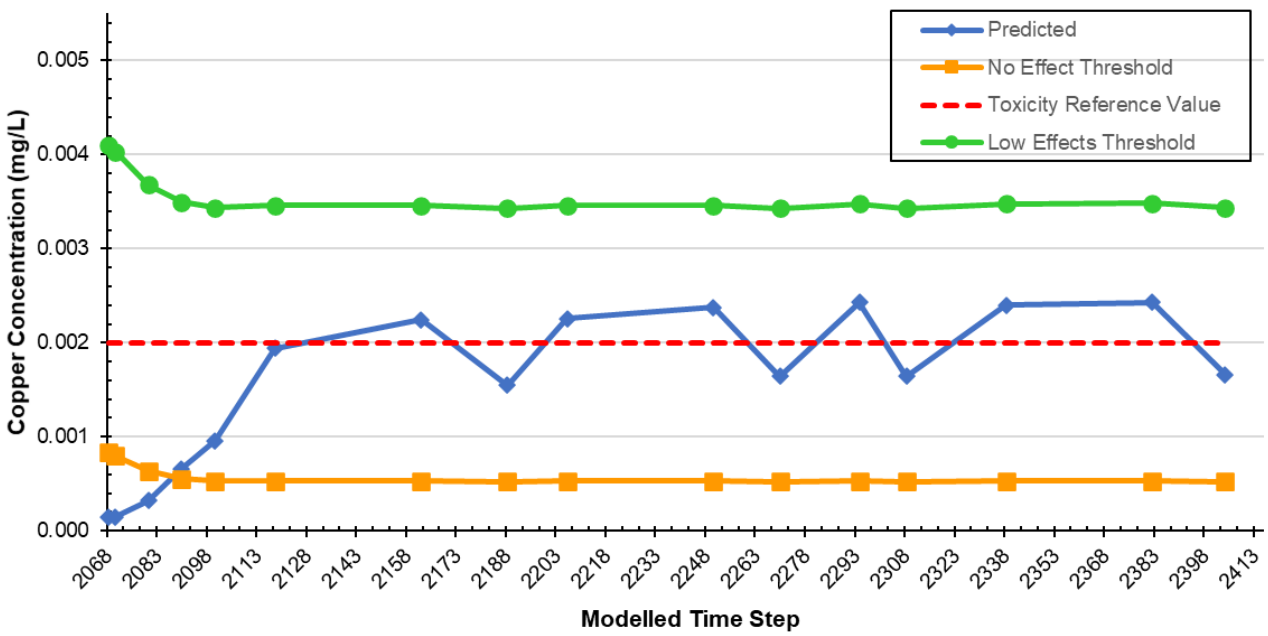
- Predicted copper concentrations that are at or below the no effect threshold are not expected to result in adverse effects on aquatic health.
- Predicted concentrations that are between the no effect and low effects thresholds are unlikely to result in adverse effects because the magnitude of effects, if any, are likely to be within the range of background variability and unlikely to be measurable. This interpretation is consistent with ecological risk assessment guidance. The low effect thresholds were developed using 20% to 25% level of effect, which is consistent with guidance for a permissible level of effect (Suter et al. 1995). Mebane (2010) also supports the use of an effects level of 20% for protection against unacceptable adverse effects on invertebrate and fish populations. A 20% difference in response to a test is widely considered to be within the range of natural variability often observed in the field among normal, unexposed populations. Environment and Climate Change Canada recommends the use of 25% for reporting the results of sublethal toxicity testing and IC_{25}s and/or EC_{25}s are commonly reported in the literature. Population or community level effects would not be expected to occur at or below the low effects thresholds.
- Predicted concentrations above the low effects threshold may result in potential adverse effects on sensitive aquatic receptors. In this case, further evaluation of the SSD is required to describe what species may be affected and the level of effect, including whether community level effects may be observed.

Summaries of the results for each retained assessment cases are provided below.

Patterson Lake North Arm – West Basin: Application Case

Based on predicted water quality in the Application Case, predicted copper concentrations in Patterson Lake North Arm – West Basin would exceed the no effect threshold from around modelled year 2090 onward. However, copper concentrations are not predicted to exceed the low effects threshold in the far future (Figure 11A-2). Predicted copper concentrations below the low effects thresholds are unlikely to result in adverse effects on fish, invertebrates, or plants.

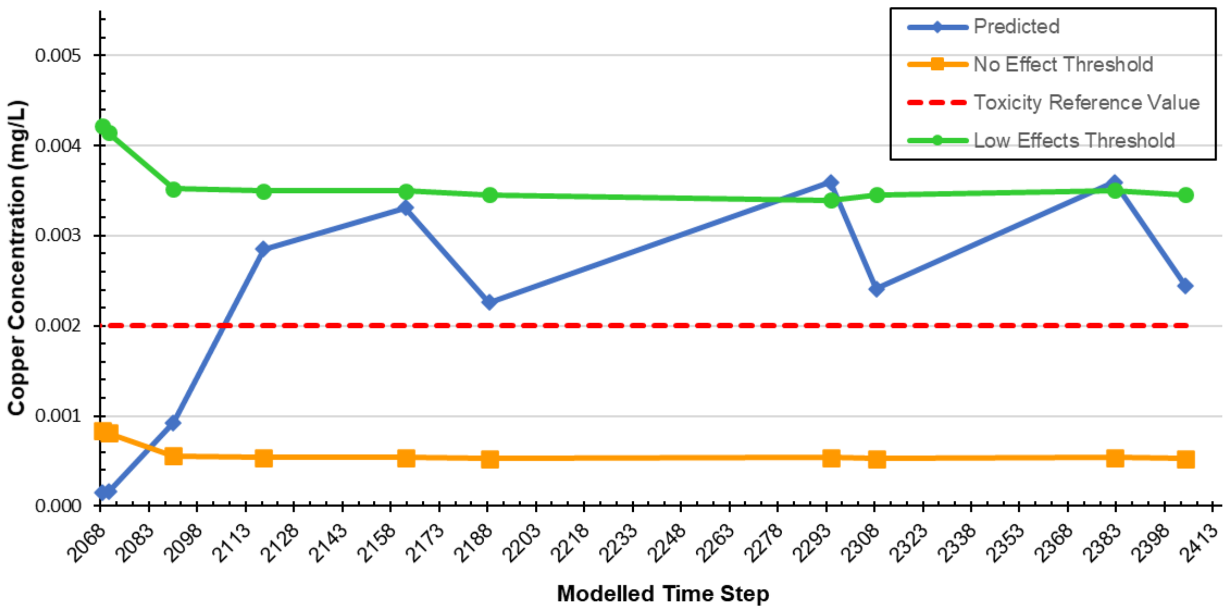
Figure 11A-2: Predicted Copper Concentrations in Patterson Lake North Arm – West Basin: Application Case



Patterson Lake North Arm – West Basin: Application Case, Reasonable Upper Bound Scenario

The use of more conservative assumptions in water quality modelling resulted in higher predicted copper concentrations for the reasonable upper bound scenario. Predicted copper concentrations were above the no effect threshold from around year 2080 onward (Figure 11A-3). Predicted copper concentrations remained below the low effects threshold, with the exception of periods of dry climatic conditions with HQs of 1.06 and 1.03 in modelled years 2294 and 2382, respectively (Figure 11A-3). Note that these peaks represent a fast-tracked timeline as described in Section 11A1.1.1, and do not represent actual future years. The maximum predicted copper concentration is 0.0036 mg/L.

Figure 11A-3: Predicted Copper Concentrations in Patterson Lake North Arm – West Basin: Application Case, Reasonable Upper Bound Scenario



The SSD for the low effects threshold (Figure 11A-4 and Table 11A-3) was reviewed to evaluate the potential magnitude of effects on sensitive species:

- The most sensitive fish species in the SSD is the white sturgeon (*Acipenser transmontanus*) with a normalized EC_{20} for biomass of 0.0039 mg/L (Wang et al. 2014). The next most sensitive fish species in the SSD is chinook salmon (*Oncorhynchus tshawytscha*) with a normalized EC_{20} for biomass of 0.0062 mg/L (Chapman 1975, 1982).
- The most sensitive invertebrate species is the pond snail (*Lymnaea stagnalis*) with a normalized geometric mean EC_{20} of 0.0057 mg/L (Brix et al. 2021).

Brix et al. (2021) did not include plant species in their SSDs. However, based on the SSD for the no effect threshold (from the ECCC BLM), plants were less sensitive to copper toxicity than fish and invertebrates. The two fish species (white sturgeon and chinook salmon) and several invertebrate species (including pond snail) were located lower on the SSD (i.e., toxicity tests with these species yielded lower no effect concentrations).

Based on the evaluation of the SSD, adverse effects on fish, invertebrates, and plants are unlikely because predicted copper concentrations are lower than the lowest low effect concentration for the most sensitive species.

Figure 11A-4: Species Sensitivity Distribution Curve for Chronic Copper Toxicity Based on the Log-Normal Distribution in Patterson Lake North Arm – West Basin: Application Case, Reasonable Upper Bound Scenario, Maximum Predicted Copper Concentration

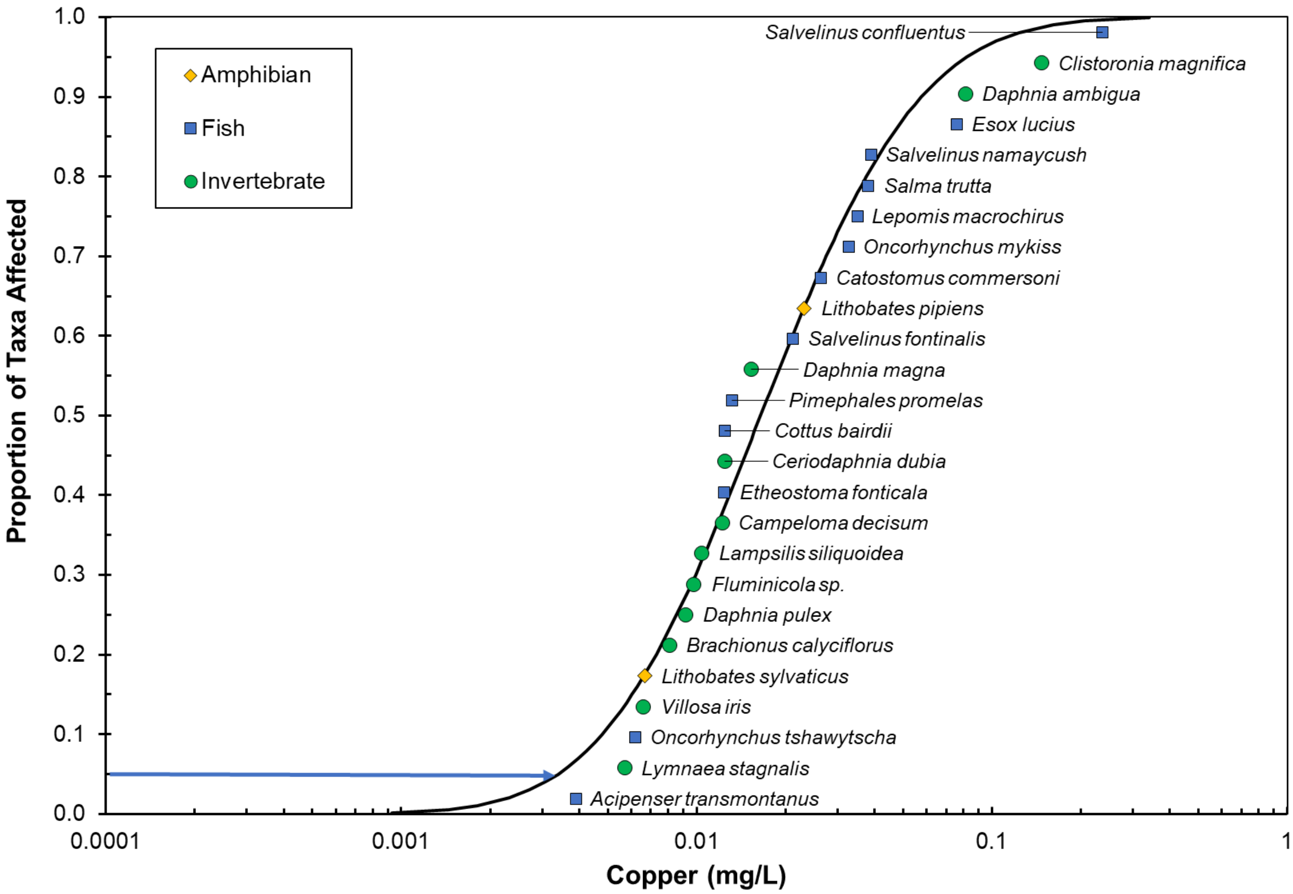


Table 11A-3: Chronic Aquatic Toxicity Data for Copper Used in the Species Sensitivity Distribution for Patterson Lake North Arm – West Basin: Application Case, Reasonable Upper Bound Scenario, Maximum Predicted Copper Concentration

Receptor Group	Species	Common Name	Endpoint	Species Mean Copper Concentration[(a)] (mg/L)
Fish	*Acipenser transmontanus*	White sturgeon	EC_{20}	0.0039
Invertebrate	*Lymnaea stagnalis*	Pond snail	EC_{20}	0.0057*
Fish	*Oncorhynchus tshawytscha*	Chinook salmon	EC_{20}	0.0062
Invertebrate	*Villosa iris*	Rainbow mussel	EC_{20}	0.0066*
Amphibian	*Lithobates sylvaticus*	Wood frog	MATC	0.0067
Invertebrate	*Brachionus calyciflorus*	Rotifer	EC_{20}	0.0081*
Invertebrate	*Daphnia pulex*	Water flea	EC_{20}, MATC	0.0092*
Invertebrate	*Fluminicola* sp.	Snail	EC_{20}	0.00975
Invertebrate	*Lampsilis siliquoidea*	Fatmucket clam	LOEC, EC_{20}	0.0104*
Invertebrate	*Campeloma decisum*	Pointed campeloma (snail)	EC_{20}	0.0122*
Fish	*Etheostoma fonticala*	Fountain darter	MATC	0.0124*
Invertebrate	*Ceriodaphnia dubia*	Water flea	EC_{20}	0.0125*
Fish	*Pimephales promelas*	Fathead minnow	MATC, EC_{20}	0.0132*
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0153*
Fish	*Salvelinus fontinalis*	Brook trout	MATC, LOEC	0.0212*
Amphibian	*Lithobates pipiens*	Northern leopard frog	MATC	0.0231*
Fish	*Catostomus commersonii*	White sucker	MATC, EC_{20}, EC_{25}	0.0264*
Fish	*Cottus bairdii*	Mottled sculpin	EC_{20}	0.0320*
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}, MATC	0.0328*
Fish	*Lepomis macrochirus*	Bluegill	EC_{20}	0.0350

Table 11A-3: Chronic Aquatic Toxicity Data for Copper Used in the Species Sensitivity Distribution for Patterson Lake North Arm – West Basin: Application Case, Reasonable Upper Bound Scenario, Maximum Predicted Copper Concentration

Receptor Group	Species	Common Name	Endpoint	Species Mean Copper Concentration[(a)] (mg/L)
Fish	*Salma trutta*	Brown trout	MATC	0.0381
Fish	*Salvelinus namaycush*	Lake trout	MATC	0.0390
Fish	*Esox lucius*	Northern pike	MATC	0.0762
Invertebrate	*Daphnia ambigua*	Water flea	EC_{20}	0.0814
Invertebrate	*Clistoronia magnifica*	Caddisfly	EC_{20}	0.147
Fish	*Salvelinus confluentus*	Bull trout	MATC	0.237

Source: Chronic toxicity values are from Brix et al. (2017, 2021), citing various sources.

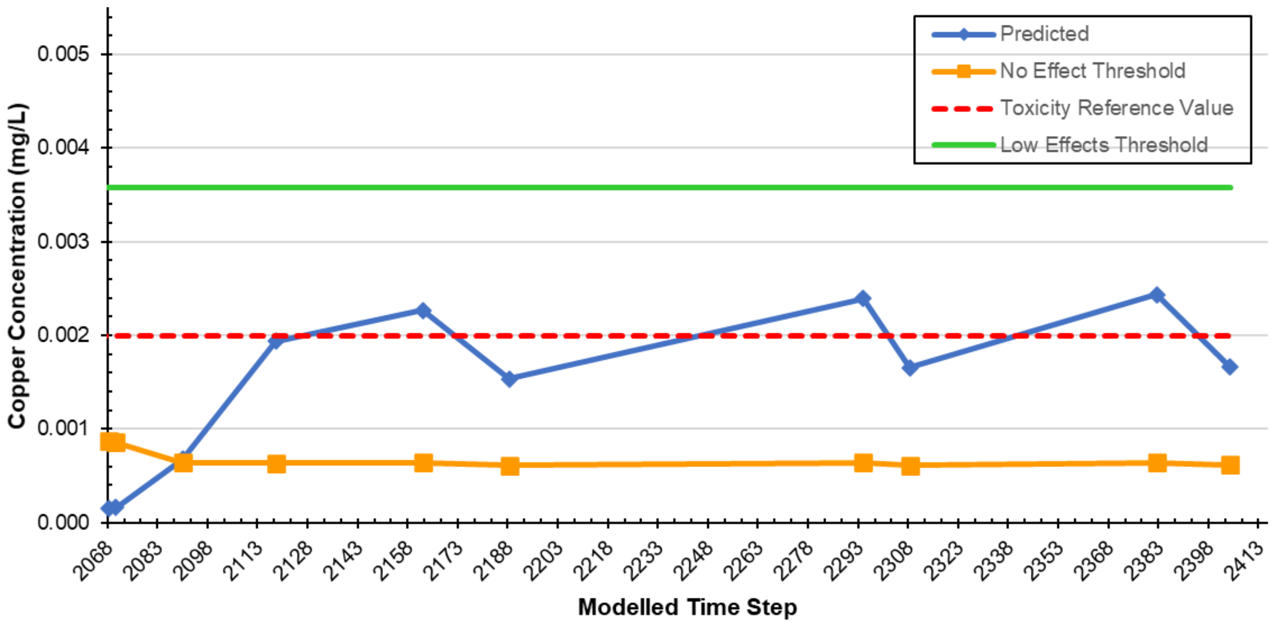
a) Effect concentrations normalized to pH 6.95, DOC of 2.3 mg/L, and hardness of 14.4 mg/L as $CaCO_3$ using the MLR provided in Table S5 of Brix et al. (2021). When multiple effect concentrations were available for the same species, geometric means were calculated and are marked with an asterisk (*). The full dataset is provided in Attachment 11A-2.

EC_{20} = 20% effect concentration; MATC = maximum acceptable toxicant concentration; LOEC = lowest observed effect concentration; EC_{25} = 25% effect concentration; $CaCO_3$ = calcium carbonate; DOC = dissolved organic carbon; MLR = multiple linear regression.

Patterson Lake North Arm – West Basin: Reasonably Foreseeable Development Case

The BLM and MLR model results for the RFD Case produced similar results to the Application Case. Concentrations of copper are predicted to exceed the no effect threshold beginning around modelled year 2090 but are not expected to exceed the low effects threshold during the far future (Figure 11A-5). Predicted copper concentrations below the low effects thresholds are unlikely to result in adverse effects on fish, invertebrates, or plants.

Figure 11A-5: Predicted Copper Concentrations in Patterson Lake North Arm – West Basin: Reasonably Foreseeable Development Case

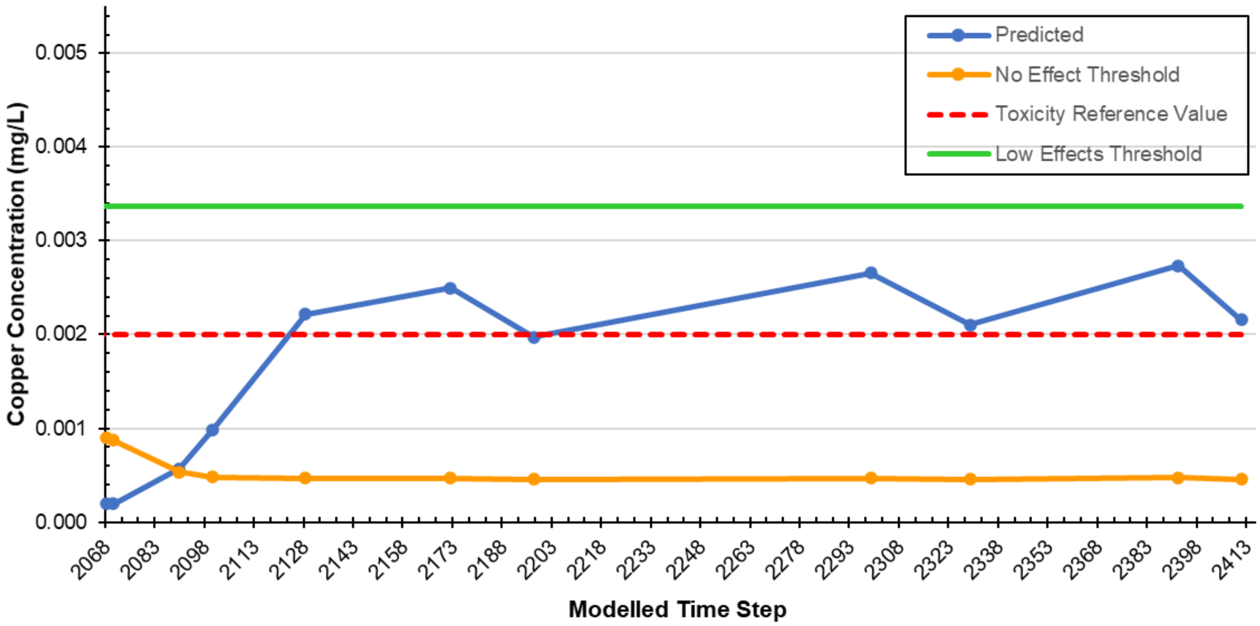


Note: The low effects threshold shown on the plot is based on the HC_5 derived with the lowest predicted hardness.
HC_5 = hazard concentration at 5%.

Patterson Lake South Arm: Application Case, Reasonable Upper Bound Scenario

The use of more conservative assumptions in water quality modelling resulted in higher predicted copper concentrations for the reasonable upper bound scenario for the Patterson Lake South Arm, which exceed the no effect threshold from around year 2090 onward (Figure 11A-6). However, predicted copper concentrations remain below the low effects threshold. Predicted copper concentrations below the low effects thresholds are unlikely to result in adverse effects on fish, invertebrates, or plants.

Figure 11A-6: Predicted Copper Concentrations in Patterson Lake South Arm: Application Case, Reasonable Upper Bound Scenario



Note: The low effects threshold shown on the plot is based on the HC_5 derived with the lowest predicted hardness.
HC_5 = hazard concentration at 5%.

11A4 UNCERTAINTY

As with all models, the BLM and MLR models have limitations based on their assumptions and data inputs. Model limitations mainly related to uncertainty associated with measured and predicted water quality used as inputs. Specific uncertainties associated with the use of the BLM and the MLR model to support the aquatic health assessment are summarized in Table 11A-4. The assessment concluded that the identified uncertainties had low influence on the interpretation or use of the results for the purpose of evaluating the potential for adverse effects on aquatic health due to predicted copper concentrations. The predictive abilities of the BLM and MLR models are expected to offset the uncertainties in parameterization, such that these models as implemented are anticipated to be more accurate than through the use of hardness alone.

Predicted copper concentrations in all scenarios, including the reasonable upper bound scenario, indicated no effects or unlikely effects. Therefore, there is high degree of certainty that the potential effects on aquatic biota have not been under-predicted.

Table 11A-4: Uncertainties Associated with the Biotic Ligand Model and Multiple Linear Regression Model Approaches to Derive No Effect and Low Effects Thresholds

Uncertainty Source / Assumption	Influence on the Interpretation or Use of the BLM and MLR Model Results
Use of the baseline average values to define future conditions	Low: using baseline average values for pH and DOC could lead to lower or higher copper thresholds if future concentrations vary substantially from this condition. ▪ Increased DOC concentrations would mitigate copper toxicity (Grosell 2012) and result in a higher effects thresholds for copper. ▪ Increased pH would also mitigate copper toxicity but a decrease in pH would exacerbate copper toxicity. ▪ Long-term changes in pH or DOC in Patterson Lake due to groundwater seepage is not expected. The reasonableness of the input parameters used in this assessment can be assessed over time through ongoing water quality monitoring in Patterson Lake and waste rock chemistry during Operations and re-evaluating predictions of water quality following Closure using measured data.
Average baseline temperature was outside the prescribed range for the BLM	Low: ECCC (2021c) notes that temperature effects on copper toxicity are relatively minor, and the application of temperature input values outside the range is not a concern. Brix et al. (2017, 2021) did not identify temperature as a key parameter for copper bioavailability.
Use of water quality predictions for the far-future projection	Low: uncertainty associated with the water quality predictions is discussed in EIS Section 10. Water quality predictions for the far-future projection incorporated conservative assumptions, particularly in the reasonable upper bound scenario for the Application Case.
Use of the MLR model to derive low effects thresholds	Low: the MLR model was derived using the same principles of the BLM, which incorporates the latest scientific understanding of copper bioavailability and toxicity. The toxicity database of low effects concentrations was recently compiled according to federal and international standards and provides sufficient information to evaluate predicted copper concentrations.

BLM = biotic ligand model; MLR = multiple linear regression; DOC = dissolved organic carbon; ECCC = Environment and Climate Change Canada.

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Attachment 11A-1 Patterson Lake Water Quality Data Used in the Biotic Ligand Model and Multiple Linear Regression Analyses

Table 11A-1-1: Model Input Parameters Used in the Aquatic Health Assessment

Patterson Lake Area	Assessment Case or Modelling Scenario	Modelling Time Step	Temperature (°C)	pH	Predicted Copper (mg/L)	DOC (mg/L)	Humic Acids (%)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Sulphate (mg/L)	Chloride (mg/L)	Alkalinity (mg/L)	Hardness (mg/L)	BLM HC_5 (mg/L)	MLR HC_5 (mg/L)
North Arm – West Basin	Application Case	2068-01-01	6.9	6.95	0.000147	2.3	10	8.732	1.882	8.959	0.55	24.130	1.315	29.0	29.545	0.000832	0.004102
North Arm – West Basin	Application Case	2070-01-01	6.9	6.95	0.000151	2.3	10	8.031	1.786	7.951	0.55	21.194	1.237	29.0	27.401	0.0008	0.004032
North Arm – West Basin	Application Case	2080-01-01	6.9	6.95	0.000321	2.3	10	5.042	1.366	3.730	0.55	8.784	0.875	29.0	18.205	0.000639	0.00368
North Arm – West Basin	Application Case	2090-01-01	6.9	6.95	0.00066	2.3	10	3.795	1.184	2.009	0.55	3.776	0.764	29.0	14.343	0.000555	0.003496
North Arm – West Basin	Application Case	2100-01-01	6.9	6.95	0.000959	2.3	10	3.473	1.143	1.569	0.55	2.556	0.750	29.0	13.367	0.000531	0.003438
North Arm – West Basin	Application Case	2118-04-01	6.9	6.95	0.001943	2.3	10	3.543	1.200	1.523	0.55	2.807	0.936	29.0	13.776	0.000531	0.00346
North Arm – West Basin	Application Case	2162-04-01	6.9	6.95	0.002245	2.3	10	3.530	1.212	1.506	0.55	2.867	0.939	29.0	13.792	0.00053	0.00346
North Arm – West Basin	Application Case	2188-11-01	6.9	6.95	0.001546	2.3	10	3.373	1.153	1.439	0.55	2.374	0.747	29.0	13.162	0.000524	0.003431
North Arm – West Basin	Application Case	2206-04-01	6.9	6.95	0.002259	2.3	10	3.533	1.213	1.508	0.55	2.877	0.942	29.0	13.806	0.00053	0.003459
North Arm – West Basin	Application Case	2250-04-01	6.9	6.95	0.002376	2.3	10	3.543	1.220	1.510	0.55	2.927	0.958	29.0	13.862	0.000531	0.003458
North Arm – West Basin	Application Case	2270-07-01	6.9	6.95	0.001642	2.3	10	3.380	1.158	1.440	0.55	2.416	0.762	29.0	13.198	0.000524	0.003431
North Arm – West Basin	Application Case	2294-04-01	6.9	6.95	0.002431	2.3	10	3.554	1.225	1.514	0.55	2.962	0.971	29.0	13.907	0.000531	0.003479
North Arm – West Basin	Application Case	2308-07-01	6.9	6.95	0.001644	2.3	10	3.372	1.156	1.437	0.55	2.413	0.761	29.0	13.170	0.000524	0.003431
North Arm – West Basin	Application Case	2338-04-01	6.9	6.95	0.002402	2.3	10	3.552	1.224	1.513	0.55	2.944	0.964	29.0	13.897	0.000531	0.003477
North Arm – West Basin	Application Case	2382-04-01	6.9	6.95	0.002431	2.3	10	3.560	1.227	1.517	0.55	2.964	0.972	29.0	13.928	0.000532	0.003486
North Arm – West Basin	Application Case	2404-08-01	6.9	6.95	0.001661	2.3	10	3.391	1.163	1.445	0.55	2.433	0.767	29.0	13.244	0.000525	0.003433
North Arm – West Basin	Application Case, reasonable upper bound scenario	2068-01-01	6.9	6.95	0.000149	2.3	10	10.3	1.9	9.7	0.55	24.54	22.41	29.0	33.571	0.000839	0.004219
North Arm – West Basin	Application Case, reasonable upper bound scenario	2070-01-01	6.9	6.95	0.000157	2.3	10	9.378	1.819	8.611	0.55	21.579	19.481	29.0	30.902	0.000807	0.004143
North Arm – West Basin	Application Case, reasonable upper bound scenario	2090-01-01	6.9	6.95	0.000927	2.3	10	3.979	1.196	2.113	0.55	4.096	2.484	29.0	14.850	0.000559	0.003523
North Arm – West Basin	Application Case, reasonable upper bound scenario	2118-04-01	6.9	6.95	0.002852	2.3	10	3.681	1.236	1.612	0.55	3.538	1.261	29.0	14.273	0.000536	0.003497
North Arm – West Basin	Application Case, reasonable upper bound scenario	2162-04-01	6.9	6.95	0.003307	2.3	10	3.668	1.257	1.595	0.55	3.681	1.223	29.0	14.324	0.000536	0.003496
North Arm – West Basin	Application Case, reasonable upper bound scenario	2188-11-01	6.9	6.95	0.002261	2.3	10	3.467	1.184	1.499	0.55	2.922	0.938	29.0	13.520	0.000528	0.003453
North Arm – West Basin	Application Case, reasonable upper bound scenario	2294-04-01	6.9	6.95	0.003593	2.3	10	3.689	1.274	1.606	0.55	3.829	1.249	29.0	14.447	0.000537	0.003391
North Arm – West Basin	Application Case, reasonable upper bound scenario	2308-07-01	6.9	6.95	0.002412	2.3	10	3.461	1.189	1.498	0.55	2.987	0.944	29.0	13.527	0.000528	0.003453
North Arm – West Basin	Application Case, reasonable upper bound scenario	2382-04-01	6.9	6.95	0.003594	2.3	10	3.695	1.276	1.608	0.55	3.831	1.249	29.0	14.468	0.000537	0.003505
North Arm – West Basin	Application Case, reasonable upper bound scenario	2404-08-01	6.9	6.95	0.002439	2.3	10	3.481	1.196	1.506	0.55	3.012	0.952	29.0	13.606	0.000529	0.003453
North Arm – West Basin	RFD Case	2068-01-01	6.9	6.95	0.000156	2.3	10	9.551	1.969	10.59	0.55	29.49	1.404	29.0	31.951	0.000878	0.004173
North Arm – West Basin	RFD Case	2070-01-01	6.9	6.95	0.000161	2.3	10	9.025	1.895	9.879	0.55	27.514	1.351	29.0	30.332	0.000857	n/m
North Arm – West Basin	RFD Case	2090-01-01	6.9	6.95	0.000677	2.3	10	4.788	1.293	3.925	0.55	10.060	0.884	29.0	17.272	0.000642	n/m
North Arm – West Basin	RFD Case	2118-04-01	6.9	6.95	0.001939	2.3	10	4.741	1.329	3.861	0.55	10.465	1.068	29.0	17.299	0.000639	n/m
North Arm – West Basin	RFD Case	2162-04-01	6.9	6.95	0.002266	2.3	10	4.747	1.344	3.878	0.55	10.652	1.080	29.0	17.376	0.00064	n/m

Table 11A-1-1: Model Input Parameters Used in the Aquatic Health Assessment

Patterson Lake Area	Assessment Case or Modelling Scenario	Modelling Time Step	Temperature (°C)	pH	Predicted Copper (mg/L)	DOC (mg/L)	Humic Acids (%)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Sulphate (mg/L)	Chloride (mg/L)	Alkalinity (mg/L)	Hardness (mg/L)	BLM HC_5 (mg/L)	MLR HC_5 (mg/L)
North Arm – West Basin	RFD Case	2188-11-01	6.9	6.95	0.001538	2.3	10	4.335	1.256	3.321	0.55	8.542	0.852	29.0	15.990	0.000614	n/m
North Arm – West Basin	RFD Case	2294-04-01	6.9	6.95	0.002397	2.3	10	4.773	1.354	3.902	0.55	10.776	1.099	29.0	17.484	0.000641	n/m
North Arm – West Basin	RFD Case	2308-07-01	6.9	6.95	0.001653	2.3	10	4.328	1.259	3.301	0.55	8.528	0.870	29.0	15.982	0.000613	0.003581
North Arm – West Basin	RFD Case	2382-04-01	6.9	6.95	0.002435	2.3	10	4.806	1.361	3.950	0.55	10.943	1.112	29.0	17.594	0.000643	n/m
North Arm – West Basin	RFD Case	2404-08-01	6.9	6.95	0.001665	2.3	10	4.388	1.270	3.392	0.55	8.816	0.879	29.0	16.177	0.000617	n/m
South Arm	Application Case, reasonable upper bound scenario	2068-01-01	7.5	6.89	0.000198	2.2	10	16.65	2.775	18.87	0.57	52.05	40.53	31.0	53.002	0.000897	0.004435
South Arm	Application Case, reasonable upper bound scenario	2070-01-01	7.5	6.89	0.000196	2.2	10	15.64	2.680	17.288	0.57	47.260	37.182	31.0	50.094	0.00087	n/m
South Arm	Application Case, reasonable upper bound scenario	2090-01-01	7.5	6.89	0.000571	2.2	10	5.432	1.480	3.558	0.57	7.804	5.733	31.0	19.648	0.000534	n/m
South Arm	Application Case, reasonable upper bound scenario	2100-01-01	7.5	6.89	0.000987	2.2	10	4.340	1.370	2.132	0.57	3.913	2.198	31.0	16.468	0.00048	n/m
South Arm	Application Case, reasonable upper bound scenario	2128-12-01	7.5	6.89	0.002216	2.2	10	4.237	1.451	1.768	0.57	3.288	1.158	31.0	16.542	0.00047	n/m
South Arm	Application Case, reasonable upper bound scenario	2172-12-01	7.5	6.89	0.002498	2.2	10	4.251	1.473	1.761	0.57	3.366	1.117	31.0	16.668	0.00047	n/m
South Arm	Application Case, reasonable upper bound scenario	2197-06-01	7.5	6.89	0.001971	2.2	10	3.907	1.352	1.614	0.57	2.885	0.944	31.0	15.312	0.000458	0.003366
South Arm	Application Case, reasonable upper bound scenario	2299-08-01	7.5	6.89	0.002658	2.2	10	4.204	1.464	1.742	0.57	3.416	1.116	31.0	16.512	0.000468	n/m
South Arm	Application Case, reasonable upper bound scenario	2329-06-01	7.5	6.89	0.002102	2.2	10	3.927	1.365	1.623	0.57	2.952	0.952	31.0	15.416	0.000458	n/m
South Arm	Application Case, reasonable upper bound scenario	2392-09-01	7.5	6.89	0.002731	2.2	10	4.267	1.487	1.768	0.57	3.487	1.141	31.0	16.762	0.000471	n/m
South Arm	Application Case, reasonable upper bound scenario	2411-06-01	7.5	6.89	0.002155	2.2	10	3.887	1.352	1.608	0.57	2.969	0.960	31.0	15.260	0.000457	0.003364

BLM = biotic ligand model; DOC = dissolved organic carbon; MLR = multiple linear regression; RFD = reasonably foreseeable development; n/m = not modelled; HC_5 = 5% hazard concentration.

Attachment 11A-2 Chronic Toxicity Data Used in Species Sensitivity Distribution for Modelled Maximum Copper Concentration

Table 11A-2-1: Chronic Toxicity Data Normalized Using the Multiple Linear Regression Model, Adapted from Table S5 in Brix et al. (2021)

Receptor Group	Species	Common Name	Endpoint	Normalized Effects Concentration in Brix et al. (2021)[(a)] (mg/L)	Normalized Effect Concentration[(b)] (mg/L)	Species Mean Chronic Value (mg/L)
Fish	*Acipenser transmontanus*	White sturgeon	EC_{20}	0.0018	0.00388	0.00388
Invertebrate	*Brachionus calyciflorus*	Rotifer	EC_{20}	0.0018	0.00402	0.0081
Invertebrate	*Brachionus calyciflorus*	Rotifer	EC_{20}	0.0029	0.00642	
Invertebrate	*Brachionus calyciflorus*	Rotifer	EC_{20}	0.0062	0.01375	
Invertebrate	*Brachionus calyciflorus*	Rotifer	EC_{20}	0.0055	0.01223	
Invertebrate	*Campeloma decisum*	Pointed campeloma (snail)	EC_{20}	0.0049	0.01086	0.0122
Invertebrate	*Campeloma decisum*	Pointed campeloma (snail)	EC_{20}	0.0061	0.01361	
Fish	*Catostomus commersonii*	White sucker	MATC	0.0119	0.02635	0.02635
Invertebrate	*Ceriodaphnia dubia*	Water flea	EC_{20}	0.0052	0.01152	0.0125
Invertebrate	*Ceriodaphnia dubia*	Water flea	EC_{20}	0.0019	0.00414	
Invertebrate	*Ceriodaphnia dubia*	Water flea	EC_{20}	0.0454	0.10052	
Invertebrate	*Ceriodaphnia dubia*	Water flea	MATC	0.0343	0.07595	
Invertebrate	*Ceriodaphnia dubia*	Water flea	MATC	0.0485	0.10726	
Invertebrate	*Ceriodaphnia dubia*	Water flea	EC_{25}	0.0164	0.03621	
Invertebrate	*Ceriodaphnia dubia*	Water flea	EC_{25}	0.0035	0.00768	
Invertebrate	*Ceriodaphnia dubia*	Water flea	EC_{25}	0.0023	0.00498	
Invertebrate	*Ceriodaphnia dubia*	Water flea	EC_{25}	0.0030	0.00655	
Invertebrate	*Ceriodaphnia dubia*	Water flea	EC_{25}	0.0027	0.00593	
Invertebrate	*Ceriodaphnia dubia*	Water flea	EC_{25}	0.0065	0.01430	
Invertebrate	*Ceriodaphnia dubia*	Water flea	EC_{25}	0.0029	0.00647	
Invertebrate	*Ceriodaphnia dubia*	Water flea	EC_{20}	0.0005	0.00114	
Invertebrate	*Ceriodaphnia dubia*	Water flea	EC_{20}	0.0115	0.02553	
Invertebrate	*Ceriodaphnia dubia*	Water flea	EC_{20}	0.0074	0.01643	
Invertebrate	*Ceriodaphnia dubia*	Water flea	EC_{20}	0.0040	0.00884	
Invertebrate	*Ceriodaphnia dubia*	Water flea	EC_{20}	0.0026	0.00568	
Invertebrate	*Clistoronia magnifica*	Caddisfly	EC_{20}	0.0666	0.14744	0.14744
Fish	*Cottus bairdii*	Mottled sculpin	EC_{20}	0.0134	0.02959	0.032
Fish	*Cottus bairdii*	Mottled sculpin	EC_{20}	0.0156	0.03461	
Invertebrate	*Daphnia ambigua*	Water flea	EC_{20}	0.0368	0.08142	0.08142
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0068	0.01514	0.0153
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0070	0.01545	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0053	0.01180	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0059	0.01314	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0061	0.01359	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0117	0.02590	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0019	0.00413	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0069	0.01528	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0055	0.01211	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0084	0.01856	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0122	0.02692	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0043	0.00941	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0090	0.02000	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0086	0.01909	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0065	0.01442	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0088	0.01936	

Table 11A-2-1: Chronic Toxicity Data Normalized Using the Multiple Linear Regression Model, Adapted from Table S5 in Brix et al. (2021)

Receptor Group	Species	Common Name	Endpoint	Normalized Effects Concentration in Brix et al. (2021)[(a)] (mg/L)	Normalized Effect Concentration[(b)] (mg/L)	Species Mean Chronic Value (mg/L)
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0059	0.01309	0.0153
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0062	0.01380	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0090	0.01991	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0086	0.01912	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0050	0.01105	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0068	0.01511	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0072	0.01585	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0081	0.01791	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0068	0.01495	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0086	0.01896	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0079	0.01741	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0130	0.02876	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0068	0.01495	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0066	0.01452	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0063	0.01386	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0105	0.02330	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0073	0.01612	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0067	0.01491	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0119	0.02640	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0068	0.01500	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0146	0.03233	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0083	0.01829	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0072	0.01602	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0100	0.02208	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0077	0.01714	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0118	0.02619	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0106	0.02338	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0096	0.02120	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0081	0.01783	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0074	0.01638	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0076	0.01687	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0082	0.01807	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0057	0.01269	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0058	0.01283	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0069	0.01518	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0046	0.01011	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0074	0.01634	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0030	0.00658	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0035	0.00767	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0041	0.00905	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0049	0.01091	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0046	0.01021	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0034	0.00750	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0060	0.01336	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0062	0.01383	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0069	0.01521	

Table 11A-2-1: Chronic Toxicity Data Normalized Using the Multiple Linear Regression Model, Adapted from Table S5 in Brix et al. (2021)

Receptor Group	Species	Common Name	Endpoint	Normalized Effects Concentration in Brix et al. (2021)[a] (mg/L)	Normalized Effect Concentration[b] (mg/L)	Species Mean Chronic Value (mg/L)
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0071	0.01571	0.0153
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0059	0.01304	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0059	0.01298	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0092	0.02035	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0036	0.00795	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0033	0.00738	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0080	0.01769	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0129	0.02847	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0068	0.01512	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0061	0.01346	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0053	0.01167	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0055	0.01209	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0097	0.02147	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0082	0.01822	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0200	0.04418	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0129	0.02853	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0063	0.01393	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0065	0.01445	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0146	0.03235	
Invertebrate	*Daphnia magna*	Water flea	EC_{20}	0.0017	0.00378	
Invertebrate	*Daphnia pulex*	Water flea	EC_{20}	0.0024	0.00536	0.0092
Invertebrate	*Daphnia pulex*	Water flea	MATC	0.0051	0.01124	
Invertebrate	*Daphnia pulex*	Water flea	EC_{20}	0.0059	0.01305	
Fish	*Esox lucius*	Northern pike	MATC	0.0344	0.07618	0.07618
Fish	*Etheostoma fonticala*	Fountain darter	MATC	0.0051	0.01135	0.0124
Fish	*Etheostoma fonticala*	Fountain darter	MATC	0.0061	0.01359	
Invertebrate	*Fluminicola* sp.	Snail	EC_{20}	0.0044	0.00975	0.00975
Invertebrate	*Lampsilis siliquoidea*	Fatmucket clam	LOEC	0.0024	0.00523	0.0104
Invertebrate	*Lampsilis siliquoidea*	Fatmucket clam	EC_{20}	0.0093	0.02063	
Fish	*Lepomis macrochirus*	Bluegill	EC_{20}	0.0158	0.03501	0.03501
Amphibian	*Lithobates pipiens*	Northern leopard frog	MATC	0.0051	0.01124	0.0232
Amphibian	*Lithobates pipiens*	Northern leopard frog	MATC	0.0215	0.04766	
Amphibian	*Lithobates sylvaticus*	Wood frog	MATC	0.0030	0.00665	0.00665
Invertebrate	*Lymnaea stagnalis*	Pond snail	EC_{20}	0.0019	0.00410	0.0057
Invertebrate	*Lymnaea stagnalis*	Pond snail	EC_{20}	0.0088	0.01950	
Invertebrate	*Lymnaea stagnalis*	Pond snail	EC_{20}	0.0030	0.00666	
Invertebrate	*Lymnaea stagnalis*	Pond snail	EC_{20}	0.0009	0.00193	
Invertebrate	*Lymnaea stagnalis*	Pond snail	EC_{20}	0.0027	0.00606	
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}	0.0153	0.03392	0.0328
Fish	*Oncorhynchus mykiss*	Rainbow trout	MATC	0.0116	0.02558	
Fish	*Oncorhynchus mykiss*	Rainbow trout	MATC	0.0062	0.01375	
Fish	*Oncorhynchus mykiss*	Rainbow trout	MATC	0.0335	0.07419	
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}	0.0089	0.01979	
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}	0.0083	0.01836	
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}	0.0304	0.06729	

Table 11A-2-1: Chronic Toxicity Data Normalized Using the Multiple Linear Regression Model, Adapted from Table S5 in Brix et al. (2021)

Receptor Group	Species	Common Name	Endpoint	Normalized Effects Concentration in Brix et al. (2021)[a] (mg/L)	Normalized Effect Concentration[b] (mg/L)	Species Mean Chronic Value (mg/L)
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}	0.0100	0.02220	0.0328
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}	0.0117	0.02597	
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}	0.0130	0.02870	
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}	0.0111	0.02459	
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}	0.0118	0.02615	
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}	0.0224	0.04953	
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}	0.0139	0.03078	
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}	0.0187	0.04140	
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}	0.0178	0.03938	
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}	0.0337	0.07455	
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}	0.0091	0.02016	
Fish	*Oncorhynchus mykiss*	Rainbow trout	EC_{20}	0.0330	0.07311	
Fish	*Oncorhynchus tshawytscha*	Chinook salmon	EC_{20}	0.0028	0.00620	0.0062
Fish	*Pimephales promelas*	Fathead minnow	MATC	0.0079	0.01759	0.0132
Fish	*Pimephales promelas*	Fathead minnow	MATC	0.0021	0.00464	
Fish	*Pimephales promelas*	Fathead minnow	MATC	0.0116	0.02558	
Fish	*Pimephales promelas*	Fathead minnow	EC_{20}	0.0213	0.04724	
Fish	*Pimephales promelas*	Fathead minnow	EC_{20}	0.0019	0.00410	
Fish	*Salma trutta*	Brown trout	MATC	0.0172	0.03810	0.0381
Fish	*Salvelinus confluentus*	Bull trout	MATC	0.1072	0.23721	0.23721
Fish	*Salvelinus fontinalis*	Brook trout	MATC	0.0178	0.03931	0.0212
Fish	*Salvelinus fontinalis*	Brook trout	LOEC	0.0052	0.01144	
Fish	*Salvelinus namaycush*	Lake trout	MATC	0.0176	0.03904	0.03904
Invertebrate	*Villosa iris*	Rainbow mussel	EC_{20}	0.0069	0.01534	0.0066
Invertebrate	*Villosa iris*	Rainbow mussel	EC_{20}	0.0016	0.00344	
Invertebrate	*Villosa iris*	Rainbow mussel	EC_{20}	0.0024	0.00538	

a) As presented in Table S5 of Brix et al. (2021); these are chronic toxicity data normalized to pH 7.5, DOC of 0.5 mg/L, and hardness of 85 mg/L using the multiple regression equation in Table S5 in Brix et al. (2021).

b) Chronic toxicity data normalized to site characteristics of pH 6.95, DOC of 2.3 mg/L, and hardness of 14.447 mg/L using the MLR equation in Table S5 in Brix et al. (2021).

MATC = maximum acceptable toxicant concentration; DOC = dissolved organic carbon; EC_{20} = 20% effect concentration; EC_{25} = 25% effect concentration; LOEC = lowest observed effect concentration; MLR = multiple linear regression.

Rook I Project

Environmental Impact Statement

Section 12 Terrain and Soils

Submitted to:
Canadian Nuclear Safety Commission
Saskatchewan Ministry of Environment

Submitted by:
NexGen Energy Ltd.
3150-1021 W Hastings St
Vancouver, BC
V6E 0C3

November 2024

Executive Summary

Section Purpose

Section 12 of the Environmental Impact Statement (EIS) provides a comprehensive assessment of potential effects of the Rook I Project (Project) on terrain and soils. This assessment included consideration of both potential effects from the Project and cumulative effects from the Project and other reasonably foreseeable developments (RFDs). The terrain and soils assessment used widely accepted scientific practices and incorporated Indigenous and Local Knowledge.

Terrain and soils represented intermediate components in the Environmental Assessment (EA); the selection was based on the potential for terrain and soils to influence the establishment of plant species and vegetation communities and associated wildlife habitat and species over time. The terrain and soils assessment provided information that was used to support valued component (VC) assessments such as fish and fish habitat, vegetation, and wildlife and wildlife habitat, as well as the assessments of other intermediate components such as surface water quality, and sediment quality. Intermediate components, such as terrain and soils, were not assessed for significance.

Setting

At a regional scale, the Project would be located within the southern Athabasca Basin adjacent to Patterson Lake in northwestern Saskatchewan, approximately 40 km east of the Saskatchewan-Alberta border and 640 km northwest of the city of Saskatoon.

The local study area (LSA) for the terrain and soils assessment is within the Firebag Hills Landscape Area of the Mid-Boreal Upland Ecoregion of the Boreal Plain Ecozone of Saskatchewan (Acton et al. 1998). The LSA consists of gently to strongly rolling morainic plains that extend from the Clearwater River Valley and the upland areas along the Alberta border towards the Canadian Shield to the north (Acton et al. 1998). No unique terrain or soil features were identified within the LSA. Much of the LSA has been burned by forest fires in the past 40 years, and fire is the primary disturbance factor in the region.

Existing Conditions (Section 12.3)

Terrain in the LSA is primarily undulating to hummocky upland landscape. The slope of the local terrain ranges from relatively level to slopes of 25% or greater, with an average slope of about 7%. The LSA is composed of four terrain units, which are approximately distributed as follows:

- 79% glaciofluvial deposits;
- 14% water;
- 4% fen peat (i.e., Organic); and
- 4% anthropogenic (i.e., human-derived) disturbance.

For the soil-covered areas within the LSA, mineral soils are dominant, with some Organic soils also present. Mineral soil map units consist almost entirely of Brunisols, with small amounts of Gleysols and Mesisols also present. Organic soil map units consist almost entirely of Mesisols, with small amounts of Gleysols and Brunisols also present. Additional soil characteristics investigated during the baseline programs are shown in Table ES-1.

Table ES-1: Baseline Soil Characteristics Overview

Soil Characteristic	Details
pH values	2.9 to 5.2
salinity of soil samples	non-saline
buffering capacity against soil acidification	Low
plant nutrient content	generally low
electrical conductivity	0.10 decisiemens per metre (dS/m) to 0.35 dS/m
sodium adsorption ratio	topsoil and subsoil all within the range of Good reclamation suitability
cation exchange capacity	<0.80 mEq/100g to 7.68 mEq/100g
boron	occasional exceedance of limits[a]
sulphur	exceedance at one site
other metals	generally low
radionuclides	none exceeded release limit standards[b]

a) Criteria: Soil Quality Guideline for agricultural land use (i.e., 2 mg/kg dry weight boron; 500 mg/kg dry weight sulphur).
b) The radionuclide limits are from the *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM)* (Canadian NORM Working Group 2013).

Soils in the LSA are capable of supporting local ecosystems. No permafrost was observed in the LSA during the baseline programs.

Potential Effects and Proposed Mitigations (Section 12.4)

An analysis was completed to evaluate Project components and activities and associated effects pathways that could potentially affect terrain and soils. The evaluation also considered similar combined effects from the Fission Patterson Lake South Property, the identified RFD for the terrain and soils assessment.

Project activities that would have the potential to affect terrain and soils during the Project lifespan include:

- land clearing;
- site preparation;
- construction of facilities and infrastructure;
- handling of ore and waste rock;
- changes to air and water quality; and
- other supporting mining construction, operation, and decommissioning and reclamation activities.

As the pathways associated with these activities do not have the potential to overlap with the pathways of the Fission Patterson Lake South Property, only the potential effects of the Project were considered in the subsequent steps of the assessment process.

As part of the pathways analysis, proposed environmental design features and mitigation measures were considered to determine whether effects to the environment could be avoided or reduced to negligible levels, thereby removing the pathway. Project environmental design features such as the underground tailings management facility and site road alignment were designed, in part, to avoid removal of vegetation and wetland Organic soils, respectively. In addition, the proposed Project footprint has been optimized and would be limited to the extent practicable to minimize disturbance to terrain and soils. Proposed mitigation measures, such as the stripping and stockpiling of topsoil, would provide materials for future use in reclamation, and erosion-control techniques would minimize soil loss. These mitigations have been used extensively within the mining sector and have been proven effective. Similar mitigation and adaptive management practices would also be expected to be implemented by the Fission Patterson Lake South Property.

After mitigation measures were considered, the pathways screening analysis determined that many of the potential pathways from the Project to the environment could be removed from the assessment. However, the alteration of soil and terrain conditions (i.e., quantity, quality, and distribution) could still adversely affect soil productivity and the types of ecosystems that could be reclaimed on the landscape. Therefore, this pathway was carried forward into the residual effects analysis.

Residual Effects Analysis (Section 12.5)

A residual effects analysis was conducted to determine the potential effects of the Project on terrain and soils. The residual effects analysis considered three measurement indicators:

- quantity and distribution of terrain units;
- quantity and distribution of soil map units; and
- soil quality, which focused on soil suitability for reclamation.

The residual effects analysis followed a precautionary approach by using an assessment area, referred to as the maximum disturbance area, that assumes disturbance of an area approximately four times larger than the currently anticipated Project footprint. During the Application Case, 897.8 ha of new disturbance would be added to the 82.2 ha of existing disturbance in the maximum disturbance area for a total area of 980 ha.

Effects on terrain and soil map units covered with permanent facilities of the Project (e.g., waste rock storage areas) would be irreversible. The effects from disturbance on terrain and soil map units not covered by permanent facilities would be reversible over a long-term duration. During Operations, the Project would be progressively reclaimed. During the Active Closure Stage, non-permanent facilities and infrastructure would be fully decommissioned and reclaimed. Permanent facilities would be reclaimed to the extent possible. Reclamation is predicted to reverse effects on disturbed terrain and soils and would support the establishment and succession of vegetation communities that have a similar function to natural ecosystems. This objective would be achieved by applying best practices for soil salvage, storage, and placement. The establishment of reclaimed terrain, soils, and associated vegetation ecosystems would extend well beyond Closure (i.e., more than 60 years).

Prediction Confidence and Uncertainty (Section 12.6)

Overall, there was a moderate to high degree of confidence in predictions related to the terrain and soils assessment. Uncertainty was primarily and appropriately addressed by making assumptions that conservatively overestimated rather than underestimated potential effects (i.e., a precautionary assessment).

Monitoring, Follow-Up, and Adaptive Management (Section 12.7)

The Environmental Protection Program and associated environmental monitoring would be implemented to manage effects on terrain and soils and address the residual uncertainty in the effects prediction. The Preliminary Decommissioning and Reclamation Plan, along with future monitoring, would assist in revising or identifying additional mitigation measures to verify that terrain and soils support successful long-term reclamation.

Abbreviations and Units of Measure

Abbreviation	Definition
BNDN	Birch Narrows Dene Nation
BRDN	Buffalo River Dene Nation
CCME	Canadian Council of Ministers of the Environment
CEC	cation exchange capacity
CNSC	Canadian Nuclear Safety Commission
CRDN	Clearwater River Dene Nation
EA	Environmental Assessment
EC	electrical conductivity
EIS	Environmental Impact Statement
EXP	exposure
GIS	Geographic Information System
JWG	Joint Working Group
LPA	local priority area
LSA	local study area
MN-S	Métis Nation – Saskatchewan
NexGen	NexGen Energy Ltd.
NPAG	non-potentially acid generating
PAG	potentially acid generating
pH	potential of hydrogen
Project	Rook I Project
REF	reference
RFD	reasonably foreseeable development
RSA	regional study area
SAR	sodium adsorption ratio
SIL	Survey Intensity Level
SMU	soil map unit
VC	valued component
WRSA	waste rock storage area
YLNR	Ya'thi Néné Lands and Resources

Unit	Definition
%	percent
°C	degrees Celsius
$\mu g/m^3$	micrograms per cubic metre
Bq/g	becquerels per gram
cm	centimetre
cm^2	square centimetre
cm^3	cubic centimetre
dS/m	decisiemens per metre
g	gram
$g/m^2/yr$	grams per square metre per year
ha	hectare
kg/ha/yr	kilograms per hectare per year
km	kilometre
km^2	square kilometre
km/h	kilometres per hour
m	metre
mEq/100 g	milliequivalents per 100 grams
$mg/cm^2/30$ d	milligrams per square centimetre per 30 days
mg/kg	milligrams per kilogram
Mg/m^3	mega grams per cubic metre

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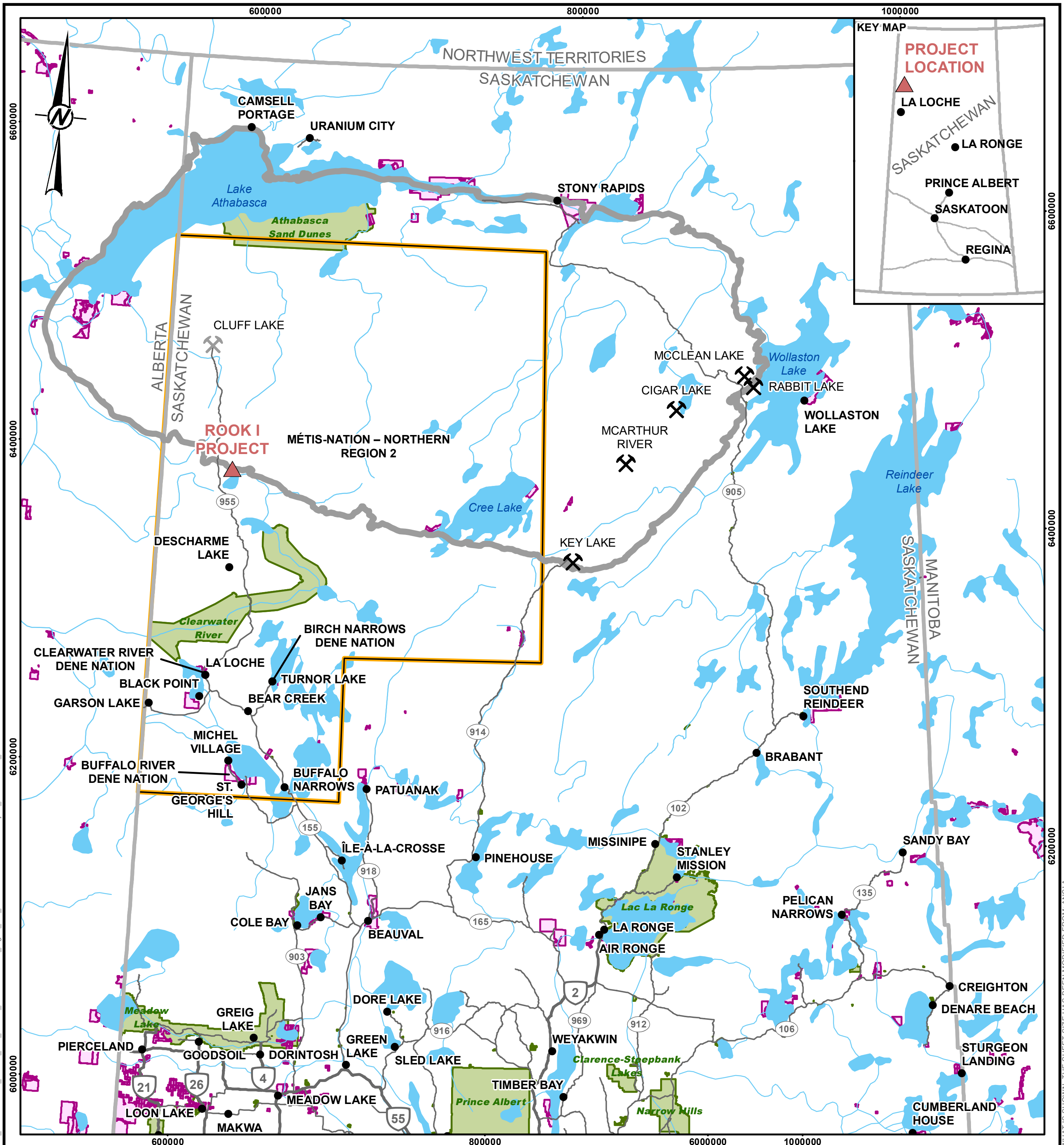
12 TERRAIN AND SOILS

12.1 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 Northern Village of La Loche, and 640 km northwest of the city of Saskatoon (Figure 12.1-1). 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. Patterson Lake is at the interface of the Boreal Shield and Boreal Plain ecozones. Access to the Project would be from an existing road off Highway 955 (Figure 12.1-2), with on-site worker accommodation serviced by fly-in/fly-out access.

Section 12, Terrain and Soils, of the Environmental Impact Statement (EIS) characterizes the potential residual effects of the Project on terrain (i.e., surficial materials and topography [elevation and slope]) and soils, which are attributes or components of the terrestrial environment. Terrain and soils represent intermediate components for the Environmental Assessment (EA). The Project has the potential to cause adverse effects on terrain and soils primarily through the construction of surface facilities and other supporting infrastructure. Atmospheric deposition of fossil-fuel combustion products (e.g., nitrogen and sulphur oxides) and the generation of dust emissions (Section 7.2, Air Quality) can alter the quality or productivity of soils. Alterations in groundwater (Section 8, Hydrogeology), and hydrology (Section 9, Hydrology) can also adversely affect the productivity of soils.

Changes in terrain and soils could influence the type of plant species, vegetation communities, and/or ecosystems that establish and develop over time (Section 13, Vegetation), which in turn can influence the variety of wildlife habitats and wildlife species on the landscape (Section 14, Wildlife and Wildlife Habitat). For these reasons, the terrain and soils assessment provides information that is used to support the assessments of other VCs such as fish and fish habitat (Section 11, Fish and Fish Habitat), vegetation (Section 13), wildlife (Section 14), human health (Section 15, Human Health), Indigenous land and resource use (Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use), and other land and resource use (Section 17, Other Land and Resource Use), and intermediate components such as surface water and sediment quality (Section 10). Terrain and soils are also important factors in the successful progressive and final reclamation of disturbed areas during the Project lifespan and after Decommissioning and Reclamation (i.e., Closure). A simplified linkage diagram, Figure 12.1-3, illustrates how proposed Project activities could result in a direct or indirect effect on terrain and soils, and the VCs that could be influenced through changes to terrain and soils.



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	SCALE AS SHOWN	REV. 0

FIGURE 12.1-1

PATH: I:\CLIENTS\NexGen\20144150\Mapping\Products\FINAL_EIS_FIGURES_WSP_LOGO_UPDATED\12_Terrain_and_Soils\8_5x11\20144150_Fig12_1-1_Location-of-the-RookI-Project_NoTitleblock_Rev0.mxd PRINTED ON: 2023-02-10 AT: 10:36:50 AM

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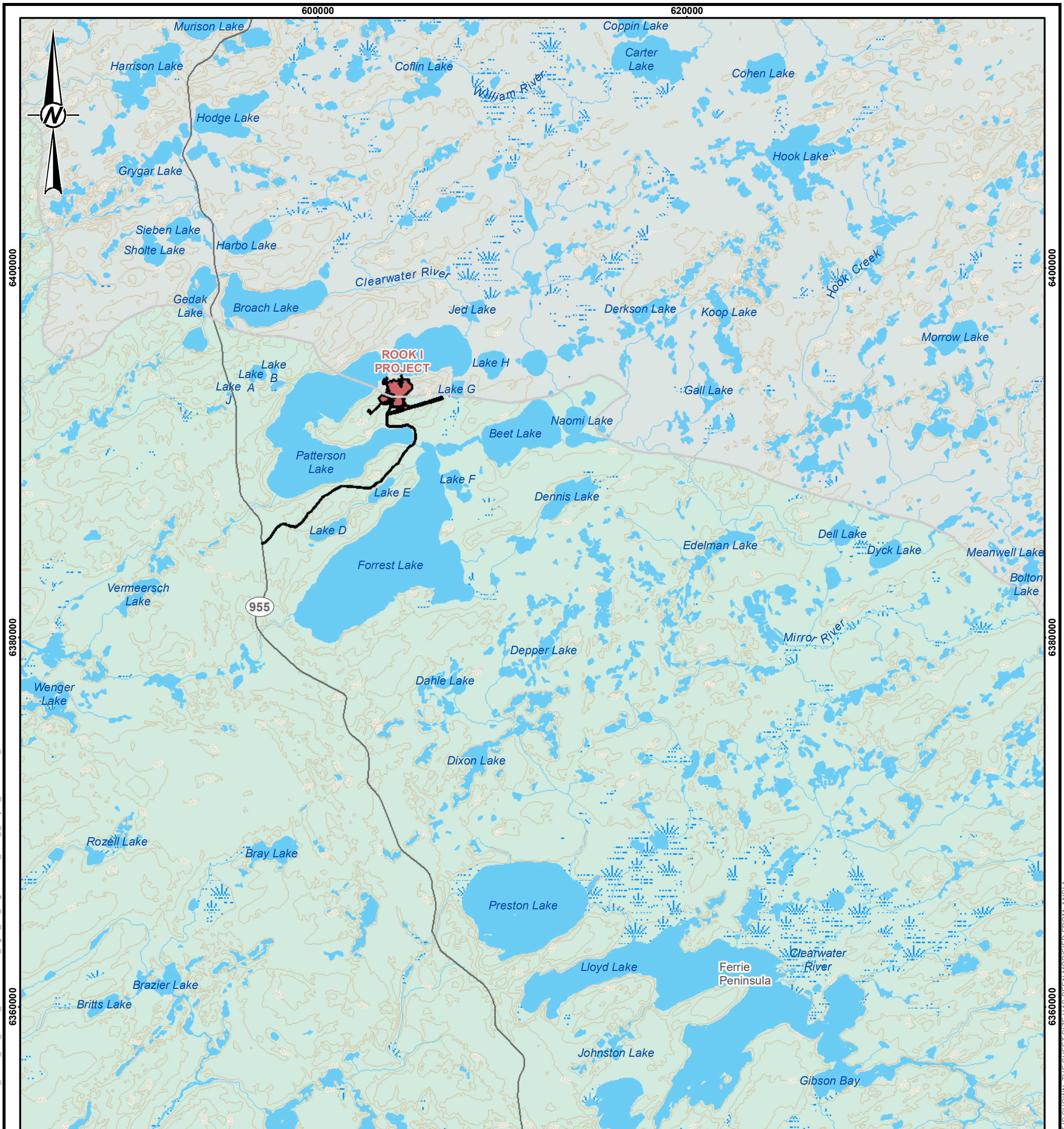

LEGEND

- 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	SCALE AS SHOWN	REV. 0

FIGURE 12.1-2

PATH: I:\CLIENTS\NexGen\20144150\Mapping\Products\FINAL_EIS_FIGURES_WSP_LOGO_UPDATED\12_Terrain_and_Soils\8_5x11\20144150_Fig12_1-2_Regional-Area_Rook_I_Project_NoTitleblock_Rev0.mxd PRINTED ON: 2023-02-08 AT: 12:00:17 PM

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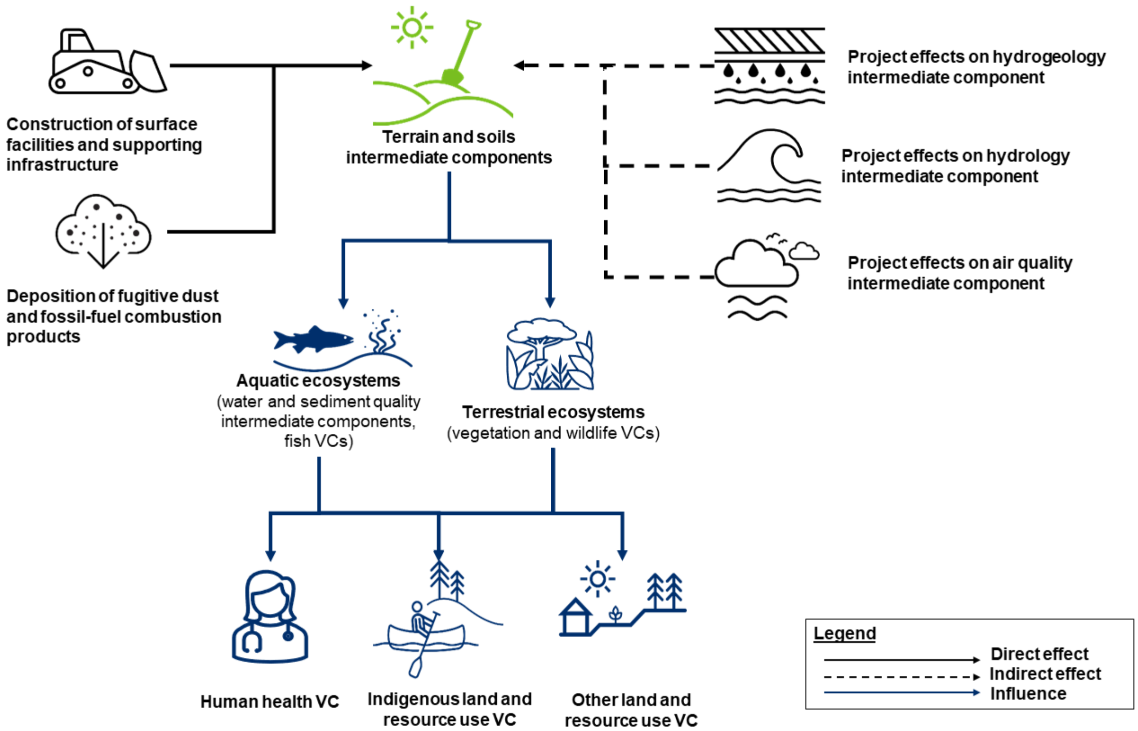
25mm 0

Figure 12.1-3: Linkage Diagram of Project Effects on Terrain and Soils and Influenced Valued Components



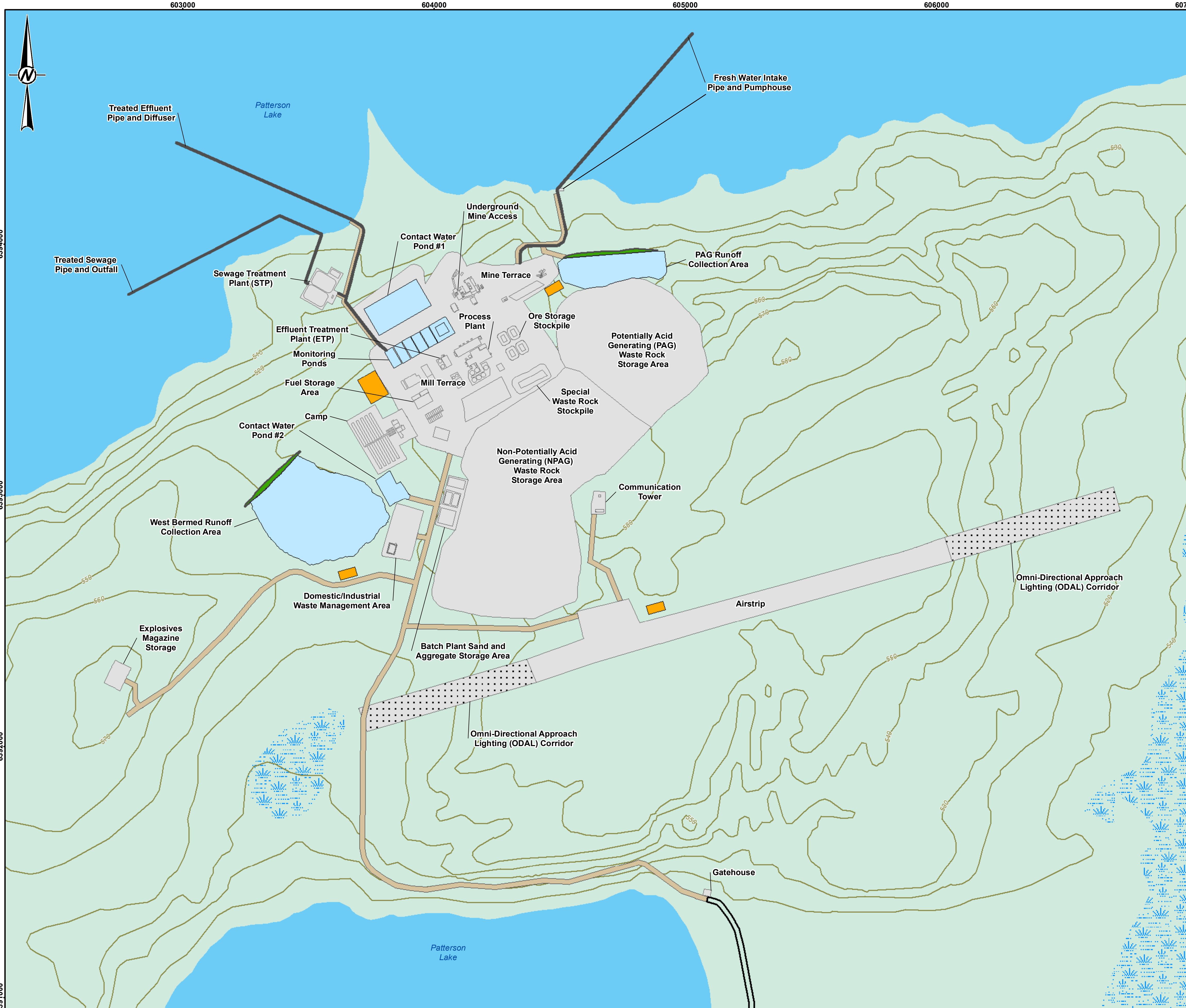
VC = valued component.

12.1.1 Project Summary

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 12.1-4):

- underground mine development;
- process plant buildings, including uranium concentrate packaging facilities;
- paste tailings distribution system;
- underground tailings management facility;
- potentially acid generating (PAG) waste rock storage area (WRSA);
- non-potentially acid generating (NPAG) WRSA;
- 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.

[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 [U3O8] and less than 0.26% U3O8). All special waste would be temporarily stored in the special waste rock stockpile.



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	SCALE AS SHOWN	REV. 0

FIGURE 12.1-4

12.1.2 Purpose and Approach to the Assessment

The purpose of Section 12 is to provide a detailed and comprehensive assessment of all potential Project-specific effects and cumulative effects from the Project and other previous, existing, and reasonably foreseeable developments (RFDs), if applicable, on terrain and soils. This section meets the Terms of Reference for the Project submitted to the Saskatchewan Ministry of Environment and the Canadian Nuclear Safety Commission (CNSC) *Generic Guidelines for the Preparation of an Environmental Impact Statement – Pursuant to the Canadian Environmental Assessment Act, 2012* (Appendix 1A, Concordance Tables). The assessment of terrain and soils followed the overall EA approach and methods (Section 6, Environmental Assessment Approach and Methods) and includes the following primary steps:

Step 1 – Define component-specific methods (Section 12.2): presents the specific approaches and methods used to measure and assess the effects of the Project on terrain and soils as well as cumulative effects from the Project, other previous and existing projects and activities, and RFDs, if applicable.

Step 2 – Characterize existing conditions (Section 12.3): describes and characterizes existing conditions to provide context and a basis for evaluating potential changes to terrain and soils caused by the Project.

Step 3 – Evaluate Project interactions and mitigations (Section 12.4): identifies Project components and/or activities with the potential to affect terrain and soils and provides environmental design features and mitigation policies and actions committed to by NexGen to avoid or minimize potential adverse effects. A pathways analysis was used to focus further assessment on key interactions between the Project and terrain and soils by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual adverse effects. Primary pathways anticipated to result in residual adverse effects after incorporation of mitigation are carried forward to Step 4 for further analysis. Where potential adverse effects are adequately mitigated and thus not forwarded for further analysis (i.e., where mitigation results in negligible effects or avoids the pathway altogether), the reasons for concluding the assessment at this stage are provided.

Step 4 – Analyze and classify residual effects (Section 12.5): evaluates and describes the potential Project effects on terrain and soils that are anticipated to occur through the primary pathways. The residual effects analysis is presented as an integrated narrative that describes the effects of the Project over time and highlights predicted effects at the point when adverse effects of the Project are expected to be greatest. The potential effects on terrain and soils that could result from the Project and RFDs were not analyzed as effects from the Project are not predicted to overlap with effects from RFDs. Residual effects are classified and tabulated using the criteria direction, magnitude, geographic extent, duration, reversibility, and frequency to provide structure and comparability across all VCs and intermediate components in the EA.

Step 5 – Describe uncertainty and define prediction confidence (Section 12.6): identifies key uncertainties and explains how these uncertainties have been addressed to achieve a conservative, precautionary assessment. The implications of the approaches used to address uncertainties and the level of confidence in the residual effects analysis are discussed.

Step 6 – Identify monitoring and follow-up (Section 12.7): outlines the proposed actions to verify predicted residual effects. The purpose of these actions is to evaluate effectiveness of planned mitigation designs, policies, and practices, and address key sources of uncertainty.

12.2 Component Methods

12.2.1 Incorporation of Indigenous and Local Knowledge

Indigenous and Local Knowledge included in the assessment of terrain and soils was shared by potentially affected First Nations and Métis Groups (collectively referred to as Indigenous Groups) and local priority area (LPA)[2] community members through the Project engagement process. The overall approach and methods for the incorporation of Indigenous and Local Knowledge into the EA is discussed in detail in Section 3, Indigenous and Local Knowledge. Issues and concerns related to terrain and soils raised by Indigenous Groups and LPA community members, and how these comments were addressed, are summarized in Appendix 2B, Summary of Issues and Concerns Identified by Indigenous Groups, and identified and addressed in this assessment, where applicable.

A key source of Indigenous and Local Knowledge is the Project-specific studies completed by Indigenous Groups, including Traditional Land Use and Occupancy studies, Traditional Knowledge and Use studies, and Indigenous Rights and Knowledge studies (henceforth referred collectively as Indigenous Knowledge and Traditional Land Use Studies). The Indigenous Knowledge and Traditional Land Use Studies that were reviewed and referenced in the EIS as technical support documents (TSDs) are listed below:

- TSD II (BNDN), Birch Narrows Dene Nation Traditional Knowledge and Use Study Specific to NexGen Energy Limited’s Proposed Rook I Project;
- TSD III (BRDN), Buffalo River Dene Nation Traditional Knowledge and Use Study Specific to NexGen Energy Limited’s Proposed Rook I Project;
- TSD IV (MN-S), Métis Nation – Saskatchewan Northern Region 2 Traditional Land Use & Diet Study for the NexGen Rook I Project;
- TSD V.1 (CRDN), Preliminary Identification of Issues and Concerns Related to the Proposed NexGen Energy Ltd. Rook I Project in the Patterson Lake Area; A Review; Clearwater River Dene Nation; Traditional Land Use and Occupancy Mapping Interviews; 2010 – 2016;
- TSD V.2 (CRDN), Clearwater River Dene Nation Indigenous Rights and Knowledge Survey Related to the Proposed NexGen Energy Ltd. Rook 1 Project in the Patterson Lake Area;
- TSD V.3 (CRDN), Socio-economic and Harvest Study; Clearwater River Dene Nation; NexGen Rook 1 Project; and
- TSD VI (YNLR), Provision of Athabasca Denesųłiné Traditional Knowledge, Land Use and Occupancy Information for the NexGen Rook I Project Environmental Assessment.

Another key source of Indigenous and Local Knowledge was information shared by Indigenous Group representatives during Joint Working Group (JWG) meetings. The JWGs represent an agreed-upon primary engagement mechanism as outlined in the Study Agreements signed by each Indigenous Group and NexGen. More details regarding the JWG can be found in Section 2, Indigenous, Regulatory, and Public Engagement and Section 3, Indigenous and Local Knowledge. There are four JWGs with the Project’s primary Indigenous Groups (Section 2.4.1, Identification of Indigenous Groups for Engagement):

[2] The LPA consists of the local communities closest to the Project that would experience most of the Project effects and for which NexGen would prioritize local training, employment, and business opportunities for the Project. These communities are located along, or accessed via, Highways 155 and 955 north of the intersection of Highways 155 and 925.

- Clearwater River Dene Nation (CRDN) JWG;
- Métis Nation – Saskatchewan (MN-S) JWG representing MN-S Northern Region 2 (NR2);
- Birch Narrows Dene Nation (BNDN) JWG; and
- Buffalo River Dene Nation (BRDN) JWG.

The leadership of each Indigenous Group selected their JWG participants with consideration of group diversity; where possible, members included Elders, youth, different genders, a range of ages, and land users around Patterson Lake.

In addition to the Indigenous Knowledge and Traditional Land Use Studies and JWGs, Indigenous and Local Knowledge shared during specific engagement activities undertaken through the EA development process was incorporated into the assessment, where appropriate. These engagement activities included, but were not limited to:

- community information sessions held in four locations in 2019 (NexGen 2019);
- site tours;
- comments from the CRDN (CRDN 2019a) on the Cluff Lake Mine licence renewal;
- other formal and informal meetings;
- workshops with specific groups (e.g., Fur Block N-19 trapper's workshop); and
- environmental and socio-economic baseline data collection.

Comments submitted by Indigenous Groups on the Project Description (CRDN 2019b; MN-S 2019; YNLRO 2019; ACFN 2019; CNSC 2019) were also reviewed for applicable Indigenous and Local Knowledge.

Indigenous and Local Knowledge related to terrain and soils was incorporated into the assessment by considering and viewing the information as complementary and influential alongside scientific information. Where possible, knowledge from each potentially affected Indigenous Group or LPA community member was described separately and cited accordingly. Where information is described for multiple potentially affected Indigenous Groups, they are collectively referred to as "Indigenous Groups" throughout the assessment.

Indigenous and Local Knowledge was included in the terrain and soils assessment in the following ways:

- **Component Methods – Valued Components and Intermediate Components:** Indigenous and Local Knowledge was considered in the selection of the terrain and soils intermediate components and reflects the broader importance of "land", in which terrain and soils are key components. Terrain and soils are interrelated with several components of the biophysical environment, and quality of soils is important to producing healthy and productive land bases for harvesting activities. The physical features of the landscape (e.g., ridges, river valleys) contribute to a sense of place, and are often used for travel and as navigational landmarks. Features of the physical landscape often have Indigenous placenames, which connect land users with their history and represent long-standing relationships with particular places Section 12.2.2.1).
- **Project Interactions and Mitigation:** Indigenous and Local Knowledge helped to inform the scoping of Project interactions, pathway analysis and consideration of mitigation measures (Section 12.4). This included observations and experiences of land users related to the cumulative effects from industry on air

and water quality, and subsequent effects to terrestrial components of the environment, as well as observations related to the successfulness of reclamation activities (Section 12.4).

- **Monitoring, Follow-Up, and Management:** Feedback provided by Indigenous Groups during engagement, including recommendations, was considered in the development of monitoring and follow-up activities (Section 12.7). In addition, it is planned that ongoing feedback from Indigenous Groups on the effectiveness of mitigations would be considered when updating monitoring and management plans. Independent Indigenous Monitors chosen by each primary Indigenous Group would also have opportunities to participate in environmental monitoring programs for the proposed Project.

Specific references to Indigenous and Local Knowledge, and Project comments and concerns related to terrain and soils raised by Indigenous Groups and LPA community members, are included in the applicable sections of this assessment.

12.2.2 Valued Components, Intermediate Components, and Measurement Indicators

12.2.2.1 Valued Components and Intermediate Components

Valued components are aspects of the biophysical, cultural, and socio-economic environments that are considered to have scientific, social, cultural, economic, historical, archaeological, or aesthetic importance (Beanlands and Duinker 1983; CNSC 2021). Intermediate components include physical attributes of the biophysical environment or media upon which VCs rely, such as air quality, terrain and soils, hydrogeology, and hydrology (Section 6.3.3, Intermediate Components). Valued components and intermediate components are assessed using the same steps; however, unlike VCs, intermediate components do not have assessment endpoints or significance criteria. Instead, the significance of changes in intermediate components is evaluated in the context of related influences to VCs, which are the ultimate receptors.

Terrain and soils were selected as intermediate components since these elements provide the physical foundation for functioning aquatic and terrestrial ecosystems and local biological processes. The rationale for selecting terrain and soils as intermediate components is provided in Table 12.2-1.

Terrain and soils are critical to the assessment of VCs for the EA; however, the importance or significance of changes in terrain and soils can only be evaluated in context of the related influences on a VC, which is the ultimate receptor of value to humans and the environment. As an example, changes in terrain and soils are challenging to evaluate without the context of what these changes would mean to vegetation and wildlife and wildlife habitat VCs. As such, the assessment of terrain and soils is fundamental to understanding the total effects of the proposed Project on the biophysical environment (Section 6.3.3).

Table 12.2-1: Rationale and Measurement Indicators for the Terrain and Soils Intermediate Components

Intermediate Components	Rationale	Measurement Indicators
Terrain and soils	Provide physical structure and foundation for aquatic and terrestrial ecosystems	▪ Quantity and distribution of terrain units, which includes surficial materials, topography, and slope stability ▪ Quantity and distribution of soil map units ▪ Soil quality (i.e., productivity)

Similar to VCs, the terrain and soils intermediate components were analyzed using a science-based approach to determine the Project-specific and cumulative changes, if applicable, in measurement indicators.

As mentioned in Section 12.2.1, the value of terrain and soils to Indigenous Groups was reflected through the concept of "land". The importance of a healthy and productive land base to access resources and continue hunting, trapping and plant gathering was highlighted by Indigenous Groups (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD VI: YNLR), including the role of the land base in the transmission of knowledge, culture, and identity:

> The Dene language cannot be divorced from the land from which it emerged; nor can the transmission of knowledge be divorced from a healthy productive land base which draws on the knowledge and experience of the ancestors, Elders and current harvesters. (TSD V.1: CRDN)

> I think without the land, the land base, we don't have anything. When we talk about traditional territory, it just doesn't mean it's bound to our reserve boundary. It's wherever we go, wherever we hunt before in the past, and we continue to go there. (TSD II: BNDN)

Indigenous Groups also commented on the linkages between air and water quality with terrestrial components of the environment, including to soils, vegetation, and wildlife, which contribute to a healthy land base (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YNLR). The CRDN described how medicinal properties of plants are related to the "quality of the grounds in which they grow" and medicinal plants are not gathered from areas that have been disturbed (TSD V.1: CRDN; TSD V.2: CRDN). The BNDN described the inter-relationships between different environmental components through the concept of "Mother Earth":

> My belief is the earth was made for a reason . . . all the minerals that are in the ground . . . [have] a reason to be there . . .[they were] put there for a reason. Not to be all taken out. It's like a human being; when you start taking out one piece here and there, that human being is not a human being anymore . . . it's the same thing with the earth. We call it Mother Earth because it's like a mother to us. it provides for us. And that's why we call it Mother Earth. (TSD II: BNDN)

A member of the MN-S described his understanding of the land based on the relationship between different soil management techniques and berry production; for example, blueberries will grow after the land is burned, while strawberries will grow after the land is ploughed (MN-S-JWG 2019a). The importance of respecting and taking care of the land so it can continue to sustain people and provide longevity was also emphasized.

The value of terrain to Indigenous Groups was reflected in the importance of the land's physical features and the concept of sense of place. Sense of place is "intricately connected to land and place" (TSD III: BRDN); it is tied to people's attachment and affiliation with the land and is an expression of identity and familiarity (TSD II: BNDN; TSD III: BRDN). Sense of place "depends on particular places . . . along with their particular features (physical, social, and symbolic) and the values and activities these features foster and enable" (TSD II: BNDN). Indigenous Groups have an inherent familiarity with the land and its physical features that contributes to sense of place and is developed from their long history navigating the landscape to access traditional use areas (TSD III: BRDN). Physical features of the landscape (e.g., hills, ridges, river valleys) often have Indigenous placenames, which represent long-standing relationships with particular places and have cultural value because they connect community members with their history and provide navigational landmarks (TSD II: BNDN; TSD V.2: CRDN).

12.2.2.2 Measurement Indicators

Measurement indicators are used to characterize changes to attributes of the environment from the Project, other human developments, and natural factors. The changes in measurement indicators are used to predict overall effects on VCs and intermediate components (Section 6.3.2, Assessment Endpoints and Measurement Indicators). Three measurement indicators were identified and used for the terrain and soils assessment (Table 12.2-1):

- **Quantity and distribution of terrain units:** refers to the amount of each terrain unit and the way each unit is distributed on the landscape. Terrain quantity and distribution are linked to the soil map unit (SMU) measurement indicator, but terrain focuses on the underlying parent material (i.e., material in which soils form). Metrics of terrain unit quantity and distribution include surficial material, topography, and slope stability.
- **Quantity and distribution of soil map units (SMUs):** refers to the amount of each SMU and the way each SMU is distributed on the landscape. The SMU quantity and distribution are linked to the terrain quantity and distribution, but SMUs focus on the mineral and organic material. Metrics of SMU quantity and distribution include soil classification, soil description, surface stoniness (i.e., the amount of rock fragments on surface or protruding above ground), and soil texture.
- **Soil quality (i.e., productivity):** refers to the productivity of the soil as a growth medium on the landscape. Productivity is typically reduced in human-altered environments due to changes in physical properties of soils (e.g., removal of soil and compaction). Metrics used to evaluate soil quality include soil chemistry, soil suitability for reclamation, erosion sensitivity, sensitivity to acidification (i.e., measure of susceptibility to chemical changes after experiencing acid inputs), permafrost potential, and sensitivity to compaction.

12.2.3 Spatial Boundaries

The spatial boundaries selected for the terrain and soils assessment support a description of the existing environment in sufficient detail to identify, understand, and assess potential Project interactions with the terrain and soils intermediate components, including the contribution of the Project to residual effects (Table 12.2-2). The spatial boundaries for the assessment of terrain and soils consisted of a site study area (i.e., Project footprint), maximum disturbance area, and local study area (LSA; Figure 12.2-1). The selection of the assessment study areas considered VC- and intermediate component-specific and ecosystem-centred attributes and boundaries, and the potential spatial extent of Project effects and other existing and future activities/developments in accordance with CEA Agency guidance (CEA Agency 2018).

The site study area is equivalent to the anticipated area of the Project footprint, which covers 228 ha and includes the access road and bridge, and all proposed mine site infrastructure and features. To the degree possible, the Project footprint was minimized to reduce both the area of restricted access to Indigenous and other land users and the effects on the terrestrial environment.

A maximum disturbance area was used for the assessment to address uncertainty in the final design of the Project so that adverse effects on terrain and soils were not underestimated (i.e., the maximum disturbance area is four times larger than the anticipated Project footprint). The maximum disturbance area, which covers 981 ha, represents the smallest scale of assessment and an area where the potential direct effects of the anticipated Project on terrain and 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 (Section 6.4.1, Spatial Boundaries). The spatial boundary for terrestrial resources was also constrained to the shoreline of Patterson Lake (Figure 12.2-1).

The LSA is approximately 2,832 ha and is defined by a 500 m buffer around the maximum disturbance area (Figure 12.2-1). The LSA provides local context for assessing Project effects. The LSA also includes disturbance from previous and existing human-related activities, such as NexGen's existing exploration camp and core shed, public trails, cutlines, clearings, and the intersection of the access road and Highway 955. The LSA was established to capture the direct effects on terrain and soils within the maximum disturbance area from the physical removal and alteration of the surficial materials and vegetation. The 500 m buffer around the maximum disturbance area is expected to capture the indirect effects on soils from fossil fuel and dust emissions and deposition, which could lead to physical, chemical, and biological changes in soil properties. For example, soil contamination from metals in gasoline additives has been found in various studies to decline within 20 m of roads but may occur up to 200 m depending on prevailing winds (Trombulak and Frissell 2000).

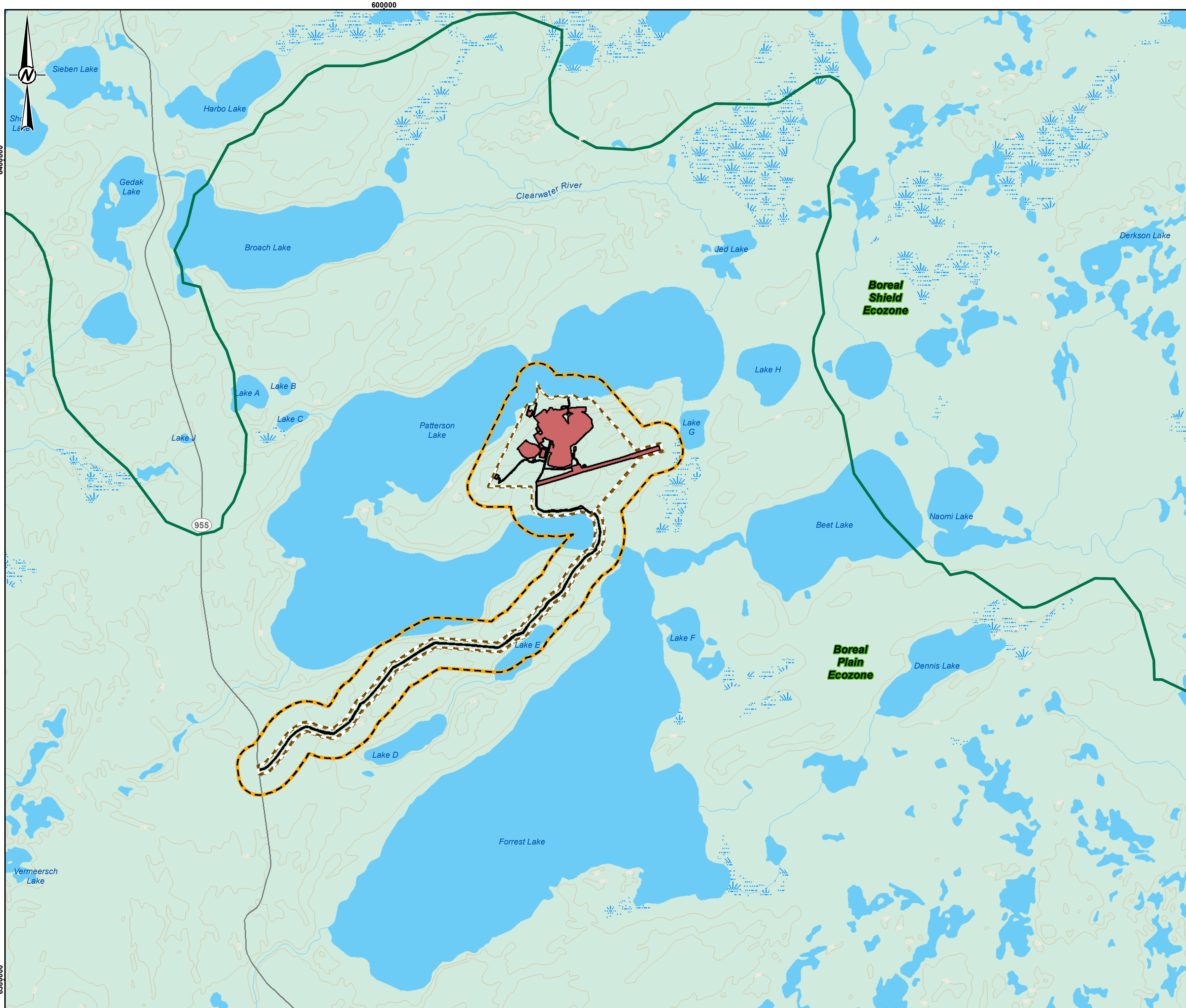
Several studies have identified dust deposition in proximity to gravel or unpaved roads, and associated vegetation community shifts, changes in snowmelt, and changes in thaw depth (Walker and Everett 1987; Farmer 1993; Rusek and Marshall 2000). Walker and Everett (1987) found effects were primarily within 50 m of a road, while Meininger and Spatt (1988) detected stronger effects within 50 m and weaker changes within 50 to 500 m from a road. Both studies were completed in Alaska. At the Ekati Mine in the Northwest Territories, dust generated from a high-traffic, 28 km haul road was found to change soil pH rapidly (i.e., exponentially) within 250 m and showed smaller changes up to 1 km away (Chen et al. 2017). Dust deposition also decreased lichen cover up to 1 km from the haul road. In contrast, at the nearby Diavik Mine, measured changes to plant communities were within 500 m of the mine (Watkinson et al. 2021). The above studies indicate that effects from fossil fuels and dust deposition largely occur within 50 to 500 m from a disturbance source, which support the chosen 500 m buffer. The exception was the study by Chen et al (2017) that showed changes to soil pH were largest within 250 m of the source with much smaller changes between 250 m and 1 km. Any indirect effects that may extend beyond the LSA were also considered in the assessment, as applicable.

Terrain and soils provide the physical structure and foundation for aquatic and terrestrial ecosystems. Although the assessment of terrain and soils does not require a larger spatial boundary than the LSA, the results are applied to a broader regional scale to support the assessments of aquatic ecosystem, vegetation, and wildlife VCs. Aquatic ecosystems (e.g., water quantity and quality, fish and fish habitat VCs) and vegetation and wildlife VCs defined a regional study area (RSA; 107,491 ha) that provided broader context for interpreting effects of the Project and cumulative effects of RFDs, where applicable. For example, the Clearwater River watershed RSA links the pathways of exposure to constituents of potential concern (COPCs) in dust and air emissions to soils, plants, and wildlife in the watershed, which are evaluated through the ecological health risk assessment (TSD XXI, Environmental Risk Assessment). The RSA includes the LSA plus Forrest Lake, Beet Lake, and Naomi Lake, and the watershed east and north of the confluence of the Clearwater and Mirror rivers as described in the hydrology assessment (Section 9.2.3, Spatial Boundaries).

Table 12.2-2: Spatial Boundaries for the Assessment of Terrain and Soils

Spatial Boundary	Surface Area	Description
Site study area	228 ha (2.3 km^2)	▪ Equivalent to the anticipated Project footprint, which includes all proposed mine infrastructure and facilities (199 ha) and the access road (29 ha)
Maximum disturbance area	981 ha (9.8 km^2)	▪ Incorporates a level of uncertainty into the Project design so that effects are not underestimated ▪ Maximum disturbance area was selected using bounding points around the outermost components of the Project footprint
LSA	2,832 ha (28 km^2)	▪ 500 m buffer around the maximum disturbance area ▪ Defined by the expected extent of the direct and indirect effects from the Project ▪ Provides local context for assessing the residual effects

Note: Numbers are rounded for presentation purposes.
LSA = local study area.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- SECONDARY HIGHWAY
- WATERCOURSE
- ECOZONE BOUNDARY
- WATERBODY
- WETLAND
- WOODED AREA
- PROPOSED PROJECT FOOTPRINT
- MAXIMUM DISTURBANCE AREA
- LOCAL STUDY AREA

0 3 6
1:95,000 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. ECOZONES OBTAINED FROM AGRICULTURE AND AGRI-FOOD CANADA (AAFC).
PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT
NexGen Energy Ltd.
ROOK I PROJECT

TITLE
SPATIAL BOUNDARIES FOR THE TERRAIN AND SOILS ASSESSMENT

CONSULTANT
wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	CK	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08	FIGURE 12.2-1	
CHECK	CM	2023-02-08		
REVIEW	KH	2023-02-08		

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12.2.4 Temporal Boundaries

The temporal scope of the assessment 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 (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 required 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 CNSC licence would be submitted to the CNSC 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.

Most of the residual effects from the Project on terrain and soils are predicted to have the largest magnitude and spatial extent at the end of Construction, when the physical footprint is near or at full development and reclamation has not yet started. For the assessment of terrain and soils, this is represented by the maximum disturbance area. Effects from the physical disturbance and alteration of terrain and soils are expected to continue through Operations and into Closure until most effects are mitigated by closure activities; some effects would be considered permanent (e.g., residual areas covered by waste rock). In consideration of these factors, effects were analyzed and predicted from Construction through Closure, which generates the maximum potential spatial and temporal extent of effects and provides confident and ecologically relevant effects predictions. Where applicable, residual effects were also assessed in terms of specific temporal snapshots of the Project defined by other intermediate components (e.g., air quality, hydrology, and water quality) that may have a linkage to potential effects on terrain and soils. These temporal snapshots represent phases or periods when the adverse effects are predicted to be most pronounced (Section 6.4.2).

The temporal boundaries applied to the cumulative effects assessment include the duration of residual effects from previous and existing developments that overlap with residual effects from the Project, and the period during which the residual effects from RFDs overlap with the Project, if applicable.

12.2.5 Assessment Cases

The concept of assessment cases was applied to the terrain and soils assessment to estimate the incremental and cumulative effects from the Project and other developments (Section 6.5, Assessment Cases). 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. There are no known approved (but not yet constructed) projects in the LSA and RSA for terrain and soils. Assessment cases for the Project included a Base Case, Application Case, and RFD Case.

Base Case for terrain and soils is represented by existing conditions. The Base Case describes the existing environment in the LSA before application of the proposed Project to provide an understanding of the current conditions that may be influenced by the Project. The temporal boundary of the Base Case includes the combined effects from previous and existing human disturbances and natural factors (e.g., fire, floods, disease, insects) on the environment and terrain and soils. As such, existing conditions represent the cumulative effects of historical and current environmental pressures that have influenced the observed condition and patterns of terrain and soils (CEA Agency 2018).

Application Case for terrain and soils 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 to terrain and soils.

Reasonably Foreseeable Development Case for terrain and soils includes the Base Case, Application Case, and RFDs that have not yet been approved. Reasonably foreseeable developments are defined as projects and activities that fit any of the first three and both of the last two criteria from the list below:

- are currently under regulatory review or have officially entered a formal regulatory application process;
- have been publicly disclosed by other proponents;
- may be induced by the Project;
- have the potential to change the Project or the effects predictions; and
- occur in the spatial assessment boundary defined by the intermediate components.

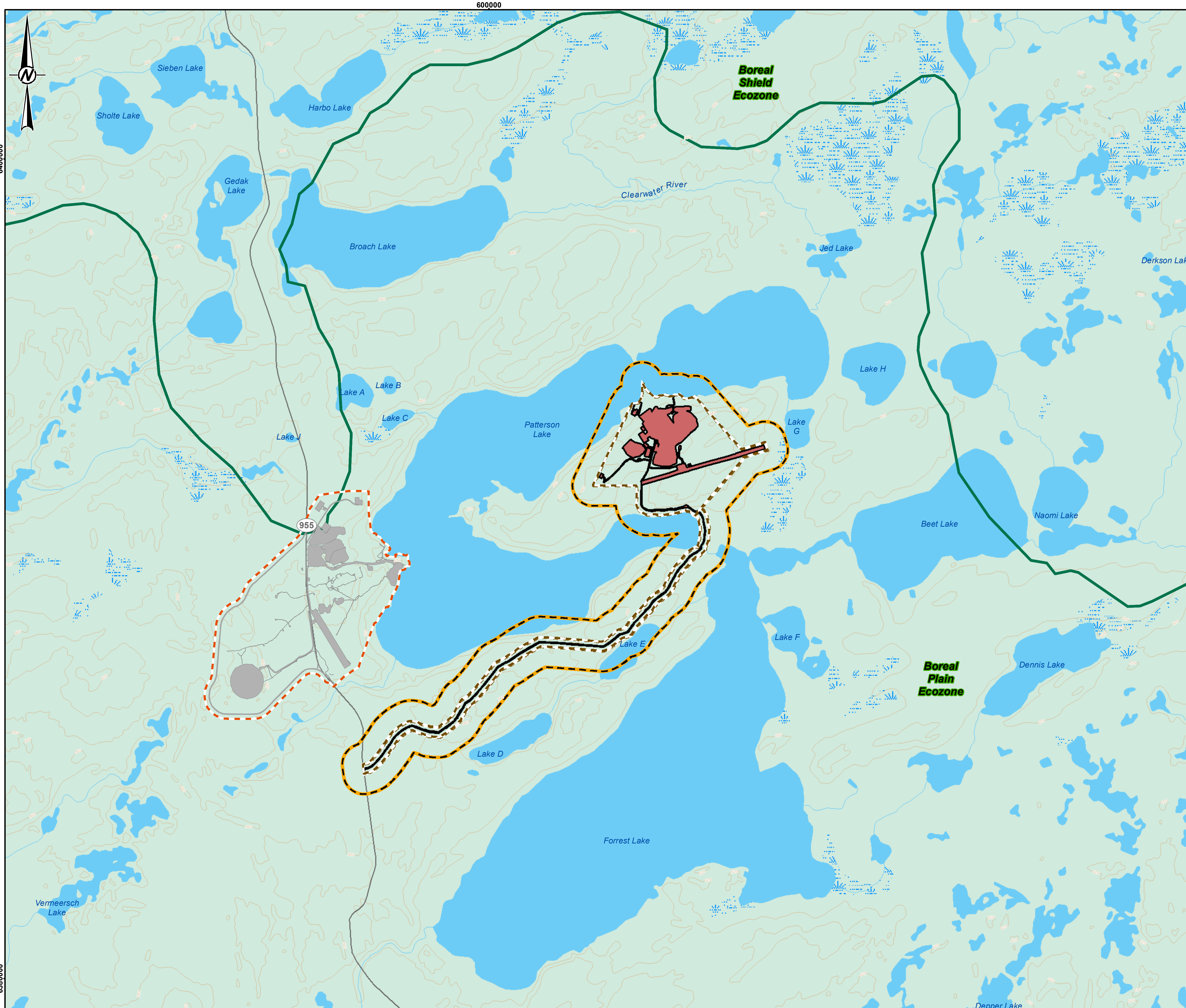
A key criterion for selecting other projects to include in the RFD Case was that the projects must cause similar effects on terrain and soils intermediate components influenced by the Project (Hegmann et al. 1999). The Fission Patterson Lake South Property, which is planned by Fission Uranium Corp. (Fission 2019, 2021), was identified as an RFD in the EA. Public information describes a projected three-year construction period and seven-year operating period (production and processing) (Fission 2019, 2021). The anticipated start of construction and duration of active decommissioning at the Fission Patterson Lake South Property were not publicly available at the time this assessment was completed. For the assessment, it was assumed that the duration of active decommissioning for the Fission Patterson Lake South Property would be similar to the Active Closure Stage for the Project (i.e., five years; Section 6.5.3, Reasonably Foreseeable Development Case).

The proposed surface infrastructure layout plan (Fission 2019, 2021) is the anticipated physical footprint of the Fission Patterson Lake South Property and includes the proposed highway bypass, airstrip, and all proposed mine site infrastructure. A hypothetical maximum disturbance area, as applied in Section 12.2.3 to the Project footprint, was also used for the Fission Patterson Lake South Property to address uncertainty in project design. The CRDN specifically mentioned the potential for cumulative effects from the Project and the nearby proposed Patterson Lake South Property (CRDN 2019b).

The hypothetical maximum disturbance area of the Fission Patterson Lake South Property is located approximately 4.8 km from the maximum disturbance area of the proposed Project and approximately 1.8 km from the access road. When considering 500 m buffers (i.e., LSA boundaries) from both the Project and Patterson Lake South Property maximum disturbance areas, effects from the proposed projects would not spatially overlap.

The primary residual effects from the Project on terrain and soils are predicted to be confined to the maximum disturbance area, which was established to account for potential Project footprint changes. No unique terrain or soil features were identified within the LSA (Section 12.3, Existing Conditions). Secondary effects on soil quality from the deposition of dust and other particulate matter that may contain metals and acidic compounds are predicted to be negligible and mostly confined to the maximum disturbance area and LSA (Section 12.4). Mitigation policies and actions implemented by the Project are expected to avoid and minimize the Project's contribution to cumulative effects. It is also expected that the Fission Patterson Lake South Property would implement appropriate mitigation and adaptive management to avoid and minimize project-specific effects. As such, there is negligible potential for cumulative effects on terrain and soils from the Project and Fission Patterson Lake South Property, which precludes the need to assess an RFD Case.

Throughout the EA, RFD Cases also consider how natural factors and climate change (e.g., fire frequency, precipitation) may interact with the Project and other developments to affect VCs and intermediate components (Section 6.5.3, Reasonably Foreseeable Development Case). Indigenous Groups expressed concerns about cumulative effects from industrial development in general, government policies and climate change (TSD V.1: CRDN; TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S). As there is no RFD Case for terrain and soils, potential changes from natural disturbance factors and climate change are qualitatively discussed in the Application Case.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- SECONDARY HIGHWAY
- WATERCOURSE
- ECOZONE BOUNDARY
- WATERBODY
- WETLAND
- WOODED AREA
- PROPOSED PROJECT FOOTPRINT
- MAXIMUM DISTURBANCE AREA
- FISSION PATTERSON LAKE SOUTH PROPERTY FOOTPRINT
- PATTERSON LAKE SOUTH PROPERTY HYPOTHETICAL MAXIMUM DISTURBANCE AREA
- LOCAL STUDY AREA

0 3 6

1:95,000 KILOMETRES

REFERENCE(S)
1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021.
2. FISSION (FISSION URANIUM CORP.) OBTAINED FROM 2019 TECHNICAL REPORT ON THE PRE-FEASIBILITY STUDY OF THE PATTERSON LAKE SOUTH PROPERTY USING UNDERGROUND MINING METHODS.
3. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. ECOZONES OBTAINED FROM AGRICULTURE AND AGRI-FOOD CANADA (AAFC).
PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT
NexGen Energy Ltd.
ROOK I PROJECT

TITLE
LOCATION OF THE PLANNED FISSION PATTERSON LAKE SOUTH PROPERTY

CONSULTANT
wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	CK	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	CM	2023-02-08	**FIGURE 12.2-2**	
REVIEW	KH	2023-02-08		

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12.2.6 Existing Conditions

Data and information collected at the local scale provided detailed and precise measurements of existing conditions to allow the prediction of direct and indirect Project-related changes to measurement indicators for terrain and soils. In designing the field study, locations of soil inspection sites varied based on terrain complexity and were selected such that each dominant soil group was inspected. Existing terrain and soil conditions were described for the LSA using a preliminary desktop review and data collected during baseline surveys in 2018 and 2019. A complete description of the terrain and soils baseline methods and results is available in Annex VI[3], Terrain and Soils Baseline Report. In total, 118 soil inspection sites were surveyed during the 2018 and 2019 field programs (110 within the LSA), and terrain and soil data and samples were used for soil classification, mapping descriptions, and chemical analysis. At each soil inspection site, detailed profile information was collected to the depth of parent material (e.g., C horizon[4]) or to a maximum depth of 120 cm for mineral soils and 2 m for organic soils.

12.2.6.1 Terrain and Soil Quantity and Distribution

Mapping of soil quantity and distribution involved the correlation of field observations and soil classification with publicly available satellite imagery for the LSA. The Topographic Data of Canada Series CanVec (1:50,000) (Government of Canada 2013) topographic data were used to identify general relief and changes in terrain. Soil inspection information was applied considering principles of geomorphology and surficial geology, in combination with ground-truthed soil patterns. Soils in the maximum disturbance area were mapped at a scale of 1:5,000 and at Survey Intensity Level (SIL) 1, which requires a minimum of one soil inspection site per 5 ha and at least one inspection in every delineated map polygon (Agriculture Canada 1981). Soils in the LSA outside of the maximum disturbance area were mapped at a 1:20,000 scale and SIL 2, which requires a minimum of one soil inspection site per 30 ha and at least one inspection in over 90% of delineated map polygons (Agriculture Canada 1981, Valentine and Lidstone 1985). The detailed level of the mapping scale and soil surveys allowed the identification of site-specific soil characteristics (i.e., specific areas that require special soil handling) and refined the accuracy and precision of soil mapping for the maximum disturbance area and LSA. In the resulting mapping, soil subgroups are defined as dominant (over 60% of map unit), sub-dominant (15% to 60% of map unit), or inclusions (less than 15%) based on the proportion of each soil subgroup present in the map unit.

The terrain analysis component integrated data from the field program to develop SMUs based on soil characteristics and terrain features that captured the range of variability in soil subgroups present within the LSA. At each soil inspection site, the parent material classification was noted and used as a basis for delineating SMUs. Terrain classification was delineated by combining SMUs with similar properties. For example, all SMUs with glaciofluvial parent materials were merged to produce larger units having similar morphological characteristics. Therefore, the terrain unit names reflect surficial material characteristics.

Soil mapping was completed following guidelines outlined in *A Soil Mapping System for Canada: Revised* (Agriculture Canada 1981). Soils were generally grouped into three landform (i.e., terrain) areas: upland landscapes with well-drained soils; depressional landscapes with very poor drainage; and transition landscapes

[3] Annex VI presents a smaller maximum disturbance area (913 ha) than what was assessed in the EIS (981 ha), as the proposed Project footprint design progressed between completion of the baseline survey and the EIS.

[4] Soil horizons are layers of mineral or organic soil that lie approximately parallel to ground surface. Each horizon has distinct characteristics based on the process of soil formation, and is assigned a letter (e.g., A, B, or C) according to definitions from the Canadian System for Soil Classification (SCWG 1998). A horizons are the mineral horizons that form at or near the ground surface, B horizons generally lie below A horizons, and C horizons are the underlying mineral horizons consisting of parent materials that are relatively unaffected by the processes of soil development.

(i.e., between upland and depressional areas) with poorly to imperfectly drained soils. Soil and terrain map units were incorporated into a Geographic Information System (GIS) platform to calculate the quantity of each map unit and display the distribution of map units within the LSA.

12.2.6.2 Soil Quality

Soil Chemistry

During the 2018 field survey, samples from each soil horizon (i.e., A, B, and B/C) of the dominant Soil Orders (i.e., Brunisolic, Gleysolic, Regosolic, and Organic [SCWG 1998]) were collected at five soil inspection sites. The samples were analyzed for chemistry and other soil quality parameters (Annex VI, Section 4.2.3, Soil Chemistry) to confirm soil classification and inform reclamation material suitability.

Baseline leachable metal chemistry is an indicator of soil quality, which can influence the growth, health, and metals uptake of plants. Therefore, samples that were collected at the five soil inspection sites were also analyzed for a suite of leachable metals for each horizon:

- aluminum;
- antimony;
- arsenic;
- barium;
- beryllium;
- bismuth;
- boron;
- cadmium;
- chromium;
- cobalt;
- copper;
- iron;
- lead;
- lithium;
- manganese;
- mercury;
- molybdenum;
- nickel;
- selenium;
- silver;
- strontium;
- thallium;
- tin;
- titanium;
- tungsten;
- uranium;
- vanadium;
- zinc; and
- zirconium.

In the 2019 field survey, soil samples were collected at the same locations as baseline vegetation chemistry samples to provide integration between the two baseline components and to meet requirements for a possible future long-term effects monitoring program (Annex VI, Section 4.2.3). Three exposure (i.e., EXP01, EXP02, EXP03) and three reference (i.e., REF04, REF05, REF06) sites were pre-selected in locations where suitable vegetation habitat intersected with either the dominant (i.e., south-southeast) or sub-dominant (i.e., west) wind direction. The exposure sites were located within the LSA to capture potential Project-related effects. The reference sites were located outside of the LSA and approximately 750 m from Highway 955 to limit the effects of dust deposition from the highway, while still allowing accessibility for potential long-term monitoring. A composite sample consisting of three subsamples of the topsoil horizons (i.e., A horizons including surface organics) was collected at each of the exposure and reference sites.

Radionuclides (i.e., lead-210, polonium-210, radium-226, thorium-228, thorium-230, thorium-232) were analyzed in samples from all six sites during the 2019 field survey as a baseline for a potential long-term effects monitoring program, and to provide data for the environmental risk assessment (TSD XXI).

Soil Suitability for Reclamation

Soil physical and chemical characteristics were used to estimate soil suitability for reclamation. Soil field observations and analytical results were compared to the criteria for evaluating the suitability of topsoil material (i.e., upper soil horizons including surface organics; or upper lift [portion of soil stripped during construction]) and the suitability of subsoil material (i.e., lower soil horizons above the parent material; or lower lift [portion of soil stripped during construction]) for revegetation in the Northern Forest Region, as outlined by the Alberta Soil Advisory Committee in *Soil Quality Criteria Relative to Disturbance and Reclamation (Revised)* (Alberta Agriculture 1987; Table 12.2-3 and Table 12.2-4). Soil reclamation suitability interpretations for individual map units were based on the specific physical and chemical characteristics of these units. Reclamation suitability classes were determined for the topsoil material based on modal (i.e., most commonly observed) characteristics and average depths of Litter (L), Fermented (F), Humus (H), and A horizons. Reclamation suitability classes for the subsoil material were determined based on modal characteristics and average depths of B and C horizons to a depth of 1 m.

Table 12.2-3: Topsoil Material Reclamation Suitability Criteria

Rating/Property	Good	Fair	Poor	Unsuitable
Reaction (pH)	5.0-6.5	4.0-5.0, 6.5-7.5	3.5-4.0, 7.5-9.0	<3.5, >9.0
Salinity (EC) (dS/m)	<2	2-4	4-8	>8
Sodicity (SAR)	<4	4-8	8-12	>12
Saturation (%)	30-60	20-30, 60-80	15-20, 80-120	<15, >120
Stoniness/Rockiness (% area)	<30 / <20	30-50 / 20-40	50-80 / 40-70	>80 / >70
Texture[(a)]	fSL, vfSL, L, SiL, SL	CL, SCL, SiCL	LS, SiC, C, HC, S	n/a
Moist consistency	Very friable, friable	Loose, firm	Very firm	Extremely firm
Calcium carbonate equivalent (%)	<2	2-20	20-70	>70

Source: Adapted from Table 8. Criteria for Evaluating the Suitability of Surface Material (Upper Lift) for Re-Vegetation in the Northern Forest Region (Alberta Agriculture 1987).
a) C = clay; CL = clay loam; fSL = fine sandy loam; HC = heavy clay; L = loam; LS = loamy sand; S = sand; SCL = sandy clay loam; SiC = silty clay; SiCL = silty clay loam; SL = sandy loam; SiL = silt loam; vfSL = very fine sandy loam.
EC = electrical conductivity; dS/m = decisiemens per metre; n/a = not applicable; SAR = sodium adsorption ratio; < = less than; > = greater than.

Table 12.2-4: Subsoil Material Reclamation Suitability Criteria

Rating/Property	Good	Fair	Poor	Unsuitable
Reaction (pH)	5.0-7.0	4.0-5.0, 7.0-8.0	3.5-4.0, 7.5-9.0	<3.5, >9.0
Salinity (EC) (dS/m)	<3	3-5	4-8	>8
Sodicity (SAR)	<4	4-8	8-12	>12
Saturation (%)	30-60	20-30, 60-80	15-20, 80-100	<15, >100
Stoniness/Rockiness (% area)	<30 / <15	30-50 / 15-30	50-70 / 30-50	>70 / >50
Texture[(a)]	fSL, vfSL, L, SiL, SL	CL, SiC, SiCL	LS, C, HC, S	Bedrock
Moist consistency	Very friable, friable, firm	Loose, very firm	Extremely firm	Hard rock
Calcium carbonate equivalent (%)	<5	5-20	20-70	>70

Source: Adapted from Table 8. Criteria for Evaluating the Suitability of Surface Material (Upper Lift) for Re-Vegetation in the Northern Forest Region (Alberta Agriculture 1987).
a) C = clay; CL = clay loam; fSL = fine sandy loam; HC = heavy clay; L = loam; LS = loamy sand; S = sand; SCL = sandy clay loam; SiC = silty clay; SiCL = silty clay loam; SL = sandy loam; SiL = silt loam; vfSL = very fine sandy loam.
EC = electrical conductivity; dS/m = decisiemens per metre; SAR = sodium adsorption ratio; < = less than; > = greater than.

12.2.6.3 Soil Sensitivities

Wind and Water Erosion

Soil erosion risk is one of the primary concerns for disturbed soils because the removal of vegetation cover exposes soil materials to wind and water. Depending on terrain and soil characteristics, soil materials may be washed or blown away with exposure to wind or rain, potentially resulting in the loss of topsoil and a reduction in soil quality. The risk of soil erosion from wind or water is influenced by many factors including soil particle size, organic matter content, water content, permeability, elevation, slope gradient, vegetation cover, and natural events (e.g., freeze-thaw), as well as human activities that cause soil disturbance (Cruse et al. 2001; Campbell et al. 2002; TAC 2005).

Mineral soil wind erosion ratings were assigned based on characteristics of the mineral topsoil horizon texture and a dimensionless index (i.e., can be applied across various landscapes and scales) described by Coote and Pettapiece (1989; Table 12.2-5). Wind erosion ratings for Organic soils were assigned based on degree of peat decomposition (Campbell et al. 2002). Wind erosion ratings were assigned to the SMUs within the LSA and were based on disturbed, bare soils for mineral soils, and dry, disturbed conditions for Organic soils.

Table 12.2-5: Criteria for Determining Wind Erosion Potential

Soil Texture	Wind Erosion Rating
Very fine sand, sand, coarse sand, loamy sand, gravelly sand, humic	High
Sandy loam, loam, silty loam, sandy clay loam, sandy clay, mesic	Moderate
Silt, silty clay loam, clay loam, silty clay, clay, heavy clay, fibric	Low

Source: Adapted from Coote and Pettapiece (1989) and Campbell et al. (2002).

Soil water erosion potential was determined based on methods described by Transportation Association of Canada (TAC 2005; Table 12.2-6 and Table 12.2-7). Water erosion ratings and potentials were assigned to SMUs within the LSA based on characteristics of terrain and soils (i.e., slope length, gradient, topsoil texture).

Table 12.2-6: Criteria for Determining Water Erosion Rating for Soil Texture

Soil Texture	Water Erosion Rating
Silt, silty loam, loam	High
Sandy loam, silt clay loam, sandy clay loam, silty clay, clay loam[(a)]	Medium
Sandy clay, clay, heavy clay, loamy sand, sand	Low

Source: Adapted from the *National Guide to Erosion and Sediment Control on Roadway Projects* (TAC 2005).
a) Clay loam is not present in the TAC (2005) guide; however, clay loam has been included in the Medium range as it is coarser than clay (Low) and finer than silt clay (High) in the texture triangle (SCWG 1998).

Table 12.2-7: Criteria for Determining Water Erosion Potential

Average Slope	Water Erosion Rating	Water Erosion Rating	Slope Length
		<70 m	>70 m
0%-10%	Low	Low	Low
	Medium	Low	Moderate
	High	Moderate	High
10%-20%	Low	Low	Moderate
	Medium	Moderate	High
	High	High	High

Table 12.2-7: Criteria for Determining Water Erosion Potential

Average Slope	Water Erosion Rating	Water Erosion Rating	Slope Length
		<70 m	>70 m
>20%	Low	Moderate	Moderate
	Medium	High	High
	High	High	High

Source: Adapted from Table 4-2 in the *National Guide to Erosion and Sediment Control on Roadway Projects* (TAC 2005; City of Calgary 2011).
< = less than; > = greater than.

Sensitivity to Acidification

Soil sensitivity to acidification is a measure of a soil's susceptibility to experiencing a decrease in pH in response to acid inputs. Soil sensitivity to acidification is inversely related to a soil's natural buffering capacity, which is the capacity of the soil to resist pH change. The SMUs in the LSA were rated for sensitivity to acidification, with ratings based on the sensitivity to the loss of base cations (i.e., primarily calcium, magnesium, and potassium), sensitivity to acidification, and sensitivity to solubilization (i.e., dissolving into soil water) of aluminum (Holowaychuk and Fessenden 1987). Mineral SMUs in the LSA were rated for sensitivity to acidification using the chemical criteria published by Holowaychuk and Fessenden (1987; Table 12.2-8). The sensitivity rating for Organic SMUs in the LSA was based on the type of wetland (Turchenek et al. 1998; Table 12.2-9).

Selected soil samples collected during the 2018 field program were analyzed for cation exchange capacity (CEC). The soil CEC measures the amount of cations that can be held in the soil at pH of 7.0 and is expressed in milliequivalents per 100 grams (mEq/100 g). The CEC indicates the potential of the soil to retain nutrients (Hausenbuiller 1972). Samples that were not submitted for laboratory CEC analysis were supplemented with CEC ranges derived from data presented in Holowaychuk and Fessenden (1987) and soil texture (Table 12.2-10) to estimate the sensitivities of soils to acidification. For soil samples where pH was obtained along with CEC, both values were considered in the determination of acidification sensitivity. Soil CEC was not analyzed on soils from the 2019 field program as the samples were composited from three subsamples and not discrete.

Table 12.2-8: Criteria for Rating the Sensitivity Potential of Mineral Soils to Acidic Inputs

Cation Exchange Capacity (mEq/100 g)	pH	Overall Sensitivity
<6	<6.5	High
	>6.5	Low
6-15	<4.6	High
	4.6-6.0	Moderate
	>6.0	Low
>15	<4.6	High
	4.6-5.5	Moderate
	>5.6	Low

Source: Adapted from Holowaychuk and Fessenden 1987.
mEq/100 g = milliequivalents of ammonium cation adsorbed by 100 grams of dry soil; < = less than; > = greater than.

Table 12.2-9: Criteria for Rating the Sensitivity Potential of Wetland Soils to Acidic Inputs

Wetland Type	Sensitivity to:		Overall Sensitivity Rating
	Base Loss	Acidification	
Extreme-rich fen	Low	Low	Low
Moderate-rich fen	Low to Moderate	Low	Low
Bog and poor fen	Moderate to High	Moderate	Moderate

Source: Turchenek et al. 1998.

Table 12.2-10: Cation Exchange Capacity Relationship to Soil Texture

Texture	Typical Range of Cation Exchange Capacities (mEq/100 g)
Sand and loamy sand	<6
Sandy loam	6-15
Loam and silt loam	12-22
Clay loam and silty clay loam	20-30
Clay	25-45

Source: Derived from soil data presented in Holowaychuk and Fessenden 1987.
mEq/100 g = milliequivalents of ammonium cation adsorbed by 100 grams of dry soil; < = less than.

Permafrost Potential

Permafrost is defined as permanently frozen ground (i.e., soil or rock and incorporated ice and organic material that remains at or below 0°C for a minimum of two continuous years due to natural climatic factors [van Everdingen 1998]). The distribution and thickness of permafrost is influenced by various factors including climate, terrain, peat thickness, winter snow accumulation, hydrology, and subsurface geology (Williams and Burn 1996). Peat thickness, vegetation cover, micro-terrain (i.e., presence of hummocks or mounds of soil and plants), and moisture content are important variables in predicting the presence of permafrost (Williams and Burn 1996). As an example, Williams and Burn (1996) indicate that the features most associated with permafrost are thick organic surface layers and hummocky micro-terrain. Thick surface organics reduce the warming effect of solar inputs to the soil and increase the soil moisture holding capacity, further reducing ground temperature, and in turn, supporting conditions for permafrost to occur.

Permafrost soils are sensitive to ground disturbances as changes to topsoil materials can alter the soil thermal regime and result in warming of the soil to a greater depth, causing permafrost to melt (Hayhoe and Tarnocai 1993). This melting can result in differential thaw settling and slumping and can increase wind and water erosion potential for a soil (Burgess and Harry 1990; Hayhoe and Tarnocai 1993). The potential effects of disturbance on permafrost soils depends on soil ice content, soil type, drainage, and vegetation cover (Magnusson and Stewart 1987). Organic soils in wetlands are particularly sensitive to disturbance and the melting of ice because of the low bulk densities and potentially high ice content (Magnusson and Stewart 1987). However, depressional topography, high moisture content, dense vegetation cover, thickness of snow cover, and thickness of surface organic matter can also have an insulating effect on permafrost (i.e., keep it frozen) (Judge 1973; Tarnocai 1984; Zoltai 1995; Williams and Burn 1996).

Permafrost potential ratings for each soil subgroup within the LSA were assigned based on soil type, drainage, soil texture, and slope. Fine-textured soils with poor to imperfect drainage were rated as having a Low to Moderate permafrost potential, whereas coarse-textured soils with moderate to rapid drainage were rated as having a Very Low potential for permafrost (Table 12.2-11).

Table 12.2-11: Permafrost Potential Ratings

Texture	Drainage	Permafrost Potential Ratings
Fine	Poor to Imperfect	Moderate
Medium	Moderately Well	Low
Coarse	Well to Rapid	Very Low

Source: Adapted from Johnson et al 2013.

Sensitivity to Compaction

Soil quality and the capability for soil to support vegetation can be reduced if soil becomes compacted (i.e., forced to become denser). Soil compaction can result from a combination of addition of weight and/or vibration from machine traffic. Compaction of topsoil and subsoil can lead to a decrease in long-term productivity because of an increase in soil bulk density and soil strength, reductions in soil aeration (i.e., soil oxygen), reduced water infiltration and available soil water, restricted root growth, reductions in soil microbiological activity, and lowered nutrient uptake by vegetation (Heuer et al. 2008; Blouin et al. 2008). Therefore, soil compaction can influence reclamation success by decreasing the amount of plant establishment and rate of plant growth.

Compaction ratings for SMUs in the LSA were determined using criteria adapted from Lewis et al. (1989) under moist conditions (Table 12.2-12). Gleysolic soils and the peaty phases were assigned compaction ratings based on soil texture under wet (i.e., saturated) soil conditions. Organic soils were not assigned compaction ratings as compaction ratings are based primarily on particle size distribution for mineral soils.

Table 12.2-12: Criteria for Determining Compaction Potential of Soils

Soil Texture	Compaction Rating[a]		
	Dry	Moist	Wet
Sandy (sand, loamy sand)	Low	Low	Moderate
Loamy (sandy loam, loam)	Low	Moderate	High
Silty (silt, silty loam)	Moderate	High	Very High
Clayey (sandy clay, silty clay, sandy clay loam, clay loam, silty clay, clay)	High	Very High	Very High

Source: Adapted from Lewis et al. 1989.
a) Based on a coarse fragment content of less than 35% (i.e., if coarse fragment content is between 35% and 70%, loamy and silty are grouped together and compaction rating is Moderate, and clayey is High).

12.2.7 Project Interactions and Mitigations

Interactions (i.e., linkages) between Project components or activities, and the corresponding potential changes to measurement indicators, were identified by a pathway analysis that was then used to inform the residual effects analysis for terrain and soils (Section 6.7, Pathways Analysis). The first part of the analysis was to identify all potential effects pathways for all phases of the Project (Section 6.7.1, Identification of Project Interactions). Each pathway was initially assumed to have a linkage to potential effects on terrain and soils.

Potential pathways from Project activities to terrain and soils were identified using the following:

- review of the Project description (Section 5) and potential effects scoping by the project development, environmental, and socio-economic teams for the Project;
- input from Indigenous, regulatory, and public engagement (Section 2) and Indigenous and Local Knowledge (Section 3);

- scientific knowledge;
- previous experience with mining projects; and
- consideration of potential effects identified from the Terms of Reference (Section 1, Appendix 1A).

Potential adverse effects of the Project were then identified, and practicable mitigation was applied to avoid, minimize, and/or rehabilitate adverse effects on terrain and soils (Section 6.7.2, Identification of Mitigation). Avoidance and minimization are widely recognized as the most important approach for biodiversity conservation (BBOP 2021). Avoidance designs and actions integrated into the Project were developed iteratively between the Project's environmental and project development teams. Minimization techniques and technology were also identified and implemented collaboratively between Project teams.

Each potential effect pathway was evaluated using proposed mitigation to predict whether the pathway had the potential to cause residual adverse effects (Section 6.7.3, Pathway Screening). A screening-level assessment was applied using Indigenous and Local Knowledge, scientific knowledge, logic, experience with similar developments, and an understanding of the effectiveness of mitigation (i.e., level of certainty that mitigation would work) to assign each pathway to one of the following categories:

- **No pathway:** Analysis reveals that the pathway could be removed (i.e., the effect is avoided) by mitigation so that the Project would result in no measurable environmental change relative to existing conditions or guideline values and, therefore, would have no residual effect on terrain and soils.
- **Secondary pathway:** The pathway could result in a measurable but minor environmental change relative to existing conditions or guideline values, but this change would be sufficiently small that it would have a negligible residual effect on terrain and soils. Therefore, the pathway is not expected to contribute to effects of RFDs to cause a significant effect.
- **Primary pathway:** The pathway is likely to result in an environmental change relative to existing conditions or guideline values and could cause a greater than negligible effect on terrain and soils.

Reclamation was considered as a mitigation for removal of natural soils. However, the time lag between removal of soils and reclamation of disturbed areas meant that an effect could be potentially present for a long period of time before reclamation would be effective. Therefore, reclamation mitigation did not lead to a determination of no pathway.

Project interactions determined as no pathway or secondary pathways were not carried forward for further assessment (Section 6.7.3). Primary pathways that could result in changes to the environment with one or more associated measurement indicator and have the potential to cause a greater than negligible effect on terrain and soils were carried forward to the residual effects analysis and residual effects classification (Section 12.5).

12.2.8 Residual Effects Analysis

The residual effects analysis measures and describes the effects of the Project on terrain and soils relative to existing conditions. The residual effects analysis was conducted using the spatial boundaries (Section 12.2.3, Spatial Boundaries) and temporal boundaries (Section 12.2.4, Temporal Boundaries) identified for the assessment. Residual effects are described for the primary pathways identified for terrain and soils in the LSA and RSA (Section 12.4.3, Primary Pathways). The residual effects analysis was completed for the Application Case (Section 12.5) for each of the following identified measurement indicators:

- **Quantity and distribution of terrain units:** measures the quantitative change in area of terrain units within the maximum disturbance area. Natural terrain units exist prior to Construction, and reclaimed terrain units exist after disturbance. The terrain measurement indicator includes surficial materials, topography, and slope stability as qualitative metrics.
- **Quantity and distribution of SMUs:** measures the quantitative change in area of SMUs within the maximum disturbance area.
- **Soil quality:** provides a qualitative assessment of the change in soil quality (i.e., productivity) in the maximum disturbance area with respect to alterations in soil chemistry, reclamation suitability, erosion susceptibility, acidification, permafrost, and compaction.

12.2.9 Residual Effects Classification

The residual effects analysis used a reasoned narrative to describe anticipated changes to each measurement indicator caused by the proposed Project and associated effects on terrain and soils. This narrative description of anticipated effects is the foundation for the residual effects classification. Residual effects are summarized or classified in tabular form using effects criteria, which is intended to provide structure and comparability across VCs and intermediate components assessed for the Project (Section 6.9.1, Residual Effects Classification).

The residual effects classification used direction, magnitude, geographic extent, duration, reversibility, frequency, and probability of occurrence as criteria. The approach to classify each residual effect criterion is provided in Table 12.2-13.

Table 12.2-13: Definitions Applied to Effects Criteria Classifications for the Assessment of Terrain and Soils

Criterion	Rating	Definition
Direction	Positive	Change in measurement indicator results in net improvement or benefit to the component
	Neutral	Change in measurement indicator results in net balance to the component
	Negative	Change in measurement indicator results in net degradation or loss to the component
Magnitude	Qualitative narrative or numeric quantification	Change in measurement indicator is described by effect size (e.g., hectares of a terrain unit)
Geographic extent	Maximum disturbance area	Change in measurement indicator is confined to the maximum disturbance area
	Local	Change in measurement indicator extends outside the maximum disturbance area but within the LSA
	Regional	Change in measurement indicator extends beyond the LSA but is confined to the RSA
	Beyond regional	Change in measurement indicator extends beyond the RSA
Duration	Qualitative narrative or numeric quantification	Change in measurement indicator is described by effect duration (e.g., months, years, decades, permanent)
Reversibility	Reversible	Change in measurement indicator is reversible within a clearly defined time period
	Irreversible	Change in measurement indicator is predicted to influence the component indefinitely
Frequency	Occasional	Change in measurement indicator is expected to occur rarely (e.g., once or a few times)
	Periodic	Change in measurement indicator is expected to occur consistently at regular intervals or associated with temporal events (e.g., during dry summers)
	Continuous	Change in measurement indicator is expected to occur all the time
Probability of occurrence	Unlikely	Change in measurement indicator is not expected to occur, but is not impossible
	Possible	Change in measurement indicator may occur, but is not likely
	Probable	Change in measurement indicator is likely to occur, but is uncertain
	Certain	Change in measurement indicator will occur

LSA = local study area; RSA = regional study area.

While most criteria were assigned categorical ratings for terrain and soils, the ratings for magnitude and duration were applied in a manner deemed more suitable for analysis. Predicted effect sizes for magnitude and duration were provided in specific terms (i.e., narrative or numeric quantification) in the residual effects characterization (Table 12.2-13). Applying a category rating to a criterion such as magnitude might lead to confusion or misinterpretation of the effects assessment or result in the criterion not being easily categorized in a meaningful way. For example, characterizing magnitude solely using an ordinal scale (i.e., low, moderate, or high) for terrain and soils is often not appropriate as additional context is required to properly characterize the effects. Universal effect size boundaries, such as a 20% change in a terrain or soil map unit at the LSA scale used to define a high magnitude effect, work poorly because these size boundaries fail to consider context. Depending on the ecological context, a 20% change from existing conditions in the study area may be required to cause a high magnitude effect on some units, whereas a 2% change in the study area may be sufficient to cause a high magnitude effect for other units. When categorical definitions were used, magnitude was classified as negligible, low, moderate, or high and supported by a reasoned narrative (Section 6.9.1). Similarly, duration was described in quantitative terms (e.g., number of months, or years, decades, or permanent).

12.2.10 Prediction Confidence and Uncertainty

The purpose of the assessment is to predict the future conditions for terrain and soils with the addition of the Project. As with all predictions of future conditions, the predictions made in this assessment embody some degree of uncertainty. The assessment applied a precautionary (i.e., conservative) approach to address uncertainty by identifying the greatest magnitude, duration, and geographic extent of potential adverse effects when a range of possible outcomes were possible (e.g., using the maximum disturbance area to assess effects for an anticipated small Project footprint). Consequently, uncertainty was addressed in a manner that increased the level of confidence that residual effects were conservatively estimated. The key uncertainties for terrain and soils and the way these uncertainties were addressed are presented as part of this assessment (Section 12.6).

12.2.11 Monitoring, Follow-Up, and Adaptive Management

Monitoring programs are proposed to address the uncertainties associated with the effects predictions and to evaluate the performance of mitigation. In general, monitoring is used to verify the effects predictions. Monitoring is also used to identify any unanticipated effects and to support the implementation of adaptive management to limit these effects. Typically, monitoring includes one or both of the following categories that may be applied during the Project lifespan:

- **Regulatory compliance monitoring:** monitoring activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation and conditions of approval, and NexGen commitments (e.g., inspecting the installation of a silt fence to control erosion).
- **Follow-up monitoring:** programs designed to test the accuracy of effects predictions, reduce or address uncertainties, determine the effectiveness of mitigation, or provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices (e.g., implementation of adaptive management). Results from these programs can be used to increase the certainty of effect predictions in future EAs.

Where relevant, conceptual monitoring programs would be proposed to confirm predictions and to address the uncertainties associated with the effects predictions and mitigation, and upon Project approval, would be included in the Integrated Management System.

The implementation of robust, long-term environmental testing and monitoring has also been requested by Indigenous Groups to verify protection of the environment, including community-led monitoring during Construction and Operations of the proposed Project (TSD IV: MN-S; TSD V.2: CRDN; TSD VI: YNLR).

In addition to environmental monitoring programs typically implemented for projects (i.e., as noted above), NexGen is working with local Indigenous Groups to implement independent environmental monitoring. In combination with standard Project monitoring processes, independent Indigenous monitoring would be used to verify Project performance and to determine if mitigations and controls are effective in protecting the receiving environment.

Adaptive management measures may also be proposed to address the uncertainties associated with the effects predictions and mitigation. The process for determining when, how, and where to use adaptive management would be described within the Integrated Management System Manual.

12.3 Existing Conditions

Of the 110 soil inspection sites surveyed in the LSA in 2018 and 2019, 104 sites (94.5%) were classified as mineral soils and six sites (5.5%) were classified as Organic soils. Terrain and soils information for all soil inspection sites are available in Appendix 12A, Soil Inspection Site Data, and locations are presented in Figure 12.3-1. A complete description of the terrain and soils baseline results is available in Annex VI.

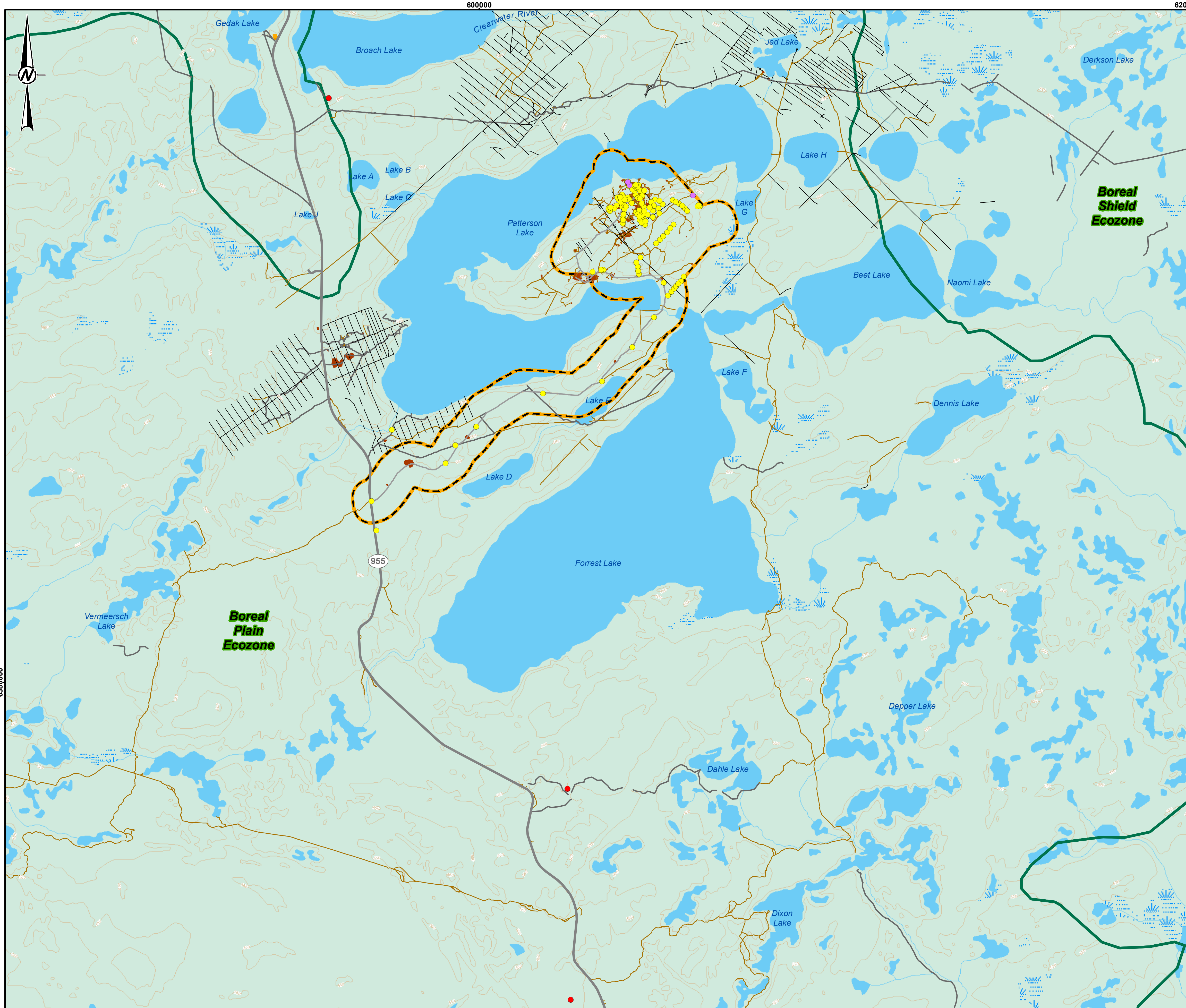
The LSA is located within the Firebag Hills Landscape Area within the Mid-Boreal Upland Ecoregion of the Boreal Plain Ecozone of Saskatchewan (Acton et al. 1998). The Firebag Hills Landscape Area consists of gently to strongly rolling morainic plains that extend from the Clearwater River Valley and the upland areas along the Alberta border towards the Canadian Shield to the north (Acton et al. 1998).

Soils in the Firebag Hills Landscape Area are dominantly Brunisolic soils that have developed on sandy glacial till and glaciofluvial deposits (Acton et al. 1998). Lower areas and depressions are typically poorly drained and contain Organic and Gleysolic soils developed on sandy till deposits.

The region around the Project includes the Churchill River Upland, Mid-Boreal Upland, and Athabasca Landscape ecoregions (Acton et al. 1998). The Churchill River Upland was developed on crystalline Precambrian rock, which was formed though igneous or metamorphic activity. The landscape consists of gently rolling hills creating a series of ridges, valleys, and basins exposing bedrock. Lakes, fens, and bogs are scattered across the low-lying areas. The slope and elevation of the bedrock is reflected by a thin layer of moraine, with Brunisolic soils associated with the sand and gravel glaciofluvial deposits. Finer-textured deposits of sand and silt have supported development of Luvisolic soils, and Gleysolic soils are dominant in the low-lying areas associated with bogs and fens (Acton et al. 1998).

The Mid-Boreal Upland consists of rolling uplands and undulating plains, with a surface covered with glacial drift, Organic soil, and numerous wetlands in the plains. On the lower slopes, Gleysolic and Organic soil dominate, while the hummocky upland slopes generally have Eutric Brunisolic and Gray Luvisolic soils. Brunisols prevail on sandy glaciofluvial deposits, though stabilizing sand dunes consist of Regosolic soil (Acton et al. 1998).

The Athabasca Plain was developed on bedrock, which is covered by a thick layer of ground moraine, outwash plains, and lacustrine plains. Sand dunes were formed by strong winds that originated from the continental ice sheet, though some dunes are still active, and all sand dunes in the area have a parabolic shape. Brunisolic soils are dominant on sandy glacial deposits, and stabilized sand dunes are where Regosolic soils prevail. In the low-lying areas, Gleysolic soils are associated with bogs and fens, and on occasion Crysolic soils are present (Acton et al. 1998).



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- SECONDARY HIGHWAY
- WATERCOURSE
- ECOZONE BOUNDARY
- WATERBODY
- WETLAND
- WOODED AREA
- LOCAL STUDY AREA

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT
- EXPOSURE PLOT SOIL SURVEY LOCATION
- REFERENCE PLOT SOIL SURVEY LOCATION
- SOIL SURVEY LOCATION

0 4 8

1:110,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021.
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PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

2018 AND 2019 BASELINE SOIL SURVEY INSPECTION SITES

CONSULTANT

wsp

PROJECT		20144150	PHASE 3314 - 6
DESIGN	CK	2020-03-13	SCALE AS SHOWN REV. 0
GIS	NO	2023-02-08	
CHECK	CM	2023-02-08	**FIGURE 12.3-1**
REVIEW	KH	2023-02-08	

25mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

PATH: I:\CLIENTS\NexGen\20144150\Mapping\Products\FINAL_EIS_FIGURES_WSP_LOGO_UPDATE\12_Terrain_and_Soils\17x11\20144150_Fig12-3-1_RookI-Project-Baseline-Soil-Survey-Inspection-Sites-LSA_Rev0.mxd PRINTED ON: 2023-02-08 AT: 11:51:08 AM

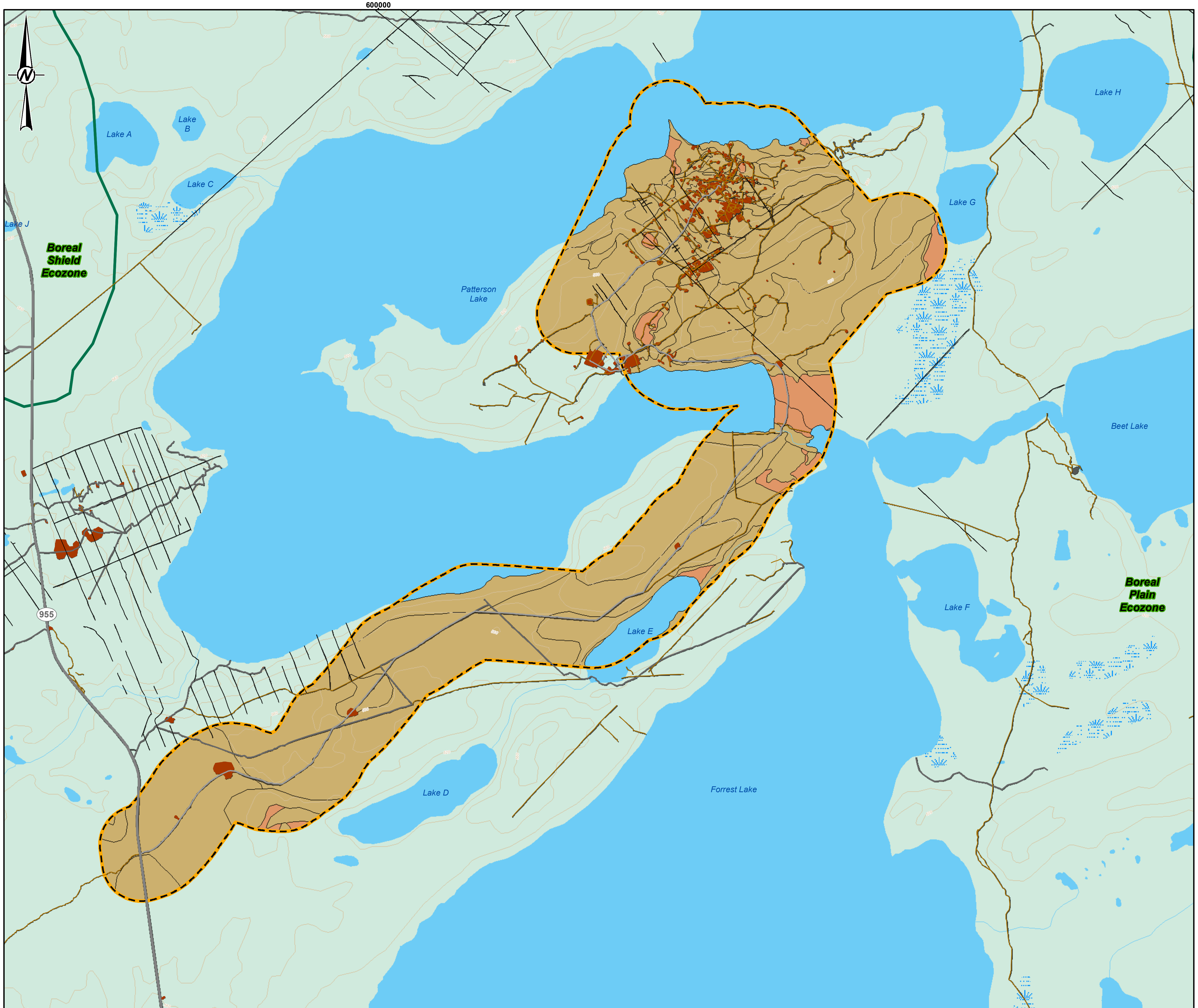
12.3.1 Surficial Material Distribution

During the baseline field programs, it was observed that the terrain in the majority (79%) of the LSA is composed of an undulating to hummocky upland landscape with high relief, with a dominant surface stoniness class of Very Stony (i.e., 3% to 15% of ground surface covered; Annex VI). Field programs also indicated that surficial materials predominantly consist of glaciofluvial and outwash deposits. The dominant terrain unit in the LSA is glaciofluvial and accounts for 2,230.0 ha (78.8%; Table 12.3-1; Figure 12.3-2). The fen peat terrain unit (i.e., Organic) accounts for 109.8 ha (3.9%) of the LSA. The water terrain unit accounts for 387.1 ha (13.7%) of the LSA and includes areas with open water on a year-round basis. The existing anthropogenic (i.e., human-derived) disturbance unit accounts for 104.7 ha (3.7%) of the LSA and includes features such as roads and infrastructure associated with the existing exploration site, community trails, and Highway 955.

Table 12.3-1: Distribution of Terrain Units in the Local Study Area

Terrain Units	Area	
	(ha)	(%)
Glaciofluvial	2,230.0	78.8
Fen Peat	109.8	3.9
Water	387.1	13.7
Anthropogenic disturbance	104.7	3.7
Total	**2,831.6**	**100.0**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- SECONDARY HIGHWAY
- WATERCOURSE
- ECOZONE BOUNDARY
- WATERBODY
- WETLAND
- WOODED AREA
- LOCAL STUDY AREA

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)

TERRAIN UNIT

- FEN PEAT
- GLFL

0 1.5 3

1:50,000 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. ECOZONES OBTAINED FROM AGRICULTURE AND AGRI-FOOD CANADA (AAFC).

PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

TERRAIN MAP UNITS WITHIN THE LOCAL STUDY AREA

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	CK	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	CM	2023-02-08	**FIGURE 12.3-2**	
REVIEW	KH	2023-02-08		

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12.3.2 Terrain and Slope Stability

The proposed Project is located in the Athabasca Plain sub-region of the Great Kazan Physiographic Region. This sub-region is characterized by discontinuous glacial drift and frequent bedrock exposures. The Project is atypical, however, with a thick continuous blanket of glacial sediments many tens of metres thick and no exposed bedrock (BGC 2019).

Terrain (i.e., surficial materials and topography) is an important factor that affects soil formation and distribution across the landscape. The soil parent material component of terrain influences local-scale soil physical properties, such as texture, nutrient retention capacity, moisture holding capacity, and soil chemical properties such as salt content and metal composition (Turk et al. 2012; Wysocki et al. 2012). These soil properties, in addition to other factors (e.g., climate), affect the types of ecosystems supported across a landscape. Topography influences surface water flows and runoff, creating well-drained soils in areas of surface water loss and poorly drained soils in water-receiving areas. Slope aspect is the direction a slope faces, and influences soil microclimates based on the amount of solar radiation a slope aspect receives (Wysocki et al. 2012). The soil types influenced by terrain and the resulting physical, chemical, and biological soil environment affects soil productivity and the type of ecosystems (i.e., vegetation communities) that soils can support.

Geotechnical assessments were completed by BGC Engineering Inc. (BGC) for NexGen in 2018 and 2019 (BGC 2018, 2019). The assessment indicated an overall average slope of 7% north-northeast towards Patterson Lake with inclusions of slopes of 25% or more. The 2018 BGC assessment described head scarps from ancient landslides or glacial thrust terrain features within the LSA. Glacial thrust terrain features have many similarities with landslide terrain, and a slope stability assessment was completed for the existing natural slopes in the LSA and focused on the maximum disturbance area (BGC 2019). The terrain analysis found two small gravity-displacement features (slope failures). The first, on the east side of the anticipated location of the PAG WRSA, was interpreted to be inactive (BGC 2019). The second, on the east side of the anticipated mine terrace, was not determined to be active or inactive (BGC 2019), and is being studied further.

12.3.3 Soil Quantity and Distribution

Upland soils within the LSA were dominantly Eluviated Dystric Brunisols and Gleyed Eluviated Dystric Brunisols developed on glaciofluvial deposits. One soil inspection site located in a transitional zone between an upland and a depressional slope position was classified as an Orthic Gleysol. Organic soils found in depressional areas included Mesic Fibrisols, Fibric Mesisols, Terric Mesisols, and Terric Humisols.

Soil mapping was completed within the LSA, and 15 SMUs were developed based on similar soil characteristics and terrain features (Figure 12.3-3). Soil map characteristics and information for all soil map units are available in Appendix 12B, Soil Map Unit Characteristics. The 15 SMUs include 12 mineral map units (i.e., Mineral-1 through Mineral-12) and 3 organic map units (i.e., Organic-1, Organic-2, and Organic-3). Detailed descriptions of the distribution and area of each map unit within the LSA are provided in Table 12.3-2. The majority of the LSA is composed of mineral SMUs, with the Mineral-12 map unit encompassing the largest proportion of the LSA (i.e., approximately 565.7 ha or 20.0%). Detailed SMU characteristics are described in the baseline report (Annex VI, Section 5.2.1). Water and existing anthropogenic disturbances are also included in the mapping as water map units and existing disturbance map units, respectively.

Table 12.3-2: Description and Quantity and Distribution of Soil Map Units within the Local Study Area

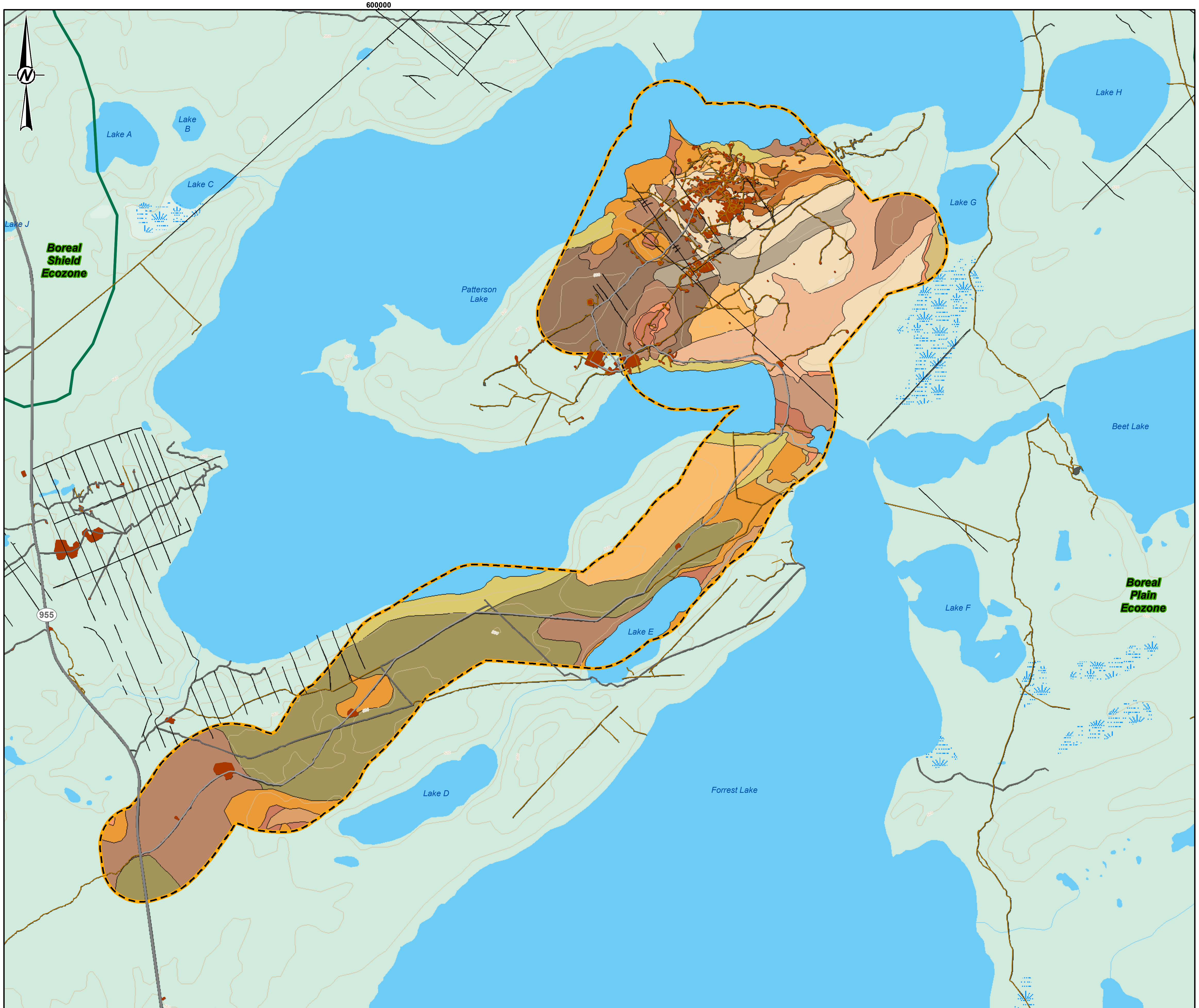
Soil Map Unit Name (Map Unit Symbol)	Proportion of LSA		Soil Subgroups in Map Unit[a]	Terrain	Stoniness (% of surface covered)	Texture
	Area (ha)	Percent (%)				
Mineral-1 (M1)	36.9	1.3	Dominantly Eluviated Dystric Brunisols	Hummocky and ridged-high relief	15-50	Loamy sand
Mineral-2 (M2)	233.7	8.3	Dominantly Eluviated Dystric Brunisols Inclusions of Gleyed Eluviated Dystric Brunisols	Undulating and rolling	0.1-15	Loamy sand, sand
Mineral-3 (M3)	218.8	7.7	Dominantly Eluviated Dystric Brunisols Inclusions of Gleyed Eluviated Dystric Brunisols	Hummocky and ridged-high relief	15-50	Sand
Mineral-4 (M4)	341.5	12.1	Dominantly Eluviated Dystric Brunisols Sub-dominantly Gleyed Eluviated Dystric Brunisols Inclusions of Gleysolic soils	Nearly level to undulating	0.1-15	Loamy sand, sand, and sandy loam
Mineral-5 (M5)	202.6	7.2	Dominantly Gleyed Eluviated Dystric Brunisols Sub-dominantly Eluviated Dystric Brunisols Inclusions of Gleysolic soils and Terric Mesisols	Undulating	0.1-15	Loamy sand, sand
Mineral-6 (M6)	13.6	0.5	Dominantly Orthic Gleysols Sub-dominantly Terric Mesisols Inclusions of Gleyed Eluviated Dystric Brunisols	Level to nearly level	<0.01-15	Loamy sand, sand
Mineral-7 (M7)	71.8	2.5	Dominantly Eluviated Dystric Brunisols Inclusions of Gleyed Eluviated Dystric Brunisols	Hummocky and ridged - low relief	0.1-3	Loamy sand
Mineral-8 (M8)	188.0	6.6	Dominantly Eluviated Dystric Brunisols Inclusions of Gleyed Eluviated Dystric Brunisols	Hummocky and ridged – high relief	15->50	Loamy sand
Mineral-9 (M9)	200.6	7.1	Dominantly Eluviated Dystric Brunisols Sub-dominantly Gleyed Eluviated Dystric Brunisols	Undulating – low relief	0.1-15	Loamy sand, sand
Mineral-10 (M10)	128.9	4.6	Dominantly Eluviated Dystric Brunisols Inclusions of Gleyed Eluviated Dystric Brunisols	Inclined - level	3-15	Sandy loam
Mineral-11 (M11)	28.0	1.0	Dominantly Gleyed Eluviated Dystric Brunisols Sub-dominantly Eluviated Dystric Brunisols and Gleysolic soils Inclusions of Terric Mesisols	Associated with watercourses and drainage channels	<0.01-15	Loamy sand, sand

Table 12.3-2: Description and Quantity and Distribution of Soil Map Units within the Local Study Area

Soil Map Unit Name (Map Unit Symbol)	Proportion of LSA		Soil Subgroups in Map Unit[(a)]	Terrain	Stoniness (% of surface covered)	Texture
	Area (ha)	Percent (%)				
Mineral-12 (M12)	565.7	20.0	Dominantly Eluviated Dystric Brunisols	Undulating and rolling	0.01-3	Loamy Sand, Sand, and Sandy Loam
			Inclusions of Gleyed Eluviated Dystric Brunisols and Gleysolic soils			
Organic-1 (O1)	41.5	1.5	Dominantly Terric Mesisols	Level to nearly level	<0.01	n/a
			Inclusions of Gleysolic soils			Sand, loamy sand
Organic-2 (O2)	27.1	1.0	Dominantly Typic Mesisols	Level to nearly level	<0.01	n/a
			Inclusions of Terric Mesisols			
Organic-3 (O3)	41.2	1.5	Dominantly Typic Mesisols	Level with mineral soil hummocks	<0.01	n/a, Loamy Sand
			Sub-dominantly Terric Mesisols			
			Inclusions of Gleysolic soils and Gleyed Eluviated Dystric Brunisols			
Water (W)	387.1	13.7	n/a	n/a	n/a	n/a
Anthropogenic Disturbance (DIS)	104.7	3.7	n/a	n/a	n/a	n/a
Total	**2,831.6**	**100.0**	**n/a**	**n/a**	**n/a**	**n/a**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
a) Dominant soil subgroup(s) = cover 60% to 100% of map unit area; co-dominant soil subgroup(s) = near equal proportion of map unit area covered; sub-dominant soil subgroup(s) = cover 15% to 40% of map unit area; inclusions = cover <15% of the map unit area.
LSA = local study area; n/a = not applicable; < = less than; > = greater than.

The soil textures found in the LSA and presented in Table 12.3-2 aligns with observations of the Patterson Lake area by BNDN and BRDN, which was characterized as having a lot of sand, rock and supporting jack pine (TSD II: BNDN; TSD III: BRDN). A member of BNDN commented that “the north” has experienced many wildfires in recent years resulting in no topsoil and only sand, which made it challenging for trees to regenerate (TSD II: BNDN).



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- SECONDARY HIGHWAY
- WATERCOURSE
- ECOZONE BOUNDARY
- WATERBODY
- WETLAND
- WOODED AREA
- LOCAL STUDY AREA

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)

SOIL MAP UNITS

- M1
- M2
- M3
- M4
- M5
- M6
- M7
- M8
- M9
- M10
- M11
- M12
- O1
- O2
- O3

0 1.5 3

1:50,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021.
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PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

SOIL MAP UNITS WITHIN THE LOCAL STUDY AREA

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	CK	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	CM	2023-02-08	**FIGURE 12.3-3**	
REVIEW	KH	2023-02-08		

25mm

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

12.3.4 Soil Quality

Soil quality and productivity influence ecosystem function and the types of ecosystems present across a landscape. Soils are the growth medium required to support terrestrial ecosystems that are naturally present within a given landscape. Some ecosystems are dependent on the presence of certain terrain features. This dependency means changes in distribution in terrain units can change which ecosystems may be able to function naturally in a landscape. Soil loss is also a risk during Construction, as reclamation activities are planned based on available material volumes. If there is a deficit of reclamation material, establishing target ecosystems during Closure may not be feasible. Likewise, if soil quality is deteriorated during construction, handling, or stockpiling, the material may not be suitable for reclamation.

Soil Chemistry and Reclamation Suitability

Soil pH values ranged from 2.86 to 5.20 for all soil horizons analyzed in 2018 and 2019, including reference sites outside of the LSA (Appendix 12C, Chemical Analysis Results). Soil pH values from B horizons sampled in 2018 ranged from 3.83 to 4.56. Soil B horizon pH values are used to differentiate between Dystric and Eutric Brunisol great groups, with a pH of less than 5.5 being diagnostic for Dystric Brunisols, and a pH greater than 5.5 being diagnostic for Eutric Brunisols (SCWG 1998). Dystric Brunisols are the dominant Great Group within the LSA (Table 12.3-2). Low pH and coarse texture for upland mineral topsoil and low pH for Organic soils are the limiting factors for reclamation suitability (Table 12.3-3) according to the *Soil Quality Criteria Relative to Disturbance and Reclamation (Revised)* (Alberta Agriculture 1987); however, the 2019 reference sites indicate that the acidic pH levels are natural to the area and therefore are not considered a limiting factor for reclamation success. Subsoil pH values ranged from Good to Unsuitable (Table 12.3-4) according to the reclamation suitability ratings outlined by the Alberta Soil Advisory Committee (Alberta Agriculture 1987).

The electrical conductivity (EC) results for the samples ranged from less than 0.10 to 0.35 decisiemens per metre (dS/m) (Appendix 12C, Table 12C-2). Soils with EC values less than 1 dS/m are considered non-saline and are rated as Good for reclamation suitability (Table 12.3-3 and Table 12.3-4; Alberta Agriculture 1987).

The majority (63%) of soil samples analyzed in 2018 had incalculable sodium adsorption ratios (SARs) due to low or undetectable levels of sodium, calcium, and/or magnesium (Appendix 12C, Table 12C-2). The remaining samples had SAR values ranging from less than 0.30 to 2.6, with the highest SAR value found in the Organic soil sample. Soil samples analyzed in 2019 had SAR values ranging from 0.1 to 0.7. The SAR values from the 2018 and 2019 baseline field programs were all within the range of Good reclamation suitability for both topsoil and subsoil (Table 12.3-3 and Table 12.3-4; Alberta Agriculture 1987).

The 2018 cation exchange capacity (CEC) values for all samples ranged from less than 0.80 to 7.68 mEq/100g, with the majority (75%) of the horizons from the collected samples having results below detectable limits. The incalculable or low CEC results indicate that soils in the LSA have a naturally low supply of, and ability to retain, nutrients for plants, and low buffering capacity against soil acidification.

Boron and sulphur soil concentrations of exceeded the *Soil Quality Guidelines for the Protection of Environmental and Human Heath* defined for agricultural or residential/parkland land uses (CCME 2014; Annex VI). Boron concentrations exceeded the Soil Quality Guideline for agricultural land use (i.e., 2 mg/kg dry weight) in nine samples (Appendix 12C). Sulphur exceeded the Soil Quality Guideline for agriculture land use (i.e., 500 mg/kg dry weight) in both soil horizon samples at the NR18MS 77 sample location (Appendix 12C, Table 12C-4). Several (11%) of the metals that were analyzed (e.g., aluminum, iron, strontium, and zirconium) do not have Soil Quality Guidelines (CCME 2014). Soil Quality Guidelines are included with the soil analysis results in Appendix 12C.

Radionuclide analysis of soil samples taken at the 2019 exposure and reference sites identified no detectable levels of lead-210, thorium-228, thorium-230, or thorium-232 (Appendix 12C). Polonium-210 levels ranged between 0.01 and 0.02 becquerels per gram (Bq/g), and radium-226 levels ranged between 0.02 and 0.03 Bq/g. Compared to the *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM*; Canadian NORM Working Group 2013), none of the radionuclides analyzed in 2019 exceeded the derived release limits.

Parameters such as soil texture, coarse fragment content, ease of salvage, and depth of soil horizons are used to determine the suitability of soils for use as reclamation material (Alberta Agriculture 1987). Based on baseline field programs and mapping, the mineral SMUs in the LSA are considered to have a poor reclamation suitability in the topsoil and subsoil (Appendix 12C). The topsoil and subsoil ratings for mineral soils were based on the dominant textures of each SMU. Soil pH suitability was not considered when determining limiting factors as the pH ranges identified were within the range of the natural background reference sites. Organic SMUs were not rated for reclamation suitability. Organic material cannot be analyzed for many of the parameters and suitability ratings defined by Alberta Agriculture (1987) as the system was developed for mineral soil. However, in general, organic materials are useful and suitable for inclusion in reclamation cover systems.

Table 12.3-3: Topsoil Reclamation Suitability Ratings for the Local Study Area

Site	Reaction (pH)	Salinity (EC) (dS/m)	Sodicity (SAR)	Texture[a]	Limiting Factor[b]
NR18MS 77	Unsuitable	Good	Good	n/a	None
NR18MS 96	Unsuitable	Good	Good	n/a	None
NR18MS 108	Unsuitable	Good	Good	Poor	Texture – Poor
EXP01	Unsuitable	Good	Good	Poor	Texture – Poor
EXP02	Unsuitable	Good	Good	Poor	Texture – Poor
EXP03	Unsuitable	Good	Good	Poor	Texture – Poor
REF04	Unsuitable	Good	Good	Poor	Texture – Poor
REF05	Unsuitable	Good	Good	Good to Poor	Texture – Poor
REF06	Unsuitable	Good	Good	Poor	Texture – Poor

Note: Suitability ratings have been determined for each site, the most limiting factor for each site was displayed when multiple horizons were sampled with different ratings.
a) For sites with mineral and organic horizons sampled, the mineral ratings were used for texture suitability ratings. For sites where only organic topsoil horizons were sampled, no ratings were determined for texture.
b) The pH suitability was not considered when determining limiting factors for the site as the pH ranges identified were within the range of the natural background reference sites.
EC = electrical conductivity; dS/m = decisiemens per metre; n/a = not applicable; SAR = sodium adsorption ratio.

Table 12.3-4: Subsoil Reclamation Suitability Ratings for the Local Study Area

Site	Reaction (pH)	Salinity (EC) (dS/m)	Sodicity (SAR)	Texture[a]	Limiting Factor[b]
NR18MS 58	Poor to Good	Good	n/a	Poor	Texture & pH – Poor
NR18MS 82	Poor to Fair	Good	Good	Poor	Texture & pH – Poor
NR18MS 96	Unsuitable to Poor	Good	Good	Good to Poor	pH – Unsuitable to Poor Texture – Poor
NR18MS 108	Poor	Good	n/a	Poor	Texture & pH – Poor

Note: Suitability ratings have been determined for each site, the most limiting factor for each site was displayed when multiple horizons were sampled with different ratings.
a) For sites with mineral and organic horizons sampled, the mineral ratings were used for texture suitability ratings. For sites where only organic topsoil horizons were sampled no ratings were determined for texture.
b) The pH suitability was not considered when determining limiting factors for the site as the pH ranges identified were within the range of the natural background reference sites.
EC = electrical conductivity; dS/m = decisiemens per metre; n/a = not applicable; SAR = sodium adsorption ratio.

12.3.5 Soil Sensitivities

Sensitivity ratings within the LSA are summarized in Table 12.3-5 and Table 12.3-6 for the mineral and Organic SMUs, respectively, from the terrain and soils baseline report (Annex VI).

Table 12.3-5: Sensitivity Ratings for Mineral Soil Map Units within the Local Study Area

SMU Name (SMU Symbol)	Soil Subgroups in the SMU[a]	Dominant Topsoil Horizon Texture	Potential Ratings					
			Water Erosion Rating	Wind Erosion	Water Erosion[b]	Acidification Sensitivity	Permafrost	Compaction
Mineral-1 (M1)	Dominantly Eluviated Dystric Brunisols	Loamy sand	Low	High	Low to Medium	High	Very Low	Low
Mineral-2 (M2)	Dominantly Eluviated Dystric Brunisols	Loamy sand	Low	High	Low to Medium	High	Very Low	Low
	Inclusions of Gleyed Eluviated Dystric Brunisols							
Mineral-3 (M3)	Dominantly Eluviated Dystric Brunisols	Sand	Low	High	Low to Medium	High	Very Low	Low
	Inclusions of Gleyed Eluviated Dystric Brunisols							
Mineral-4 (M4)	Dominantly Gleyed Eluviated Dystric Brunisols	Sand, loamy sand	Low	High	Low to Medium	Moderate to High	Low	Low
	Sub-dominantly Eluviated Dystric Brunisols	Loamy sand, sandy loam	Low to Medium	Moderate to High				
	Inclusions of Gleysolic soils and Terric Mesisols	Loamy sand / n/a	Low/ n/a	High				
Mineral-5 (M5)	Dominantly Gleyed Eluviated Dystric Brunisols	Sand, loamy sand	Low	High	Low	Moderate to High	Low	Low to Moderate
	Sub-dominantly Eluviated Dystric Brunisols							
	Inclusions of Gleysolic soils and Terric Mesisols	Loamy sand / n/a	Low / n/a	High/Low				Low / n/a

Table 12.3-5: Sensitivity Ratings for Mineral Soil Map Units within the Local Study Area

SMU Name (SMU Symbol)	Soil Subgroups in the SMU[a]	Dominant Topsoil Horizon Texture	Potential Ratings					
			Water Erosion Rating	Wind Erosion	Water Erosion[b]	Acidification Sensitivity	Permafrost	Compaction
Mineral-6 (M6)	Dominantly Orthic Gleysols	Loamy sand	Low	High	Low	Moderate to High	Low to Moderate	Moderate to High
	Sub-dominantly Terric Mesisols	n/a	n/a	Low				n/a
	Inclusions of Gleyed Eluviated Dystric Brunisols	Sand, loamy sand	Low	High				Low
Mineral-7 (M7)	Dominantly Eluviated Dystric Brunisols	Loamy sand	Low	High	Low	High	Very Low	Low
	Inclusions of Gleyed Eluviated Dystric Brunisols							
Mineral-8 (M8)	Dominantly Eluviated Dystric Brunisols	Loamy sand	Low	High	Low to Medium	High	Very Low	Low
	Inclusions of Gleyed Eluviated Dystric Brunisols							
Mineral-9 (M9)	Dominantly Eluviated Dystric Brunisols	Sand, loamy sand	Low	High	Low	High	Low	Low
	Sub-dominantly Gleyed Eluviated Dystric Brunisols	Loamy sand						
Mineral-10 (M10)	Dominantly Eluviated Dystric Brunisols	Sandy loam	Medium	Moderate	Medium to High	Moderate to High	Very Low	Moderate
	Inclusions of Gleyed Eluviated Dystric Brunisols							
Mineral-11 (M11)	Dominantly Gleyed Eluviated Dystric Brunisols	Sand, loamy sand	Low	High	Low	Moderate to High	Low to Moderate	Low to Moderate
	Sub-dominantly Eluviated Dystric Brunisols and Gleysolic soils							
	Inclusions of Terric Mesisols	n/a	n/a	Low				n/a
Mineral-12 (M12)	Dominantly Eluviated Dystric Brunisols	Loamy sand, sandy loam	Low to Medium	Moderate to High	Low to Medium	Moderate to High	Low to Moderate	Low
	Inclusions of Gleyed Eluviated Dystric Brunisols and Gleysolic soils	Loamy sand	Low	High				

Note: Summarized from the terrain and soils baseline report (Annex VI):

- wind erosion potential ratings (Section 5.3.1; Table 16);
- water erosion ratings (Section 5.3.1; Table 14);
- acidification sensitivity potential ratings (Section 5.3.2; Table 18);
- permafrost potential ratings (Section 5.3.3; Table 20); and
- compaction potential ratings (Section 5.3.4; Table 22).

a) Dominant soil subgroup(s) = cover 60% to 100% of the soil map unit area; co-dominant soil subgroup(s) = near equal proportion of map unit area covered; sub-dominant soil subgroup(s) = cover 15% to 40% of the soil map unit area; inclusions = cover <15% of the soil map unit area.

b) Determined based on slope lengths of more than 70 m and dominant slope classes for each SMU.

n/a = not applicable; LSA = local study area; SMU = soil map unit.

Table 12.3-6: Sensitivity Ratings for Organic Soil Map Units within Local Study Area

SMU Name (SMU Symbol)	Soil Subgroups in SMU[a]	Dominant Topsoil Horizon Texture	Water Erosion Rating	Potential Ratings				
				Wind Erosion	Water Erosion[b]	Acidification Sensitivity	Permafrost	Compaction
Organic-1 (O1)	Dominantly Terric Mesisols	n/a	n/a	Low	n/a	Low to Moderate	Low to Moderate	n/a
	Inclusions of Gleysolic soils	Sand, loamy sand	Low	High	Low	High		Low
Organic-2 (O2)	Dominantly Typic Mesisols	n/a	n/a	Low	n/a	Low to Moderate	Low to Moderate	n/a
	Inclusions of Terric Mesisols	n/a	n/a	Low		Low to Moderate		n/a
Organic-3 (O3)	Dominantly Typic Mesisols	n/a	n/a	Low	n/a	Low to Moderate	Low to Moderate	n/a
	Inclusions of Gleysolic soils and Gleyed Eluviated Dystric Brunisols	Loamy sand	Low	High	Low	High		Low

Note: Summarized from the terrain and soils baseline report (Annex VI):

- wind erosion potential ratings (Section 5.3.1; Table 17);
- water erosion ratings (Section 5.3.1; Table 15);
- acidification sensitivity potential ratings (Section 5.3.2; Table 19);
- permafrost potential ratings (Section 5.3.3; Table 21); and
- compaction potential ratings (Section 5.3.4; Table 23).

a) Dominant soil subgroup(s) = cover 60% to 100% of the soil map unit area; co-dominant soil subgroup(s) = cover 40% to 60% of the soil map unit area; sub-dominant soil subgroup(s) = cover 20% to 40% of the soil map unit area; inclusion = cover 15% to 20% of the soil map unit area.

b) Determined based on slope lengths of more than 70 m and dominant slope classes for each SMU.

n/a = not applicable; LSA = local study area; SMU = soil map unit.

Wind Erosion Potential

Wind erosion potentials were assigned to SMUs within the LSA (Table 12.3-5 and Table 12.3-6). Wind erosion potentials for dominant soil subgroups in the majority (92%) of the mineral SMUs had High ratings, based on sand and loamy sand-textured mineral topsoil horizons. Soils most sensitive to wind erosion include sand and loamy sand-textured Brunisolic soils. Soils with Moderate wind erosion ratings were associated with sandy loam-textured mineral topsoil horizons. Organic horizons have Low wind erosion potentials due to decomposition of the uppermost organic layer and lack of mineral soil. In the event Organic surface materials are removed and underlying mineral soil horizons are exposed, the wind erosion potential is High due to the underlying sand textures. Areas containing Organic Fibrisols and peaty phase Gleysolic soils with silt or silt loam topsoil mineral horizons have a Low potential for wind erosion.

Water Erosion Potential

Water erosion ratings were assigned to the SMUs within the LSA (Table 12.3-5 and Table 12.3-6). Water erosion potential for dominant soil subgroups in the majority (50%) of the mineral SMUs was Low to Medium, based on sand and loamy sand-textured soils associated with topsoil soil horizons, low slope gradient, and a dominant slope length greater than 70 m. Sandy to loamy sand-textured Brunisolic soils in upland landscape positions generally have a Low to Medium water erosion potential. At transitional and lower landscape positions (i.e., depressions), poorly drained Gleysolic soils also have a Low to Medium water erosion potential. In areas with shallow Organic soils where organic surface horizons may be removed and subsoil materials exposed, the water erosion potential of the underlying material is Low. Deep Organic soils were not rated for water erosion potential as bare mineral subsoil would not likely be exposed. Within all SMUs, as slope percentage or slope length increases, the water erosion potential for soils also increases.

Sensitivity to Acidification

Acidification sensitivity potentials were assigned to the SMUs within the LSA (Table 12.3-5 and Table 12.3-6). Brunisolic soils in the area have sand or loamy sand topsoil textures, and these textures are generally associated with low CEC. Additionally, given the low pH values of soils sampled in the 2018 and 2019 baseline field programs, soils in the LSA are considered acidic. Due to the low CEC and pH values of the sampled soils, and the corresponding low buffering capacity, the Brunisolic soils in the area have a High sensitivity to acidification.

Organic soils within all SMUs have Low to Moderate sensitivity to acidification, depending on the associated wetland type. Moderate-rich and extreme-rich fens have Low sensitivity to acidification because they are nutrient-rich wetlands with higher buffering capacity. Poor fens and bogs have Moderate sensitivity to acidification because they are poor in nutrients and have a lower buffering capacity (Turchenek et al. 1998).

Gleysolic soils within the LSA generally have sandy loam textures, which are associated with low to high CEC. These soils occur in transitional areas adjacent to wetlands; therefore, the pH values are influenced by adjacent wetland types. For Gleysols with a peaty phase, the shallow organic surface horizon is influenced by underlying materials. In general, Gleysolic soils have a Low to Moderate sensitivity to acidification; however, this potential increases to Moderate or High where these soils occur adjacent to acidic bogs or where textures are sandy, respectively.

Permafrost Potential

The LSA is within the sporadic scattered discontinuous permafrost zone where permafrost may occupy approximately 10% to 50% of the area (NRCan 1995). The distribution and occurrence of permafrost is highly variable in this zone, with permafrost in this area having low ice content, indicating the ground ice content in the upper 10 m to 20 m of the ground has less than 10% ice content by volume of visible ice (NRCan 1995).

In general, imperfectly to poorly drained soils have Low to Moderate permafrost potential, whereas moderately to rapidly drained soils have Very Low potential for permafrost (Table 12.3-5 and Table 12.3-6). Sandy-textured Brunisolic soils in the LSA have Very Low permafrost potential. Gleysolic soils and soils that are poor to moderately well drained have Low permafrost potential. Overall, Organic soils have Low to Moderate potential to contain permafrost.

No observations of permafrost were recorded during the baseline field programs within Organic soils.

Sensitivity to Compaction

Compaction ratings for SMUs in the LSA are listed in Table 12.3-5 and Table 12.3-6. Sandy and loamy sand-textured Brunisols have a Low sensitivity to compaction under moist soil conditions. Gleysolic soils, including peaty phase Gleysolic soils, generally have sandy, sandy loam, silt, and silt loam textures in the topsoil and subsoil mineral soil horizons, indicating Moderate to Very High sensitivity to compaction under wet soil conditions. At transitional and lower landscape positions (i.e., depressions), and areas with shallow Organic soils where organic surface horizons may be removed and subsoil materials exposed, poorly drained Gleysolic soils generally have a moderate to high sensitivity to compaction; these areas make up approximately 1.5% of the LSA.

12.4 Project Interactions and Mitigations

The pathways analysis identified potential adverse effects of the Project on terrain and soils, identified practicable mitigation for these potential effects, and determined whether potential effects could be sufficiently mitigated such that they are not expected to cause a residual adverse effect. As described in Section 12.2.7, the pathways analysis assigned each potential effect as:

- no pathway (i.e., mitigation results in no effect on terrain and soils);
- secondary pathway (i.e., mitigation results in a negligible effect on terrain and soils); or
- primary pathway (i.e., effect that is greater than negligible and carried forward for further assessment).

The pathway analysis is summarized in Table 12.4-1. The subsections following the table provide the rationale used to assign potential effects to the no pathway and secondary pathway categories and list primary pathways. Each Project interaction identified as a primary pathway was carried forward for detailed assessment in Section 12.5, Residual Effects Analysis. Effects pathways apply to all Project phases unless otherwise noted.

The environmental design features and mitigations in Table 12.4-1 represent the list of key actions used to inform the pathway analysis as part of preparing the EIS. In addition to this list of key actions, NexGen would implement the Environmental Protection Program, which would describe the processes required to monitor and characterize effects from Project facilities and activities. This program would be used to periodically evaluate mitigation performance and identify additional mitigation, where required, and prompt potential adaptive management measures (Section 12.7, Monitoring, Follow-Up, and Adaptive Management). Where relevant, adaptive management measures may also be proposed to address uncertainties associated with effects predictions and mitigation. The process for determining when, how, and where to use adaptive management would be described within the Integrated Management System Manual.

Potential accidents and malfunctions that have the capability to influence biophysical or human environments are discussed in Section 21, Accidents and Malfunctions.

Table 12.4-1: Potential Effects Pathways for Terrain and Soils

Pathway ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
TS-01	Project components/activities that alter soil conditions or final terrain conditions during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ process plant ▪ additional infrastructure (e.g., roads, airstrip, camp, maintenance shop, and offices) ▪ handling and storage of waste rock, special waste rock, and ore ▪ sewage treatment plant and water storage and effluent monitoring ponds ▪ removal of infrastructure ▪ restoration and revegetation of facilities and infrastructure	**<u>Alteration of soil and terrain conditions:</u>** ▪ Alteration of soil and terrain conditions (i.e., quantity, quality, and distribution) may adversely affect soil productivity and the types of ecosystems that can be reclaimed on the landscape	▪ **Site access road** between gatehouse and mine terrace realigned during Project design **to avoid a wetland** ▪ To the extent practical, **work in sensitive areas** (i.e., erosive soils, wetland features, and fish habitats) would be scheduled **to avoid periods that may result in high flow volumes and/or increase erosion and sedimentation** (e.g., spring freshet) ▪ **Limit the Project footprint** to the extent practical using practices such as: o designing an efficient infrastructure footprint (i.e., buildings clustered together) o optimizing the use of cleared areas for Project activity o using existing road infrastructure, including existing access road and bridge crossing o storing tailings underground o maximizing water diversion away from site facilities through design and the establishment of berms and grading ▪ **Use clearing equipment that minimizes surface disturbance, soil compaction, and topsoil loss** (e.g., equipment with low ground pressure tracks or tires, blade shoes, and brushes), where feasible ▪ **Minimize steepness and length of slopes of disturbed areas** and stockpiled soils ▪ Implement **progressive reclamation and revegetation** of disturbed areas no longer required ▪ **Restore and revegetate areas** where non-permanent Project facilities have been removed ▪ Develop and implement a **Detailed Decommissioning and Reclamation Plan** to decommission and transfer the site to the province under the Institutional Control Program	Primary pathway

Table 12.4-1: Potential Effects Pathways for Terrain and Soils

Pathway ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
TS-02	Project components/activities that contribute to the Project footprint and may alter soils during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ process plant ▪ additional infrastructure (e.g., roads, airstrip, camp, maintenance shop, and offices) ▪ handling and storage of waste rock, special waste rock, and ore ▪ sewage and effluent treatment plants and water storage and effluent monitoring ponds ▪ removal of infrastructure ▪ restoration and revegetation of facilities and infrastructure	**Admixing and compaction:** ▪ Site clearing, contouring, and excavation can cause admixing and compaction and increase erosion potential, which may change the quantity, quality, and distribution of soil	▪ **Avoid new Project footprint disturbances** to the extent practicable (e.g., use previously disturbed areas) ▪ **Use clearing equipment that minimizes surface disturbance, soil compaction, and topsoil loss** (e.g., equipment with low ground pressure tracks or tires, blade shoes, and brushes), where feasible ▪ **Minimize Project footprint, while maintaining safe traffic and pedestrian flows**, and follow best practices for design speeds and expected vehicle traffic ▪ Implement a Project-specific **Environmental Protection Program** ▪ Develop and implement a **Detailed Decommissioning and Reclamation Plan** to decommission and transfer the site to the province under the Institutional Control Program	Secondary pathway
TS-03	Project components/activities that contribute to deposition of fugitive dust and radon emissions during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ underground shaft and mine development ▪ site traffic ▪ transportation of personnel and material to and from the site ▪ handling and storage of waste rock, special waste rock, and ore ▪ removal of infrastructure ▪ restoration and revegetation of facilities and infrastructure	**Change in soil quality from fugitive dust:** ▪ Deposition of fugitive dust emissions and associated constituents (e.g., metals, radionuclides) may change soil chemistry and adversely affect soil quality	▪ **Limit vehicle speed** on unpaved site roads to reduce fugitive dust during Construction and Operations ▪ **Optimize haul routes** to reduce fuel consumption and emissions from equipment ▪ **Apply water and/or suppressants to site roads, access road, and airstrip**, as necessary. Use dust suppressants that minimize environmental risk and are government approved for use ▪ Implement a Project-specific **Environmental Monitoring Plan** that includes soil quality and ambient air monitoring	Secondary pathway

Table 12.4-1: Potential Effects Pathways for Terrain and Soils

Pathway ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
TS-04	Project components/activities that contribute to criteria air contaminant emissions during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ underground shaft and mine development ▪ site traffic ▪ transportation of personnel and materials to and from the site ▪ power generation ▪ process plant and underground operations ▪ handling and storage of waste rock, special waste rock, and ore ▪ additional infrastructure (e.g., camp, maintenance shop, and offices) ▪ waste incineration ▪ removal of infrastructure ▪ restoration and revegetation of facilities and infrastructure	<u>**Changes in soil quality from Project emissions:**</u> ▪ Deposition of air contaminant emissions from (e.g., potential acid inputs) may change soil chemistry and adversely affect soil quality	▪ Primarily **use liquified natural gas for power generation** ▪ Evaluate opportunities to **reduce fuel combustion requirements** of infrastructure and equipment, to the extent practical, during detailed design ▪ **Limit idling of vehicles and equipment** to the extent practical ▪ **Optimize haul routes** to reduce fuel consumption and emissions from equipment ▪ **Use and maintain emissions control devices** on combustion-based equipment ▪ **Maintain mobile mining equipment and vehicles** and operate the equipment within parameters for engine exhaust system design ▪ Conduct **regular equipment maintenance** ▪ Identify and implement **procurement criteria** to confirm stationary and mobile engines meet applicable performance standards ▪ Implement a Project-specific **Environmental Monitoring Plan** that includes soil quality and ambient air monitoring	Secondary pathway

Table 12.4-1: Potential Effects Pathways for Terrain and Soils

<table>
<tr><th>Pathway ID</th><th>Project Components/Activities</th><th>Effects Pathway</th><th>Environmental Design Features and Mitigation</th><th>Pathway Assessment</th></tr>
<tr><td>TS-05</td><td rowspan="2">Project components/activities that potentially increase soil erosion through changes in surface water runoff and drainage areas during Construction, Operations, and Closure:
▪ land clearing, site preparation, and construction of facilities and infrastructure
▪ underground shaft and mine development
▪ process plant and underground operations
▪ handling and storage of waste rock, special waste rock, and ore
▪ effluent treatment plant and treated effluent discharge
▪ domestic wastewater discharge following treatment in sewage treatment plant
▪ additional infrastructure (e.g., roads, airstrip, and camp, maintenance shop, and offices)
▪ removal of infrastructure
▪ reclamation and revegetation of facilities and infrastructure</td><td><u>Increased erosion from changes in site runoff:</u>
▪ Changes in site surface water runoff can increase soil erosion and affect soil quality and distribution</td><td rowspan="2">▪ Limit the Project footprint to the extent practical using practices such as:
o designing an efficient infrastructure footprint (i.e., buildings clustered together
o optimizing the use of cleared areas for Project activity
o using existing road infrastructure, including existing access road and bridge crossing
o storing tailings underground
o maximizing water diversion away from site facilities through design and the establishment of berms and grading
▪ Avoid placing soil stockpiles near waterbodies (i.e., maintaining a 150 m buffer from waterbodies and watercourses), and near natural drainage features, unless required for temporary storage
▪ To the extent practical, work in sensitive areas (i.e., erosive soils, wetland features, and fish habitats) would be scheduled to avoid periods that may result in high flow volumes and/or increase erosion and sedimentation (e.g., spring freshet)
▪ Minimize areas of vegetation clearing and soil disturbance
▪ Minimize steepness and length of slopes of disturbed areas and stockpiled soils
▪ Provide adequate contact water storage capacity to allow controlled rate of release during both routine and non-routine operation scenarios
▪ Use erosion control measures as required
▪ Perform routine inspection and maintenance of water containment and conveyance structures (i.e., roadside ditches and culverts) to limit the risk of road wash-out or sediment release to the environment
▪ Implement progressive reclamation and revegetation of disturbed areas no longer required
▪ Reclaim and revegetate areas where non-permanent Project facilities have been decommissioned
▪ Implement a Project-specific Environmental Protection Program that includes processes for site water management
▪ Implement a Project-specific Environmental Monitoring Plan that includes monitoring water levels and flows and applying adaptive management, if necessary
▪ Develop and implement a Detailed Decommissioning and Reclamation Plan to decommission and transfer the site to the Province under the Institutional Control Program</td><td>Secondary pathway</td></tr>
<tr><td>TS-06</td><td><u>Redistribution of soils:</u>
▪ Changes in surface water levels, flows, and drainage areas can increase soil erosion and sedimentation along waterbodies and watercourses and affect soil quality and distribution</td><td>Secondary pathway</td></tr>
</table>

Table 12.4-1: Potential Effects Pathways for Terrain and Soils

Pathway ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
TS-07	Project components/activities that contribute to changes in site surface water quality and affect soil chemistry and quality during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ process plant ▪ handling and storage of waste rock, special waste rock, and ore ▪ additional infrastructure (e.g., roads, airstrip, camp, maintenance shop, and offices) ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure	**Changes in soil quality from contact water:** ▪ Changes in surface water quality from contact with surface facilities and additional infrastructure may alter soil chemistry and affect soil quality	▪ Implement **progressive reclamation and revegetation** of disturbed areas no longer required ▪ **Reclaim and revegetate areas** where non-permanent Project facilities have been decommissioned ▪ Implement a Project-specific **Environmental Protection Program** that includes processes for site water management ▪ Develop and implement a **Detailed Decommissioning and Reclamation Plan** to decommission and transfer the site to the Province under the Institutional Control Program	Secondary pathway
TS-08	Project components/activities that contribute to the Project footprint and may alter soils during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ process plant ▪ additional infrastructure (e.g., roads, airstrip, camp, maintenance shop, and offices) ▪ handling and storage of waste rock, special waste rock, and ore ▪ sewage and effluent treatment plants and water storage and effluent monitoring ponds ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure	**Increased erosion from soil transport and stockpiling:** ▪ Soil transport and stockpiling can increase erosion potential resulting in changes to soil quality	▪ Use **erosion control measures** as required ▪ Where soils are prone to wind erosion, **tackify, cover, seed, and/or apply water during periods of high erosion potential** (e.g., summer and fall) ▪ Implement a Project-specific **Environmental Protection Program**	No pathway

Table 12.4-1: Potential Effects Pathways for Terrain and Soils

Pathway ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
TS-09	Project components/activities that may contribute to slope instability during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ handling and storage of waste rock, special waste rock, and ore ▪ sewage treatment plant and water storage and effluent monitoring ponds ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure	**Slope instability and/or failures:** ▪ Activities may affect terrain through an increase in potential slope instability and/or failures	▪ **Design slopes for long-term stability** ▪ **Minimize areas of vegetation clearing** and soil disturbance ▪ Use **erosion control measures** as required ▪ Implement **progressive reclamation and revegetation** of disturbed areas no longer required ▪ **Reclaim and revegetate areas** where non-permanent Project facilities have been decommissioned ▪ Perform routine inspection and maintenance of **water containment and conveyance structures** (i.e., roadside ditches and culverts) to limit the risk of road wash-out or sediment release to the environment ▪ Implement a Project-specific **Environmental Protection Program** ▪ Develop and implement a **Detailed Decommissioning and Reclamation Plan** to decommission and transfer the site to the Province under the Institutional Control Program	No pathway
TS-10	Project components/activities that contribute to deposition of fugitive dust and radon emissions during **Construction, Operations, and Closure**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ underground shaft and mine development ▪ site traffic ▪ transportation of personnel and material to and from the site ▪ handling and storage of waste rock, special waste rock, and ore ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure	**Change in soil quality from radon:** ▪ Radon emissions may change soil chemistry and adversely affect soil quality	▪ Implement a Project-specific **Environmental Monitoring Plan** that includes soil quality and ambient air monitoring	No pathway
TS-11	Project components/activities that potentially change groundwater quality during **Construction, Operations, and Closure**: ▪ handling and storage of waste rock, special waste rock, and ore	**Change in soil quality from the WRSAs:** ▪ Seepage from the WRSAs may cause changes in groundwater quality and alter soil quality	▪ **Segregate PAG material** from NPAG material and store separately ▪ **Contain and divert runoff and seepage from PAG** waste rock, special waste rock, and ore to the effluent treatment plant ▪ Implement a Project-specific **Mine Waste Management Plan** ▪ Implement site water management procedures under an **Environmental Protection Program** that include monitoring seepage from WRSAs and applying adaptive management, if necessary ▪ Develop and implement a **Detailed Decommissioning and Reclamation Plan** to decommission and transfer the site to the Province under the Institutional Control Program	No pathway

Bolded text represents the key topic of the environmental design features and mitigation.
WRSAs = waste rock storage areas; PAG = potentially acid generating; NPAG = non-potentially acid generating.

12.4.1 No Pathways

The following Project interactions are predicted to result in no pathway to terrain and soils and were not carried forward in the assessment.

TS-08: Increased erosion from soil transport and stockpiling:

- Soil transport and stockpiling can increase erosion potential resulting in changes to soil quality.

Soil disturbance from soil transportation and stockpiling during Construction, Operations, and Closure has the potential to increase erosion, which may alter soil quality. Soil erosion risk is one of the primary concerns for disturbed soils because the removal of vegetation cover exposes soil materials to wind and water. Depending on terrain and soil characteristics, with continuous exposure of soil to wind or rain, soil materials may be blown or washed away and may result in the loss of the upper organic layer and a reduction in soil quality.

Soils within the LSA dominantly have Low or Low to Moderate susceptibility to water erosion, and High susceptibility to wind erosion because of predominantly coarse-textured topsoil horizons (Section 12.3.4, Soil Quality). However, potential for soil erosion, particularly by wind, would be mitigated by implementing erosion control measures during periods of high erosion potential. Erosion control measures include tackifying (i.e., applying binding agents to the soil surface), seeding, covering, and/or applying water to disturbed soils that are being transported or stockpiled (Table 12.4-1). Materials required for erosion control would be available on site, and personnel would be knowledgeable in their proper use. Additional actions and procedures outlined in the Environmental Protection Program would also be applied to avoid potential erosion of soils due to soil transport and stockpiling and are predicted to result in no change to soil quality in the maximum disturbance area relative to existing conditions. Therefore, there is no residual effect on soils, and the pathway was not carried forward in the assessment.

TS-09: Slope instability and/or failures:

- Project activities may affect terrain through an increase in potential slope instability and/or failures.

Project activities such as land clearing and site preparation infrastructure construction and/or removal have the potential to cause slope instability and failure, and subsequently have a negative effect on the stability of local terrain. Terrain in the LSA is typically undulating to hummocky upland landscape with high relief and dominant surface stoniness class of Very Stony (i.e., 3% to 15% of ground surface covered). Field programs indicated that terrain predominantly consists of loamy sand-textured soils formed from glaciofluvial parent material and outwash depositional settings (Section 12.3.3, Soil Quantity and Distribution). Geotechnical assessments found two gravity displacement features of concern for the Project (Section 12.3.2, Terrain and Slope Stability). One of these areas near the PAG WRSA was inactive, and the other near the mine terrace is undergoing further investigation.

Project design and mitigation would be implemented to avoid the potential for slope instability and/or failure (Table 12.4-1). Vegetation clearing and soil disturbance would be restricted to those areas required for Project activities and infrastructure. Erosion control measures would be used where applicable, and on-site personnel would be knowledgeable in their proper use. Roads and roadside ditches and culverts would be routinely inspected and maintained to limit the risk of wash-out or sediment transfer to the surrounding environment and potential instability or failure of roadside slopes. Progressive reclamation and revegetation would be implemented in disturbed areas as they are no longer required for the Project. The Environmental Protection Program and Preliminary Decommissioning and Reclamation Plan are also expected to include practices and mitigations to prevent slope failure and maintain the integrity of terrain stability in the maximum disturbance area.

The implementation of environmental design features, mitigation, and monitoring is expected to avoid adverse changes to slope stability and failures and result in no residual effects on terrain relative to existing conditions; the pathway was not carried forward in the assessment.

TS-10: Change in soil quality from radon:

- Radon emissions may change soil chemistry and adversely affect soil quality.

Radon would be released as a gas from the process plant, underground operations, ore stockpiles, contact water, and WRSAs. Indigenous Groups expressed concerns about radiation from the Project on the environment in general, which are in part, based on their observations from previous mining developments (i.e., the Cluff Lake Mine) and their belief that the Cluff Lake Mine was not properly decommissioned (TSD II: BNDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; CRDN 2019a; CRDN 2019b). Members of the BNDN expressed concerns about controlling radon gas and how far chemical emissions (e.g., radon) from the Project travel, as well as the effects of radon gas on terrestrial resources and how it would be monitored (BNDN-JWG 2020; BNDN-JWG 2021a; BNDN-JWG 2021c).

Soils in the maximum disturbance area are not expected to absorb radon gas and cause measurable changes to soil quality. Radon atoms are released through radium decay and once released into soil pore space are able to emanate into the atmosphere. The radon emanation coefficient is dependent on soil pore size, moisture content and grain size (Schumann 1993). Once released, radon atoms travel via air or water within soil pore space and are dispersed to the atmosphere, and do not reabsorb into the soil particle. Project design and mitigation policies and procedures are intended to minimize disturbance and distribution of mine materials to limit radon gas emissions (Table 12.4-1). Radon emissions are not expected to change soil quality and the pathway was not carried forward in the assessment.

TS-11: Change in soil quality from the WRSAs:

- Seepage from the WRSAs may cause changes in groundwater quality and alter soil quality.

Extracted ore, special waste rock, and waste rock would be stored at surface in designated areas or WRSAs (Section 5.4.4, Mine Rock Management). Seepage from these storage areas during Construction, Operations, and Closure could cause changes to groundwater quality, which has the potential to change soil quality.

Seepage from the WRSAs during the Project lifespan would be mitigated by a number of proven engineering design features and techniques. Management of waste rock would begin when materials are hoisted from the underground mine to the surface. Ore, special waste rock, PAG and NPAG material would be separated and stored separately. Ore stockpiles, special waste stockpiles and the PAG WRSA would be lined with high density polyethylene to prevent seepage (Mine Waste Management Plan). The NPAG WRSA would be unlined and used for short- and long-term storage of NPAG waste rock.

Runoff from the ore stockpiles, special waste stockpiles, and PAG WRSA would be contained and diverted to the effluent treatment plant and released to the environment after meeting discharge criteria. Runoff from the NPAG WRSA would be collected for containment and if it meets discharge criteria would be released to the environment. Water not meeting discharge criteria would be considered mineralized contact water and diverted to the effluent treatment plant prior to release. The WRSAs would be monitored for seepage to support groundwater protection and to confirm the Mine Waste Management Plan is effective. A Detailed Decommissioning and Reclamation Plan and Cost Estimate would also be developed to decommission and transfer the Project back to the Province per the Institutional Control Program.

Groundwater potentially affected by seepage from WRSAs is not expected to interact with the top layers of soils that support the establishment and growth of vegetation. Any changes to groundwater from the WRSAs would occur below the surficial soil layers. In the ecological health risk assessment direct contact or uptake exposure pathways associated with groundwater were predicted to be incomplete, as it was assumed that groundwater is inaccessible to ecological receptors (e.g., terrestrial plants and earthworms) or negligible relative to other pathways (TSD XXI). Therefore, seepage from WRSAs is not predicted to influence soil quality relative to existing conditions and the pathway was removed from further assessment.

12.4.2 Secondary Pathways

The following Project interactions are predicted to result in secondary pathways to terrain and soils and were not carried forward in the assessment.

TS-02: Admixing and compaction:

- Site clearing, contouring, and excavation can cause admixing and compaction and increase erosion potential, which may change the quantity, quality, and distribution of soil.

Ground disturbance (i.e., site clearing, contouring, and excavation) would be required to prepare the area for construction of Project facilities and infrastructure and can lead to soil admixing, compaction, and erosion, which can change soil quantity, quality, and distribution. Site clearing, contouring, and excavation would also take place during removal of infrastructure, and reclamation and revegetation of facilities and infrastructure during Closure.

Soil compaction can occur during site clearing, contouring, and excavation if heavy equipment passes over soils that are sensitive to compaction. Generally, well-drained, coarse- and medium-textured soils (i.e., loams, sandy loam, loamy sand, loam) are less prone to compaction than fine-textured soils (i.e., silty clay loam, silty clay, clay loam, and clay). However, sensitivity to compaction can change based on soil moisture conditions (Lewis et al. 1989). Soils within the LSA generally have Low susceptibility to compaction; however, soils in low-lying areas that are under higher moisture conditions (e.g., Orthic Gleysols in the Mineral-6 map unit) have a Moderate to High susceptibility to compaction (Section 12.3.5, Soil Sensitivities).

Admixing of the topsoil (i.e., upper soil horizon or upper lift) with subsoil (i.e., lower soil horizons or lower lift) can occur during site clearing, contouring, and excavation if there is not a clear division (e.g., colour, texture, structural change) between topsoil and subsoil horizons. Admixing can reduce organic matter and carbon content in topsoil materials by incorporating subsoil materials with lower organic matter content, which can alter microbiological activity and composition and increase the rate of organic matter decomposition due to soil aeration (Wick et al. 2009). Soils in the LSA were generally uniform in texture throughout the soil profile. Therefore, it is not anticipated that admixing would result in textural changes in topsoil material. However, the seed bank, soil organic matter, and surface organic horizons would be diluted if topsoil and subsoil materials were mixed, leading to a decrease in soil quality.

The risk of soil erosion from wind and/or water is influenced by soil particle size, organic matter content, water content, permeability, elevation and slope, vegetation cover, and natural events (e.g., freeze-thaw), as well as human activities that cause soil disturbance (Cruse et al. 2001; Campbell et al. 2002; TAC 2005). Considering the dominant slope length, grade, and texture of the topsoil horizon, soils within the LSA dominantly have Low or Low to Moderate susceptibility to water erosion and High susceptibility to wind erosion because of predominantly coarse-textured topsoil horizons (Section 12.3.5).

Several environmental design features and mitigation measures would be implemented to avoid and minimize disturbance to soils during Construction, Operations, and Closure (Table 12.4-1). Project facilities and infrastructure would be developed on areas of previous disturbance to the extent practicable, and areas of new disturbance would be designed to occupy the minimum area required for the Project (e.g., roads would be designed to be the minimum possible width while maintaining adherence to safety regulations). The tailings management facility would be located underground, which avoids permanent removal of land for this purpose and considers the concerns of Indigenous Groups and communities regarding surface deposition of mine wastes (Section 2). Equipment with low ground pressure tracks or tires, skid shoes (i.e., blade wear runners), and brush skirt would be used as much as feasible to limit adverse effects on soils. A Detailed Decommissioning and Reclamation Plan would also be developed and implemented to decommission and transfer the Project site to the Province per the Institutional Control Program.

Implementation of environmental design features and mitigation is expected to minimize admixing, compaction, and erosion from site clearing, contouring, and excavation. Project activities could result in a measurable minor change to soil quantity, quality, and distribution within the maximum disturbance area relative to existing conditions; however, the change is predicted to have negligible residual effects on terrain and soils. Therefore, the pathway was not carried forward for further assessment.

TS-03: Change in soil quality from fugitive dust:

- Deposition of fugitive dust emissions and associated constituents (e.g., metals, radionuclides) may change soil chemistry and adversely affect soil quality.

Activities such as land clearing, site preparation, construction of facilities, site traffic, handling of waste rock during Construction and Operations, and removal of infrastructure and revegetation during Closure would generate fugitive dust, which contains constituents such as metals and radionuclides. Accumulation of dust (i.e., total suspended particulate deposition) and associated constituents, such as metals, may result in changes to the chemical content of soil within affected areas. Changes to the chemical content of soil can alter soil pH and affect soil productivity. At the Ekati Mine in the Northwest Territories, dust generated from a high-traffic, 28 km haul road was found to change soil pH rapidly (i.e., exponentially) within 250 m with smaller changes from 250 m to 1 km away (Chen et al. 2017).

Indigenous Groups expressed concerns specifically related to the effects of uranium dust generated from Project activities affecting the air, water, soil and vegetation, which are based in part on their experience with other mining developments (i.e., Cluff Lake Mine) (TSD II: BNDN; TSD IV: MN-S; TSD V.2: CRDN). Relative to soils, the MN-S commented that uranium dust 'covers everything' because of its ability to travel long distances with the wind (TSD IV: MN-S).

Air quality modelling was completed to predict the amount and spatial extent of dust deposition and associated constituents from the Project during Construction and Operations (Section 7.2; Appendix 7A, Air Dispersion Modelling Report). Results indicate that dust deposition rate was higher during Operations than Construction, which is a function of the type of dust, height that dust is released, and the fraction of coarse particulate matter in total suspended particulates (i.e., particulates greater than PM_{10}). The annual average dust deposition rate during Operations is predicted to be 0.095 mg/cm^2/30 d (113.86 kg/ha/yr) at the boundary of the maximum disturbance area (Section 7.2; Appendix 7A).

Predicted soil metal concentrations were calculated by adding the existing soil concentration to the incremental increase in soil metal concentration predicted using the USEPA method and formulas (USEPA 2005). The incremental increase in soil metal concentrations was calculated for each metal using Equation 1 below, as suggested by USEPA (2005):

$$C_S = 100 \text{ X } ((D/Zs*BD)) \text{ X } t_D$$

where:

Cs = Soil concentration over exposure duration (mg/kg soil)

100 = Unit conversion factor (from mg/m^2 to kg/cm^2)

D = Yearly dry deposition rate of metal (g/m^2/yr)

tD = Time period over which deposition occurs (years)

Zs = Soil mixing zone depth (cm)

BD = Soil bulk density (g/cm^3)

The predicted yearly dry deposition rate of contaminants (D) is provided in Table 12.4-2 for Operations. The time period (tD) over which dust deposition would occur was assumed to be the full duration of Operations (i.e., 24 years). Metals deposited with fugitive dust were assumed to mix with the top 20 cm of soil (Zs), as recommended by CSA N288.1-20 (CSA 2020) and used in TSD XXI. The bulk density (BD) for soil was set at the default value of 1.5 g/cm^3 of soil, as recommended by the USEPA (2005).

Table 12.4-2: Predicted Annual Deposition of Metals from the Rook I Project during Operations

Metal	Deposition (kg/ha/yr)	Deposition g/m^2/yr
Arsenic	0.0008	0.00008
Antimony	0.0001	0.00001
Barium	0.066	0.0066
Beryllium	0.0001	0.00001
Cadmium	0.00001	0.000001
Chromium	0.0157	0.00157
Cobalt	0.0019	0.00019
Copper	0.0134	0.00134
Lead	0.0203	0.00203
Mercury	0	0
Molybdenum	0.0096	0.00096
Nickel[(a)]	0.0049	0.00049
Selenium	0.0002	0.00002
Silver	0.0001	0.00001
Thallium[(b)]	0	0
Tin	0.0002	0.00002
Uranium[(c)]	0.6227	0.06227
Vanadium	0.0141	0.00141
Zinc	0.0031	0.00031

a) Nickel in total suspended particulates.
b) No thallium detected in source material.
c) Uranium in total suspended particulates.

The amount of deposited metal was added to the highest metal concentration value in surface layers of soil sampled during baseline studies (Table 12.4-3) to provide the most conservative values. The predicted concentrations of metals after adding the deposition of metals in dust were compared with Canadian Council of Ministers of the Environment (CCME) soil quality guidelines (CCME 2014). Although there is an addition to many of the metals, the soil concentrations do not exceed the guidelines for any of the metals following the entire period of maximum deposition (i.e., 24 years; Table 12.4-3).

Table 12.4-3: Concentration of Metals in Surface Soil Layers Due to Dust Deposition

Metal	CCME Guideline (mg/kg)[(a)]	Baseline Concentration in Surface Layer[(d)] (mg/kg)	Predicted Deposition in Litter Layer following Operations (mg/kg)[(e)]	Predicted Concentration in Soil after Deposition (mg/kg)
Arsenic	12	0.80	0.01	0.81
Antimony	20	nd	0.00	0.00
Barium	750	235.00	0.53	235.53
Beryllium	4	0.31	0.00	0.31
Cadmium	1.4	0.26	0.00	0.26
Chromium	64	3.40	0.13	3.53
Cobalt	40	0.70	0.02	0.72
Copper	63	6.82	0.11	6.93
Lead	70	6.43	0.16	6.59
Mercury	6.6	0.85	0.00	0.85
Molybdenum	5	0.34	0.08	0.42
Nickel[(b)]	45	4.39	0.04	4.43
Selenium	1	0.38	0.00	0.38
Silver	20	nd	0.00	0.00
Thallium[(f)]	1	n/a	n/a	n/a
Tin	5	nd	0.00	0.00
Uranium[(c)]	23	0.12	4.98	5.10
Vanadium	130	4.32	0.11	4.43
Zinc	250	17.40	0.02	17.42

a) Source: CCME (2014) Guideline for Agricultural Soils.
b) Nickel in total suspended particulates.
c) Uranium in total suspended particulates.
d) Surface layer maximum value to estimate worst-case scenario.
e) Calculation CS = 100 X ((D/Zs*BD)) X tD.
f) No thallium detected in source material.
nd = non-detect; n/a = not applicable.

Air quality modelling was completed to predict the amount and spatial extent of deposition of radionuclides from the Project during Operations (Section 7.2; Appendix 7A). The deposition of radionuclides on the upper soil layer was compared with the Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (Canadian NORM Working Group 2013). Although there is an addition of radionuclides to the soil, the deposition values do not exceed the guidelines (Table 12.4-4).

Table 12.4-4: Predicted Annual Deposition of Radionuclides from the Rook I Project

Radionuclide	Deposition ($Bq/cm^2/yr$)	Total Deposition[(a)] (Bq/cm^2)	Guideline[(b)]
Lead-210	0.025	0.6	1 Bq/cm^2 averaged over a 100 cm^2 area
Polonium-210	0.025	0.6	1 Bq/cm^2 averaged over a 100 cm^2 area
Radium-226	0.025	0.6	1 Bq/cm^2 averaged over a 100 cm^2 area
Thorium-230	0.025	0.6	1 Bq/cm^2 averaged over a 100 cm^2 area

a) Assume 24 years of operation.
b) Source: Canadian NORM Working Group 2013.
Bq/cm2/yr = becquerels per square centimetre per year; Bq/cm2 = becquerels per square centimetre.

Project design and mitigation policies and procedures are anticipated to limit fugitive dust emissions from the Project. The Environmental Monitoring Plan includes plans for monitoring soil quality and ambient air quality during the Project lifespan and applying adaptive management, if necessary. Several mitigation measures would be applied to minimize dust deposition, such as watering the airstrip, site roads, and access road during dry conditions, and establishing and enforcing speed limits on site roads and the access road to reduce dust production (Table 12.4-1). Deposition of fugitive dust and associated metals are predicted to have a negligible residual effect on soils in the maximum disturbance area and the pathway was not carried forward in the assessment.

TS-04: Changes in soil quality from Project emissions:

- Deposition of air contaminant emissions (e.g., potential acid inputs) may change soil chemistry and adversely affect soil quality.

Deposition of air contaminant emissions associated with Project activities are expected to occur from the combustion of fossil fuels in large equipment, aircraft, trucks, vehicles, power generation, and the burning of non-hazardous waste materials (e.g., food waste). Criteria air contaminants include particulate matter less than 2.5 µm (micrometres) in diameter ($PM_{2.5}$) and 10 µm in diameter (PM_{10}), total suspended particulates, carbon monoxide (CO), sulphuric acid (H_2SO_4), sulphur dioxide (SO_2), and nitrogen dioxides (NO_2).

Air particulate emissions can change soil quality by altering soil pH, nutrient content, and the composition of soil organisms (Rusek and Marshall 2000; Jung et al. 2011; Chen et al. 2017). Air particulates may also affect cation and anion exchange in soil, decomposition rate of organic matter, and nutrient cycling (John et al. 2009; Jung et al. 2011). Deposition of SO_2 and NO_2 could lead to acidification of soils (Holowaychuck and Fessenden 1987; Bobbink et al. 1998).

Indigenous Groups have expressed concerns about Project-related contamination of the land and environment in general, through changes in air and water quality. These concerns are based, in part, on Indigenous Groups indicating that they are already experiencing the effects of pollution and contamination from other industrial developments, which they believe has impacted the health of the landscape (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; CRDN-JWG 2020b; MN-S-JWG 2019b; BRDN-JWG 2021a). A member of the MN-S commented that the north was pristine when they were young, but the mining industry has brought changes to environmental conditions, and they are concerned about the effects of existing pollution from mining on their children, grandchildren and on future generations (MN-S-JWG 2019a).

The assessment of effects of the deposition of suspended solids in criteria air contaminant emissions on soil quality is assessed in the following paragraphs.

Air quality modelling was used to predict maximum ground-level concentrations of criteria air contaminant emissions during Construction and Operations (Section 7.2.5.1.1, Construction and Operations). Cumulative concentrations were calculated by adding values for the Base Case to maximum predicted values for Construction and Operations. Results indicate that concentrations of criteria air contaminants beyond the maximum disturbance area are well within Saskatchewan air quality guidelines during Construction and Operations (Table 12.4-5), including carbon monoxide and sulphuric acid (Section 7.2.5.2). The exception is PM_{10}, which exceeds the air quality guideline value during both Project phases. During Construction, most of the area of exceedance (279 ha) overlaps the North Arm of Patterson Lake and extends from the boundary of the maximum disturbance area to approximately 1.2 km (Section 7.2.5.2). In contrast, during Operations, the area of exceedance is substantially reduced (9 ha) and extends 203 m from the boundary of the maximum disturbance area.

Table 12.4-5: Annual Criteria Air Contaminant Emissions from the Rook I Project during Construction and Operations

Criteria Air Contaminant	Construction (μg/m³)	Operations (μg/m³)	Guideline (Annual)[(a)]
Total suspended particulates	13.2	11.2	60
PM_{10}	**147.0**	**65.4**	50[(b)]
$PM_{2.5}$	4.1	3.7	10
Nitrogen dioxide	9.7	6.7	45
Sulphur dioxide	0.0	0.1	20

Bold values indicate exceedance of guidelines.
a) Saskatchewan Ambient Air Quality Standards (SAAQS; ENV 2021).
b) 24-hour average period.
PM_{10} = particulate matter 10 microns or less in diameter; $PM_{2.5}$ = particulate matter 2.5 microns or less in diameter.

Environmental protection and monitoring plans developed for the Project, which include adaptive management, are expected to limit the emissions of criteria air contaminants and associated effects on soils (Effluent and Emissions Plan, Environmental Protection Program, Environmental Monitoring Plan). Project designs and mitigation include primary use of liquid natural gas for power generation, emission control devices on combustion-based equipment and vehicles, regular maintenance of equipment, and procurement criteria that specific stationary and mobile equipment would meet applicable performance standards (Table 12.4-1).

After implementing environmental design features, mitigation, and monitoring deposition of some criteria air contaminants could result in a measurable minor change to soil chemistry and soil quality within the maximum disturbance area, but changes are likely to be not measurable for emissions of sulphur dioxide and sulphuric acid (0.2 μg/m³; Section 7.2.5.2) relative to existing conditions. Emissions of PM_{10} above air quality guideline values are predicted to extend beyond the LSA and may result in a minor change to soil chemistry, however, the majority of this portion of the LSA is open water. Therefore, the pathway was not carried forward for further assessment.

TS-05: Increased erosion from changes in site runoff:

- Changes in site surface water runoff can increase soil erosion and affect soil quality and distribution.

AND

TS-06: Redistribution of soils:

- Changes in surface water levels, flows, and drainage areas can increase soil erosion and sedimentation along waterbodies and watercourses and affect soil quality and distribution.

Surface water runoff from the Project site, and changes in surface water levels, flows, and drainage areas have potential to increase soil erosion and change soil quality and distribution. Soils within the LSA dominantly have Low or Low to Moderate susceptibility to water erosion because of predominantly coarse textured topsoil horizons (Section 12.3.5). Several environmental design features and mitigation measures would be implemented to avoid and minimize changes in surface water patterns during Construction, Operations, and Closure, which would also mitigate effects on soil quality and distribution (Table 12.4-1). The Project footprint has been designed to minimize areas of vegetation clearing and soil disturbance and optimize use of the existing access road and disturbed areas. The tailings management facility would be located underground, which would avoid permanent disturbance to vegetation (i.e., natural control for soil erosion) and considers the concerns of Indigenous Groups regarding surface deposition of mine wastes (Section 2).

A regional hydrological model was used to characterize and predict changes from Project activities to water surface levels and watercourse flow rates for the RSA (Section 9.6, Residual Effects Analysis). Outputs from the regional hydrological model were used as inputs to stream channel relationships and a fluvial sediment transport model. The regional hydrological model predicted surface water flows and levels from the start Construction to the end of Closure. The results indicate that the net discharge of water to Patterson Lake from Project activities is expected to create small and difficult to measure changes such as increasing water surface elevation by 5 cm, increasing flows in the Clearwater River between Patterson Lake and Forrest Lake by less than five percent, and changing stream channel parameters (i.e., wetted area) by less than 1%. Erosional losses in the upper reach of the Clearwater River and subsequent sediment deposition in the lower reach may increase by a non-detectable margin and the net balance of sediment transported to Forrest Lake is expected to remain unchanged.

Surface water in the receiving environment downstream of the Project would be protected and managed through the Environmental Monitoring Plan. Site contact water would be intercepted and managed in ways to reduce effects on the surrounding environment in accordance with the Environmental Protection Program. More specifically, work required in sensitive areas that may be more prone to erosion from surface water runoff and changes in surface water levels, flows, and drainage areas would be scheduled to be avoid the time(s) of year when erosion is most likely (e.g., spring freshet), to the extent practical. The rate of discharge from the effluent treatment plant would be managed by having adequate surface water storage capacity to allow for controlled release rates, if required. A minimum 150 m buffer between soil stockpiles and waterbodies or drainages would be maintained (unless temporary soil storage is required) and all containment and conveyance structures (i.e., ditches and culverts) would be routinely inspected and maintained to limit risk of road wash-out or sediment release. Progressive reclamation and revegetation would also be implemented as disturbed areas are no longer required, and non-permanent features would be restored and revegetated as they are removed.

The Environmental Monitoring Plan includes monitoring surface water levels and flows and applying adaptive management, as required. During Construction and Operations, a Preliminary Decommissioning and Reclamation Plan would be developed and periodically updated to reflect changing site-specific conditions and surface water effects. Prior to transitioning to Closure, a Detailed Decommissioning and Reclamation Plan would be developed to reflect mitigations necessary to maintain protection of surface water and transfer the site to the Province under the Institutional Control Program.

Environmental design features, mitigation, and monitoring are anticipated to minimize changes in surface water levels and flows. Changes in surface water patterns from the Project could result in a measurable minor change to soil quality and distribution within the maximum disturbance area and LSA relative to existing conditions; however, these changes are predicted to have a negligible residual effect on soils and the pathway was not carried forward in the assessment.

TS-07: Changes in soil quality from contact water:

- Changes in surface water quality from contact with surface facilities and additional infrastructure may alter soil chemistry and affect soil quality.

Rain and snowfall that contacts Project facilities and infrastructure (e.g., WRSAs, on-site process plant, roads) may alter surface water quality through collection of metals and radionuclides in dust deposited on infrastructure.

Runoff of precipitation from potentially acid generating rock or ore would also alter surface water quality. Changes in surface water quality have the potential to alter soil chemistry and affect soil quality.

Mitigation in the Environmental Protection Program is expected to be effective at reducing the amount and spatial extent fugitive dust deposition (Table 12.4-1). Dust deposition (i.e., total suspended particulates) is predicted to be largely confined to the maximum disturbance area with concentrations of metals and radionuclides in dust well below guideline values — see above secondary pathway analysis: Deposition of fugitive dust emissions and associated constituents (e.g., metals, radionuclides) may change soil chemistry and adversely affect soil quality.

An Environmental Protection Program would be implemented to avoid the potential for untreated contact water to leave the site during Construction, Operations, and Closure, which would mitigate effects on soil quality.

Collection ditches would be sized to accommodate a full PMP 24-hour event. Diversion ditches and perimeter berms are designed to divert clean non-contact water away from any disturbed areas, facilities, or works where that water may become contaminated. Diversion ditches would be sized to accommodate 1:100 year, 24-hour precipitation events. To maintain integrity, diversion ditches and collection ditches would include erosion control measures reflective of ditch slopes and flows rates, where required. Swales would be on surface-graded pads where ditches are not possible, and where the initial anticipated contributing precipitation would not warrant a full ditch (Section 5.4.5, Site Water Management). Surface water quality would also be monitored using the principles of adaptive management (Environmental Monitoring Plan). Disturbed areas that are no longer needed would be progressively reclaimed and revegetated, which would reduce the areas generating site contact water.

Environmental design features, mitigation, and monitoring are anticipated to minimize changes in surface water quality. Changes in surface water quality from the Project could result in a measurable minor change to soil quality within the maximum disturbance area relative to existing conditions, but the changes are predicted to have a negligible residual effect on soils and the pathway was not carried forward in the assessment.

12.4.3 Primary Pathways

The following Project interaction was predicted to be the primary pathway affecting terrain and soils (Table 12.4-1) and was carried forward for further assessment in the residual effects analysis (Section 12.5):

TS-01: Alteration of soil and terrain conditions:

- Alteration of soil and terrain conditions (i.e., quantity, quality, distribution) may adversely affect soil productivity and the types of ecosystems that can be reclaimed on the landscape.

The need for a detailed and comprehensive analysis of this primary pathway is also supported by comments by the CRDN and MN-S who are concerned about the ability of Project reclamation activities to restore the land to previous conditions, which is in part based on their observations from previous mining exploration and developments (e.g., the Cluff Lake Mine).

12.5 Residual Effects Analysis

12.5.1 Application Case

Project activities and components would alter soil and terrain conditions (i.e., quantity, quality, distribution), which could subsequently adversely affect soil productivity and the types of ecosystems that can be re-established on the landscape through reclamation. Project activities that would affect terrain and soil quantity and quality include: land clearing and site preparation for infrastructure and facilities during Construction; hauling and deposition of ore, waste rock, and other materials during Operations; and removal of infrastructure and facilities and associated reclamation and revegetation of non-permanent Project components during Closure.

The residual effects analysis considers the primary pathway expected to result in effects on terrain and soils after implementing mitigation (Table 12.4-1) and was structured using separate subsections for each of the terrain and soils measurement indicators in the maximum disturbance area. The measurement indicators for terrain and soils are:

- quantity and distribution of terrain units;
- quantity and distribution of soil map units; and
- soil quality (i.e., productivity).

Because there is no RFD Case for terrain and soils, potential changes from natural disturbance factors and climate change are also discussed in this subsection (Section 12.2.5, Assessment Cases).

Residual effects resulting from the Project have been assessed using the assumption that terrain and soils in the entire maximum disturbance area would be altered (Section 12.2.3, Spatial Boundaries). In practice, the extent of alteration would not be this large since the area disturbed by the anticipated Project footprint is about ¼ (25%) the size of the maximum disturbance area, which provides a conservative (i.e., precautionary) assessment so effects are not underestimated.

12.5.1.1 Quantity and Distribution of Terrain Units

In the Base Case, surficial material (i.e., terrain units) distribution and slope stability were assessed. The glaciofluvial terrain unit comprises the largest proportion (89.1%) of the maximum disturbance area. The anthropogenic disturbance (8.4%), and fen peat (2.4%) were also identified in the maximum disturbance area (Table 12.5-1), along with the terrain map unit of water (0.1%). During the Application Case, the amount of anthropogenic disturbance increases to 980.0 ha and represents 99.9% of the maximum disturbance area; this disturbance includes 897.8 ha of new disturbance plus the 82.2 ha of existing disturbance in the Base Case. All natural terrain units in the maximum disturbance area would change to disturbance units, with the exception of water, which is assumed to remain unchanged in available area. Because the glaciofluvial terrain unit constitutes the largest natural unit in the maximum disturbance area, this unit has a much larger change in area relative to the fen peat unit (Table 12.5-1).

Table 12.5-1: Change in Terrain Map Unit Areas in the Maximum Disturbance Area from the Application Case

Terrain Map Unit	Base Case		Application Case		Area Lost/Gained	
	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
Glaciofluvial	874.2	89.1	0.0	0.0	-874.2	-89.1
Fen Peat	23.6	2.4	0.0	0.0	-23.6	-2.4
Water	0.7	0.1	0.7	0.1	0.0	0.0
Anthropogenic Disturbance	82.2	8.4	980.0	99.9	897.8	91.5
Total Terrain Unit Area	980.7	100.0	980.7	100.0	0.0	0.0

Residual effects from Project-related changes in natural terrain units would be certain. Effects would be expected to be confined to the maximum disturbance area and continuous from the start of Construction through Closure. The magnitude and geographic extent of effects are conservatively overestimated as the actual anticipated Project footprint is about ¼ (25%) of the size of the maximum disturbance area used in the assessment.

The Project footprint would be limited to the extent practicable to minimize changes in quantity and distribution of terrain units and has been designed to avoid wetlands and the associated fen peat terrain units. A small amount (5.5 ha) of the fen peat terrain unit would be disturbed by the anticipated Project footprint. Should changes to Project design require additional disturbance within the maximum disturbance area, all reasonable efforts would be made to avoid further disturbance to the fen peat terrain unit. The footprint is planned to be limited by optimizing the use of cleared areas for Project infrastructure and activities, storing tailings underground, using existing road infrastructure, and efficiently designing the infrastructure and facilities (e.g., clustering buildings together).

Effects associated with permanent features of the Project (e.g., WRSAs) are irreversible. The effects from disturbance on terrain units not covered by permanent features are reversible beyond Closure (i.e., long-term duration). The removal of geomorphic characteristics of natural terrain units cannot be recovered, but over time, these units are expected to provide functional substrates for soils and the establishment of early seral vegetation communities (i.e., young vegetation communities that occupy reclaimed areas).

There would be progressive reclamation of areas no longer required for Project activities and decommissioning and reclamation of non-permanent facilities and infrastructure during the Active Closure Stage. Reclamation is predicted to reverse effects on reclaimed terrain units and provide adequate material for the development of productive soils, which would support the establishment and succession of vegetation communities with similar function to natural ecosystems not influenced by the Project. The establishment of reclaimed terrain, soils, and associated vegetation ecosystems is predicted to occur well beyond Closure, particularly for mature forest types (e.g., more than 60 years) such as jack pine and black spruce-bog ecosites (Section 13.3, Existing Conditions). In a study conducted in central Alberta, Macyk (1986) suggested that reconstructed soils are composites of the original soil units and the resultant soil properties are largely controlled by surficial material characteristics and material handling procedures.

12.5.1.2 Quantity and Distribution of Soil Map Units

In the Base Case, the Mineral-2 soil unit comprises the largest proportion (16.5%) of the maximum disturbance area, followed by the Mineral-12 (12.2%), Mineral-9 (11.1%), and Mineral-8 (10.9%) soil units (Table 12.5-2). During the Application Case, the amount of anthropogenic disturbance increases to 980.0 ha and represents 99.9% of the maximum disturbance area; this area includes 897.8 ha of new disturbance plus the 82.2 ha of existing disturbance in the Base Case. All natural soil units in the maximum disturbance area change to disturbance units, with the exception of water, which is assumed to remain unchanged in available area.

Table 12.5-2: Change in Soil Map Unit Areas in the Maximum Disturbance Area from the Application Case

Soil Map Unit (Map Unit Symbol)	Base Case		Application Case		Area Lost/Gained	
	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
Mineral-1 (M1)	28.3	2.9	0.0	0.0	-28.3	-2.9
Mineral-2 (M2)	161.7	16.5	0.0	0.0	-161.7	-16.5
Mineral-3 (M3)	82.0	8.4	0.0	0.0	-82.0	-8.4
Mineral-4 (M4)	94.0	9.6	0.0	0.0	-94.0	-9.6
Mineral-5 (M5)	66.0	6.7	0.0	0.0	-66.0	-6.7

Table 12.5-2: Change in Soil Map Unit Areas in the Maximum Disturbance Area from the Application Case

Soil Map Unit (Map Unit Symbol)	Base Case		Application Case		Area Lost/Gained	
	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
Mineral-6 (M6)	4.3	0.4	0.0	0.0	-4.3	-0.4
Mineral-7 (M7)	67.1	6.8	0.0	0.0	-67.1	-6.8
Mineral-8 (M8)	107.0	10.9	0.0	0.0	-107.0	-10.9
Mineral-9 (M9)	108.6	11.1	0.0	0.0	-108.6	-11.1
Mineral-10 (M10)	33.6	3.4	0.0	0.0	-33.6	-3.4
Mineral-11 (M11)	2.1	0.2	0.0	0.0	-2.1	-0.2
Mineral-12 (M12)	119.5	12.2	0.0	0.0	-119.5	-12.2
Organic-1 (O1)	15.5	1.6	0.0	0.0	-15.5	-1.6
Organic-2 (O2)	0	0.0	0.0	0.0	0.0	0.0
Organic-3 (O3)	8.1	0.8	0.0	0.0	-8.1	-0.8
Water (W)	0.7	0.1	0.7	0.1	0.0	0.0
Anthropogenic Disturbance (DIS)	82.2	8.4	980.0	99.9	897.8	91.5
Total	980.7	100.0	980.7	100.0	0.0	0.0

Residual effects from Project-related changes in the quantity and distribution of soil map units would be certain. Effects would be expected to be confined to the maximum disturbance area and continuous from the start of Construction through Closure. The magnitude and geographic extent of effects are overestimated as the actual anticipated Project footprint is approximately ¼ (25%) the size of the maximum disturbance area used in the assessment. A small amount of the Organic-1 (4.8 ha) and Organic-3 (0.7 ha) SMUs would be disturbed by the anticipated Project footprint. The Project footprint would be limited to the extent practicable to minimize changes in quantity and distribution of soil units and has been designed to avoid wetlands (Section 12.4, Table 12.4-1). Vegetation clearing and soil disturbance would also be limited to the minimum area required and work in areas containing soils sensitive to loss (e.g., by erosion) would be scheduled during non-sensitive times of the year (e.g., outside of spring freshet), to the extent practical. Progressive reclamation and revegetation would be completed as facilities are removed and areas are no longer required for the Project to avoid prolonged soil exposure and potential soil loss.

Natural soils form from complex interactions between terrain, weather, and other factors, and may take thousands of years to develop. For example, Canadian prairie soils have formed over ten to fifteen thousand years (Anderson and Cerkowniak 2010). Disturbed soils can be reclaimed with appropriate mixing of materials, and over time, support similar ecosystem functions as natural soils. Studies have shown that reconstructed soils can perform similarly in function to natural soils and can support equivalent plant communities (Holl 2002; Séré et al. 2008). Therefore, the conversion of natural soils to disturbed soils is considered to be reversible.

Effects associated with permanent features of the Project (e.g., WRSAs) are irreversible. However, there would be progressive reclamation of areas no longer required for Project activities and decommissioning and reclamation of non-permanent facilities and infrastructure during the Active Closure Stage. Reclamation is predicted to reverse effects on disturbed soil map units and provide productive soils to support the establishment and succession of vegetation communities with similar function to natural ecosystems not influenced by the Project. The establishment of reclaimed soils and associated vegetation ecosystems is predicted to occur well beyond Closure, particularly for mature forest types (e.g., forests more than 60 years of age).

12.5.1.3 Soil Quality

Soil quality is associated with several parameters such as sensitivity to wind and water erosion, acidification, and compaction, and suitability for reclamation. The pathway analysis determined that the Project would result in no measurable (i.e., no pathway) or negligible residual effects (i.e., secondary pathway) to these soil parameters, except for suitability for reclamation (Section 12.4, Table 12.4-1). As a result, the residual effects analysis for soil quality is focused on the suitability of disturbed soils for reclamation.

Soil Suitability for Reclamation

The ability for soil to be successfully reclaimed depends on various soil chemical, physical, and biological characteristics (Alberta Agriculture 1987). These characteristics typically change through the soil profile and require that during land clearing and site preparation, benefits of stripping the topsoil separately from the subsoil are considered. Topsoil in mineral soils typically comprises the upper 30 cm of the soil profile and includes the organic (LFH) layers, A horizon, and upper B horizon. Separating the topsoil from the subsoil (i.e., below 30 cm) prevents dilution of the organic matter and the upper soil profile, maintains the plant propagule (e.g., seed) bank within the topsoil, and provides capacity for the topsoil to support ecosystem function after reclamation (Alberta Agriculture 1987). Soil reclamation suitability in forested environments can be classified based on several properties, including pH, salinity, sodicity (i.e., the amount of sodium present), base saturation, stoniness or coarse fragment content, texture, moisture content, and calcium carbonate equivalent[5] (Alberta Agriculture 1987). Soil reclamation suitability for mineral soils within the LSA, which contains the maximum disturbance area (and anticipated Project footprint), is largely limited by texture (Section 12.3). The pH suitability was not considered when determining limiting factors for the LSA as the pH ranges identified were within the range of the natural background collected during baseline studies (although classed as unsuitable according to Alberta Agriculture [1987]).

Coarse-textured soils can have poor nutrient retention and low available water holding capacity and can be susceptible to organic matter loss (Section 12.3). Given the coarse textures of upland soils within the LSA, land capability following reclamation would depend on measures taken to mitigate the potential effects on soil quality. Mitigation strategies would be implemented to maximize reclamation suitability of salvaged soils for successful reclamation of both upland and wetland ecosystems. Recommendations include timing soil salvage and reclamation plans to prioritize direct placement opportunities, soil handling recommendations to segregate topsoil materials and minimize soil loss and degradation, stockpiling requirements for long-term storage of reclamation material, and other strategies based on existing conditions. Direct placement reduces soil loss from overhandling, reduces organic carbon loss from topsoil, and increases seed viability. Seed banks in salvaged topsoil are valuable for natural revegetation of reclamation areas, given that the propagules (i.e., seeds or roots capable of regenerating plants) are adapted to local climatic conditions and already present on the landscape. Soil handling recommendations and stockpiling requirements would vary based on weather conditions, seasonality, and operational constraints.

Reclaimed soils are expected to provide similar ecological function as natural soils surrounding the Project and are expected to result in the establishment of early-stage vegetation communities within 5 to 10 years after the Active Closure Stage, and perhaps mature seral stages well beyond Closure (e.g., more than 60 years). The net effect is predicted to be negative, reversible, continuous, and certain.

[5] The calcium carbonate equivalent property is applicable to topsoil only.

12.5.1.4 Climate and Natural Disturbance Factors

Section 22, Assessment of Effects of the Environment on the Project, outlines that the future climate extreme projections are consistent with the current climate and the future climate temperature and precipitation trends. From the median (i.e., 50% exceedance probability) values for the 2050s and 2080s, the projected future climate extremes are indicating a future that is likely to be warmer and wetter on an annual basis. Temperature is projected to increase, resulting in increased warm nights, and reduced ice and frost days. Precipitation is also projected to increase, resulting in increased annual total wet-day precipitation, and very wet and extremely wet days.

An increase in temperature and precipitation over time could shift the soil thermal regime. Longer growing seasons can alter ecological succession by increasing carbon and nutrient exports to the soil from increased vegetation, which would result in an increase of soil productivity. These changes to soil quality could have a positive effect on the ability to sustain natural vegetation communities. Alternatively, increased precipitation can cause groundwater levels to rise, which can increase mobility of solutes from the soil to waterbodies (Oni et al. 2017). The removal of solutes can negatively change soil quality due to the decrease in available soil nutrients for plants.

Forest fires in boreal environments can remove vegetative cover, increase erosion potential, and affect soil nutrients, primarily on surface horizons, which can decrease soil quality. Fire can substantially alter the distribution of nutrient concentrations through the soil profile, with large losses of nitrogen and smaller losses of calcium, potassium, magnesium, and phosphorus (Neff et al. 2005). Such changes can have negative effects on the natural regeneration vegetation ecosystems and plants. As noted by the BNDN, the increasing frequency and magnitude of forest fires in the north has removed vegetation and made regeneration more challenging because of the slow rate of regrowth and lack of topsoil required for plants to re-establish (TSD II: BNDN).

12.5.2 Reasonably Foreseeable Development Case

There is no RFD Case for terrain and soils, as described in Section 12.2.5.

12.5.3 Residual Effects Classification

Residual effects for the Application Case on terrain and soils are classified from Construction through Closure, which generates the maximum potential spatial and temporal extent of effects and provides confident and ecologically relevant effects predictions. Construction is expected to result in the largest changes to terrain and soils, as Project activities during this phase would be most intense and occur over most of the maximum disturbance area, which represents the Project footprint. In contrast, the intensity of disturbance activities during Operations would be substantially reduced and confined to the smaller Project footprint. Activities during Closure are expected to reverse effects on terrain and soils on reclaimed areas.

Residual effects on terrain and soils due to the Project are summarized in Table 12.5-3 according to direction, magnitude, geographic extent, duration, reversibility, frequency, and probability of occurrence following the methods described in Section 12.2.8, Residual Effects Analysis. Localized Project-related changes to terrain and soils measurement indicators are predicted to have no to little interaction with potential regional effects on soils from climate change and would not change the conclusions of the assessment. As such, climate change effects were not classified.

Effective implementation of mitigation outlined in Section 12.4 (Table 12.4-1) and progressive reclamation, restoration, and revegetation are anticipated to reduce the magnitude and duration of residual effects on terrain and soils. Monitoring and follow-up activities would be performed to help facilitate effective implementation of these mitigation, progressive reclamation, restoration, and revegetation activities.

Table 12.5-3: Classification of Residual Effects on Terrain and Soils Measurement Indicators for the Application Case

Measurement Indicator	Criterion	Rating / Effect Size
Quantity and distribution of terrain units	Direction	▪ Negative
	Magnitude	▪ 897.8 ha of natural terrain units under existing conditions converted to the disturbance map unit (i.e., high magnitude) ▪ 82.2 ha of the disturbance map unit remain in the maximum disturbance area
	Geographic extent	▪ Maximum disturbance area
	Duration	▪ Permanent: natural terrain units covered by permanent features (e.g., WRSAs) ▪ Long-term: for reclaimed terrain units, 33 years (start of Construction to end of Active Closure Stage) or earlier with progressive reclamation, and extending well beyond Closure
	Reversibility	▪ Irreversible: natural terrain units covered by permanent features (e.g., WRSAs) ▪ Reversible: for reclaimed terrain units
	Frequency	▪ Continuous
	Probability of occurrence	▪ Certain
Quantity and distribution of soil map units	Direction	▪ Negative
	Magnitude	▪ 897.8 ha of soil map units under existing conditions converted to the disturbance map unit (i.e., high magnitude) ▪ 82.2 ha of the disturbance map unit remain in the maximum disturbance area
	Geographic extent	▪ Maximum disturbance area
	Duration	▪ Permanent: for natural soil map units covered by permanent features (e.g., WRSAs) ▪ Long-term: for disturbed soil map units, 33 years (start of Construction to end of Active Closure Stage), or earlier with progressive reclamation, and extending well beyond Closure
	Reversibility	▪ Irreversible: natural soil map units covered by permanent features (e.g., WRSAs) ▪ Reversible: for reclaimed soil map units
	Frequency	▪ Continuous
	Probability of occurrence	▪ Certain
Soil quality (i.e., productivity)	Direction	▪ Negative
	Magnitude	▪ 897.8 ha of soil map units under existing conditions converted to the disturbance map unit (i.e., high magnitude) ▪ 82.2 ha of the disturbance map unit remain in the maximum disturbance area
	Geographic extent	▪ Maximum disturbance area
	Duration	▪ Long-term: for disturbed soil map units, 33 years (start of Construction to end of Active Closure Stage), or earlier with progressive reclamation, and extending well beyond Closure
	Reversibility	▪ Reversible
	Frequency	▪ Continuous
	Probability of occurrence	▪ Certain

WRSAs = waste rock storage areas.

12.6 Prediction Confidence and Uncertainty

Scientific inference is associated with uncertainty, and prediction confidence depends on the level of uncertainty and the way it is addressed. Primary factors affecting confidence in the predictions made in the terrain and soils assessment include:

- availability and accuracy of baseline data;
- accuracy of ecosystem maps;

- level of understanding of the strength of primary pathways in terms of the effects they are likely to have on terrain and soils;
- level of certainty associated with the effectiveness of proposed mitigations, where applicable; and
- level of understanding of baseline terrain and soils conditions and range of natural variation.

Uncertainty was managed by:

- reviewing historical data and conducting relevant baseline studies in the LSA;
- completing quality assurance and quality control of baseline data;
- inferring that terrain and soil types would be present in delineated mapped areas where they were not directly observed;
- using the best available land cover data for mapping upland, wetland, and riparian vegetation ecosystems in the LSA and using that information to aid in extrapolating soil map unit types;
- using data to make inferences about potential changes to terrain and soils from Project effects;
- using the maximum disturbance area to enable Project refinements and increase confidence that effects were not underestimated; and
- comparing assessment results to relevant published scientific literature.

Overall, there is a moderate to high degree of confidence in predictions related to the changes to terrain and soils. Uncertainty was primarily and appropriately addressed by making assumptions that conservatively overestimated rather than underestimated potential effects (i.e., a precautionary assessment). There is some residual uncertainty regarding the quantity and distribution of reclaimed terrain and soils units, and the level of soil productivity for revegetation during and after Closure. Monitoring is proposed to be used to address residual uncertainty by evaluating the progress of reclamation activities. Different approaches and methods would be implemented, if necessary, to establish a trajectory towards the successful regeneration and succession of vegetation ecosystems that are functionally similar to natural plant communities in the region.

12.7 Monitoring, Follow-Up, and Adaptive Management

Monitoring and follow-up programs would be used to:

- evaluate the effectiveness of the environmental protection measures (e.g., soils erosion and stockpiling soil for reclamation), and modify or enhance as necessary through monitoring and updating mitigation measures, if needed;
- identify and create mitigation and/or avoidance measures for unanticipated negative effects, including possible accidents and malfunctions; and
- contribute to the overall continual improvement of the Project.

The Environmental Protection Program would be implemented to mitigate effects on terrain and soils and apply adaptive management, where necessary. Examples of monitoring activities for terrain and soils are outlined in Table 12.7-1.

Table 12.7-1: Examples of Monitoring Activities for Terrain and Soil

Plan	Component	Monitoring Activities
Environmental Protection Program	Terrain Stability	▪ Monitor slope stability during land clearing, site preparation, and construction of facilities ▪ Perform routine inspection and maintenance of containment and conveyance structures (i.e., roadside ditches and culverts) to limit the risk of road wash-out or sediment release to the environment
	Soil Quality and Quantity	▪ Monitor site clearing, contouring, and excavation activities for signs of admixing, compaction, and erosion ▪ Monitor soil transport and stockpiling activities for signs of erosion ▪ Monitor dust deposition ▪ Monitor soil chemistry

The proposed monitoring programs are outlined in Section 23, Summary of Mitigation, Monitoring, and Follow-up Programs. The Preliminary Decommissioning and Reclamation Plan, along with monitoring, would assist in revising or adding mitigation measures to facilitate successful long-term reclamation of terrain and soils to support the establishment of vegetation communities and provide functional wildlife habitat.

In addition, Environmental Committees (i.e., one per primary Indigenous Group) composed of two NexGen and two Indigenous Group representatives would be established to act in an oversight manner to monitor the environmental performance of the Project and verify the parties are implementing the regulatory and environmental commitments made in respect of the Project.

Indigenous Groups have made recommendations related to mitigating the effects of the Project on the environment, including community-led long-term environmental testing and monitoring during Construction and Operations of the proposed Project (TSD IV: MN-S; TSD V.2: CRDN; YNLRO 2019). NexGen has committed to provide funding for the lifespan of the Project for a full-time independent Indigenous Monitor chosen by each primary Indigenous Group; this Indigenous Monitor would have access to conduct environmental sampling for the Project, subject to the Indigenous Monitor complying with appropriate health and safety and other reasonable site-specific policies. The Indigenous Monitor would be able to report openly and without restriction to the Environmental Committee and Indigenous Group’s community members on the performance of the Project. The Indigenous Monitor would also provide regular reports to the Environmental Committee.

12.8 Key Findings

The objectives of Section 12 were to provide a detailed and comprehensive assessment of all potential Project-specific effects and cumulative effects from the Project on terrain and soils; these objectives were met. A summary of key findings for terrain and soils is outlined below:

- No unique terrain or soil features were identified within the LSA. The Fission Patterson Lake South Property does not spatially overlap the LSA, and it is expected that the Patterson Lake South Property would implement appropriate mitigation and adaptive management to avoid and minimize project-specific effects. Therefore, there was negligible potential for cumulative effects on terrain and soils from the Project and Fission Patterson Lake South Property, and an RFD Case was not assessed.
- There would be a permanent change to natural terrain and soil units disturbed by the Project and covered by permanent features (e.g., WRSAs).
- Progressive reclamation during Operations and reclamation during Closure are predicted to reverse effects on disturbed terrain and soil map units and provide productive soils to support the establishment and

succession of vegetation communities with similar function to natural ecosystems not influenced by the Project. Soils would be reclaimed during the Active Closure Stage, with vegetation ecosystems predicted to be established well beyond Closure, particularly for mature forest types (i.e., more than 60 years).

- Monitoring programs would be implemented to evaluate the effectiveness of the environmental protection measures. Monitoring and adaptive management would also be implemented to achieve successful long-term reclamation of terrain and soils to support the establishment of vegetation communities and to provide functional wildlife habitat.
- Key information from the terrain and soils assessment was carried forward to the vegetation and wildlife discipline sections for consideration in the assessment of valued components.

12.9 References

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Appendix 12A Soil Inspection Site Data

NexGen Energy Ltd.

Table 12A-1: Terrain and Soil Characteristics Obtained at Each Inspection Site

Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
NR18MS001	Brunisol	GLE.DYB	LFH	-	SGR	14	0	14	-	-	-	-	-	-	-	-	-
			Ae	sand	SGR	0	10	10	10YR 5/3	-	-	-	-	MW	T	3	GLFL
			Bmgj	sand	SGR	10	24	14	7.5YR 3/3	-	-	-	-	-	-	-	-
			BC	sand	SGR	24	40	16	7.5YR 6/3	-	-	-	-	-	-	-	-
NR18MS002	Brunisol	E.DYB	LFH	-	-	9	0	9	-	-	-	-	-	R	L	5	GLFL
			Ae	sand	SGR	0	23	23	-	-	-	-	-				
			Bm	sand	SGR	23	50	27	-	-	-	-	-				
			BC	loamy sand	MA	50	65	15	-	-	-	-	-				
NR18MS003	Brunisol	GLE.DYB	LFH	-	-	20	0	20	-	-	-	-	-	-	-	-	GLFL
			Aegj	sand	SGR	0	10	10	-	-	-	-	-				
			Bmgj	sand	SGR	10	30	20	-	-	-	-	-				
NR18MS004	Brunisol	E.DYB	LFH	-	-	5	0	5	-	-	-	-	-	R	M	4	GLFL
			Ae	sand	SGR	0	28	28	7.5YR 7/1	-	-	-	-				
			Bm	sand	SGR	28	55	27	7.5YR 5/8	-	-	-	-				
			BC	sand	SGR	55	65	10	-	-	-	-	-				
NR18MS005	Brunisol	E.DYB	LFH	-	-	5	0	5	-	-	-	-	-	R	M	4	GLFL
			Ae	sand	SGR	0	14	14	7.5YR 7/1	-	-	-	-				
			Bm	sand	SGR	14	26	12	7.5YR 5/8	-	-	-	-				
			BC	sand	SGR	26	50	24	-	-	-	-	-				
			C	sand	SGR	50	75	25	-	-	-	-	-				
NR18MS006	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	R	U	7	GLFL
			Ae	sand	SGR	0	20	20	-	-	-	-	-				
			Bm	sand	SGR	20	35	15	-	-	-	-	-				
			BC	sandy loam	MA	35	45	10	-	-	-	-	-				
NR18MS007	Brunisol	E.DYB	LFH	-	-	6	0	6	-	-	-	-	-	W	L	4	GLFL
			Ae	sand	-	0	12	12	-	-	-	-	-				
			Bm	sand	-	12	33	21	-	-	-	-	-				
			BC	sand	-	33	65	32	-	-	-	-	-				
			C	loamy sand	-	65	100	35	-	-	-	-	-				
NR18MS008	Brunisol	E.DYB	LFH	-	-	5	0	5	-	-	-	-	-	R	U	4	GLFL
			Ae	sand	-	0	32	32	-	-	-	-	-				
			Bm	sand	-	32	45	13	-	-	-	-	-				
NR18MS009	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	R	U	3	GLFL
			Ae	sand	-	0	19	19	-	-	-	-	-				
			Bm	sand	-	19	35	16	-	-	-	-	-				
NR18MS010	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	R	U	5	GLFL
			Ae	sand	-	0	25	25	-	-	-	-	-				
			Bm	sand	-	25	40	15	-	-	-	-	-				

Table 12A-1: Terrain and Soil Characteristics Obtained at Each Inspection Site

Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
NR18MS011	Brunisol	E.DYB	LFH	-	-	6	0	6	-	-	-	-	-	R	U	5	GLFL
			Ae	sand	-	0	30	30	-	-	-	-	-				
			Bm	sand	-	30	60	30	-	-	-	-	-				
NR18MS012	Brunisol	E.DYB	LFH	-	-	5	0	5	-	-	-	-	-	R	U	5	GLFL
			Ae	sand	SGR	0	25	25	-	-	-	-	-				
			Bm	sand	SGR	25	35	10	-	-	-	-	-				
NR18MS013	Brunisol	E.DYB	LFH	-	-	6	0	6	-	-	-	-	-	R	M	6	GLFL
			Ae	sand	SGR	0	30	30	-	-	-	-	-				
			Bm	sandy loam	SGR	30	35	5	-	-	-	-	-				
NR18MS014	Brunisol	E.DYB	LFH	-	-	5	0	5	-	-	-	-	-	R	L	4	GLFL
			Ae	sand	SGR	0	15	15	-	-	-	-	-				
			Bm	sand	SGR	15	27	12	-	-	-	-	-				
			BCgj	sand	SGR	27	55	28	-	-	-	-	-				
			C	sand	SGR	55	100	45	-	-	-	-	-				
NR18MS015	Brunisol	GLE.DYB	Of	-	-	10	4	6	-	-	-	-	-	I	L	3	GLFL
			Oh	-	-	4	0	4	-	-	-	-	-				
			Aegj	loamy sand	PL	0	18	18	-	-	-	-	-				
			Bmgj	loamy sand	SBK	18	40	22	7.5YR 4/3	Few	Coarse	Faint	Faint				
			BCg	loamy sand	MA	40	100	60	-	-	-	-	-				
NR18MS016	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	R	C	2	GLFL
			Ae	sand	SGR	4	35	31	-	-	-	-	-				
			Ahe	sand	SGR	0	4	4	-	-	-	-	-				
			Bm	sand	SGR	35	45	10	-	-	-	-	-				
NR18MS017	Brunisol	E.DYB	LFH	-	-	5	0	5	-	-	-	-	-	W	L	3	GLFL
			Ae	loamy sand	PL	0	12	12	-	-	-	-	-				
			Bm	sand	SGR	12	30	18	-	-	-	-	-				
			C	sand	SGR	30	75	45	-	-	-	-	-				
NR18MS018	Brunisol	E.DYB	LFH	-	-	5	0	5	-	-	-	-	-	W	L	5	GLFL
			Ae	loamy sand	PL	0	10	10	-	-	-	-	-				
			Bm	sandy loam	SBK	10	40	30	-	-	-	-	-				
			C	sand	SGR	40	50	10	-	-	-	-	-				

Table 12A-1: Terrain and Soil Characteristics Obtained at Each Inspection Site

Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
NR18MS019	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	R	U	2	GLFL
			Ae	sand	SGR	0	12	12	7.5YR 6/2	-	-	-	-				
			Bm	loamy sand	SBK	12	26	14	10YR 5/8	-	-	-	-				
			C	sandy loam	MA	55	100	45	-	-	-	-	-				
			C	sand	SGR	26	55	29	10YR 7/6	-	-	-	-				
NR18MS020	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	R	U	2	GLFL
			Ae	sand	PL	0	9	9	7.5YR 6/2	-	-	-	-				
			Bm	loamy sand	SBK	9	22	13	10YR 5/8	-	-	-	-				
			BC	loamy sand	-	22	40	18	-	-	-	-	-				
			C	sand	-	40	60	20	-	-	-	-	-				
NR18MS021	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	U	2	GLFL
			Ae	loamy sand	-	0	20	20	-	-	-	-	-				
			Bm	loamy sand	-	20	40	20	-	-	-	-	-				
			C	sand	-	40	45	5	-	-	-	-	-				
NR18MS022	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	W	C	1	GLFL
			Ae	sand	SGR	0	18	18	-	-	-	-	-				
			Bm	loamy sand	SBK	18	45	27	-	-	-	-	-				
			C	sand	SGR	45	60	15	-	-	-	-	-				
NR18MS023	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	W	C	2	GLFL
			Ae	loamy sand	PL	0	6	6	-	-	-	-	-				
			Bm	loamy sand	SBK	6	30	24	-	-	-	-	-				
			C	sand	SGR	30	45	15	-	-	-	-	-				
NR18MS024	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	R	U	3	GLFL
			Ae	sand	SGR	0	22	22	-	-	-	-	-				
			Bm	sand	SGR	22	40	18	-	-	-	-	-				
			BC	sand	SGR	40	50	10	-	-	-	-	-				
NR18MS025	Brunisol	E.DYB	LFH	-	-	4	0	4	-	-	-	-	-	R	U	3	GLFL
			Ae	loamy sand	PL	0	22	22	-	-	-	-	-				
			Bm	loamy sand	SBK	22	35	13	-	-	-	-	-				
			BC	sand	SGR	35	50	15	-	-	-	-	-				
NR18MS026	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	R	U	3	GLFL
			Ae	sand	SGR	0	15	15	-	-	-	-	-				
			Bm	sand	SGR	15	40	25	-	-	-	-	-				
			C	sand	SGR	40	50	10	-	-	-	-	-				
NR18MS027	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	R	L	4	GLFL
			Ae	loamy sand	PL	0	20	20	-	-	-	-	-				
			Bm	loamy sand	SBK	20	35	15	-	-	-	-	-				
			C	sand	SGR	35	65	30	-	-	-	-	-				
			C	sand	SGR	65	75	10	-	-	-	-	-				

Table 12A-1: Terrain and Soil Characteristics Obtained at Each Inspection Site

Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
NR18MS028	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	R	C	3	GLFL
			Ae	loamy sand	PL	0	9	9	-	-	-	-	-				
			Bm	loamy sand	SGR	9	35	26	-	-	-	-	-				
			C	sand	SGR	35	45	10	-	-	-	-	-				
NR18MS029	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	W	L	5	GLFL
			Ae	loamy sand	PL	0	7	7	10YR 6/1	-	-	-	-				
			Btj	sandy loam	SBK	22	35	13	10YR 5/6	-	-	-	-				
			Bm	loamy sand	SBK	7	22	15	10YR 5/8	-	-	-	-				
			BC	sandy loam	MA	35	50	15	2.5Y 7/2	-	-	-	-				
			C	sand	SGR	50	75	25	7.5YR 7/3	-	-	-	-				
NR18MS030	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	R	M	4	GLFL
			Ae	sand	SGR	0	20	20	-	-	-	-	-				
			Bm	sand	SGR	20	40	20	-	-	-	-	-				
			C	sand	SGR	40	100	60	-	-	-	-	-				
NR18MS031	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	W	U	4	GLFL
			Ae	sand	SGR	1	18	17	-	-	-	-	-				
			Ah	loamy sand	-	0	1	1	-	-	-	-	-				
			Btj	sandy loam	SBK	18	40	22	-	-	-	-	-				
NR18MS032	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	W	C	2	GLFL
			Ae	loamy sand	PL	0	16	16	-	-	-	-	-				
			Bm	loamy sand	SBK	16	37	21	-	-	-	-	-				
			C	sand	SGR	37	70	33	-	-	-	-	-				
NR18MS033	Brunisol	GLE.DYB	LFH	-	-	4	0	4	-	-	-	-	-	MW	L	2	GLFL
			Aegj	loamy sand	-	8	20	12	-	-	-	-	-				
			Ahe	loamy sand	-	0	8	8	-	-	-	-	-				
			Btgj	sandy loam	SBK	20	38	18	-	Common	Medium	Faint	Faint				
			BCgj	sandy loam	MA	38	75	37	-	-	-	-	-				
NR18MS034	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	MW	U	3	GLFL
			Ae	loamy sand	-	0	12	12	-	-	-	-	-				
			Bm	loamy sand	-	12	30	18	-	-	-	-	-				
			C	loamy sand	-	30	45	15	-	-	-	-	-				
NR18MS035	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	MW	U	3	GLFL
			Ae	loamy sand	-	0	9	9	-	-	-	-	-				
			Bm	loamy sand	-	9	26	17	-	-	-	-	-				
			C	loamy sand	-	26	30	4	-	-	-	-	-				
NR18MS036	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	M	5	GLFL
			Ae	loamy sand	PL	0	15	15	-	-	-	-	-				
			Bm	loamy sand	SBK	15	37	22	-	-	-	-	-				
			C	loamy sand	SGR	37	40	3	-	-	-	-	-				

Table 12A-1: Terrain and Soil Characteristics Obtained at Each Inspection Site

Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
NR18MS037	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	C	3	GLFL
			Ae	loamy sand	PL	0	10	10	-	-	-	-	-				
			Bm	loamy sand	SBK	10	22	12	-	-	-	-	-				
			BC	loamy sand	SBK	22	37	15	-	-	-	-	-				
			C	loamy sand	-	37	65	28	-	-	-	-	-				
NR18MS038	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	R	M	3	GLFL
			Ae	sand	SGR	5	20	15	7.5YR 6/2	-	-	-	-				
			Ahe	loamy sand	SGR	0	5	5	7.5YR 4/1	-	-	-	-				
			Bm	loamy sand	SBK	20	40	20	10YR 5/6	-	-	-	-				
			C	sand	SGR	40	50	10	-	-	-	-	-				
NR18MS039	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	R	U	2	GLFL
			Ae	sand	SGR	2	11	9	-	-	-	-	-				
			Ahe	loamy sand	-	0	2	2	-	-	-	-	-				
			Bm	loamy sand	SBK	11	36	25	-	-	-	-	-				
			C	sand	SGR	36	80	44	-	-	-	-	-				
NR18MS040	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	R	V	2	GLFL
			Ae	loamy sand	-	0	10	10	-	-	-	-	-				
			Bm	loamy sand	-	10	29	19	-	-	-	-	-				
			C	sand	SGR	29	60	31	-	-	-	-	-				
NR18MS041	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	R	M	3	GLFL
			Ae	loamy sand	SGR	0	17	17	-	-	-	-	-				
			Bm	loamy sand	SBK	17	40	23	-	-	-	-	-				
			C	sand	SBK	40	70	30	-	-	-	-	-				
NR18MS042	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	R	M	4	GLFL
			Ae	loamy sand	PL	0	10	10	-	-	-	-	-				
			Btj	sandy loam	SBK	10	35	25	-	-	-	-	-				
			C	sand	SGR	35	65	30	-	-	-	-	-				
NR18MS043	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	R	M	4	GLFL
			Ae	loamy sand	PL	1	1	0	-	-	-	-	-				
			Ahe	loamy sand	-	0	1	1	10YR 4/1	-	-	-	-				
			Bm	loamy sand	SBK	1	3	2	-	-	-	-	-				
			C	sand	SGR	3	25	22	-	-	-	-	-				
NR18MS044	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	R	M	3	GLFL
			Ae	-	-	0	8	8	-	-	-	-	-				
			Bm	loamy sand	-	8	30	22	-	-	-	-	-				

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Table 12A-1: Terrain and Soil Characteristics Obtained at Each Inspection Site

Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
NR18MS045	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	W	M	4	GLFL
			Ae	loamy sand	PL	2	20	18	-	-	-	-	-				
			Ahe	loamy sand	-	0	2	2	-	-	-	-	-				
			Bm	loamy sand	SBK	20	40	20	-	-	-	-	-				
			C	loamy sand	-	40	100	60	-	-	-	-	-				
NR18MS046	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	R	M	5	GLFL
			Ae	loamy sand	-	2	10	8	-	-	-	-	-				
			Ahe	loamy sand	-	0	2	2	-	-	-	-	-				
			Bm	loamy sand	-	10	40	30	-	-	-	-	-				
			C	loamy sand	-	40	45	5	-	-	-	-	-				
NR18MS047	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	W	M	5	GLFL
			Ae	loamy sand	PL	0	19	19	-	-	-	-	-				
			Bm	loamy sand	SBK	19	45	26	-	-	-	-	-				
			BC	loamy sand	SBK	45	60	15	-	-	-	-	-				
			C	sand	SGR	60	75	15	-	-	-	-	-				
NR18MS048	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	W	M	6	GLFL
			Ae	loamy sand	-	0	20	20	-	-	-	-	-				
			Bm	loamy sand	-	20	35	15	-	-	-	-	-				
			C	loamy sand	-	35	50	15	-	-	-	-	-				
NR18MS049	Brunisol	GLE.DYB	LFH	-	-	5	0	5	-	-	-	-	-	MW	L	6	GLFL
			Ae	loamy sand	PL	0	24	24	-	-	-	-	-				
			Aegj	sandy loam	PL	24	32	8	-	Few	Fine	Faint	Faint				
			Btjgj	loam	SBK	32	47	15	-	Few	Fine	Faint	Faint				
			C	loamy sand	MA	47	65	18	-	-	-	-	-				
NR18MS050	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	U	3	GLFL
			Ae	loamy sand	PL	0	24	24	-	-	-	-	-				
			Bm	loamy sand	SBK	24	42	18	-	-	-	-	-				
			C	loamy sand	-	42	70	28	-	-	-	-	-				
NR18MS051	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	U	3	GLFL
			Ae	loamy sand	PL	0	9	9	-	-	-	-	-				
			Bm	loamy sand	SBK	9	30	21	-	-	-	-	-				
			C	sand	-	30	50	20	-	-	-	-	-				
NR18MS052	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	C	3	GLFL
			Ae	loamy sand	-	0	22	22	-	-	-	-	-				
			Bm	loamy sand	-	22	35	13	-	-	-	-	-				
			C	loamy sand	-	35	40	5	-	-	-	-	-				

Table 12A-1: Terrain and Soil Characteristics Obtained at Each Inspection Site

Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
NR18MS053	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	M	3	GLFL
			Ae	loamy sand	-	0	20	20	-	-	-	-	-				
			Bm	loamy sand	-	20	45	25	-	-	-	-	-				
			BC	loamy sand	-	45	55	10	-	-	-	-	-				
			C	loamy sand	-	55	60	5	-	-	-	-	-				
NR18MS054	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	M	4	GLFL
			Ae	loamy sand	PL	0	17	17	7.5YR 6/2	-	-	-	-				
			Bm	loamy sand	SBK	17	40	23	7.5YR 5/8	-	-	-	-				
NR18MS055	Gleysol	O.G	LFH	-	-	5	0	5	-	-	-	-	-	P	L	4	GLFL
			Aegj	loamy sand	PL	0	14	14	-	Few	Medium	Faint	Faint				
			Bg	loamy sand	SBK	14	50	36	-	Many	Medium	Prominent	Prominent				
			Cg	loamy sand	-	50	65	15	-	-	-	-	-				
NR18MS056	Brunisol	E.DYB	LFH	-	-	4	0	4	-	-	-	-	-	W	M	7	GLFL
			Ae	loamy sand	PL	0	16	16	-	-	-	-	-				
			Bm	loamy sand	SBK	16	45	29	-	-	-	-	-				
			C	loamy sand	MA	45	70	25	-	-	-	-	-				
NR18MS057	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	W	M	4	GLFL
			Ae	loamy sand	SBK	0	15	15	-	-	-	-	-				
			Bm	loamy sand	SBK	15	35	20	-	-	-	-	-				
			C	sand	SGR	35	60	25	-	-	-	-	-				
NR18MS058	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	U	3	GLFL
			Ae	loamy sand	PL	0	13	13	7.5 7/1	-	-	-	-				
			Bm	loamy sand	SBK	13	34	21	7.5YR 5/6	-	-	-	-				
			C	sand	SGR	34	100	66	10YR 7/3	-	-	-	-				
NR18MS059	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	M	3	GLFL
			Ae	sand	-	0	20	20	-	-	-	-	-				
			Bm	loamy sand	-	20	40	20	-	-	-	-	-				
			C	sand	-	40	100	60	-	-	-	-	-				
NR18MS060	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	M	4	GLFL
			Ae	loamy sand	SGR	0	14	14	-	-	-	-	-				
			Bm	loamy sand	SBK	14	34	20	-	-	-	-	-				
			C	sand	SGR	34	55	21	-	-	-	-	-				
NR18MS061	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	U	3	GLFL
			Ae	sand	SGR	0	14	14	-	-	-	-	-				
			Bm	loamy sand	SBK	14	40	26	-	-	-	-	-				
			BC	sand	SGR	40	55	15	-	-	-	-	-				
			C	sand	SGR	55	75	20	-	-	-	-	-				

Table 12A-1: Terrain and Soil Characteristics Obtained at Each Inspection Site

Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
NR18MS062	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	R	U	6	GLFL
			Ae	loamy sand	-	0	30	30	-	-	-	-	-				
			Bm	loamy sand	-	30	50	20	-	-	-	-	-				
			C	loamy sand	-	50	55	5	-	-	-	-	-				
NR18MS063	Brunisol	GLE.DYB	LFH	-	-	11	0	11	-	-	-	-	-	MW	M	3	GLFL
			Ae	sandy loam	PL	0	10	10	-	-	-	-	-				
			ABgj	sandy loam	PL	10	18	8	-	-	-	-	-				
			Bmgj	sandy loam	SBK	18	40	22	-	-	-	-	-				
			BCgj	sandy loam	MA	40	55	15	-	-	-	-	-				
			C	sandy loam	MA	55	75	20	-	-	-	-	-				
NR18MS064	Brunisol	E.DYB	LFH	-	-	8	0	8	-	-	-	-	-	W	M	3	GLFL
			Ae	loamy sand	PL	0	11	11	-	-	-	-	-				
			Btgj	sandy loam	SBK	11	25	14	-	-	-	-	-				
			C	loamy sand	MA	25	75	50	-	-	-	-	-				
			C	sand	SGR	75	100	25	-	-	-	-	-				
NR18MS065	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	W	L	3	GLFL
			Ae	sandy loam	PL	0	5	5	-	-	-	-	-				
			Bm	sandy loam	SBK	5	26	21	-	-	-	-	-				
			BCgj	sandy loam	SBK	26	40	14	-	-	-	-	-				
			Cgj	sand	MA	40	90	50	-	-	-	-	-				
NR18MS066	Brunisol	GLE.DYB	LFH	-	-	3	0	3	-	-	-	-	-	MW	V	1	GLFL
			Ae	sandy loam	-	0	22	22	-	-	-	-	-				
			Bmgj	sandy loam	-	22	35	13	-	Few	Fine	Faint	Faint				
			BCgj	loam	-	35	52	17	-	Many	Medium	Faint	Faint				
			Cgj	loamy sand	-	52	90	38	-	-	-	-	-				
NR18MS067	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	V	1	GLFL
			Ae	loamy sand	PL	0	15	15	-	-	-	-	-				
			Bm	loamy sand	SBK	15	29	14	-	-	-	-	-				
			C	sand	-	29	65	36	-	-	-	-	-				
NR18MS068	Brunisol	E.DYB	LFH	-	-	5	0	5	-	-	-	-	-	W	M	4	GLFL
			Ahb	silt loam	GR	18	21	3	-	-	-	-	-				
			Ae	sandy loam	PL	0	5	5	-	-	-	-	-				
			Aeb	sandy loam	PL	21	34	13	-	-	-	-	-				
			Bm	sandy loam	SBK	5	18	13	-	-	-	-	-				
			BC	sandy loam	MA	34	36	2	-	-	-	-	-				
			C	sand	SGR	56	70	14	-	-	-	-	-				
			C	sandy loam	MA	36	56	20	-	-	-	-	-				

Table 12A-1: Terrain and Soil Characteristics Obtained at Each Inspection Site

Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
NR18MS069	Brunisol	E.DYB	LFH	-	-	5	0	5	-	-	-	-	-	W	L	3	GLFL
			Ae	loamy sand	SBK	0	20	20	-	-	-	-	-				
			Bm	loamy sand	SBK	20	35	15	-	-	-	-	-				
			C	sand	SGR	35	60	25	-	-	-	-	-				
NR18MS070	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	M	6	GLFL
			Ae	loamy sand	PL	0	22	22	-	-	-	-	-				
			Bm	loamy sand	SBK	22	42	20	-	-	-	-	-				
			C	sand	SGR	42	95	53	-	-	-	-	-				
NR18MS071	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	M	6	GLFL
			Ae	loamy sand	PL	0	30	30	-	-	-	-	-				
			Bm	loamy sand	SBK	30	40	10	-	-	-	-	-				
NR18MS072	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	W	U	5	GLFL
			Ae	loamy sand	-	0	16	16	-	-	-	-	-				
			Bm	loamy sand	SBK	16	35	19	-	-	-	-	-				
			C	loamy sand	-	35	65	30	-	-	-	-	-				
NR18MS073	Brunisol	E.DYB	LFH	-	-	4	0	4	-	-	-	-	-	W	L	3	GLFL
			Ae	loamy sand	PL	0	17	17	-	-	-	-	-				
			Bm	sandy loam	SBK	17	40	23	-	-	-	-	-				
			C	sand	SGR	40	100	60	-	-	-	-	-				
NR18MS074	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	W	U	3	GLFL
			Ae	loamy sand	-	0	10	10	-	-	-	-	-				
			Bm	sandy loam	-	10	35	25	-	-	-	-	-				
			C	loamy sand	-	35	70	35	-	-	-	-	-				
NR18MS075	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	M	6	GLFL
			Ae	loamy sand	PL	0	19	19	7.5YR 6/2	-	-	-	-				
			Bm	loamy sand	SBK	19	40	21	10YR 4/6	-	-	-	-				
			C	sand	SGR	65	85	20	10YR 6/4	-	-	-	-				
			C	sand	SGR	40	65	25	10YR 6/4	-	-	-	-				
NR18MS076	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	M	6	GLFL
			Ae	sand	PL	0	15	15	-	-	-	-	-				
			Bm	sandy loam	SBK	15	38	23	-	-	-	-	-				
			C	sand	SGR	38	60	22	-	-	-	-	-				
NR18MS077	Organic	T.M	Of	-	-	0	40	40	-	-	-	-	-	VP	D	1	FNPT/GLFL
			Om	sand	-	40	95	55	-	-	-	-	-				
			Cg	loamy sand	-	95	110	15	-	-	-	-	-				
NR18MS078	Brunisol	E.DYB	LFH	-	-	8	0	8	-	-	-	-	-	W	U	7	GLFL
			Ae	loamy sand	PL	0	12	12	-	-	-	-	-				
			Btj	sandy loam	SBK	12	30	18	-	-	-	-	-				
			BC	loamy sand	-	30	45	15	-	-	-	-	-				

Table 12A-1: Terrain and Soil Characteristics Obtained at Each Inspection Site

Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
NR18MS079	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	W	U	4	GLFL
			Ae	loamy sand	PL	0	8	8	-	-	-	-	-				
			Bm	loamy sand	SBK	8	40	32	-	-	-	-	-				
			C	sand	SGR	40	90	50	-	-	-	-	-				
NR18MS080	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	W	M	3	GLFL
			Ae	loamy sand	-	0	12	12	-	-	-	-	-				
			Btj	sandy loam	-	12	25	13	-	-	-	-	-				
NR18MS081	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	R	M	4	GLFL
			Ae	sand	SGR	0	10	10	-	-	-	-	-				
			Bm	loamy sand	SBK	10	35	25	-	-	-	-	-				
			BC	loamy sand	SGR	35	40	5	-	-	-	-	-				
			C	-	-	40	-	-	-	-	-	-	-				
NR18MS082	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	R	U	3	GLFL
			Ae	loamy sand	PL	0	7	7	10YR 6/1	-	-	-	-				
			Btj	sandy loam	SBK	7	35	28	10YR 5/6	-	-	-	-				
			BC	loamy sand	MA	35	45	10	-	-	-	-	-				
NR18MS083	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	R	M	4	GLFL
			Ae	loamy sand	PL	0	8	8	-	-	-	-	-				
			Bm	loamy sand	SBK	8	30	22	-	-	-	-	-				
			C	loamy sand	SGR	30	55	25	-	-	-	-	-				
NR18MS084	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	R	M	3	GLFL
			Ae	loamy sand	-	0	10	10	-	-	-	-	-				
			Bm	loamy sand	-	10	35	25	-	-	-	-	-				
			C	loamy sand	-	35	100	65	-	-	-	-	-				
NR18MS085	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	R	M	2	GLFL
			Ae	loamy sand	PL	3	33	30	7.5YR 7/2	-	-	-	-				
			Ahe	loamy sand	PL	0	3	3	10YR 4/1	-	-	-	-				
			Bm	loamy sand	SBK	33	58	25	10YR 5/8	-	-	-	-				
			C	loamy sand	SGR	58	90	32	-	-	-	-	-				
NR18MS086	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	W	V	1	GLFL
			Ae	loamy sand	PL	0	9	9	-	-	-	-	-				
			Bm	loamy sand	SBK	9	34	25	-	-	-	-	-				
			C	loamy sand	MA	34	75	41	-	-	-	-	-				
NR18MS087	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	U	4	GLFL
			Ae	loamy sand	-	0	15	15	-	-	-	-	-				
			Bm	loamy sand	-	15	32	17	-	-	-	-	-				
			C	loamy sand	-	32	65	33	-	-	-	-	-				

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Table 12A-1: Terrain and Soil Characteristics Obtained at Each Inspection Site

Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
NR18MS088	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	W	U	2	GLFL
			Ae	loamy sand	PL	0	5	5	-	-	-	-	-				
			AB	loamy sand	PL	5	10	5	-	-	-	-	-				
			Bm	loamy sand	SBK	10	30	20	-	-	-	-	-				
			C	loamy sand	SGR	30	100	70	-	-	-	-	-				
NR18MS089	Organic	FI.M	Of	-	-	0	80	80	-	-	-	-	-	VP	V	1	SPPT
			Om	-	-	80	220	140	-	-	-	-	-				
NR18MS090	Organic	ME.F	Of	-	-	0	125	125	-	-	-	-	-	VP	V	1	SPPT
			Om	-	-	125	220	95	-	-	-	-	-				
NR18MS091	Organic	FI.M	Of	-	-	0	85	85	-	-	-	-	-	VP	V	1	SPPT
			Om	-	-	85	220	135	-	-	-	-	-				
NR18MS092	Brunisol	GLE.DYB	LFH	-	-	1	0	1	-	-	-	-	-	MW	M	4	GLFL
			Ahe	loamy sand	-	0	3	3	-	-	-	-	-				
			Ae	sand	SGR	3	13	10	-	-	-	-	-				
			Bmgj	sand	SGR	13	37	24	-	-	-	-	-				
			Cgj	sand	SGR	37	65	28	-	-	-	-	-				
NR18MS093	Organic	T.M	Of	-	-	0	40	40	-	-	-	-	-	VP	V	1	SPPT
			Om	-	-	40	145	105	-	-	-	-	-				
			Cg	loamy sand	-	145	155	10	-	-	-	-	-				
NR18MS094	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	M	6	GLFL
			Ae	loamy sand	PL	0	12	12	-	-	-	-	-				
			Btj	sandy loam	SBK	12	40	28	-	-	-	-	-				
			C	loamy sand	MA	40	50	10	-	-	-	-	-				
NR18MS095	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	U	6	GLFL
			Ae	loamy sand	PL	0	10	10	-	-	-	-	-				
			Bm	loamy sand	SBK	10	33	23	-	-	-	-	-				
			C	loamy sand	MA	33	70	37	-	-	-	-	-				
NR18MS096	Brunisol	GLE.DYB	LFH	-	-	9	0	9	-	-	-	-	-	I	L	3	GLFL
			Ahe	silt loam	PL	0	5	5	10YR 5/1	Few	Fine	Faint	Faint				
			Bmgj	silt loam	SBK	5	24	19	10YR 6/6	Many	Medium	Distinct	Distinct				
			BCgj	sandy loam	SBK	24	55	31	10YR 6/4	Many	Fine	Faint	Faint				
			C	loamy sand	MA	55	100	45	10YR 7/4	Many	Fine	Faint	Faint				
NR18MS097	Brunisol	E.DYB	LFH	-	-	9	0	9	-	-	-	-	-	W	M	4	GLFL
			Ae	sandy loam	PL	0	14	14	-	-	-	-	-				
			Bm	sandy loam	-	14	19	5	-	-	-	-	-				
NR18MS098	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	W	L	4	GLFL
			Ae	loamy sand	PL	0	16	16	-	-	-	-	-				
			Bm	sandy loam	SBK	16	37	21	-	-	-	-	-				
			C	sand	SGR	37	65	28	-	-	-	-	-				

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Table 12A-1: Terrain and Soil Characteristics Obtained at Each Inspection Site

Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
NR18MS099	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	W	M	4	GLFL
			Ae	loamy sand	PL	0	15	15	-	-	-	-	-				
			Bm	loamy sand	SBK	15	40	25	-	-	-	-	-				
			C	sand	SGR	40	70	30	-	-	-	-	-				
NR18MS100	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	W	M	4	GLFL
			Ae	loamy sand	-	0	17	17	-	-	-	-	-				
			Bm	loamy sand	-	17	35	18	-	-	-	-	-				
			BC	loamy sand	-	35	45	10	-	-	-	-	-				
			C	loamy sand	-	45	-	-	-	-	-	-	-				
NR18MS101	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	M	5	GLFL
			Ae	loamy sand	PL	0	10	10	-	-	-	-	-				
			Bm	loamy sand	SBK	10	35	25	-	-	-	-	-				
			C	loamy sand	MA	35	100	65	-	-	-	-	-				
NR18MS102	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	M	4	GLFL
			Ae	loamy sand	-	0	14	14	-	-	-	-	-				
			Bm	loamy sand	-	14	34	20	-	-	-	-	-				
			BC	loamy sand	-	34	45	11	-	-	-	-	-				
			C	sand	SGR	45	100	55	-	-	-	-	-				
NR18MS103	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	M	4	GLFL
			Ae	loamy sand	PL	0	7	7	7.5YR 6/1	-	-	-	-				
			Btj	sandy loam	SBK	7	32	25	10YR 5/8	-	-	-	-				
			C	loamy sand	MA	32	100	68	10YR 6/6	-	-	-	-				
NR18MS104	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	L	5	GLFL
			Ae	loamy sand	PL	0	19	19	7.5YR 7/2	-	-	-	-				
			Bm	loamy sand	SBK	19	40	21	7.5YR 5/6	-	-	-	-				
			BC	loamy sand	-	40	65	25	10YR 6/6	-	-	-	-				
			C	sand	-	65	100	35	10YR 7/4	-	-	-	-				
NR18MS105	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	U	5	GLFL
			Ahe	loamy sand	PL	0	3	3	-	-	-	-	-				
			Ae	loamy sand	PL	3	12	9	-	-	-	-	-				
			Btg	loamy sand	SBK	12	30	18	-	-	-	-	-				
			C	loamy sand	-	30	60	30	-	-	-	-	-				
NR18MS106	Brunisol	GLE.DYB	LFH	-	-	2	0	2	-	-	-	-	-	MW	T	4	GLFL
			Ae	sandy loam	-	0	5	5	-	-	-	-	-				
			Bmgj	sandy loam	-	5	40	35	-	Common	Medium	Faint	Faint				
			BCgj	sandy loam	-	40	75	35	-	Many	Medium	Distinct	Distinct				
NR18MS107	Organic	T.H	Of	-	-	0	20	20	-	-	-	-	-	VP	M	3	FNPT/GLFL
			Om	-	-	20	30	10	-	-	-	-	-				
			Oh	-	-	30	60	30	-	-	-	-	-				
			Cg	loamy sand	-	60	75	15	-	-	-	-	-				

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Table 12A-1: Terrain and Soil Characteristics Obtained at Each Inspection Site

Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
NR18MS008	Brunisol	E.DYB	LFH	-	-	5	0	5	-	-	-	-	-	R	U	4	GLFL
			Aegj	sand	-	0	32	32	-	-	-	-	-				
			Bg	sand	-	32	45	13	-	-	-	-	-				
NR18MS109	Brunisol	E.DYB	LFH	-	-	2	0	2	-	-	-	-	-	W	U	3	GLFL
			Ae	loamy sand	PL	0	5	5	-	-	-	-	-				
			Bm	loamy sand	SBK	5	30	25	-	-	-	-	-				
			C	loamy sand	MA	30	60	30	-	-	-	-	-				
NR18MS110	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	W	V	2	GLFL
			Ahe	loamy sand	PL	3	9	6	10YR 5/1	-	-	-	-				
			Ah	loamy sand	PL	0	3	3	10YR 3/1	-	-	-	-				
			Bm	loamy sand	PL	9	50	41	10YR 6/8	-	-	-	-				
			C	sand	SGR	50	65	15	-	-	-	-	-				
NR18MS111	Brunisol	GLE.DYB	LFH	-	-	3	0	3	-	-	-	-	-	MW	L	3	GLFL
			Ae	loamy sand	PL	0	6	6	7.5YR 6/2	-	-	-	-				
			Btjgj	sandy loam	SBK	6	30	24	10YR 6/6	Many	Medium	Distinct	Distinct				
			BCgj	sandy clay loam	MA	30	50	20	2.5Y 5/2	Few	Fine	Faint	Faint				
			C	sand	SGR	50	65	15	10YR 7/6	-	-	-	-				
NR18MS112	Brunisol	GLE.DYB	LFH	-	-	10	0	10	-	-	-	-	-	MW	M	3	GLFL
			Ae	sandy loam	PL	0	10	10	-	-	-	-	-				
			Bmgj	sandy loam	SBK	10	40	30	-	Many	Medium	Distinct	Distinct				
			Cgj	sandy loam	MA	60	80	20	-	-	-	-	-				
			Cgj	sandy loam	MA	40	60	20	-	-	-	-	-				
19-EXP01-A-SO1	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	-	-	-	GLFL
			Ahe	loamy sand	SGR	0	3	3	7.5YR 5/1	-	-	-	-				
			Ae	loamy sand	SGR	3	17	14	10YR 7/1	-	-	-	-				
			Bm	loamy sand	SBK	17	34	17	10YR 6/6	-	-	-	-				
			C	sand	MA	34	-	-	10YR 7/2	-	-	-	-				
19-EXP01-A-SO2	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	-	-	-	GLFL
			Ahe	loamy sand	SGR	0	1	1	7.5YR 5/1	-	-	-	-				
			Ae	loamy sand	SGR	1	22	21	10YR 7/1	-	-	-	-				
			Bm	loamy sand	SBK	22	36	14	10YR 6/6	-	-	-	-				
			C	loamy sand	MA	36	-	-	10YR 7/2	-	-	-	-				
19-EXP01-A-SO3	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	-	-	-	GLFL
			Ahe	loamy sand	SGR	0	4	4	7.5YR 5/1	-	-	-	-				
			Ae	loamy sand	SGR	4	18	14	10YR 7/1	-	-	-	-				
			Bm	loamy sand	SBK	18	45	27	7.5YR 5/8	-	-	-	-				
			C	loamy sand	MA	45	-	-	10YR 7/2	-	-	-	-				
19-EXP01-B-SO1	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	-	-	-	GLFL

Table 12A-1: Terrain and Soil Characteristics Obtained at Each Inspection Site

Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
			Ahe	loamy sand	SGR	0	4	4	7.5YR 4/1	-	-	-	-				
			Ae	loamy sand	SGR	4	27	23	7.5YR 7/2	-	-	-	-				
			Bm	loamy sand	SBK	27	40	13	10YR 5/8	-	-	-	-				
			C	loamy sand	MA	40	-	-	10YR 8/3	-	-	-	-				
19-EXP01-B-SO2	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	-	-	-	GLFL
			Ahe	loamy sand	SGR	0	3	3	7.5YR 5/2	-	-	-	-				
			Ae	loamy sand	SGR	3	13	10	7.5YR 6/2	-	-	-	-				
			Bm	loamy sand	SBK	13	20	7	7.5YR 5/8	-	-	-	-				
			C	loamy sand	MA	20	-	-	10YR 6/4	-	-	-	-				
19-EXP01-B-SO3	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	-	-	-	GLFL
			Ae	loamy sand	SGR	0	17	17	10YR 7/3	-	-	-	-				
			Bm	loamy sand	SBK	17	32	15	7.5YR 5/8	-	-	-	-				
			C	loamy sand	MA	32	-	-	10YR 5/6	-	-	-	-				
19-EXP01-C-SO1	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	-	-	-	GLFL
			Ahe	loamy sand	SGR	0	2	2	7.5YR 5/2	-	-	-	-				
			Ae	loamy sand	SGR	2	14	12	10YR 7/2	-	-	-	-				
			Bm	loamy sand	SBK	14	39	25	10YR 5/8	-	-	-	-				
			C	sand	MA	39	-	-	10YR 7/2	-	-	-	-				
19-EXP01-C-SO2	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	-	-	-	GLFL
			Ahe	loamy sand	SGR	0	4	4	7.5YR 4/1	-	-	-	-				
			Ae	loamy sand	SGR	4	13	9	7.5YR 7/2	-	-	-	-				
			Bm	loamy sand	SBK	13	36	23	7.5YR 5/8	-	-	-	-				
			C	loamy sand	MA	36	-	-	10YR 8/3	-	-	-	-				
19-EXP01-C-SO3	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	-	-	-	GLFL
			Ahe	loamy sand	SGR	0	3	3	7.5YR 5/2	-	-	-	-				
			Ae	loamy sand	SGR	3	24	21	7.5YR 7/2	-	-	-	-				
			Bm	loamy sand	SBK	24	40	16	7.5YR 5/8	-	-	-	-				
			C	sand	MA	40	-	-	7.5YR 8/3	-	-	-	-				
19-EXP02-A-SO1	Regosol	O.R	LFH	-	-	8	0	8	-	-	-	-	-	-	-	-	GLFL
			Ae	loamy sand	SGR	0	17	17	10YR 5/4	-	-	-	-				
			C	loamy sand	MA	17	-	-	10YR 6/6	-	-	-	-				
19-EXP02-A-SO2	Brunisol	E.DYB	LFH	-	-	7	0	7	-	-	-	-	-	-	-	-	GLFL
			Ae	loamy sand	SGR	0	15	15	7.5YR 7/2	-	-	-	-				
			Bm	loamy sand	SGR	15	32	17	10YR 6/8	-	-	-	-				
			C	loamy sand	MA	32	-	-	10YR 6/3	-	-	-	-				
19-EXP02-A-SO3	Regosol	O.R	LFH	-	-	7	0	7	-	-	-	-	-	-	-	-	GLFL
			Ae	loamy sand	SGR	0	8	8	7.5YR 5/2	-	-	-	-				
			C	-	MA	8	-	-	7.5YR 6/2	-	-	-	-				

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Table 12A-1: Terrain and Soil Characteristics Obtained at Each Inspection Site

Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
19-EXP02-B-SO1	Brunisol	E.DYB	LFH	-	-	7	0	7	-	-	-	-	-	-	-	-	GLFL
			Ahe	loamy sand	SGR	0	9	9	10YR 3/2	-	-	-	-				
			Ae	loamy sand	SGR	9	33	24	7.5YR 7/2	-	-	-	-				
			Bm	loamy sand	SGR	33	49	16	10YR 7/8	-	-	-	-				
			C	loamy sand	MA	49	-	-	10YR 8/4	-	-	-	-				
19-EXP02-B-SO2	Regosol	O.R	LFH	-	-	5	0	5	-	-	-	-	-	-	-	-	GLFL
			Ae	loamy sand	SGR	0	37	37	10YR 8/1	-	-	-	-				
			C	loamy sand	MA	37	-	-	10YR 5/6	-	-	-	-				
19-EXP02-B-SO3	Brunisol	E.DYB	LFH	-	-	9	0	9	-	-	-	-	-	-	-	-	GLFL
			Ahe	loamy sand	SGR	0	1	1	5YR 5/2	-	-	-	-				
			Ae	loamy sand	SGR	1	18	17	7.5YR 7/1	-	-	-	-				
			Bm	loamy sand	SGR	18	34	16	7.5YR 5/6	-	-	-	-				
			C	loamy sand	MA	34	-	-	10YR 7/1	-	-	-	-				
19-EXP02-C-SO1	Brunisol	E.DYB	LFH	-	-	7	0	7	-	-	-	-	-	-	-	-	GLFL
			Ae	loamy sand	SGR	0	23	23	7.5YR 5/3	-	-	-	-				
			Bm	loamy sand	SBK	23	38	15	7.5YR 4/4	-	-	-	-				
			C	loamy sand	MA	38	-	-	10YR 4/3	-	-	-	-				
19-EXP02-C-SO2	Brunisol	E.DYB	LFH	-	-	6	0	6	-	-	-	-	-	-	-	-	GLFL
			Ae	loamy sand	SGR	0	14		7.5YR 6/2	-	-	-	-				
			Bm	loamy sand	SBK	14	39	25	7.5YR 4/4	-	-	-	-				
			C	loamy sand	MA	39	-	-	10YR 4/4	-	-	-	-				
19-EXPO3-A-SO1	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	-	-	-	GLFL
			Ahe	loamy sand	SGR	0	1	1	5YR 5/1	-	-	-	-				
			Ae	loamy sand	SGR	1	28	27	5YR 8/1	-	-	-	-				
			Bm	loamy sand	SBK	28	36	8	10YR 6/8	-	-	-	-				
			C	loamy sand	MA	36	-	-	10YR 7/4	-	-	-	-				
19-EXPO3-B-SO1	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	-	-	-	GLFL
			Ahe	loamy sand	SGR	0	6	6	7.5YR 3/1	-	-	-	-				
			Ae	loamy sand	SGR	6	25	19	5YR 7/2	-	-	-	-				
			Bm	loamy sand	SBK	25	40	15	10YR 6/8	-	-	-	-				
			C	loamy sand	MA	40	-	-	10YR 7/3	-	-	-	-				
19-EXPO3-C-SO3	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	-	-	-	GLFL
			Ahe	loamy sand	SGR	0	1	1	10YR 5/1	-	-	-	-				
			Ae	loamy sand	SGR	1	22	21	7.5YR 7/3	-	-	-	-				
			Bm	loamy sand	SBK	22	33	11	10YR 5/6	-	-	-	-				
			C	loamy sand	MA	33	-	-	10YR 6/4	-	-	-	-				

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Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
19-REF04-A-SO1	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	-	-	-	GLFL
			Ahe	loamy sand	SGR	0	2	2	10YR 4/1	-	-	-	-				
			Ae	loamy sand	SGR	2	12	10	10YR 7/2	-	-	-	-				
			Bm	loamy sand	SBK	12	42	30	10YR 5/6	-	-	-	-				
			C	loamy sand	MA	42	-	-	10YR 8/4	-	-	-	-				
19-REF04-B-SO1	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	-	-	-	GLFL
			Ae	sand	SGR	0	12	12	10YR 7/2	-	-	-	-				
			Bm	loamy sand	SGR	12	21	9	10YR 5/8	-	-	-	-				
			C	sand	MA	21	-	-	5Y 7/2	-	-	-	-				
19-REF04-C-SO1	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	-	-	-	GLFL
			Ae	sand	SGR	0	5	5	5YR 7/2	-	-	-	-				
			Bm	sand	SGR	5	22	17	10YR 8/6	-	-	-	-				
			C	sand	MA	22	-	-	5Y 8/4	-	-	-	-				
19-REF05-A-SO1	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	-	-	-	GLFL
			Ahe	loamy sand	SGR	0	4	4	10YR 4/1	-	-	-	-				
			Ae	loamy sand	SGR	4	9	5	10YR 7/1	-	-	-	-				
			Bm	loamy sand	SBK	9	32	23	7.5YR 5/8	-	-	-	-				
			C	loamy sand	MA	32	-	-	10YR 6/6	-	-	-	-				
19-REF05-B-SO1	Brunisol	E.DYB	LFH	-	-	-	0	-	-	-	-	-	-	-	-	-	GLFL
			Ae	sandy loam	SGR	0	5	5	7.5YR 6/2	-	-	-	-				
			Bm	sandy loam	SBK	5	18	13	7.5YR 4/4	-	-	-	-				
			C	loamy sand	MA	18	-	-	10YR 5/6	-	-	-	-				
19-REF05-C-SO1	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	-	-	-	GLFL
			Ahe	loamy sand	SGR	0	3	3	7.5YR 4/1	-	-	-	-				
			Ae	loamy sand	SGR	3	10	7	7.5YR 7/2	-	-	-	-				
			Bm	sandy loam	SBK	10	40	30	10YR 5/8	-	-	-	-				
			C	loamy sand	MA	40	-	-	10YR 5/6	-	-	-	-				
19-REF06-A-SO1	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	-	-	-	GLFL
			Ahe	sand	SGR	0	1	1	10YR 3/2	-	-	-	-				
			Ae	sand	SGR	1	23	22	5Y 7/3	-	-	-	-				
			Bm	sand	SBK	23	30	7	7.5YR 5/8	-	-	-	-				
			C	sand	MA	30	-	-	10YR 8/4	-	-	-	-				

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Site	Soil Order	Subgroup[a]	Horizon	Texture	Structure[b]	Top Depth (cm)	Bottom Depth (cm)	Horizon Thickness (cm)	Colour	Mottle Abundance	Mottle Dimension	Mottle Contrast	Mottle Color	Drainage[c]	Slope Position[d]	Slope Class[e]	Parent Material[f]
19-REF06-B-SO1	Brunisol	E.DYB	LFH	-	-	3	0	3	-	-	-	-	-	-	-	-	GLFL
			Ahe	sand	SGR	0	4	4	10YR 4/1	-	-	-	-				
			Ae	sand	SGR	4	59	55	5Y 7/2	-	-	-	-				
			Bm	sand	SGR	59	66	7	7.5YR 5/8	-	-	-	-				
			C	sand	MA	66	-	-	10YR 6/6	-	-	-	-				
19-REF06-C-SO1	Brunisol	E.DYB	LFH	-	-	1	0	1	-	-	-	-	-	-	-	-	GLFL
			Ae	sand	SGR	0	10	10	7.5YR 7/2	-	-	-	-				
			Bm	loamy sand	SGR	10	34	24	10YR 5/8	-	-	-	-				
			C	loamy sand	MA	34	-	-	10YR 7/4	-	-	-	-				

a) Soil subgroups: E.DYB = Eluviated Dystric Brunisol; FI.M = Fibric Mesisol; GLE.DYB = Gleyed Eluviated Dystric Brunisol; ME.F = Mesic Fibrisol; O.G = Orthic Gleysol; O.R = Orthic Regosol; T.H = Terric Humisol; T.M = Terric Mesisol.
b) Soil structure: SGR = single grain; SBK = subangular blocky; PL = platy; MA = amorphous (massive); GR = granular.
c) Drainage: W = well; VP = very poor; R = ; MW = moderately well; I = imperfect.
d) Slope position: V = level; U = upper slope; T = toe slope; M = mid slope; L = lower slope; D = depression; C = crest.
e) Slope class: 1 = level (0 to 0.5%); 2 = nearly level (0.5 to 2.0%); 3 = very gentle (2.0 to 5.0%); 4 = gentle (5.0 to 10.0%); 5 = moderate (10 to 15%); 6 = strong (15 to 30%); 7 = very strong (30 to 45%).
f) Parent material: SPPT = sphagnum peat; GLFL = glacial fluvial; FNPT = sedge (fen) peat.

Appendix 12B Soil Map Unit Characteristics

Table 12B-1: Soil Map Unit Characteristics

Soil Map Unit	Dominant/Co-dominant Soil Subgroup		Sub-dominant Soil Subgroup	Inclusions	Landscape	Slope Class Range	Drainage	Surface Stoniness	Comments
	>30% To between 60% To 100%	Parent Material	>10% To 40%	<10% To 20%					
Mineral Soils									
Mineral-1 (M1)	Eluviated Dystric Brunisol	GLFL	n/a	n/a	Hummocky and ridged - high relief	3 to 6 (>2% to 30%)	Rapid to well	S4 to S5 (15% to >50%)	n/a
Mineral-2 (M2)	Eluviated Dystric Brunisol	GLFL	n/a	Gleyed Eluviated Dystric Brunisol	Undulating and rolling	3 to 5 (>2% to 15%)	Rapid to moderately well	S2 to S3 (0.1% to 3%)	Gleyed Eluviated Dystric Brunisol found at low area at the toe end of the slope.
Mineral-3 (M3)	Eluviated Dystric Brunisol	GLFL	n/a	Gleyed Eluviated Dystric Brunisol	Hummocky and ridged - high relief	4 to 7 (>5% to 45%)	Rapid	S4 to S5 (15% to >50%)	Gleyed Eluviated Dystric Brunisol at low area at the toe end of the slope; high coarse fragments in profile.
Mineral-4 (M4)	Eluviated Dystric Brunisol	GLFL	Gleyed Eluviated Dystric Brunisol	Misc. Gleysols	Nearly level to undulating	1 to 3 (0% to 5%)	Well to imperfect	S2 to S3 (0.1% to 3%)	n/a
Mineral-5 (M5)	Gleyed Eluviated Dystric Brunisol	GLFL	Eluviated Dystric Brunisol	Misc. Gleysols, Terric Mesisols	Undulating	2 to 3 (>0.5% to 5%)	Moderately Well	S2 to S3 (0.1% to 3%)	n/a
Mineral-6 (M6)	Orthic Gleysol	GLFL	Terric Mesisols	Gleyed Eluviated Dystric Brunisol	Level to nearly level	1 to 2 (0% to 2%)	Imperfect to very poor	S0 to S1 (<0.01% to 0.1%)	n/a
Mineral-7 (M7)	Eluviated Dystric Brunisol	GLFL	n/a	Gleyed Eluviated Dystric Brunisol	Hummocky and ridged - low relief	2 to 4 (>0.5% to 10%)	Rapid to well	S2 (0.1% to 3%)	Gleyed Eluviated Dystric Brunisol at low area at the toe end of the slope; minor amount (10% to 20%) of inspections showed evidence of clay eluviation in B horizon.
Mineral-8 (M8)	Eluviated Dystric Brunisol	GLFL	n/a	Gleyed Eluviated Dystric Brunisol	Hummocky and ridged - high relief	4 to 7 (>5% to 45%)	Rapid	S4 to S5 (15% to >50%)	Gleyed Eluviated Dystric Brunisol found at low area at the toe end of the slope; high coarse fragments in profile; and moderate amount (20% to 40%) of inspections showed evidence of clay eluviation in B horizon.
Mineral-9 (M9)	Eluviated Dystric Brunisol	GLFL	Gleyed Eluviated Dystric Brunisol	n/a	Undulating - low relief	2 to 4 (>0.5% to 10%)	Well to moderately well	S2 to S3 (0.1% to 3%)	n/a
Mineral-10 (M10)	Eluviated Dystric Brunisol	GLFL	n/a	Gleyed Eluviated Dystric Brunisol	Inclined - level	2 to 5 (>0.5% to 15%)	Rapid to well	S3 (3% to 15%)	Gleyed Eluviated Dystric Brunisol found at low area at the toe end of the slope; high coarse fragments in soil profile.
Mineral-11 (M11)	Gleyed Eluviated Dystric Brunisol	GLFL	Eluviated Dystric Brunisol Misc. Gleysols	Terric Mesisol	Associated with watercourses and significant drainage channels	2 to 3 (>0.5% to 5%)	Moderately well to very poor	S0 to S3 (<0.01% to 15%)	n/a
Mineral-12 (M12)	Eluviated Dystric Brunisol	GLFL	n/a	Gleyed Eluviated Dystric Brunisol, misc. Gleysols	Undulating and rolling	2 to 4 (>0.5% to 10%)	Rapid to moderately well	S1 to S2 (0.01% to 3%)	Gleyed Eluviated Dystric Brunisol found at low area at the toe end of the slope; low coarse fragments in soil profile.
Organic Soils									
Organic-1 (O1)	Terric Mesisol	FNPT / GLFL	n/a	Misc. Gleysols	Organic - level	1 (0% to 0.5%)	Very poor	S0 (<0.01%)	n/a
Organic-2 (O2)	Typic Mesisol	FNPT	n/a	Terric Mesisol	Organic - level	1 (0% to 0.5%)	Very poor	S0 (<0.01%)	n/a
Organic-3 (O3)	Typic Mesisol	FNPT	Terric Mesisol	Misc. Gleysols, Gleyed Eluviated Dystric Brunisol	Organic - level with mineral soil hummocks	1 to 3 (0% to 5%)	Imperfect to very poor	S0 to S2 (<0.01% to 3%)	n/a

GLFL = glacial-fluvial; FNPT = sedge (fen) peat; n/a = not applicable; < = less than.

Appendix 12C Chemical Analysis Results

List of Tables

Table 12C-1: Soil pH Results

Sampling Program	Sample	Horizon	Depth	pH
			cm	1:2 $CaCl_2$
2018 soil survey baseline	NR18MS 58	AC	0-13	4.13
	NR18MS 58	Bm	13-34	4.56
	NR18MS 58	Cg	34-100	5.20
	NR18MS 77	Of	0-40	3.41
	NR18MS 77	Om	40-95	3.17
	NR18MS 82	AC	0-7	4.09
	NR18MS 82	Bj	7-35	4.54
	NR18MS 96	LFH	9-0	2.86
	NR18MS 96	AhC	0-5	3.20
	NR18MS 96	Bmgj	5-24	4.24
	NR18MS 96	BC	24-55	3.91
	NR18MS 96	C	55-100	4.33
	NR18MS 108	LFH	4-0	3.22
	NR18MS 108	Aegj	0-14	3.18
	NR18MS 108	Bg	14-40	3.83
	NR18MS 108	Cg	40-100	4.30
			Lowest Detection Limit	**2.86**
			Highest Detection Limit	**5.20**
2019 soil survey baseline	EXP01 A	Ahe/Ae	0-19	3.39
	EXP01 B	Ahe/Ae	0-19	3.17
	EXP01 C	Ahe/Ae	0-17	3.53
	EXP02 A	Ae	0-13	3.17
	EXP02 B	Ahe/Ae	0-29	3.18
	EXP02 C	Ahe/Ae	0-24	3.08
	EXP03 A	Ahe/Ae	0-28	4.27
	EXP03 B	Ahe/Ae	0-25	3.75
	EXP03 C	Ahe/Ae	0-22	3.57
	REF04 A	Ahe/Ae	0-12	3.75
	REF04 B	Ae	0-12	3.93
	REF04 C	Ae	0-5	3.78
	REF05 A	Ahe/Ae	0-9	4.06
	REF05 B	Ae	0-5	3.80
	REF05 C	Ahe/Ae	0-10	3.76
	REF06 A	Ahe/Ae	0-23	3.42
	REF06 B	Ahe/Ae	0-59	3.59
	REF06 C	Ae	0-10	3.85
			Lowest Detection Limit	**3.08**
			Highest Detection Limit	**4.27**

pH = potential of hydrogen; $CaCl_2$ = calcium chloride; 1:2 = 1 part dry soil and 2 parts de-ionized 0.01M $CaCl_2$ (by volume).

Table 12C-2: Soil Analytical Results (Saturated Paste Extractables)

Sampling Program	Sample	Horizon	Depth	pH	SAR[a]	Sodium	Calcium	Magnesium	Potassium	Conductivity Sat. Paste	Saturation
			cm	1:2 $CaCl_2$		mg/L	mg/L	mg/L	mg/L	dS/m	%
2018 soil survey baseline	NR18MS 58	AC	0-13	4.13	Incalculable	<5.0	<5.0	<5.0	5.6	<0.10	25.9
	NR18MS 58	Bm	13-34	4.56	Incalculable	14.5	<5.0	<5.0	<5.0	0.10	28.0
	NR18MS 58	Cg	34-100	5.20	Incalculable	<5.0	<5.0	<5.0	<5.0	<0.10	25.3
	NR18MS 77	Of	0-40	3.41	2.6	22.3	5.6	<5.0	9.4	0.18	941
	NR18MS 77	Om	40-95	3.17	0.83	9.7	10.3	<5.0	<5.0	0.15	601
	NR18MS 82	AC	0-7	4.09	<0.50	<5.0	7.3	<5.0	<5.0	<0.10	24.8
	NR18MS 82	Bj	7-35	4.54	Incalculable	<5.0	<5.0	<5.0	<5.0	<0.10	29.6
	NR18MS 96	LFH	9-0	2.86	<0.40	<5.0	10.2	<5.0	12.2	0.20	428
	NR18MS 96	AhC	0-5	3.20	0.64	5.6	5.9	<5.0	8.1	0.17	56.7
	NR18MS 96	Bmgj	5-24	4.24	Incalculable	<5.0	<5.0	<5.0	<5.0	<0.10	41.2
	NR18MS 96	BC	24-55	3.91	Incalculable	6.0	<5.0	<5.0	<5.0	<0.10	34.2
	NR18MS 96	C	55-100	4.33	Incalculable	<5.0	<5.0	<5.0	<5.0	<0.10	23.5
	NR18MS 108	LFH	4-0	3.22	<0.30	<5.0	17.4	6.7	35.6	0.29	247
	NR18MS 108	Aegj	0-14	3.18	Incalculable	<5.0	<5.0	<5.0	<5.0	<0.10	32.9
	NR18MS 108	Bg	14-40	3.83	Incalculable	<5.0	<5.0	<5.0	<5.0	<0.10	35.0
	NR18MS 108	Cg	40-100	4.30	Incalculable	<5.0	<5.0	<5.0	<5.0	<0.10	32.4
	Lowest Detection Limit			**2.86**	**0.30**	**5.0**	**5.0**	**5.0**	**5.0**	**0.10**	**1.0**
	Highest Detection Limit			**5.20**	**2.60**	**22.30**	**17.40**	**6.70**	**35.60**	**0.29**	**941.00**

Table 12C-2: Soil Analytical Results (Saturated Paste Extractables)

Sampling Program	Sample	Horizon	Depth	pH	SAR[a]	Sodium	Calcium	Magnesium	Potassium	Conductivity Sat. Paste	Saturation
			cm	1:2 $CaCl_2$		mg/L	mg/L	mg/L	mg/L	dS/m	%
2019 soil survey baseline	EXP01 A	Ahe/Ae	0-19	3.39	0.2	2	10	3	8	0.19	29.2
	EXP01 B	Ahe/Ae	0-19	3.17	0.2	3	8	2	12	0.24	32.8
	EXP01 C	Ahe/Ae	0-17	3.53	2	22	5	2	11	0.25	31.2
	EXP02 A	Ae	0-13	3.17	0.2	2	6	3	7	0.23	27.9
	EXP02 B	Ahe/Ae	0-29	3.18	0.3	5	13	4	10	0.30	36.5
	EXP02 C	Ahe/Ae	0-24	3.08	0.7	6	5	2	11	0.35	37.0
	EXP03 A	Ahe/Ae	0-28	4.27	0.2	2	10	3	6	0.15	32.1
	EXP03 B	Ahe/Ae	0-25	3.75	0.5	6	10	2	10	0.17	23.2
	EXP03 C	Ahe/Ae	0-22	3.57	0.2	3	10	2	7	0.18	24.5
	REF04 A	Ahe/Ae	0-12	3.75	0.3	5	13	2	5	0.19	27.4
	REF04 B	Ae	0-12	3.93	0.1	3	20	3	6	0.22	31.2
	REF04 C	Ae	0-5	3.78	0.2	3	13	3	9	0.23	33.4
	REF05 A	Ahe/Ae	0-9	4.06	0.1	3	20	4	4	0.20	29.2
	REF05 B	Ae	0-5	3.80	0.2	4	18	6	7	0.24	34.5
	REF05 C	Ahe/Ae	0-10	3.76	0.3	5	14	5	6	0.24	38.7
	REF06 A	Ahe/Ae	0-23	3.42	0.2	2	10	2	6	0.16	29.0
	REF06 B	Ahe/Ae	0-59	3.59	0.1	3	24	5	22	0.32	36.6
	REF06 C	Ae	0-10	3.85	0.2	3	11	4	8	0.18	25.7
	Lowest Detection Limit			**3.08**	**0.1**	**2**	**5**	**2**	**4**	**0.15**	**23.20**
	Highest Detection Limit			**4.27**	**0.70**	**22**	**24**	**6**	**22**	**0.35**	**38.70**

a) Incalculable due to undetectable sodium, calcium, or magnesium. Detection limit represents maximum possible SAR value. Actual SAR values may be lower if both calcium and magnesium were detectable.

SAR = sodium adsorption ratio; $CaCl_2$ = calcium chloride; dS/m = decisiemens per metre; < = less than; pH = potential of hydrogen.

Table 12C-3: Soil Cation Exchange Capacity Results

Sample	Horizon	Depth	Cation Exchange Capacity
		cm	mEq/100 g
NR18MS 58	AC	0-13	<0.80
NR18MS 82	AC	0-7	<0.80
NR18MS 96	AhC	0-5	7.68
NR18MS 108	Aegj	0-14	<0.80
		Lowest Detection Limit	**0.80**
		Highest Detection Limit	**7.68**

mEq/100 g = milliequivalents per 100 grams; < = less than.

Table 12C-4: Soil Analytical Results for Leachable Metals

Sampling Program	Sample	Horizon	Depth	Aluminum (Al)	Antimony (Sb)	Arsenic (As)	Barium (Ba)	Beryllium (Be)	Bismuth (Bi)	Boron (B)	Cadmium (Cd)	Calcium (Ca)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Lithium (Li)	Magnesium (Mg)	Manganese (Mn)	Mercury (Hg)
			cm	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
2018 soil survey baseline	NR18MS 58	AC	0-13	187	<0.10	0.20	6.98	<0.10	<0.20	<5.0	<0.020	<50	<0.50	<0.10	<0.50	250	<0.50	<2.0	54	3.7	<0.0050
	NR18MS 58	Bm	13-34	4,560	<0.10	0.64	10.2	<0.10	<0.20	<5.0	<0.020	64	3.62	0.38	2.98	3,830	1.97	3.2	179	10.5	0.0232
	NR18MS 58	Cg	34-100	782	<0.10	0.41	3.82	<0.10	<0.20	<5.0	<0.020	<50	1.02	0.30	<0.50	1,020	0.59	<2.0	98	7.1	<0.0050
	NR18MS 77	Of	0-40	3,210	0.17	1.46	200	0.18	0.28	<5.0	0.339	7,210	7.32	2.03	10.2	3,210	3.87	3.3	1,980	71.2	0.0763
	NR18MS 77	Om	40-95	2,810	<0.10	0.61	266	0.18	<0.20	<5.0	0.275	5,910	4.50	0.79	3.95	1,490	0.66	<2.0	955	20.2	0.0716
	NR18MS 82	AC	0-7	354	<0.10	0.22	3.75	<0.10	<0.20	<5.0	<0.020	58	0.51	<0.10	<0.50	491	0.67	<2.0	31	14.7	<0.0050
	NR18MS 82	Bj	7-35	4,760	<0.10	0.82	12.0	0.11	<0.20	<5.0	<0.020	92	3.95	0.57	1.91	4,140	1.88	4.3	266	14.5	0.0211
	NR18MS 96	LFH	9-0	4,140	<0.10	1.08	235	0.31	<0.20	<5.0	0.257	2,870	3.40	0.70	6.82	2,420	6.43	<2.0	324	33.6	0.0853
	NR18MS 96	AhC	0-5	1,980	<0.10	0.52	17.3	<0.10	<0.20	<5.0	<0.020	83	2.93	0.16	0.91	1,750	2.14	<2.0	136	6.2	0.0126
	NR18MS 96	Bmgj	5-24	7,180	<0.10	0.97	22.3	0.16	<0.20	<5.0	<0.020	161	7.60	1.00	0.85	6,350	2.44	4.6	688	20.3	0.0124
	NR18MS 96	BC	24-55	5,460	<0.10	1.06	22.6	0.15	<0.20	<5.0	<0.020	136	8.47	1.25	0.89	5,160	1.85	4.6	1,010	24.8	0.0119
	NR18MS 96	C	55-100	1,870	<0.10	0.59	8.46	<0.10	<0.20	<5.0	<0.020	104	2.81	0.58	0.57	1,860	0.94	<2.0	324	19.7	<0.0050
	NR18MS 108	LFH	4-0	816	<0.10	0.51	69.9	<0.10	<0.20	<5.0	0.156	2,090	1.63	0.24	3.29	854	3.37	<2.0	279	234	0.0642
	NR18MS 108	Aegj	0-14	130	<0.10	0.16	1.64	<0.10	<0.20	<5.0	<0.020	<50	<0.50	<0.10	<0.50	95	<0.50	<2.0	<20	<1.0	<0.0050
	NR18MS 108	Bg	14-40	1,300	<0.10	0.83	3.62	<0.10	<0.20	<5.0	<0.020	63	1.72	0.13	<0.50	5,090	<0.50	<2.0	55	1.6	<0.0050
	NR18MS 108	Cg	40-100	592	<0.10	0.27	2.85	<0.10	<0.20	<5.0	<0.020	55	0.93	<0.10	<0.50	353	<0.50	<2.0	47	1.2	<0.0050
	Lowest Concentration			**130**	**<0.10**	**0.20**	**1.64**	**<0.10**	**<0.20**	**<5.0**	**<0.020**	**<50**	**<0.50**	**<0.10**	**<0.50**	**95**	**<0.50**	**<2.0**	**<20**	**<1.0**	**<0.0050**
	Highest Concentration			**7,180**	**0.17**	**1.46**	**266**	**0.31**	**0.28**	**<5.0**	**0.339**	**7,210**	**8.47**	**2.03**	**10.20**	**6,350**	**6.43**	**4.6**	**1,980**	**234**	**0.0853**
2019 soil survey baseline	EXP01 A	Ahe/Ae	0-19	2,030	<0.2	0.5	24	<0.1	<0.2	***3***	<0.1	140	3.0	0.2	<0.5	910	1.4	1.3	130	24	<0.05
	EXP01 B	Ahe/Ae	0-19	1,680	<0.2	0.4	27	<0.1	<0.2	2	<0.1	170	2.9	0.2	<0.5	890	1.4	1.2	120	19	<0.05
	EXP01 C	Ahe/Ae	0-17	1,190	<0.2	0.5	28	<0.1	<0.2	2	<0.1	160	1.7	<0.2	<0.5	630	1.5	0.7	70	18	<0.05
	EXP02 A	Ae	0-13	2,220	<0.2	0.8	22	<0.1	<0.2	***4***	<0.1	150	5.3	2.5	<0.5	6,200	1.6	3.5	110	74	<0.05
	EXP02 B	Ahe/Ae	0-29	2,580	<0.2	0.8	27	<0.1	<0.2	***4***	<0.1	130	5.0	0.3	0.5	2,940	1.6	1.8	130	40	<0.05
	EXP02 C	Ahe/Ae	0-24	2,820	<0.2	0.7	30	<0.1	<0.2	***5***	<0.1	180	4.3	0.4	0.7	7,300	1.8	1.9	160	110	<0.05
	EXP03 A	Ahe/Ae	0-28	1,700	<0.2	0.5	17	<0.1	<0.2	***3***	<0.1	130	4.7	<0.2	<0.5	840	1.4	1.4	110	16	<0.05
	EXP03 B	Ahe/Ae	0-25	1,060	<0.2	0.4	16	<0.1	<0.2	2	<0.1	130	2.1	0.4	<0.5	600	1.3	0.8	70	12	<0.05
	EXP03 C	Ahe/Ae	0-22	940	<0.2	0.4	14	<0.1	<0.2	<1	<0.1	160	1.5	<0.2	<0.5	570	1.2	0.6	80	22	<0.05
	REF04 A	Ahe/Ae	0-12	3,650	<0.2	0.9	28	<0.1	<0.2	***3***	<0.1	330	4.2	0.5	0.8	2,870	2.4	3.9	360	35	<0.05
	REF04 B	Ae	0-12	2,440	<0.2	0.5	31	<0.1	<0.2	2	<0.1	290	3.6	0.2	<0.5	1,590	1.8	1.8	180	34	<0.05
	REF04 C	Ae	0-5	2,530	<0.2	0.7	24	<0.1	<0.2	2	<0.1	280	2.8	0.5	<0.5	1,420	1.7	2.3	200	43	<0.05
	REF05 A	Ahe/Ae	0-9	4,750	<0.2	0.8	41	<0.1	<0.2	2	<0.1	550	5.8	0.9	1.0	4,770	2.3	3.6	490	70	<0.05
	REF05 B	Ae	0-5	5,200	<0.2	0.8	33	<0.1	<0.2	***3***	<0.1	540	7.2	0.8	1.0	4,900	2.4	4.2	570	60	<0.05
	REF05 C	Ahe/Ae	0-10	5,400	<0.2	0.9	30	<0.1	<0.2	2	<0.1	510	8.1	1.1	0.9	5,400	2.6	4.1	540	56	<0.05
	REF06 A	Ahe/Ae	0-23	850	<0.2	0.4	15	<0.1	<0.2	2	<0.1	150	16	0.4	0.6	480	1.3	0.6	60	18	<0.05
	REF06 B	Ahe/Ae	0-59	840	<0.2	0.4	17	<0.1	<0.2	***3***	<0.1	200	4.6	0.9	<0.5	330	1.4	0.6	60	21	<0.05
	REF06 C	Ae	0-10	3,690	<0.2	0.7	28	<0.1	<0.2	***4***	<0.1	310	3.9	0.5	0.7	2,150	2.1	2.6	240	26	<0.05
	Lowest Detection Limit			**0.5**	**0.2**	**0.1**	**0.5**	**0.1**	**0.2**	**1.0**	**0.1**	**10.0**	**0.5**	**0.2**	**0.5**	**0.5**	**0.1**	**0.1**	**10.0**	**0.5**	**0.1**
	Highest Detection Limit			**5,400**	**0.2**	**0.9**	**41**	**0.1**	**0.2**	**5.0**	**0.1**	**550**	**16**	**2.5**	**1.00**	**7,300**	**2.6**	**4.2**	**570**	**110**	**0.05**
	CCME Guidelines (mg/kg)	**Agricultural**		**-**	**20**	**12**	**750**	**4**	**-**	**2**	**1.4**	**-**	**64**	**40**	**63**	**-**	**70**	**-**	**-**	**-**	**6.6**
		Residential/Parkland		**-**	**20**	**12**	**500**	**4**	**-**	**-**	**10**	**-**	**64**	**50**	**63**	**-**	**140**	**-**	**-**	**-**	**6.6**

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Table 12C-4: Soil Analytical Results for Leachable Metals

Sampling Program	Sample	Horizon	Depth	Molybdenum	Nickel	Phosphorus	Potassium	Selenium	Silver	Sodium	Strontium	Sulphate	Sulphur	Thallium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zinc	Zirconium
			cm	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
2018 soil survey baseline	NR18MS 58	AC	0-13	<0.10	<0.50	<50	<100	<0.20	<0.10	<50	1.75	n/d	<1,000	<0.050	<1.0	25.5	0.62	<0.050	0.68	<2.0	<1.0
	NR18MS 58	Bm	13-34	0.15	1.06	373	<100	<0.20	<0.10	<50	4.10	n/d	<1,000	<0.050	<1.0	78.0	<0.50	0.158	8.52	16.8	1.7
	NR18MS 58	Cg	34-100	<0.10	0.62	<50	<100	<0.20	<0.10	<50	3.88	n/d	<1,000	<0.050	<1.0	29.5	<0.50	0.086	1.92	2.1	1.0
	NR18MS 77	Of	0-40	4.09	9.10	545	660	0.29	0.78	567	71.5	n/d	**1,900**	<0.050	<1.0	11.4	13.3	30.9	5.86	28.1	2.5
	NR18MS 77	Om	40-95	0.56	5.90	504	160	0.33	0.12	154	52.6	n/d	**2,400**	<0.050	<1.0	20.9	<0.50	0.794	4.37	20.9	<1.0
	NR18MS 82	AC	0-7	<0.10	<0.50	<50	<100	<0.20	<0.10	<50	1.78	n/d	<1,000	<0.050	<1.0	25.9	<0.50	<0.050	1.28	<2.0	<1.0
	NR18MS 82	Bj	7-35	0.12	1.41	242	<100	<0.20	<0.10	<50	3.89	n/d	<1,000	<0.050	<1.0	99.4	<0.50	0.214	8.42	8.1	1.8
	NR18MS 96	LFH	9-0	0.34	4.39	814	400	0.38	<0.10	<50	33.2	n/d	<1,000	<0.050	<1.0	18.0	<0.50	0.181	4.32	10.6	<1.0
	NR18MS 96	AhC	0-5	<0.10	0.61	109	<100	<0.20	<0.10	<50	2.84	n/d	<1,000	<0.050	<1.0	13.8	<0.50	0.180	4.31	2.6	<1.0
	NR18MS 96	Bmgj	5-24	0.13	2.18	145	120	<0.20	<0.10	<50	5.40	n/d	<1,000	<0.050	<1.0	161	<0.50	0.348	11.9	5.6	<1.0
	NR18MS 96	BC	24-55	0.16	3.11	68	160	<0.20	<0.10	<50	7.95	n/d	<1,000	<0.050	<1.0	197	<0.50	0.397	11.9	6.5	3.2
	NR18MS 96	C	55-100	<0.10	1.28	55	130	<0.20	<0.10	<50	6.47	n/d	<1,000	<0.050	<1.0	60.9	<0.50	0.157	4.45	2.7	1.3
	NR18MS 108	LFH	4-0	0.24	1.53	410	450	<0.20	<0.10	<50	9.07	n/d	<1,000	<0.050	<1.0	15.9	<0.50	0.060	1.90	17.4	<1.0
	NR18MS 108	Aegj	0-14	<0.10	<0.50	<50	<100	<0.20	<0.10	<50	2.09	n/d	<1,000	<0.050	<1.0	7.7	<0.50	<0.050	0.27	<2.0	<1.0
	NR18MS 108	Bg	14-40	0.11	<0.50	57	<100	<0.20	<0.10	<50	2.84	n/d	<1,000	<0.050	<1.0	24.5	<0.50	0.103	7.69	<2.0	<1.0
	NR18MS 108	Cg	40-100	<0.10	<0.50	51	<100	<0.20	<0.10	<50	3.53	n/d	<1,000	<0.050	<1.0	18.2	<0.50	0.078	1.21	<2.0	<1.0
	Lowest Detection Limit			**0.10**	**0.50**	**50**	**100**	**0.20**	**0.10**	**50**	**0.50**	**n/d**	**1,000**	**0.050**	**1.0**	**1.0**	**0.50**	**0.050**	**0.20**	**2.0**	**1.0**
	Highest Detection Limit			**4.09**	**9.10**	**814**	**660**	**0.38**	**0.78**	**567**	**71.50**	**n/d**	**2,400**	**0.050**	**1.0**	**197**	**13.3**	**30.90**	**11.90**	**28.10**	**3.2**
2019 soil survey baseline	EXP01 A	Ahe/Ae	0-19	<0.1	0.5	40	620	<0.1	<0.1	110	15	18	n/d	<0.2	<0.1	210	<0.5	0.2	3.1	1.7	13
	EXP01 B	Ahe/Ae	0-19	<0.1	0.4	40	560	<0.1	<0.1	120	16	20	n/d	<0.2	<0.1	220	<0.5	0.3	3.4	1.8	17
	EXP01 C	Ahe/Ae	0-17	<0.1	0.3	40	460	<0.1	<0.1	130	16	20	n/d	<0.2	<0.1	130	<0.5	0.2	2.0	2.2	13
	EXP02 A	Ae	0-13	0.1	2.0	130	560	<0.1	<0.1	80	24	23	n/d	<0.2	<0.1	160	<0.5	0.3	4.4	2.4	13
	EXP02 B	Ahe/Ae	0-29	0.1	0.7	70	580	<0.1	<0.1	80	17	32	n/d	<0.2	0.1	280	<0.5	0.3	5.2	2.5	16
	EXP02 C	Ahe/Ae	0-24	0.2	1.2	110	710	<0.1	<0.1	140	20	31	n/d	<0.2	0.1	240	<0.5	0.3	5.4	3.2	16
	EXP03 A	Ahe/Ae	0-28	0.2	1.4	40	450	<0.1	<0.1	120	18	10	n/d	<0.2	<0.1	140	<0.5	0.2	2.3	0.9	16
	EXP03 B	Ahe/Ae	0-25	<0.1	0.4	40	360	<0.1	<0.1	100	18	12	n/d	<0.2	<0.1	120	<0.5	0.2	1.8	1.0	14
	EXP03 C	Ahe/Ae	0-22	<0.1	0.3	30	320	<0.1	<0.1	120	14	12	n/d	<0.2	<0.1	130	<0.5	0.2	1.7	1.9	9.2
	REF04 A	Ahe/Ae	0-12	<0.1	1.2	70	630	<0.1	<0.1	100	32	10	n/d	<0.2	0.2	280	<0.5	0.3	8.3	5.4	18
	REF04 B	Ae	0-12	0.1	0.9	80	630	<0.1	<0.1	110	17	13	n/d	<0.2	0.1	200	<0.5	0.2	4.9	3.8	14
	REF04 C	Ae	0-5	<0.1	0.9	50	600	<0.1	<0.1	150	20	11	n/d	<0.2	<0.1	130	<0.5	0.2	3.5	3.3	10
	REF05 A	Ahe/Ae	0-9	0.1	1.7	90	770	<0.1	<0.1	150	18	12	n/d	<0.2	0.2	360	<0.5	0.3	10	7.1	17
	REF05 B	Ae	0-5	0.2	2.1	80	610	<0.1	<0.1	110	17	10	n/d	<0.2	4.2	420	<0.5	0.4	13	5.5	17
	REF05 C	Ahe/Ae	0-10	0.2	2.2	120	500	<0.1	<0.1	120	16	14	n/d	<0.2	0.3	460	<0.5	0.4	14	7.4	17
	REF06 A	Ahe/Ae	0-23	1.8	7.4	40	330	<0.1	<0.1	120	13	14	n/d	<0.2	<0.1	75	<0.5	0.2	1.3	1.4	8.6
	REF06 B	Ahe/Ae	0-59	0.2	2.0	40	250	<0.1	<0.1	80	15	27	n/d	<0.2	<0.1	61	<0.5	0.2	1.1	2.8	8.7
	REF06 C	Ae	0-10	<0.1	0.9	160	1,600	<0.1	<0.1	870	18	6	n/d	<0.2	0.1	150	<0.5	0.2	5.5	3.9	14
	Lowest Detection Limit			**0.1**	**0.1**	**10**	**10**	**0.1**	**0.1**	**10**	**0.50**	**2**	**n/d**	**0.2**	**0.1**	**0.5**	**0.5**	**0.1**	**0.1**	**0.5**	**0.1**
	Highest Detection Limit			**1.80**	**7.4**	**160**	**1,600**	**0.1**	**0.1**	**870**	**32**	**32**	**n/d**	**0.2**	**4.2**	**460**	**0.5**	**0.40**	**14**	**7.40**	**18.0**
	CCME Guidelines (mg/kg)	**Agricultural**		**5**	**45**	**n/d**	**n/d**	**1**	**20**	**n/d**	**n/d**	**n/d**	**500**	**1**	**5**	**n/d**	**n/d**	**23**	**130**	**250**	**n/d**
		Residential/Parkland		**10**	**45**	**n/d**	**n/d**	**1**	**20**	**n/d**	**n/d**	**n/d**	**n/d**	**1**	**50**	**n/d**	**n/d**	**23**	**130**	**250**	**n/d**

Note: Based on soil chemistry results from the 2018 and 2019 field programs, concentrations of samples are considered to be below Canadian Council of Ministers of the Environment Soil Quality Guidelines for the Protection of Environmental and Human Heath (CCME 2014).
< = less than; n/d = no data available or no guidelines; CCME = Canadian Council of Ministers of the Environment.

Table 12C-5: Soil Analytical Results for Particle Size

Sample	Horizon	Depth	% Sand	% Silt	% Clay	Texture
		cm	(2.0 mm To 0.05 mm)	(0.05 mm To 2 µm)	<2 µm	
NR18MS 58	AC	0-13	94.0	5.8	<1.0	Sand
NR18MS 58	Bm	13-34	83.7	15.9	<1.0	Loamy sand
NR18MS 58	Cg	34-100	96.3	3.6	<1.0	Sand
NR18MS 82	AC	0-7	91.0	8.9	<1.0	Sand
NR18MS 82	Bj	7-35	74.3	24.8	<1.0	Loamy sand
NR18MS 96	AhC	0-5	27.9	69.6	2.5	Silt loam
NR18MS 96	Bmgj	5-24	26.3	71.6	2.1	Silt loam
NR18MS 96	BC	24-55	28.5	67.7	3.8	Silt loam
NR18MS 96	C	55-100	81.3	17.9	<1.0	Loamy sand
NR18MS 108	Aegj	0-14	94.8	5.1	<1.0	Sand
NR18MS 108	Bg	14-40	93.4	5.6	1.0	Sand
NR18MS 108	Cg	40-100	98.9	<1.0	<1.0	Sand

< = less than.

Table 12C-6: Baseline Total Radionuclides in Soil at the 2019 Soil Monitoring Program Reference and Exposure Locations

Sampling Program	Sample	Horizon	Depth	Lead-210	Polonium-210	Radium-226	Thorium-228	Thorium-230	Thorium-232
			cm	Bq/g	Bq/g	Bq/g	Bq/g	Bq/g	Bq/g
2019 soil survey baseline	EXP01 A	Ahe/Ae	0-19	<0.04	0.01	0.02	<0.02	<0.02	<0.02
	EXP01 B	Ahe/Ae	0-19	<0.04	<0.01	0.02	<0.02	<0.02	<0.02
	EXP01 C	Ahe/Ae	0-17	<0.04	<0.01	0.01	<0.02	<0.02	<0.02
	EXP02 A	Ae	0-13	<0.04	0.01	<0.01	<0.02	<0.02	<0.02
	EXP02 B	Ahe/Ae	0-29	<0.04	<0.01	0.02	<0.02	<0.02	<0.02
	EXP02 C	Ahe/Ae	0-24	<0.04	<0.01	0.02	<0.02	<0.02	<0.02
	EXP03 A	Ahe/Ae	0-28	<0.04	<0.01	0.02	<0.02	<0.02	<0.02
	EXP03 B	Ahe/Ae	0-25	<0.04	<0.01	<0.01	<0.02	<0.02	<0.02
	EXP03 C	Ahe/Ae	0-22	<0.04	<0.01	<0.01	<0.02	<0.02	<0.02
	REF04 A	Ahe/Ae	0-12	<0.04	<0.01	0.02	<0.02	<0.02	<0.02
	REF04 B	Ae	0-12	<0.04	0.01	0.02	<0.02	<0.02	<0.02
	REF04 C	Ae	0-5	<0.04	0.01	0.02	<0.02	<0.02	<0.02
	REF05 A	Ahe/Ae	0-9	<0.04	0.02	0.02	<0.02	<0.02	<0.02
	REF05 B	Ae	0-5	<0.04	0.01	0.02	<0.02	<0.02	<0.02
	REF05 C	Ahe/Ae	0-10	<0.04	<0.01	0.02	<0.02	<0.02	<0.02
	REF06 A	Ahe/Ae	0-23	<0.04	<0.01	0.03	<0.02	<0.02	<0.02
	REF06 B	Ahe/Ae	0-59	<0.04	0.02	0.03	<0.02	<0.02	<0.02
	REF06 C	Ae	0-10	<0.04	0.02	0.02	<0.02	<0.02	<0.02
			Detection Limit	0.04	0.01	0.01	0.02	0.02	0.02

Bq/g = becquerels per gram; < = less than.

Rook I Project

Environmental Impact Statement

Section 13 Vegetation

Submitted to:
Canadian Nuclear Safety Commission
Saskatchewan Ministry of Environment

Submitted by:
NexGen Energy Ltd.
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November 2024

Executive Summary

Section Purpose

Section 13 of the Environmental Impact Statement (EIS) provides a comprehensive assessment of potential effects of the Rook I Project (Project) on vegetation, including ecosystems and traditional use plants. This assessment included consideration of both potential effects from the Project and cumulative effects from the Project and other reasonably foreseeable developments (RFDs). The vegetation assessment used widely accepted scientific practices and incorporated Indigenous and Local Knowledge.

Three vegetation ecosystems (i.e., upland ecosystems, wetland ecosystems, and riparian ecosystems) and traditional use plants represented valued components (VCs) in the Environmental Assessment (EA). The assessment of vegetation ecosystems and traditional use plants provided information that was used to support VC assessments such as wildlife and wildlife habitat, human health, Indigenous land and resource use, and other land and resource use. Ecosystem services (i.e., the benefits people gain from the environment) provided by traditional use plant species were also assessed in Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use, and Section 17, Other Land and Resource Use.

Setting

At a regional scale, the Project would be located within the southern Athabasca Basin adjacent to Patterson Lake, along the upper Clearwater River system, approximately 40 km east of the Saskatchewan-Alberta border and 640 km northwest of the city of Saskatoon. The local study area (LSA; 2,832 ha) and the anticipated Project footprint (228 ha) are located within the Mid-Boreal Upland Ecoregion of the Boreal Plain Ecozone of Saskatchewan (Acton et al. 1998). The regional study area (RSA) of 107,491 ha overlaps the transition between the Boreal Shield and Boreal Plain ecozones; Patterson Lake also overlaps this ecozone transition.

Existing Conditions (Section 13.3)

The LSA and RSA are broadly composed of upland ecosystems (i.e., deciduous, mixed, and coniferous forests) over most of these study areas (Table ES-1). Wetland ecosystems and anthropogenic (i.e., human-caused) disturbance both account for smaller portions of the study areas.

Table ES-1: Vegetation Ecosystem Type in Local Study Area and Regional Study Area

Vegetation Ecosystem	LSA	RSA
Upland ecosystems	76.7%	69.6%
Wetland ecosystems	19.5%	30.0%
Anthropogenic disturbance	3.7%	0.4%

Note: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
LSA = local study area; RSA = regional study area.

Riparian ecosystems, which were identified as a subset of upland and wetland ecosystems, cover 7.3% and 8.9% of the LSA and RSA, respectively.

Over the last 40 years, 65,296 ha (61%) of the RSA has been burned in historical fires. However, historical fire extents overlap each other within the RSA; therefore, the amount of area within the RSA classified as burned is 61,997 ha (58%).

Twenty-eight traditional use plant species were identified from Indigenous Knowledge and Traditional Land Use (IKTLU) Studies and from comments from the Clearwater River Dene Nation (CRDN 2019b) on the Cluff Lake Mine licence renewal. Of these 28 species, the most available traditional use plant species within the LSA and RSA are:

- jack pine;
- mosses;
- blueberry; and
- bog cranberry.

Traditional use plant species are located in various locations across the RSA. Overall, a higher frequency of traditional use plant species was observed within wetland ecosystems.

Potential Effects and Proposed Mitigations (Section 13.4)

An analysis was completed to evaluate Project components and activities and associated effects pathways that could potentially affect vegetation. The evaluation also considered similar combined effects from the Fission Patterson Lake South Property, the identified RFD for the vegetation assessment.

Project activities that would have the potential to affect vegetation during the Project lifespan include:

- land clearing;
- site preparation;
- construction of facilities and infrastructure;
- handling of ore and waste rock;
- changes to water and air quality; and
- other supporting mining construction, operation, and decommissioning and reclamation activities.

Similar activities that could affect vegetation would be expected to occur for the Fission Patterson Lake South Property.

As part of the pathways analysis, proposed environmental design features and mitigation measures were considered to determine whether effects on the environment could be avoided or reduced to negligible levels, thereby removing the pathway. Project environmental design features such as the underground tailings management facility and site road alignment were designed, in part, to minimize the Project's effects on vegetation ecosystems and traditional use plants. In addition, the proposed Project footprint has been optimized and would be limited to the extent practical to minimize disturbance to vegetation. Proposed mitigation measures, such as progressive reclamation and revegetation of disturbed areas where non-permanent Project components have been removed, would reduce effects on vegetation ecosystems and traditional use plants. These mitigations have been used extensively within the mining sector and have been proven effective. Similar mitigation and adaptive management practices would also be expected to be implemented by the Fission Patterson Lake South Property.

After mitigation measures were considered, the pathways analysis determined that many of the potential pathways from the Project to the environment could be removed. However, it was identified that the Project could still adversely affect vegetation from the following pathways:

- direct loss, alteration, and fragmentation of upland, wetland, and riparian ecosystems and traditional use plants; and
- alteration of the final terrain, soil conditions, and/or plant species composition, which could change the types of ecosystems and traditional use plants that can be reclaimed on the landscape and adversely affect ecosystem availability, distribution, and condition.

Therefore, these pathways were carried forward into the residual effects analysis.

Residual Effects Analysis (Section 13.5)

A residual effects analysis was conducted to determine the potential effects on vegetation ecosystems and traditional use plants under two assessment cases: effects of the Project (i.e., Application Case), and combined effects of the Project and the Fission Patterson Lake South Property (i.e., RFD Case). For upland, wetland, and riparian ecosystems, three measurement indicators were considered:

- ecosystem availability;
- ecosystem distribution; and
- ecosystem condition.

For traditional use plant species, two measurement indicators were considered:

- traditional plant habitat availability; and
- traditional plant distribution.

The residual effects analysis followed a precautionary approach by using an assessment area, referred to as the maximum disturbance area, that assumed disturbance of an area approximately four times larger than the currently anticipated Project footprint.

In the RFD Case, a precautionary approach was used by applying a maximum disturbance area to the Fission Patterson Lake South Property using the same assumptions made for the Project; this approach resulted in a maximum disturbance area approximately six times larger than the footprint presented in the Fission (2019) prefeasibility study.

Similar conservatism was incorporated into the overlapping temporal boundaries for the Project and RFD. The assessment assumed the period of residual effects from the Fission Patterson Lake South Property would completely overlap with similar effects associated with the Project for a maximum duration of 95 years.

Upland Ecosystems

Upland ecosystems would be expected to experience the following residual effects:

- The Project is predicted to contribute to a loss in availability of approximately 868 ha of upland ecosystems, which represents 1.2% of upland ecosystems in the RSA (i.e., low magnitude).
- The Fission Patterson Lake South Property activities are predicted to contribute an incremental loss of 1,450 ha of upland ecosystems availability in the RSA.

- In combination, the Project, Fission Patterson Lake South Property, and existing anthropogenic disturbance (e.g., Highway 955, seismic lines) would account for 2,390 ha (3.1%) of disturbance across upland ecosystem types in the RSA (i.e., low magnitude).

Despite the loss of upland ecosystems that would occur as a result of the Project and the Fission Patterson Lake South Property, the distribution of most upland ecosystems would remain abundant and well connected across the RSA.

Wetland Ecosystems

Wetland ecosystems would be expected to experience the following residual effects:

- The Project is predicted to contribute to a loss in availability of approximately 28 ha of wetland ecosystems (i.e., less than 0.1% of the RSA), which would be limited to the Project's maximum disturbance area (i.e., low magnitude).
- Cumulatively, the Project and the Fission Patterson Lake South Property are predicted to contribute to a loss in availability of approximately 56 ha (i.e., 0.1% of the RSA) of wetland ecosystems (i.e., low magnitude).

Following Decommissioning and Reclamation (i.e., Closure), it is anticipated that wetland ecosystems would be reclaimed to the extent possible in an attempt to achieve no net loss of wetland functions, consistent with the guideline of the Federal Policy on Wetland Conservation (Government of Canada 1991). Although the establishment of functioning wetland ecosystems following the Active Closure Stage was considered possible, restoration of wetland species composition and ecological function similar to the wetland ecosystems observed under existing conditions would be unlikely. As such, the loss of all wetland ecosystems was conservatively assumed to be permanent.

Wetland ecosystem fragmentation from the Project and Fission Patterson Lake South Property would be limited and localized to the area around Patterson Lake and a portion of the RSA already influenced by existing anthropogenic disturbances. Therefore, there would be almost no change to connectivity in wetland ecosystems in most of the RSA.

It is expected that the Fission Patterson Lake South Property would include mitigations similar to the Project to limit cumulative effects.

Riparian Ecosystems

Riparian ecosystems would be expected to experience the following residual effects:

- The Project is predicted to contribute to a loss in availability of approximately 40 ha of riparian ecosystems (i.e., 0.4% of the RSA), which would be limited to the Project's maximum disturbance area (i.e., low magnitude).
- Cumulatively, the Project and the Fission Patterson Lake South Property are predicted to contribute to a loss in availability of approximately 103 ha (i.e., 1.1% of the RSA) of riparian ecosystems (i.e., low magnitude).
- The majority of Project infrastructure would be set back from Patterson Lake, and the final disturbance with riparian ecosystems would be minimized.

Despite the potential for fragmentation due to losses from the Project and the Fission Patterson Lake South Property, most riparian-associated wetland ecosystems would remain abundant and well connected across the RSA. The loss of riparian ecosystems in the RSA would result in localized minor changes in riparian distribution around Patterson Lake, and these effects were assumed to be long term for upland Ecological Land Classification (ELC) units and permanent for wetland ELC units within riparian ecosystems.

It is expected that the Fission Patterson Lake South Property would include mitigations similar to the Project to avoid and limit the cumulative effects on riparian ecosystem availability and distribution.

Traditional Use Plants

Under existing conditions, the total amount of traditional use plant habitat within the LSA is 721.6 ha (25.5%) and within the RSA is 24,988 ha (23.2%). Traditional use plants would be expected to experience the following residual effects:

- The Project is predicted to contribute to a loss in availability of approximately 282 ha (1.1% of the RSA) of traditional use plant habitat, which would be limited to the Project's maximum disturbance area (i.e., low magnitude).
- Cumulatively, the Project and the Fission Patterson Lake South Property are predicted to contribute to a loss in availability of approximately 732 ha (i.e., 2.9% of the RSA) of traditional use plant habitat (i.e., low magnitude).
- Traditional use plant habitat is predicted to remain abundant across the RSA.

Although there has already been some change in connectivity because of previous and existing developments, the connectivity and arrangement of traditional use plant habitat is predicted to remain abundant and well connected across the RSA.

General Considerations

Edge Effects

Edge effects can adversely influence the condition of upland, wetland, and riparian ecosystems due to potential ingress of generalist or invasive species and changes in conditions along the peripherals of the ecosystem. Edge effects on upland, wetland, and riparian ecosystems are predicted to be limited to the maximum disturbance areas for the Project and the Fission Patterson Lake South Property.

Rare Plant Species

The Project mitigation measures would have provisions for the management of rare plant species. One provincially tracked vascular plant species (i.e., beautiful sedge) was observed within the maximum disturbance area and could be lost or removed by the Project. Such rare plant species would be clearly marked and avoided, where feasible. Where disturbance to rare plants was unavoidable, the Saskatchewan Ministry of Environment (ENV) would be consulted to determine the best course of action.

Invasive Plant Species

Project activities and disturbances could create the potential for the introduction or encroachment of designated weed species; weed and invasive species management strategies would be used to prevent, detect, control (i.e., remove), and monitor designated weed species.

Climate Change

Climate change effects on ecosystems and traditional use plant species were considered. Currently, it is unclear whether climate change would positively and/or negatively affect vegetation VCs. Projected future climate extremes indicate a future that is likely to be warmer and wetter on an annual basis. Changes to upland ecosystems would likely be driven by shifts in the fire regime, which is closely related to weather and climate; such changes would be permanent and occur beyond the RSA scale. Wetland ecosystems may be adversely affected by climate change as these ecosystems are considered one of most sensitive to changes in precipitation and temperature.

Effects on Biodiversity

Effects on biodiversity were assessed based on the changes to vegetation ecosystems and habitat for traditional use plants, which provided both finer (i.e., species level) and coarser (i.e., ecosystem level) elements of biodiversity. Effects of the Project on biodiversity are anticipated to be low in magnitude for the Application and RFD cases.

The geographic extent of effects would be restricted to the maximum disturbance area in the Application Case and extend to the RSA in the RFD Case. The residual effects are predicted to be mostly reversible over the long term for all ecosystems and plant communities that would regenerate after reclamation. Changes in the Application Case and RFD Case are expected to increase landscape fragmentation; however, biodiversity in the RSA is predicted to be maintained and similar to existing conditions.

Significance Determination (Section 13.5)

The weight of evidence from the analysis predicts that changes to the availability, distribution, and condition of upland, wetland, and riparian ecosystems that overlap the RSA would be within the resilience and adaptability limits for these VCs. Similarly, the analysis predicts that changes to the availability and distribution of traditional use plant habitat within the RSA would also be within the resilience and adaptability limits for this VC. The residual effects on vegetation VCs in the Application Case are predicted to be **not significant**.

The incremental and cumulative effects resulting from the Project, previous and existing developments, and the Fission Patterson Lake South Property on the vegetation ecosystems and traditional use plants are also predicted to be **not significant**.

Prediction Confidence and Uncertainty (Section 13.6)

Overall, there was a moderate to high degree of confidence in the predictions related to the assessment of the vegetation ecosystems and traditional use plants. Uncertainty was primarily and appropriately addressed by making assumptions that conservatively overestimated rather than underestimated potential effects (i.e., a precautionary assessment).

Monitoring, Follow-Up, and Adaptive Management (Section 13.7)

The Environmental Protection Program, Environmental Monitoring Plan, and associated environmental monitoring would be implemented to verify effects predictions and effectiveness of mitigation on vegetation, identify unanticipated effects (i.e., manage the residual uncertainty in the effects prediction), and apply adaptive management, if required. A noxious and nuisance weeds follow-up study would be carried out for weed management to monitor the establishment of designated weed species within the disturbance area and apply appropriate mitigation to avoid the unintended spread of such species.

The Preliminary Decommissioning and Reclamation Plan would be implemented to establish vegetation ecosites that contribute to the maintenance of self-sustaining and ecologically effective ecosystems, including traditional use plants and biodiversity. Monitoring and follow-up actions would be implemented to verify that reclamation was trending towards the successful regeneration and succession of vegetation ecosystems that are functionally similar to natural plant communities in the region. Results from monitoring would be used to modify or apply different reclamation procedures through the process of adaptive management.

Abbreviations and Units of Measure

Abbreviation	Definition
BNDN	Birch Narrows Dene Nation
BRDN	Buffalo River Dene Nation
CNSC	Canadian Nuclear Safety Commission
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CRDN	Clearwater River Dene Nation
EA	Environmental Assessment
EIS	Environmental Impact Statement
ELC	Ecological Land Classification
ENV	Saskatchewan Ministry of Environment
IKTLU	Indigenous Knowledge and Traditional Land Use
JWG	Joint Working Group
LSA	local study area
NexGen	NexGen Energy Ltd.
NPAG	non-potentially acid generating
PAG	potentially acid generating
PEM	Predictive Ecosite Map
PM_{10}	particulate matter with a diameter of 10 microns or less
Project	Rook I Project
RFD	reasonably foreseeable development
RSA	regional study area
SARA	*Species at Risk Act*
TSD	technical support document
UGTMF	underground tailings management facility
VC	valued component
WRSA	waste rock storage area
YNLR	Ya'thi Néné Lands and Resources

Unit	Definition
%	percent
°C	degrees Celsius
µm	micron
$\mu g/m^3$	micrograms per cubic metre
cm	centimetre
$g/m^2/d$	grams per square metre per day
ha	hectare
km	kilometre
km/km^2	kilometres per square kilometre
km/m^2	kilometres per square metre
km^2	square kilometre
m	metre
$mg/cm^2/30\ d$	milligrams per square centimetre per 30 days
mg/L	milligrams per litre

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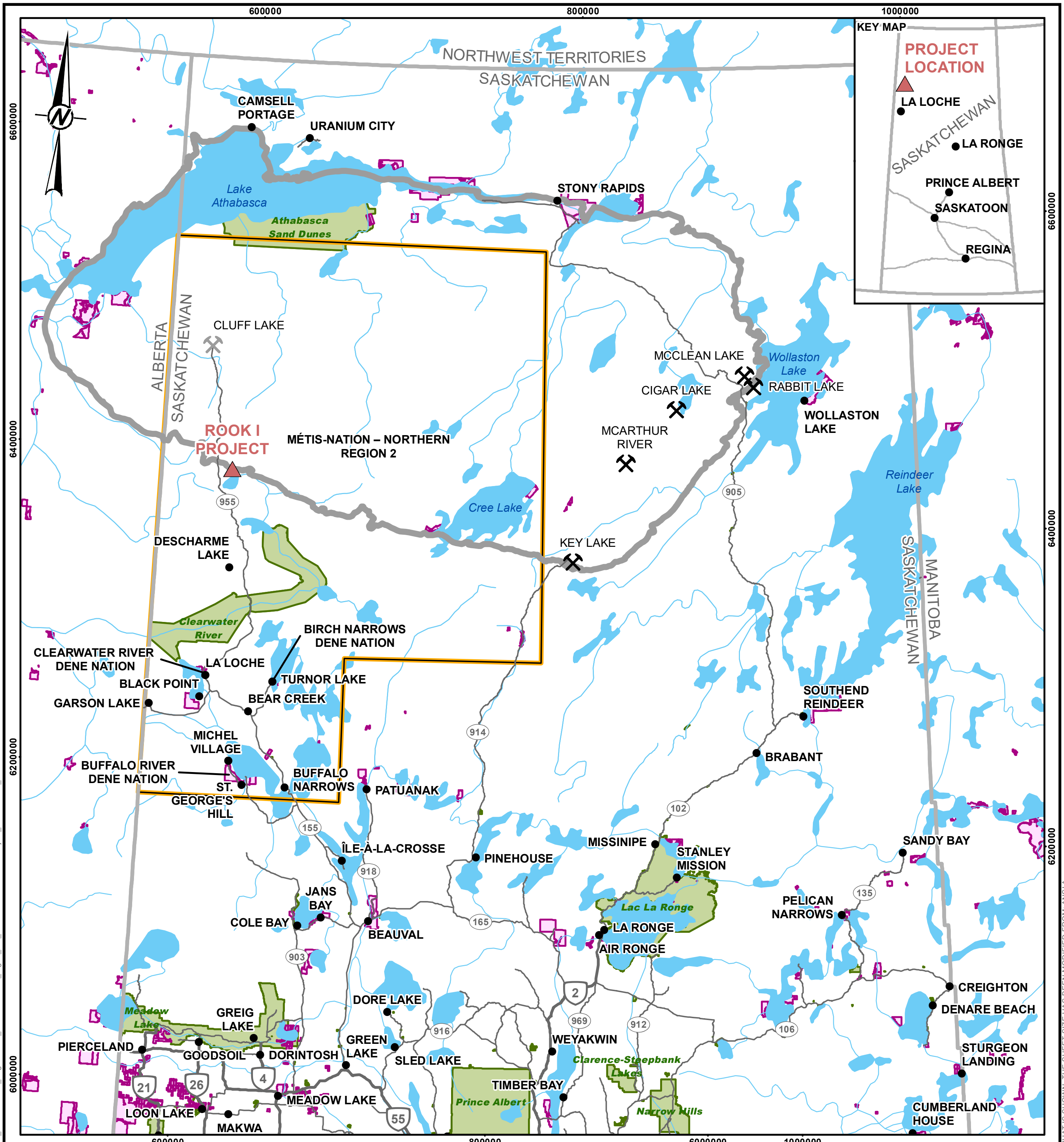
13 VEGETATION

13.1 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 Northern Village of La Loche, and 640 km northwest of the city of Saskatoon (Figure 13.1-1). 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. Patterson Lake is at the interface of the Boreal Shield and Boreal Plain ecozones. Access to the Project would be from an existing road off Highway 955 (Figure 13.1-2), with on-site worker accommodation serviced by fly-in/fly-out access.

Section 13, Vegetation, of the Environmental Impact Statement (EIS) characterizes the potential residual effects of the Project on vegetation ecosystems and traditional use plants, which are attributes or components of the biophysical environment. Vegetation ecosystems (i.e., upland, wetland, and riparian) and traditional use plants represent valued components (VCs) for the Environmental Assessment (EA). The Project has the potential to cause adverse effects on vegetation ecosystems and traditional use plants primarily through removing existing natural vegetation or altering terrain and soil conditions (Section 12, Terrain and Soils), and plant species composition during Construction, the effects of which would continue through Operations and Decommissioning and Reclamation (i.e., Closure) until vegetation is restored. Deposition of dust and fossil fuel emissions (Section 7.2, Air Quality) may also influence vegetation. Changes to groundwater (Section 8, Hydrogeology), hydrology (Section 9, Hydrology), and surface water quality (Section 10, Surface Water Quality and Sediment Quality) could affect vegetation ecosystems and traditional use plants. Changes in vegetation ecosystems could influence wildlife habitat and wildlife, and potentially fish and fish habitat (e.g., vegetation adjacent to streams).

Changes in vegetation ecosystems and traditional use plants could influence ecological services (e.g., availability of plants) for people who use these resources. For this reason, the vegetation assessment provides information that is used to support the assessments of other VCs such as wildlife and wildlife habitat (Section 14, Wildlife and Wildlife Habitat), human health (Section 15, Human Health), Indigenous land and resource use (Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use), and other land and resource use (Section 17, Other Land and Resource Use). A simplified linkage diagram, Figure 13.1-3, illustrates how anticipated Project activities could result in a direct or indirect effect on vegetation ecosystems and traditional use plants, and the associated VCs that could be influenced through changes to vegetation ecosystems and traditional use plants.



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

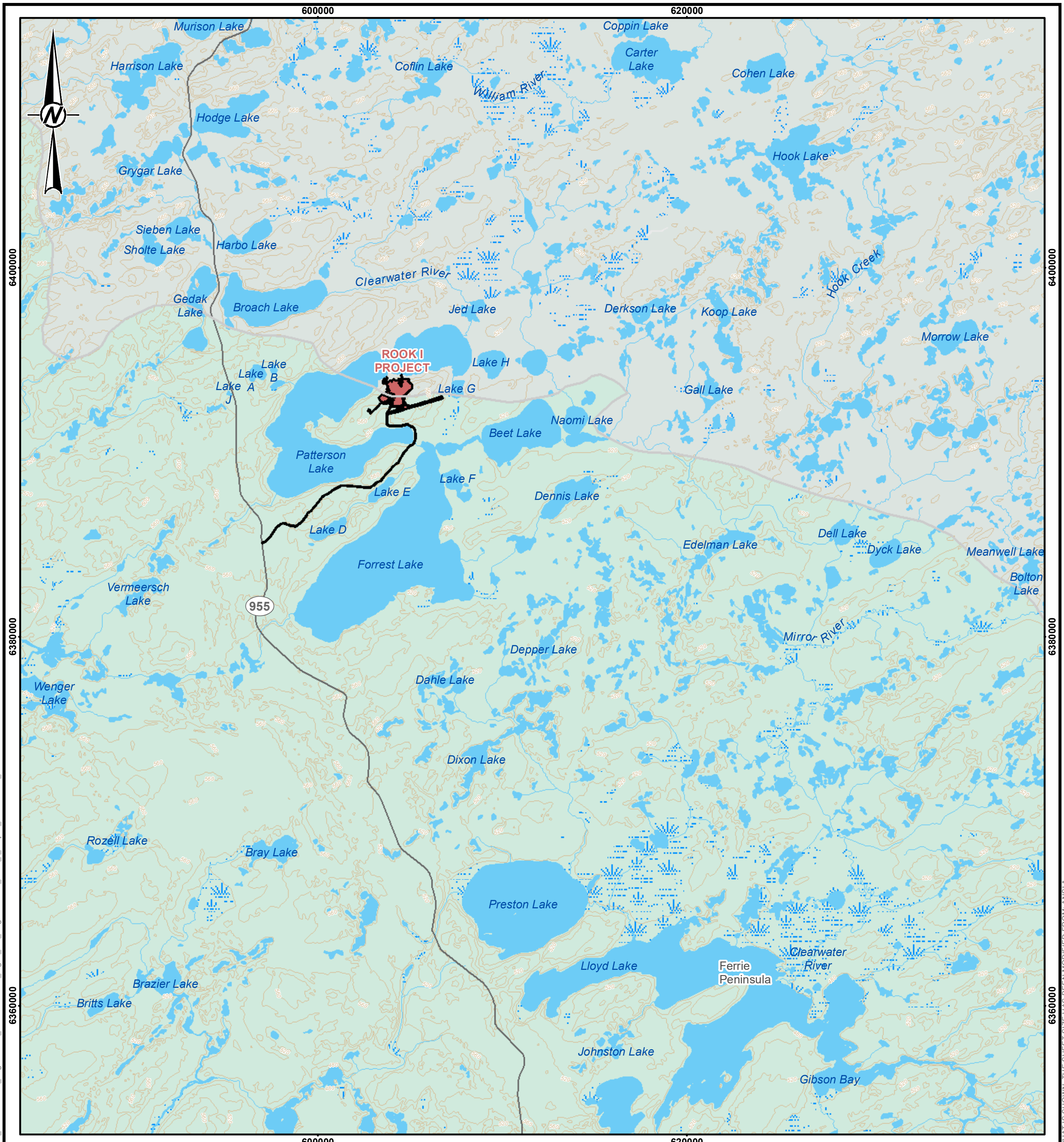
PROJECT
NexGen Energy Ltd.
ROOK I PROJECT

TITLE
LOCATION OF THE ROOK I PROJECT

CONSULTANT
wsp

PROJECT 20144150 SCALE AS SHOWN REV. 0

FIGURE 13.1-1



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

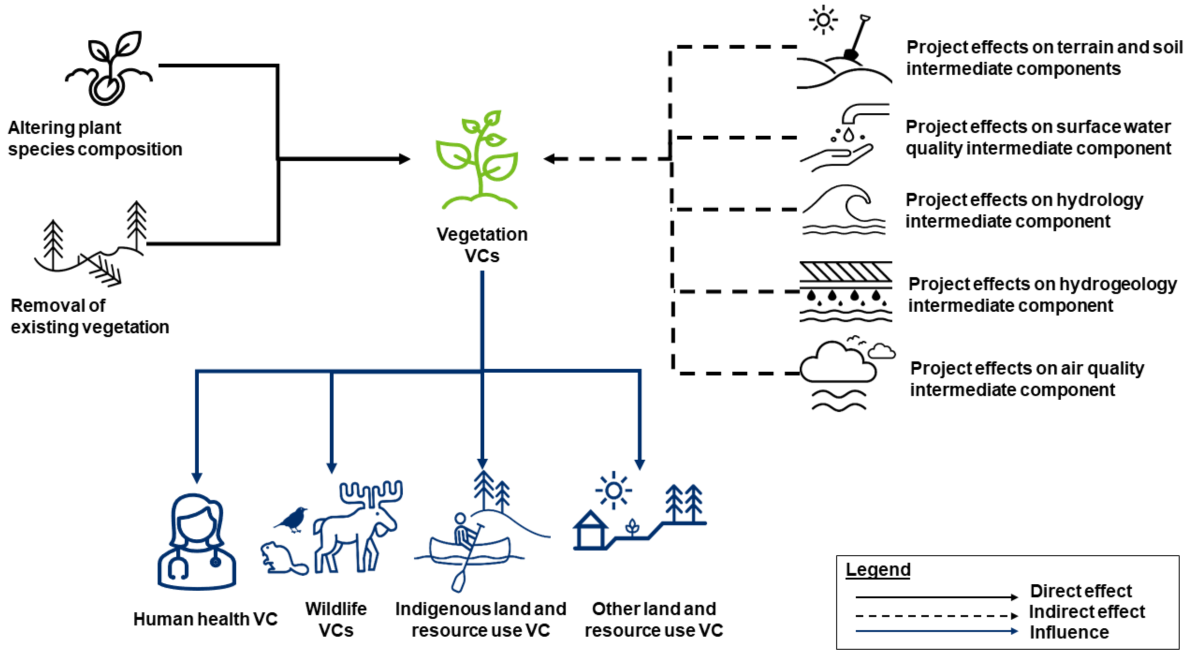
PROJECT	20144150	SCALE AS SHOWN	REV. 0

FIGURE 13.1-2

PATH: I:\CLIENTS\NexGen\20144150\Mapping\Products\FINAL_EIS_FIGURES_WSP_LOGO_UPDATED\13_Vegetation\8_5x11\20144150_Fig13_1-2_Regional-Area_Rook_I_Project_NoTitleblock_Rev0.mxd PRINTED ON: 2023-02-08 AT: 12:12:20 PM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
25mm 0

Figure 13.1-3: Linkage Diagram of Project Effects on Vegetation Valued Components and Influence on other Valued Components



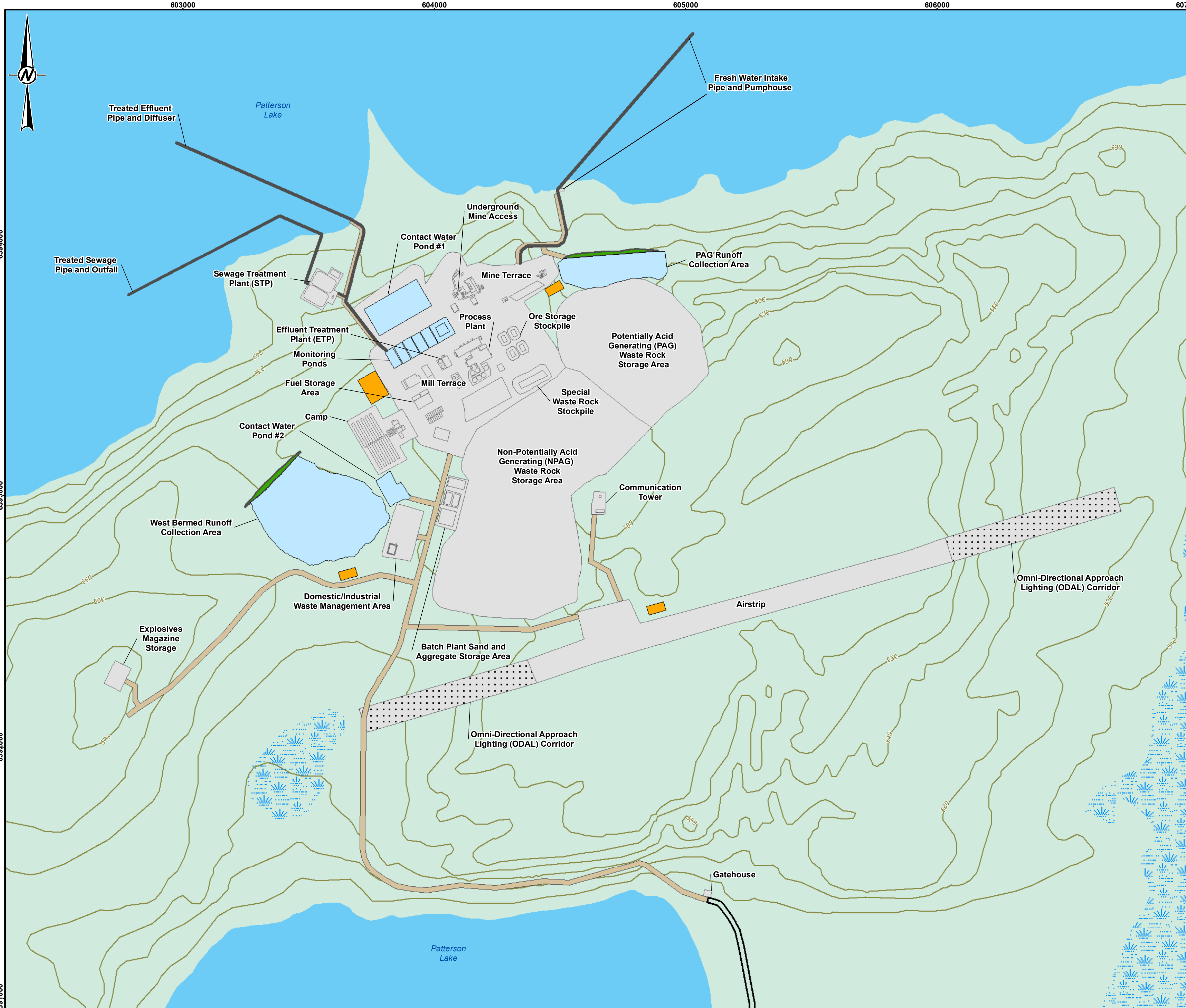
VC = valued component

13.1.1 Project Summary

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 13.1-4):

- underground mine development;
- process plant buildings, including uranium concentrate packaging facilities;
- paste tailings distribution system;
- underground tailings management facility (UGTMF);
- potentially acid generating (PAG) waste rock storage area (WRSA);
- non-potentially acid generating (NPAG) WRSA;
- 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.

[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.



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	SCALE AS SHOWN	REV. 0

FIGURE 13.1-4

13.1.2 Purpose and Approach to the Assessment

The purpose of Section 13 is to provide a detailed and comprehensive assessment of all potential Project-specific effects and cumulative effects from the Project and other previous, existing, and reasonably foreseeable developments (RFDs), if applicable, on vegetation. This section meets the Terms of Reference for the Project submitted to the Saskatchewan Ministry of Environment (ENV) and the Canadian Nuclear Safety Commission (CNSC) *Generic Guidelines for the Preparation of an Environmental Impact Statement – Pursuant to the Canadian Environmental Assessment Act, 2012* (Appendix 1A, Concordance Tables). The assessment of vegetation followed the overall EA approach and methods (Section 6, Environmental Assessment Approach and Methods) and includes the following primary steps:

- **Step 1 – Define component-specific methods (Section 13.2):** presents the specific approaches and methods used to measure and assess the effects of the Project on vegetation as well as cumulative effects from the Project, other previous and existing projects and activities, and RFDs, if applicable.
- **Step 2 – Characterize existing conditions (Section 13.3):** describes and characterizes existing conditions to provide context and a basis for evaluating potential changes to vegetation caused by the Project.
- **Step 3 – Evaluate Project interactions and mitigations (Section 13.4):** identifies Project components and/or activities with the potential to affect vegetation and provides environmental design features and mitigation policies and actions committed to by NexGen to avoid or minimize potential adverse effects. A pathways analysis was used to focus further assessment on key interactions between the Project and vegetation by evaluating the different effect pathways to determine if, after incorporation of mitigation, there is still potential to cause residual adverse effects. Primary pathways anticipated to result in residual adverse effects after incorporation of mitigation are carried forward to Step 4 for further analysis. Where potential adverse effects are adequately mitigated and thus not forwarded for further analysis (i.e., where mitigation results in negligible effects or avoids the pathway altogether), the reasons for concluding the assessment at this stage are provided.
- **Step 4 – Analyze residual effects (Section 13.5):** evaluates and describes the potential Project effects on vegetation that are anticipated to occur through the primary pathways. The residual effects analysis is presented as an integrated narrative that describes the effects of the Project over time and highlights predicted effects at the point when adverse effects of the Project are expected to be greatest. This step also includes an analysis of residual cumulative effects from the Project, other previous and existing projects and activities, and RFDs.
- **Step 5 – Classify residual effects and determine significance** (Section 13.5.1.3; Section 13.5.2.3; Section 13.5.3.3; Section 13.5.4.3): summarizes the results of the residual effects analysis using effects criteria (i.e., direction, magnitude, geographic extent, duration, reversibility, frequency, and probability of occurrence). Significance was determined using the results of the residual effects analysis and classification. Significance was determined for adverse effects only and for the maximum adverse effects of the Project and the cumulative effects from the Project, other previous and existing projects and activities, and RFDs.
- **Step 6 – Describe uncertainty and define prediction confidence (Section 13.6):** identifies key uncertainties and explains how these uncertainties have been addressed to achieve a conservative, precautionary assessment. The implications of the approaches used to address uncertainties and the level of confidence in the residual effects analysis are discussed.

- **Step 7 – Identify monitoring and follow-up (Section 13.7):** outlines the proposed actions to verify predicted residual effects. The purpose of these actions is to evaluate effectiveness of planned mitigation designs, policies, and practices, and address key sources of uncertainty.

13.2 Component Methods

13.2.1 Incorporation of Indigenous and Local Knowledge

Indigenous and Local Knowledge included in the assessment of vegetation was shared by potentially affected First Nations and Métis Groups (collectively referred to as Indigenous Groups) and local priority area (LPA)[2] community members through the Project engagement process. The overall approach and methods for the incorporation of Indigenous and Local Knowledge into the EA is discussed in detail in Section 3, Indigenous and Local Knowledge. Issues and concerns related to vegetation raised by Indigenous Groups and LPA community members, and how these comments were addressed, are summarized in Appendix 2B, Summary of Issues and Concerns Identified by Indigenous Groups, and identified and addressed in this assessment, where applicable.

A key source of Indigenous and Local Knowledge is the Project-specific studies completed by Indigenous Groups, including Traditional Land Use and Occupancy studies, Traditional Knowledge and Use studies, and Indigenous Rights and Knowledge studies (henceforth referred collectively as Indigenous Knowledge and Traditional Land Use [IKTLU] Studies). The IKTLU Studies that were reviewed and referenced in the EIS as technical support documents (TSDs) are listed below:

- TSD II (BNDN), Birch Narrows Dene Nation Traditional Knowledge and Use Study Specific to NexGen Energy Limited’s Proposed Rook I Project;
- TSD III (BRDN), Buffalo River Dene Nation Traditional Knowledge and Use Study Specific to NexGen Energy Limited’s Proposed Rook I Project;
- TSD IV (MN-S), Métis Nation – Saskatchewan Northern Region 2 Traditional Land Use & Diet Study for the NexGen Rook I Project;
- TSD V.1 (CRDN), Preliminary Identification of Issues and Concerns Related to the Proposed NexGen Energy Ltd. Rook I Project in the Patterson Lake Area; A Review; Clearwater River Dene Nation; Traditional Land Use and Occupancy Mapping Interviews; 2010 – 2016;
- TSD V.2 (CRDN), Clearwater River Dene Nation Indigenous Rights and Knowledge Survey Related to the Proposed NexGen Energy Ltd. Rook 1 Project in the Patterson Lake Area;
- TSD V.3 (CRDN), Socio-economic and Harvest Study; Clearwater River Dene Nation; NexGen Rook 1 Project; and
- TSD VI (YNLR), Provision of Athabasca Denesųłiné Traditional Knowledge, Land Use and Occupancy Information for the NexGen Rook I Project Environmental Assessment.

Another key source of Indigenous and Local Knowledge was information shared by Indigenous Group representatives during Joint Working Group (JWG) meetings. The JWGs represent an agreed-upon primary engagement mechanism as outlined in the Study Agreements signed by each Indigenous Group and NexGen. More details regarding the JWGs can be found in Section 2, Indigenous, Regulatory, and Public Engagement

[2] The LPA consists of the local communities closest to the Project that would experience most of the Project effects and for which NexGen would prioritize local training, employment, and business opportunities for the Project. These communities are located along, or accessed via, Highways 155 and 955 north of the intersection of Highways 155 and 925.

and Section 3, Indigenous and Local Knowledge. There are four JWGs with the Project's primary Indigenous Groups (Section 2.4.1, Identification of Indigenous Groups for Engagement):

- Clearwater River Dene Nation (CRDN) JWG;
- Métis Nation – Saskatchewan (MN-S) JWG representing MN-S Northern Region 2 (NR2);
- Birch Narrows Dene Nation (BNDN) JWG; and
- Buffalo River Dene Nation (BRDN) JWG.

The leadership of each Indigenous Group selected their JWG participants with consideration of group diversity; where possible, members included Elders, youth, different genders, a range of ages, and land users around Patterson Lake.

In addition to the IKTLU Studies and JWGs, Indigenous and Local Knowledge shared during specific engagement activities undertaken through the EA development process was incorporated into the assessment, where appropriate. These engagement activities included, but were not limited to:

- community information sessions held in four locations in 2019 (NexGen 2019);
- site tours;
- comments from the CRDN (CRDN 2019a) on the Cluff Lake Mine licence renewal;
- other formal and informal meetings;
- workshops with specific groups (e.g., Fur Block N-19 trapper's workshop); and
- environmental and socio-economic baseline data collection.

Comments submitted by Indigenous Groups on the Project Description (CRDN 2019b; MN-S 2019; YNLRO 2019; ACFN 2019; CNSC 2019) were also reviewed for applicable Indigenous and Local Knowledge.

Indigenous and Local Knowledge related to vegetation was incorporated into the assessment by considering and viewing the information as complementary and influential alongside scientific information. Where possible, knowledge from each potentially affected local Indigenous Group or LPA community member was described separately and cited accordingly. Where information is described for multiple potentially affected Indigenous Groups, they are collectively referred to as "Indigenous Groups" throughout the assessment.

Indigenous and Local Knowledge was included in the vegetation assessment in the following ways:

- **Component Methods – Valued Components:** Indigenous and Local Knowledge was considered in the selection of the valued component of traditional use plant species and reflects the importance of traditional use plants and plant gathering as a cultural activity that contributes to community well-being. Traditional plants are used for spiritual and ceremonial purposes, are a vital part of traditional diets and health, and play a critical role it plays in the transmission of knowledge and maintenance of culture. Traditional plant gathering and their locations also contribute to sense of place. The selection of traditional use plants was identified by Indigenous Groups and represents a diversity of vegetation species that are used for food, medicinal, spiritual, and ceremonial purposes (Section 13.2.2.1).
- **Component Methods – Existing Conditions – Traditional Use Plants:** Indigenous and Local Knowledge informed the list of traditional use plant species (e.g., medicinal plants, berries, and other plants) used in the description of baseline conditions for traditional use plants (Section 13.2.6.2).

- **Existing Conditions:** Traditional use plant species identified by Indigenous Groups (e.g., medicinal plants, berries, and other plants) were used to inform the baseline conditions for availability and distribution of traditional use plants (Section 13.3.4). Indigenous and Local Knowledge was shared about traditional use plant gathering areas in the regional study area (RSA) (Section 13.3.4.2), existing conditions related to increasing wildfires in northern Saskatchewan in recent years (Section 13.3.1.2), and observations of the existing cumulative effects of air and water pollution on vegetation (Section 13.3.1.3).
- **Project Interactions and Mitigation:** Indigenous and Local Knowledge helped to inform the scoping of Project interactions and pathway analysis and consideration of mitigation measures (Section 13.4). This included observations and experiences of land users related to the existing cumulative effects on vegetation, including traditional use plants, resulting from changes to air and water quality. Indigenous Groups also provided observations related to the successfulness of reclamation activities and recommendations on reclamation, including returning the land to pre-disturbance conditions suitable for traditional land use activities, properly reclaiming disturbed areas with native plants, and conducting reclamation planning and implementation in collaboration with Indigenous Groups.
- **Residual Effects Analysis:** Effects of the Project on traditional use plant habitat availability and habitat distribution were assessed (Section 13.5.4).
- **Monitoring, Follow-Up, and Management:** Feedback provided by Indigenous Groups during engagement, including recommendations, was considered in the development of monitoring and follow-up activities (Section 13.7). In addition, it is planned that ongoing feedback from Indigenous Groups on the effectiveness of mitigations would be considered when updating monitoring and management plans. Independent Indigenous Monitors chosen by each primary Indigenous Group would have opportunities to participate in environmental monitoring programs for the Project.

Specific references to Indigenous and Local Knowledge, and Project comments and concerns related to vegetation raised by Indigenous Groups and LPA community members, are included in the applicable subsections of this assessment.

13.2.2 Valued Components, Measurement Indicators, and Assessment Endpoints

13.2.2.1 Valued Components

Valued components are aspects of the biophysical, cultural, and socio-economic environments that are considered to have scientific, social, cultural, economic, historical, archaeological, or aesthetic importance (Beanlands and Duinker 1983; CNSC 2021). The BNDN and BRDN define VCs as tangible biophysical resources (e.g., particular places and species) and less tangible social, economic, cultural, health, and knowledge-based values (e.g., social cohesion, place names, Indigenous language) (TSD II: BNDN; TSD III: BRDN).

Valued components were selected based on multiple considerations (Section 6.3.1, Valued Components) such as:

- potential for interaction with the Project and degree of interaction, including presence, abundance, and amount of spatial overlap of a VC with the Project;
- sensitivity of a VC to potential Project effects and level of damage or harm that could be realized should an adverse effect occur;

- species conservation status or concern (e.g., rarity, sensitivity, uniqueness);
- ecological and socio-economic/cultural value to Indigenous Groups and local communities, government agencies, and the public;
- recent experience with similar projects in Saskatchewan and other jurisdictions in Canada; and
- avoidance of redundancy with other VCs; for example, if two potential VCs represent the same attributes, mitigation actions, and potential effects from the Project, only one was evaluated as part of the assessment.

Selection of vegetation VCs was based, in part, on Indigenous and Local Knowledge and feedback obtained during community information sessions for the Project in La Loche, Turnor Lake, Buffalo River, and Buffalo Narrows, JWG meetings, (Section 2; Section 3, Indigenous and Local Knowledge) as well as Indigenous and Local Knowledge presented in the IKTLU Studies (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YNLR).

Gathering plants for food, medicinal, spiritual, and ceremonial purposes is an important traditional activity for Indigenous Groups and an important aspect of culture and community well-being (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YNLR). During community information sessions, LPA community members also identified plants as an important valued component of the environment (NexGen 2019). The importance of traditional plants, and gathering activities was highlighted by Indigenous Groups:

> As in the past, harvesting from Mother Earth remains an integral inherited tradition of [the] Métis Nation . . . . MN-S Northern Region 2 members truly live off the land . . . tapping trees for birch syrup and gathering berries, mint and medicine all over the north, especially near Patterson Lake. It is important that this tradition continues. (TSD IV: MN-S)

> And we can have all our medicines on the land too, that we take because I practice medicine . . . . Because it was passed down from my mom and my dad to me . . . when people ask me to make them medicine . . . I go out and I look for medicines and I find them and I help people with it. (TSD II: BNDN)

> There is a lot of medicine, my dad and I use to collect them. Ts'aili Teli (Frog Tail) on the side of the road, it looks like red rose, that is medicine. They pay respect to the lake and plants when they harvested the plants . . . . He used to bring it to mom, and mom would drink it. It is good for body aches, made into tea. She mixed it with another plant, and made it into a tea. (TSD VI: YNLR)

The MN-S considers the Region 2 (i.e., Northern R2) territory as a vital source of food and traditional medicines which provide members “a shared identity, sense of community and permanence” (TSD IV: MN-S). Community members still rely on the land and its resources, and it is estimated that approximately 70% of their food comes from hunting, trapping, fishing, and gathering (TSD IV: MN-S). Members of the MN-S also reported that berries are very important and are harvested and consumed year-round (MN-S-JWG 2019a).

Showing respect for and giving thanks to plant resources through ceremonies is an important aspect of gathering (TSD III BRDN; TSD V.2: CRDN). For example, when a tree is cut down, community members pay respect to it by making an offering to the land for the service the tree is going to provide (e.g., providing shelter) (BRDN-JWG 2020). The importance of trees on the landscape, which are sometimes used as navigational landmarks, was noted by the CRDN (TSD V.1: CRDN). An MN-S member described the important services that trees provide in terms of producing oxygen and emitting humidity that helps to keep the temperature down (MN-S-JWG 2019a).

Knowledge of traditional medicines, where they are gathered, and how they are prepared and used is considered a specialised knowledge carried by certain individuals in the community (TSD III: BRDN; TSD V.2: CRDN). This knowledge is important for the maintenance of culture that is passed down to younger generations. The intergenerational transmission of knowledge is often experiential, learned from Elders and relatives while out on the land, and requires access to a healthy environment and abundant resources (TSD II: BNDN; TSD III: BRDN; TSD V.2: CRDN). The importance of knowledge transmission was described by members of the CRDN and BRDN:

> My grandpa was a traditional medicine man . . . . Yea [his grandfather taught him], from the bush. But he told us it's not an easy thing . . .you . . .[have to] know something and you . . . [have to] respect it. When I was young, he wanted to give it to me . . . . He . . . [taught] me a lot of things about medicine. (TSD III: BRDN)

> I've always wanted to live in the bush. And, so I could be self-sufficient. And there's a lot of reasons why I wanted to build a cabin. I wanted to teach my kids the traditional cultural lifestyle. Where they can make dry fish, pick berries and all that traditional stuff. (TSD V.2: CRDN)

Locations where berries and medicinal plants have been harvested for generations are also associated with particular stories and teachings (TSD V.2: CRDN). The long history of gathering in the same locations over generations and knowledge acquired of those particular places contributes to sense of place which is "intricately connected to land and place". Sense of places is tied to people's attachment and affiliation with the land and is an expression of identity and familiarity, and "depends on particular places . . . along with their particular features (physical, social, and symbolic) and the values and activities these features foster and enable" (TSD II: BNDN; TSD III: BRDN). These physical features include vegetation ecosystems and distribution of plant species that are found across a particular landscape. For example, the unique environmental features that characterize the region around Patterson Lake were described by a BNDN member:

> It's nice [around Patterson Lake], you know? It's a lot of sand and jack pine and it's not really thick. It's, I think it's old growth, if I could remember. It's a really nice area. Anywhere north is nice. It's kind of the same from Patterson . . . west and east. A lot of sand and nice clear water. (TSD II: BNDN)

Indigenous Groups have noted the inter-relationships between different biophysical components of the environment and the role that air and water quality plays in contributing to a healthy terrestrial environment, including to vegetation (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YNLR). For example, the CRDN described how medicinal properties of plants are related to the quality of the grounds in which they grow, and that medicinal plants are not gathered from areas which have been disturbed (TSD V.1: CRDN; TSD V.2: CRDN). The CRDN noted that they assess the quality of soil, in addition to water and air, based on their close observations of vegetation quality (TSD V.2: CRDN).

The application of both a coarse- and fine-filter approach to the selection of vegetation VCs is consistent with feedback received during engagement regarding the value that Indigenous Groups place both on individual components (e.g., plant species) and ecosystems as a whole.

A coarse-filter approach (i.e., an approach that focuses on protecting the structure of an ecosystem as a whole) was used to select vegetation VCs and determine effects on the different vegetated ecosystems that would be influenced by the Project. At the broadest level, upland, wetland, and riparian ecosystems were selected as VCs to assess the effects on vegetation, wetlands, and overall biodiversity. Assessing and managing biodiversity at the vegetation and wetland ecosystems level means that large numbers of biodiversity elements are addressed together. Analysis of the availability, distribution, and function of upland, wetland, and riparian ecosystems provides an assessment of species richness (i.e., number of species within an ecological community), diversity, and distribution across the landscape. Analysis at the ecosystem level also provides an understanding of natural processes (e.g., disturbance caused by fire, insects, and disease) and existing anthropogenic (i.e., human-caused) disturbances occurring on the landscape, both spatially and temporally.

To complement the assessment of vegetation ecosystems, a fine-filter approach (i.e., an approach that focuses on protecting particular components within an ecosystem) was applied by assessing effects on plant species identified as important by Indigenous Groups (i.e., traditional use plant species). In total, 28 plant species were identified as traditional plant species used for food, medicinal, ceremonial, or other purposes (TSD V.1: CRDN; TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD VI: YNLR; CRDN 2019a). Each traditional use plant species was assessed using the baseline vegetation data (Annex VII.1, Vegetation Baseline Report 1 [Mapping]; Annex VII.2: Vegetation Baseline Report 2 [Inventory, Rare Plants, and Wetlands]) to provide an understanding of species presence and abundance within the Project study areas. This fine-filter level of assessment is important to understand the effects on biodiversity that are sometimes distinct from the effects on ecosystems, and for which targeted mitigation at the species level may be required. The assessment of traditional use plant species outlines how the Project would affect the abundance and distribution of these resources, and if the change is sufficient to significantly influence the ability of a VC to be self-sustaining and ecologically effective. The assessment of traditional use plant species as a vegetation VC is complementary to the assessments in Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use and Section 17, Other Land and Resource Use, which include availability of plants as a measurement indicator (i.e., ecological resource), where changes in the abundance and distribution of biological VCs are assessed based on the societal or cultural value of resource, which is as important as biological effects on the ecosystem. The assessments of biological and socio-economic VCs and the connections among them provide an overall holistic evaluation of effects from the Project on the social-ecological system.

The coarse- and fine-filter assessments complement and interact with one another, with each assessment providing context for the other. Combined, the coarse- and fine-filter assessments provide a holistic assessment of the potential effects of the Project on biodiversity.

Selection of vegetation VCs also considered federally and provincially listed and/or tracked vascular plant species (i.e., plants with specialized tissue for transporting water and nutrients) that have the potential to interact with the Project. Collectively referred to as “rare” vascular plant species for this Project, these include the following:

- plants listed as endangered or threatened under The Wild Species at Risk Regulations;
- species included in the Saskatchewan Vascular Plant Tracked Taxa List (SKCDC 2021a);
- species listed in Schedule 1, 2, and 3 as Endangered, Threatened, or of Special Concern under the *Species at Risk Act* (SARA) Public Registry (Government of Canada 2021a); and
- species listed as endangered, threatened, or of special concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC; Government of Canada 2021a).

Potential for rare plant species to occur in the RSA was determined through review of historical element occurrences on the Hunting, Angling, and Biodiversity of Saskatchewan (HABISask) database (SKCDC 2021b) and the Tracked Vascular Plant Taxa by Ecoregion and Landscape Area (SKCDC 2021c), vegetation data collected during the baseline surveys (Annex VII.1; Annex VII.2), and habitat and distribution data detailed in COSEWIC Assessment and Status Reports (COSEWIC 2002a, COSEWIC 2002b, COSEWIC 2006a, COSEWIC 2006b, COSEWIC 2011a, COSEWIC 2011b, COSEWIC 2012, COSEWIC 2013, COSEWIC 2018), and SARA recovery strategies (Environment Canada 2012).

No COSEWIC- or SARA-listed species have been previously identified within the RSA (SKCDC 2021a) or within the landscape areas overlapped by the RSA (i.e., Firebag Hills Landscape Area, Black Birch Plain Landscape Area, McTaggart Plain Landscape Area, and McFarlane Upland) (SKCDC 2021c). Information provided by COSEWIC Assessment and Status Reports (COSEWIC 2002a, COSEWIC 2002b, COSEWIC 2006a, COSEWIC 2006b, COSEWIC 2011a, COSEWIC 2011b, COSEWIC 2012, COSEWIC 2013, COSEWIC 2018), and SARA recovery strategies (Environment Canada 2012) indicate that the Project occurs outside of known species distribution ranges and there is no critical habitat defined for any federally listed vascular plant species in the RSA. No COSEWIC- or SARA-listed vascular plant species were detected during baseline field surveys (Annex VII.1; Annex VII.2). Seven provincially tracked plant species were observed during the baseline field surveys; however, only a single rare vascular plant occurrence of beautiful sedge (*Carex concinna*) was observed that would be potentially affected by the Project (Annex VII.1; Annex VII.2). Due to the low risk of encountering federally listed vascular plant species and the limited amount of rare vascular plant observations during the baseline field surveys, an ecosystem-based approach was applied to the assessment of rare plants, which examined how the condition of Ecological Land Classification (ELC) units (i.e., discrete unit classification on the basis of vegetation and soil attributes) with rare plant potential may be adversely affected by Project activities (e.g., effects from habitat loss and changes in moisture and light levels).

Habitat requirements for species that are not well known or understood (i.e., tracked bryophytes, such as mosses, and lichens) were excluded as VCs because of the high degree of uncertainty associated with the distribution of these taxa (e.g., species) within the area of the anticipated Project (and generally in Saskatchewan) (DeVries and Wright 2015) and because such organisms often require detailed chemical or taxonomic procedures for their identification (Eldridge et al. 2003).

The following vegetation VCs were selected for the Project:

- **Upland ecosystems:** selected because they are the basis for local biological processes, provide habitat for wildlife, and contribute to overall biodiversity.
- **Wetland ecosystems:** selected because they are of conservation concern, sensitive to development, perform hydrological and biochemical cycling functions, provide habitat for fish and wildlife, and contribute to biodiversity.
- **Riparian ecosystems:** selected because they are of conservation concern and are sensitive to development, perform hydrological and biochemical cycling functions, provide fish habitat and movement corridors for wildlife, and contribute to biodiversity.
- **Traditional use plant species:** selected because they are important to the culture and way of life of Indigenous Peoples. Plant use varies and includes nutritional, ceremonial, medicinal, and other purposes.

13.2.2.2 Measurement Indicators

Measurement indicators are used to characterize changes to attributes of the environment from the Project, other human developments, and natural factors. The changes in measurement indicators are used to predict the overall effects on VCs and assessment endpoints (Section 6.3.2, Assessment Endpoints and Measurement Indicators). Several measurement indicators were identified and used for vegetation VC assessments (Table 13.2-1). Importantly, the measurement indicators for vegetation VCs are connected to intermediate components in the EA such as air quality, hydrology, surface water quality, and terrain and soils. Accordingly, the assessments of these intermediate components are fundamental to understanding the total effects of the Project on the vegetation VCs (Section 6.3.3, Intermediate Components). Results from the ecological health risk assessment were also incorporated into the ecosystem condition measurement indicator for vegetation VCs.

The measurement indicators for vegetation VCs are defined as follows:

- **Ecosystem or habitat availability:** refers to the amount of ecosystem or habitat present for each VC. Ecosystem or habitat availability is primarily affected by physical changes (e.g., vegetation clearing). Ecosystem or habitat availability is represented as the amount of area (i.e., hectares) of each VC.
- **Ecosystem or habitat distribution:** refers to the way each ecosystem type or habitat is distributed on the landscape. Availability and distribution are linked; distribution focuses on the spatial configuration and connectivity of ecosystems or habitat, whereas availability focuses on the amount of those ecosystems or habitats. Metrics of distribution include effects on connectivity, changes in size, distribution of ELC units, and linear feature density (e.g., roads). Estimates were supported by the scientific literature and Indigenous and Local Knowledge, where available.
- **Ecosystem condition:** refers to the integrity, or naturalness, of ecosystems on the landscape; the ability of ecosystems to support the community of organisms naturally associated with them; and the ability of ecosystems to perform ecological functions. The condition is typically reduced in human-altered ecosystems due to changes in physical (e.g., water quantity, water quality, soil quality) and biological (e.g., vegetation and wildlife communities) properties. Examples of metrics used to evaluate ecosystem condition include proximity to disturbance, presence and potential of rare species, and number of invasive species. Ecosystem condition is primarily affected by changes in the amount of moisture and sunlight, competition with invasive species, and dust deposition. Ecosystem condition also considers the results from the ecological health risk assessment and the exposure of aquatic and terrestrial plant receptors to constituents of potential concern (COPCs; TSD XXI, Environmental Risk Assessment).

Each measurement indicator was evaluated quantitatively where sufficient information existed to support a numerical assessment and qualitatively where necessary.

13.2.2.3 Assessment Endpoints

Assessment endpoints are qualitative expressions that represent the key properties of VCs that should be protected; as such, assessment endpoints incorporate the concept of sustainability and function as significance thresholds (Section 6.3.2). The significance of effects from the Project and other human developments on vegetation VCs was evaluated by linking changes in measurement indicators to the influence on self-sustaining and ecologically effective ecosystems and self-sustaining traditional use plant populations (Table 13.2-1). Details on the application of self-sustaining and ecologically effective ecosystems and self-sustaining traditional use plant populations as significance thresholds are provided in Section 13.2.9, Residual Effects Classification and Determination of Significance. The compilation and interpretation of the results from analyzing changes in measurement indicators provides lines of evidence that collectively provide a determination of whether the assessment endpoints are maintained or achieved (Section 6.3.2). Ecosystem services (i.e., the benefits people gain from the environment) provided by traditional use plant species are assessed in Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use, and Section 17, Other Land and Resource Use, and are not considered during the residual effects classification and determination of significance in this section. The results from the ecological health risk assessment (TSD XXI) provide another important line of evidence in the determination of significance of effects on vegetation VCs (Section 6.3.4, Environmental Risk Assessment Receptors).

Table 13.2-1: Valued Components, Rationale, Measurement Indicators, and Assessment Endpoints

VCs	Rationale	Measurement Indicators	Assessment Endpoints
▪ Upland ecosystems ▪ Wetland ecosystems ▪ Riparian ecosystems	▪ Ecosystems contain plants that represent both traditional and current food sources ▪ Socio-economic/cultural importance ▪ Critical attribute of biodiversity ▪ Provide wildlife habitat ▪ Wetlands provide important hydrological and biochemical functions ▪ Sensitive to disturbance ▪ Federal and/or provincial species at risk protected by legislation	▪ Ecosystem availability (i.e., amount) ▪ Ecosystem distribution (i.e., arrangement and connectivity) ▪ Ecosystem condition (i.e., integrity)	▪ Self-sustaining and ecologically effective ecosystems
▪ Traditional use plant species	▪ Plant species identified during IKTLU Studies and JWG meetings ▪ Social/cultural importance	▪ Habitat availability (i.e., amount of habitat occupied by traditional use plant species) ▪ Habitat distribution (i.e., arrangement and connectivity of habitat occupied by traditional use plant species)	▪ Self-sustaining and ecologically effective traditional use plant populations

Note: Ecosystem services provided by traditional use plant species are assessed in Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use, and Section 17, Other Land and Resource Use.
IKTLU = Indigenous Knowledge and Traditional Land Use; JWG = Joint Working Group; VC = valued component.

13.2.3 Spatial Boundaries

The spatial boundaries were different for the baseline field surveys and the EA for the vegetation VCs. The baseline field survey boundaries were selected based on early Project design information, and the study areas for the EA were more refined considering the potential effects from more detailed Project design and additional ecological context as the Project design progressed. The following discussion elaborates further on the rationale for the spatial boundaries for collecting field data and assessing effects from the Project on vegetation.

13.2.3.1 Baseline Survey Boundaries

Field surveys for vegetation and rare plants were completed within specific baseline study areas, which were defined according to knowledge of ore deposit location, preliminary Project site layout, provincial requirements, and surveys completed for other northern mining developments. Canada North Environmental Services (CanNorth) conducted vegetation and rare plant surveys within a baseline site study area that consisted of a 25 km^2 area centred on the preliminary site layout and was selected to capture site-specific effects (Annex VII.2). Omnia Ecological Services (Omnia) conducted vegetation surveys within a baseline local study area (LSA). The baseline LSA (41 km^2) was defined by applying an approximate 1.6 km buffer to the preliminary Project site layout and existing access road, which was intended to capture direct effects from the physical footprint and indirect effects on wildlife from sensory disturbance associated with construction noise and truck traffic (Annex VII.1).

The baseline study areas were designed to measure and characterize existing environmental conditions on a continuum of scales from the preliminary site layout to the broader, local area. The sampling and survey locations were concentrated adjacent to the preliminary site and existing access road within the baseline site study area and baseline LSA (e.g., listed plant species and vegetation plots [Annex VII.1; Annex VII.2]). Baseline study areas were selected with limited knowledge of the precise location and layout of the Project footprint to be used in the assessment. As a result, the baseline study areas are different than the spatial boundaries or assessment study areas defined for the EA, which were based on more recent and detailed Project design information. The spatial boundaries selected for the vegetation assessment were designed to provide a description of the existing environment in sufficient detail to identify, understand, and assess potential Project-VC interactions and effects, including cumulative effects (Table 13.2-2). Importantly, the vegetation assessment study areas capture the information collected from field studies in the baseline study areas. Specifically, the LSA defined for the EA is overlapped by the CanNorth baseline site study area and the Omnia baseline LSA (Figure 13.2-1). Therefore, the data collected during the baseline field programs is deemed to be sufficient for the purposes of the EA.

13.2.3.2 Environmental Assessment Boundaries

The assessment of vegetation was completed using spatial boundaries complementary to those for terrain and soils (Section 12.2.3, Spatial Boundaries) and wildlife and wildlife habitat (Section 14.2.3, Spatial Boundaries), and consists of a site study area, maximum disturbance area, LSA, and RSA (Figure 13.2-2). The selection of the vegetation assessment study areas considered VC-specific and ecosystem-centred attributes and boundaries, and the predicted spatial extent (i.e., zone of influence) of Project effects and other existing and reasonably foreseeable developments in accordance with CEA Agency guidance (CEA Agency 2018).

The site study area is equivalent to the anticipated area of the Project footprint, which covers 228 ha and includes the access road and bridge, and all proposed Project infrastructure and facilities. To the degree possible, the Project footprint was minimized to reduce both the effects on the terrestrial environment and the area of restricted access to Indigenous and other land users.

A maximum disturbance area was used for the assessment to address uncertainty in the final design of the Project so that adverse effects on vegetation ecosystems were not underestimated (i.e., the maximum disturbance area is four times larger than the currently anticipated Project footprint). The maximum disturbance area, which covers 981 ha, 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 (Section 6.4.1 Spatial Boundaries). The spatial boundary for terrestrial resources was also constrained to the shoreline of Patterson Lake (Figure 13.2-2).

The LSA for the EA is approximately 2,832 ha (28 km^2) and is defined by a 500 m buffer around the maximum disturbance area. The LSA provides local context for assessing Project effects (Figure 13.2-2). The LSA also includes disturbance from previous and existing anthropogenic activities, such as NexGen's existing exploration camp and core shed, public trails, cutlines, clearings, and the intersection of the access road and Highway 955. The LSA was established to capture the direct effects on vegetation ecosystems and traditional use plants from the physical removal and alteration of soils and vegetation. The 500 m buffer around the maximum disturbance area is expected to capture most of the small-scale indirect effects on vegetation VCs from changes in soil chemistry and plant communities due to dust deposition. For example, the strongest effects from dust on vegetation are typically near the source, such as from roads (Walker and Everett 1987; Farmer 1993). Walker and Everett (1987) found effects were primarily within 50 m of a road, while Meininger and Spatt (1988) detected stronger effects within 50 m and weaker changes within 50 to 500 m from a road (both studies in Alaska). At the Ekati Mine in the Northwest Territories, dust generated from a high-traffic, 28 km haul road was found to decrease lichen cover up to 1 km away (Chen et al. 2017). However, at the nearby Diavik Mine, measured changes to plant communities were within 500 m of the mine (Watkinson et al. 2021). These studies support the chosen 500 m buffer. Indirect effects that may extend beyond the LSA were also considered in the assessment, as applicable.

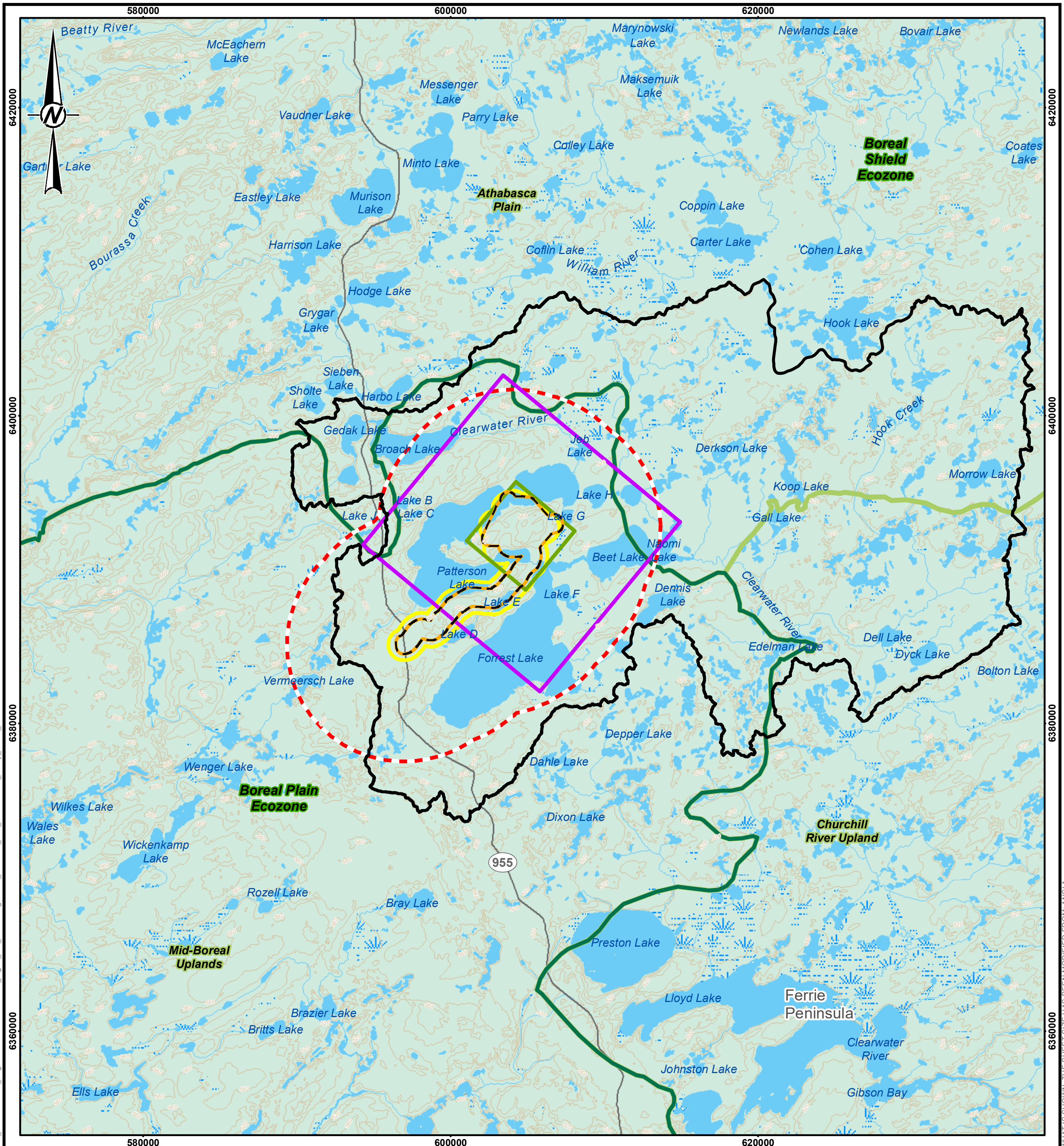
Due to the inter-relationships among physical and biological components in aquatic and terrestrial ecosystems, the RSA for the EA was defined for the aquatic and terrestrial assessments and provides a watershed-based context for interpreting the local effects of the Project. More specifically, the Clearwater River watershed RSA links the pathways of exposure to COPCs in dust, air emissions, soils, and water to vegetation ecosystems in the watershed, which are evaluated through the ecological health risk assessment (TSD XXI). The RSA includes the LSA, Forrest Lake, Beet Lake, Naomi Lake, and the watershed east and north of the confluence of the Clearwater and Mirror rivers as described in the hydrology assessment (Section 9.2.3, Spatial Boundaries). The RSA also overlaps the transition between the Boreal Plain and Boreal Shield ecozones and likely includes any potential variability in diversity between the two ecozones. The combined coarse- and fine-filter approach applied to the assessment of vegetation (Section 13.2.2.1, Valued Components) and wildlife VCs (Section 14.2.2.1, Valued Components) and the assessment of fish and fish habitat (Section 11.2.3, Spatial Boundaries) at the watershed scale and represents the use of both VC- and ecosystem-centred approaches to defining the RSA (CEA Agency 2018) and in determining Project effects on overall biodiversity.

The RSA is the largest scale at which data were collected, compiled, and analyzed and covers approximately 107,491 ha (1,075 km^2; Figure 13.2-2); this area includes indirect effects that may extend beyond the LSA (CEA Agency 2018). The RSA is expected to be at a scale suitable for assessing the significance of effects on upland, wetland, and riparian ecosystems and traditional use plant species distributed inside the RSA. The RSA is considered large enough to provide an ecologically relevant and confident assessment of the direct and indirect effects on vegetation VCs from the Project, and the cumulative effects from the Project as well as those from previous, existing, and approved projects/activities, and RFDs, and in consideration of natural factors.

Table 13.2-2: Spatial Boundaries for Assessment of Vegetation Valued Components

Spatial Boundary	Surface Area	Description
Site study area	228 ha (2.3 km^2)	▪ Equivalent to the anticipated Project footprint, which includes all proposed mine infrastructure and facilities (199 ha) and the access road (29 ha)
Maximum disturbance area	981 ha (9.8 km^2)	▪ Incorporates a level of uncertainty into the Project design so that effects are not underestimated. The maximum disturbance area was defined using bounding points offset from outermost components of the anticipated Project footprint
LSA	2,832 ha (28 km^2)	▪ 500 m buffer around the maximum disturbance area ▪ Defined by the expected extent of the direct and small-scale indirect effects from the Project ▪ Provides local context for assessing the residual effects on vegetation VCs
RSA	107,491 ha (1,075 km^2)	▪ Watershed draining to the Clearwater River above the Mirror River confluence ▪ Provides broader scale context to capture and assess Project effects and is linked to terrestrial and aquatic-related exposure pathways in the ecological health risk assessment ▪ Provides a large enough area to assess the cumulative effects on vegetation VCs and is the scale at which significance is determined

Note: Numbers are rounded for presentation purposes.
LSA = local study area; RSA = regional study area; VC = valued component.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- LOCAL ROAD
- SECONDARY HIGHWAY
- WATERCOURSE
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- WATERBODY
- WETLAND
- WOODED AREA
- ASSESSMENT LOCAL STUDY AREA
- ASSESSMENT REGIONAL STUDY AREA
- CANNORTH BASELINE SITE STUDY AREA
- CANNORTH BASELINE LOCAL STUDY AREA
- OMNIA BASELINE LOCAL STUDY AREA
- OMNIA BASELINE REGIONAL STUDY AREA

REFERENCE(S)

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PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

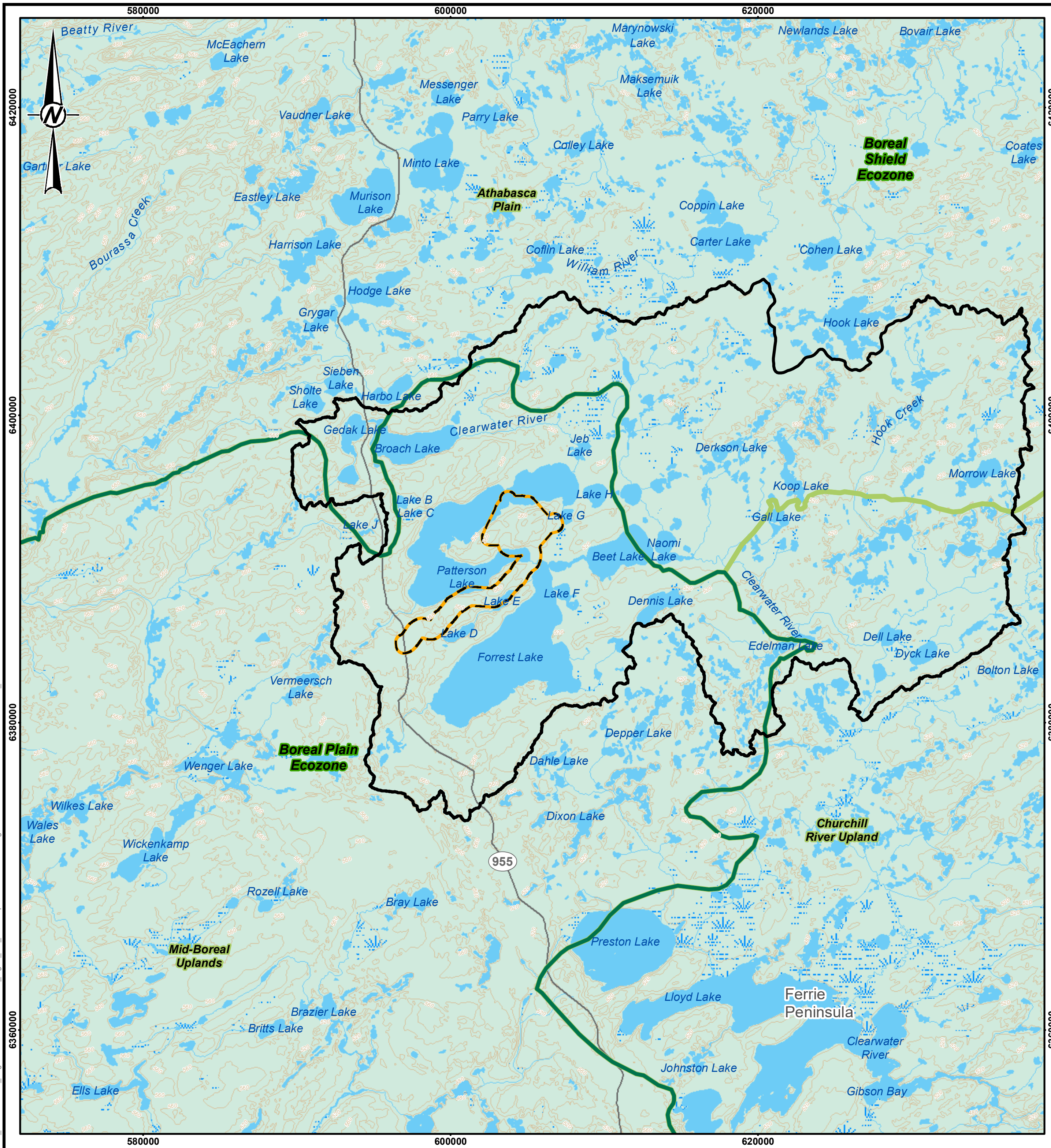
TITLE

VEGETATION BASELINE AND ASSESSMENT STUDY AREAS

CONSULTANT

wsp

PROJECT		20144150	PHASE	3310 - 2
DESIGN	AS	2023-02-08	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08	FIGURE 13.2-1	
CHECK	HH	2023-02-08		
REVIEW	JV	2023-02-08		



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- LOCAL ROAD
- SECONDARY HIGHWAY
- WATERCOURSE
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- WATERBODY
- WETLAND
- WOODED AREA
- ASSESSMENT LOCAL STUDY AREA
- ASSESSMENT REGIONAL STUDY AREA

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PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

SPATIAL BOUNDARIES FOR THE VEGETATION AND TRADITIONAL PLANT USE ASSESSMENTS

CONSULTANT

wsp

PROJECT		20144150	PHASE	3310 - 2
DESIGN	AS	2023-02-08	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08	**FIGURE 13.2-2**	
CHECK	HH	2023-02-08		
REVIEW	JV	2023-02-08		

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13.2.4 Temporal Boundaries

The temporal scope of the assessment 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 (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 required 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 CNSC licence would be submitted to the CNSC 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.

Most of the residual effects from the Project on vegetation VCs are predicted to have the largest magnitude and spatial extent at the end of Construction, when the physical footprint is near or at full development and reclamation has not yet started and continue through Operations, Closure, and for a period after Closure until effects are reversed or determined to be permanent (e.g., areas permanently covered by waste rock). In consideration of these factors, effects on vegetation were analyzed and predicted from Construction through to Closure and typically beyond, which generates the maximum potential spatial and temporal extent of effects and provides confident and ecologically relevant effects predictions. Where applicable, residual effects were also assessed in terms of specific temporal snapshots of the Project defined by intermediate components (e.g., air quality, hydrology, and water quality) that may have a linkage to potential effects on vegetation VCs. These temporal snapshots represent phases or periods when adverse effects are predicted to be most pronounced (Section 6.4.2, Temporal Boundaries).

The temporal boundaries applied to the cumulative effects assessments include the duration of residual effects from previous and existing developments that overlap with residual effects from the Project, and the period during which the residual effects from RFDs overlap with the Project, if applicable.

13.2.5 Assessment Cases

The concept of assessment cases was applied to the vegetation assessment to estimate the incremental and cumulative effects from the Project and other developments (Section 6.5, Assessment Cases). 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. There are no known approved (but not yet constructed) projects in the LSA and RSA for vegetation VCs. Assessment cases for the Project included a Base Case, Application Case, and RFD Case.

Base Case for vegetation is represented by existing conditions. The Base Case describes the existing environment in the LSA and RSA before application of the proposed Project to provide an understanding of the current conditions that may be influenced by the Project. The temporal boundary of the Base Case includes the combined effects from previous and existing human disturbances and natural factors (e.g., fire, floods, disease, insects) on the environment and vegetation. As such, existing conditions represent the cumulative effects of historical and current environmental pressures that have influenced the observed condition and patterns of the vegetation VCs (CEA Agency 2018).

Application Case for vegetation 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 to vegetation VCs.

Reasonably Foreseeable Development (RFD) Case for vegetation includes the Base Case, Application Case, and RFDs that have not yet been approved. Reasonably foreseeable developments are defined as projects and activities that fit any of the first three and both of the last two criteria from the list below:

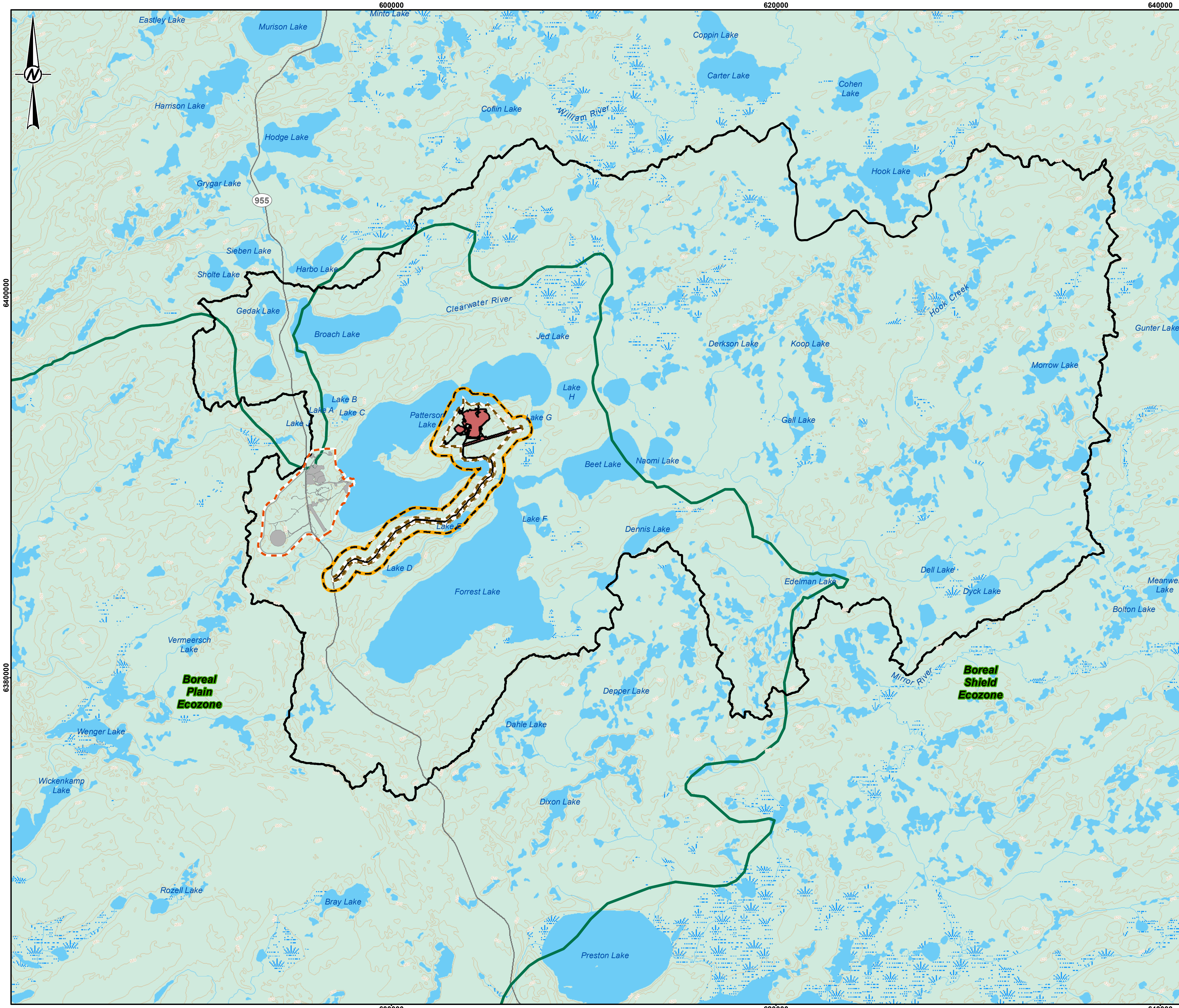
- are currently under regulatory review or have officially entered a formal regulatory application process;
- have been publicly disclosed by other proponents;
- may be induced by the Project;
- have the potential to change the Project or the effects predictions; and
- occur in the spatial assessment boundary defined by the VCs.

A key criterion for selecting other projects to include in the RFD Case was that the projects must cause similar effects on vegetation VCs influenced by the Project (Hegmann et al. 1999). The Fission Patterson Lake South Property, which is planned by Fission Uranium Corp. (Fission 2019, 2021), was included in the RFD Case (Figure 13.2-3). Public information describes a projected three-year construction period and seven-year operating period (production and processing) (Fission 2019, 2021). The anticipated start of construction and duration of active decommissioning at the Fission Patterson Lake South Property were not publicly available at the time this assessment was completed. For the assessment, it was assumed that the duration of active decommissioning for the Fission Patterson Lake South Property would be similar to the Active Closure Stage for the Project (i.e., five years; Section 6.5.3, Reasonably Foreseeable Development Case).

The proposed surface infrastructure layout plan (Fission 2019, 2021) is the anticipated physical footprint of the Fission Patterson Lake South Property and includes the proposed highway bypass, airstrip, and all proposed Project site infrastructure. A hypothetical maximum disturbance area, as applied in Section 13.2.3 to the Project footprint, was also used for the Fission Patterson Lake South Property to address uncertainty in project design. The CRDN specifically mentioned the potential for of cumulative effects from the Project and the nearby proposed Patterson Lake South Property (CRDN 2019b).

As a scenario within the RFD Case (where applicable), potential effects from climate change, including how natural factors (e.g., fire and insects) may be altered resulting from climate change, was considered within the assessment. Indigenous Groups indicated concerns about cumulative effects from human development, policies, and climate change (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN).

The vegetation assessment includes a quantitative and qualitative analysis of predicted changes on measurement indicators and associated effects from the Fission Patterson Lake South Property on vegetation VCs. In addition, potential changes from natural disturbance factors and climate change are qualitatively discussed for vegetation VCs.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- SECONDARY HIGHWAY
- WATERCOURSE
- ECOZONE BOUNDARY
- WATERBODY
- WETLAND
- WOODED AREA
- PROPOSED PROJECT FOOTPRINT
- MAXIMUM DISTURBANCE AREA
- FISSION PATTERSON LAKE SOUTH PROPERTY FOOTPRINT
- PATTERSON LAKE SOUTH PROPERTY HYPOTHETICAL MAXIMUM DISTURBANCE AREA
- LOCAL STUDY AREA
- REGIONAL STUDY AREA

0 6 12

1:200,000 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. ECOZONES OBTAINED FROM AGRICULTURE AND AGRI-FOOD CANADA (AAFC).
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

REASONABLY FORESEEABLE DEVELOPMENT IN THE REGIONAL STUDY AREA

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08	**FIGURE 13.2-3**	
REVIEW	JV	2023-02-08		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

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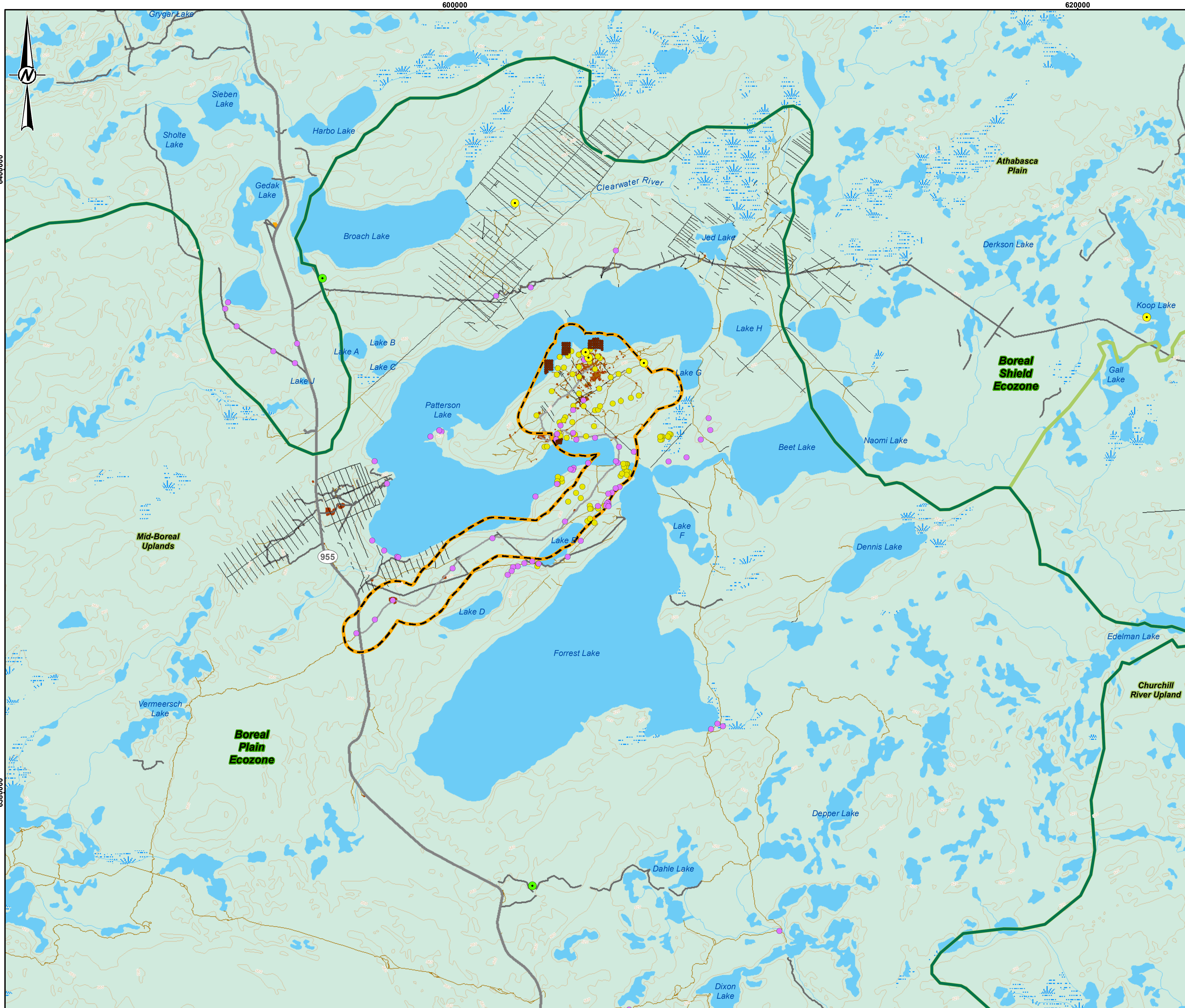
13.2.6 Existing Conditions

Existing conditions were characterized to provide context for the assessment of incremental and cumulative effects from the Project and other developments in the LSA and RSA. Existing conditions were evaluated quantitatively where information was available and qualitatively where necessary using the most up-to-date information. Data used to characterize existing conditions were collected from the following information sources:

- Annex VII.1, which summarizes baseline conditions for vegetation obtained during field programs completed in 2018 (Annex VII.2):
  - database searches (2018);
  - vegetation inventory and rare plant survey (2018; Figure 13.2-4); and
  - wetland classification (2018).
- Terrestrial Environment Vegetation Baseline Inventory (Annex VII.1), which summarized baseline conditions for vegetation obtained during field programs completed in 2018 and 2019, including:
  - ecosite mapping (2018);
  - fire mapping (2018);
  - anthropogenic mapping (2018);
  - ecosite characterization, structural diversity, and species richness (2018; Figure 13.2-4); and
  - linear feature natural regeneration assessment (2019).
- Species at risk resources including the Saskatchewan Conservation Data Centre (SKCDC 2021a) and the Species at Risk Public Registry (Government of Canada 2021a).
- Federal status reports and recovery strategy documents available through the Species at Risk Public Registry (Government of Canada 2021a).
- Species designated as prohibited, noxious, or nuisance under *The Weed Control Act*.
- Supplemental vegetation inventory and rare plant surveys completed in 2021 to further characterize baseline conditions for vegetation (Dolmage 2021).



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- SECONDARY HIGHWAY
- WATERCOURSE
- ECOZONE BOUNDARY
- WATERBODY
- WETLAND
- WOODED AREA
- LOCAL STUDY AREA

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

- 2018 CANNORTH AQUATIC VEGETAION INVENTORY
- 2018 CANNORTH VEGETATION INVENTORY
- 2018 OMNIA VEGETATION PLOT

GOLDER VEGETATION CHEMISTRY PLOT LOCATIONS

- 2018 VEGETATION CHEMISTRY SAMPLE SITE
- 2019 VEGETATION CHEMISTRY SAMPLE SITE

0 4 8

1:125,000 KILOMETRES

REFERENCE(S)

1. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. ECOZONES OBTAINED FROM AGRICULTURE AND AGRI-FOOD CANADA (AAFC).

PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

BASELINE VEGETATION SURVEY LOCATIONS

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08	**FIGURE 13.2-4**	
CHECK	HH	2023-02-08		
REVIEW	JV	2023-02-08		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

13.2.6.1 Ecological Land Classification

An ELC map was developed for the LSA and RSA to provide a basis for understanding the existing conditions for vegetation VCs, as well as supporting the development of wildlife habitat suitability index models (Section 14, Wildlife and Wildlife Habitat; Appendix 14B, Wildlife Habitat Models). Ecological Land Classification unit information classified as per the *Field Guide to the Ecosites of Saskatchewan's Provincial Forests* in McLaughlan et al. (2010) was compiled from a number of sources:

- Omnia Predictive Ecosite Map (PEM) (Annex VII.1);
- the ENV Forest Service Branch (ENV 2014) forest ecosystem classification system for the Boreal Plain (10 m by 10 m pixel; v2.0_rf_f);
- the ENV Forest Service Branch (ENV 2019a) PEM for the Boreal Shield (10 m by 10 m pixel, v1);
- the ENV Forest Service Branch (ENV 2019b) forest ecosite classification for the Boreal Shield and Taiga Shield Ecosite Groups (30 m by 30 m pixel);
- Northern Plant Ecology Lab (NPEL; University of Saskatchewan 2015) PEM for the Boreal Shield (30 m by 30 m pixel);
- the Saskatchewan Research Council's Northern Digital Land Cover (SRC 2000);
- Wildfire Management Branch burn severity mapping for 1988-2018 (ENV 2018);
- SPSA Wildfire History 1945-2020: Wildfires Greater Than 100 ha (SPSA 2020);
- Axiom orthorectified (i.e., processed to correct for distortions and assign accurate coordinates) aerial map (4.88 cm pixel; June 2019) of the existing exploration camp and access road;
- Environment and Climate Change Canada disturbance layer (Environment Canada 2015);
- ENV SK2 West Caribou Administration Unit disturbance layer (ENV 2019c); and
- Topographic Data of Canada Series CanVec 1:50,000 spatial data (NRCan 2019).

An initial ELC dataset of the RSA, which includes the LSA, was completed by combining the Omnia PEM (Annex VII.1), ENV (2014) forest ecosystem classification system for the Boreal Plain, and ENV (2019a) PEM for the Boreal Shield. Classification and delineation completed by Omnia during baseline studies were given priority over the ENV datasets as this information represented the most recent mapping within the Project study areas and is supported by field data collected. The forest ecosystem classification system for the Boreal Plain (ENV 2014) and the PEM for the Boreal Shield (ENV 2019a) were used to complete the ELC for the respective ecozones. Where required, pixel values from the Northern Digital Land Cover dataset were assigned equivalent Boreal Shield ecosite codes based on communications from the Forest Service Branch (Oldford 2019) or supplemented using the Northern Plant Ecology Lab (University of Saskatchewan 2015) predicted ecosite mapping for the Boreal Shield and the forest ecosite classification for the Boreal Shield and Taiga Shield Ecosite Groups (ENV 2019b). Watercourse and waterbody features were added to the dataset using the CanVec 1:50,000 spatial data layer. All available datasets were combined or overlaid to provide consistent classification across the RSA for the Project.

The Project is located within the Boreal Plain Ecozone, near the boundary between Boreal Plain and Boreal Shield Ecozones. The RSA overlaps both the Boreal Shield Ecozone and the Boreal Plain Ecozone. The Boreal Shield Ecozone extends across Canada from the Atlantic coast to northern Alberta (Government of Canada 2019). In Saskatchewan, the Boreal Shield Ecozone is located between the Boreal Plain Ecozone to the south and the Taiga Shield Ecozone to the north (Acton et al. 1998). The Boreal Shield Ecozone consists of boreal forest associated with the Canadian Shield and has two ecoregions: the Athabasca Plain and Churchill River Upland. Where soil conditions allow moderate tree growth, the climax vegetation community is closed black spruce (*Picea mariana)* forest with understory (i.e., vegetation layer below the forest canopy) of feather mosses. Mixed stands of jack pine (*Pinus banksiana*) and black spruce grow on thin upland soils, and tamarack (*Larix laricina*) are typically found within poorly drained lowlands. Fire is the dominant disturbance mechanism. White spruce (*Picea glauca*), balsam fir (*Abies balsamea*), trembling aspen (*Populus tremuloides*), and balsam poplar (*Populus balsamifera* spp. *balsamifera*) grow on more productive sites.

The Boreal Plain Ecozone covers portions of Manitoba, Saskatchewan, and Alberta with minor extensions into British Columbia and the Northwest Territories (Government of Canada 2019). Most of the ecozone is covered by boreal forest, although a portion along the southern boundary has been converted to agricultural cropland (Acton et al. 1998). In Saskatchewan, the Boreal Plain Ecozone has three ecoregions: Mid-Boreal Upland, where the Project is located; Mid-Boreal Lowland; and Mid-Boreal Transition. The climate is warmer than the Boreal Shield Ecozone, and consequently the productivity is higher and the diversity of vegetation is greater. Climax communities include closed-crown mixedwood and coniferous forest with trembling aspen, balsam poplar, and paper birch (*Betula papyrifera*) in the Mid-Boreal Transition Ecoregion and white and black spruce, tamarack, and jack pine in the Mid-Boreal Upland and Mid-Boreal Lowland ecoregions.

Ecosites used for the ELC are described based on their unique classification within each ecozone (e.g., Boreal Plain, Boreal Shield); however, McLaughlan et al. (2010) provide ecozonal synonyms that can be used to identify similar ecosites found in other ecozones. In some cases, ecosites are unique to an ecozone and have no documented equivalent, analogue, or similar condition in other ecozones.

13.2.6.1.1 Upland Ecosystem Mapping

Upland ecosystems consist of graminoid, shrub-dominated, and treed communities containing mainly facultative upland (i.e., species that can grow in either upland or alternate habitats), and obligate upland plant species (i.e., species that grow in upland ecosystems only). The water table is rarely above the substrate surface and vernal pooling (i.e., seasonal depressional wetlands) is minimal. Substrates consist of mineral parent materials, and organic matter accumulation less than 40 cm in depth. Moisture regime refers to the available moisture supply for plant growth estimated in relative or absolute terms. The moisture regime of uplands is moist or drier (McLaughlan et al. 2010). Upland ecosystems (i.e., upland ELC units) were mapped as polygons using the methods described in Section 13.2.6.1, Ecological Land Classification, and are defined in Table 13.2-3.

Table 13.2-3: Upland Ecological Land Classification Units within the Local and Regional Study Areas

Upland Ecosystem ELC Units
Boreal Plain
BP02 - Jack pine/lichen: moderately fresh sand
BP03 - Jack pine/feathermoss: moderately fresh loamy sand
BP04 - Jack pine - trembling aspen/feathermoss: moderately fresh sand
BP06 - Trembling aspen/beaked hazel/sarsaparilla: fresh loamy sand
BP07 - Trembling aspen - white birch/sarsaparilla: fresh loamy sand
BP11 - White birch - white spruce - balsam fir: fresh sandy clay loam
BP12 - Jack pine - spruce/feathermoss: fresh loamy sand
BP14 - Black spruce/Labrador tea/feathermoss: very moist sandy clay loam
BP16 - Balsam poplar - trembling aspen/prickly rose: fresh clay loam
Boreal Shield
BS02 - Lichen/felsenmeer - bedrock: dry nonsoil
BS03 - Jack pine/blueberry/lichen: moderately fresh sand
BS04 - Jack pine - black spruce/feathermoss: moderately dry sand
BS05 - Jack pine - white birch/feathermoss: moderately dry sand
BS06 - Jack pine - trembling aspen/green alder: moderately fresh loamy sand
BS07 - Black spruce/blueberry/lichen: moderately dry sand
BS08 - Black spruce - white birch/lichen: moderately dry sandy loam
BS09 - Black spruce - jack pine/feathermoss: moderately fresh sandy loam
BS10 - Black spruce - white birch/feathermoss: fresh sand
BS13 - White birch - black spruce - trembling aspen: moderately fresh sand
BS14 - White birch/lingonberry - Labrador tea: moderately dry sand
BS15 - Trembling aspen - white birch/green alder: moderately fresh loamy sand

Source: McLaughlan et al. 2010.
ELC = Ecological Land Classification.

13.2.6.1.2 Wetland Ecosystem Mapping

Wetlands are ecosystems containing soils that are saturated with moisture either permanently or seasonally and are further characterized by the presence of hydrophytic (i.e., water-adapted) vegetation (National Wetlands Working Group 1997). Wetlands can be open, shrub-dominated, or treed communities consisting of mainly facultative and obligate wetland plant species. The water table is seasonally or permanently at, near, or above the substrate surface. The soil substrate consists of organic materials greater than 40 cm in depth for peatlands, or saturated, hydric mineral soils, or bedrock with organic matter accumulation less than 40 cm in depth for mineral wetlands. Wetland ecosystems (i.e., wetland ELC units) were mapped as polygons using the methods described in Section 13.2.6.1, and are defined in Table 13.2-4.

Table 13.2-4: Wetland Ecological Land Classification Units within the Local and Regional Study Areas

Wetland Ecosystem ELC Units
Boreal Plain
BP18 - Black spruce - tamarack treed swamp: wet humic organic
BP19 - Black spruce treed bog: moderately wet fibric organic
BP20 - Labrador tea shrubby bog: wet fibric organic
BP21 - Graminoid bog: wet fibric organic
BP22 - Open bog: wet humic organic
BP23 - Tamarack treed fen: wet fibric organic
BP24 - Leatherleaf shrubby poor fen: wet fibric organic
BP25 - Willow shrubby rich fen: wet humic organic

Table 13.2-4: Wetland Ecological Land Classification Units within the Local and Regional Study Areas

Wetland Ecosystem ELC Units
BP26 - Graminoid fen: wet humic organic
BP27 - Open fen: wet fibric organic
BP28 - Seaside arrow-grass marsh: very moist humic organic
Boreal Shield
BS16 - Black spruce/balsam poplar/river alder swamp: very moist mesic organic
BS17 - Black spruce treed bog: very moist mesic organic
BS18 - Labrador tea shrubby bog: moderately wet mesic organic
BS19 - Graminoid bog: very wet humic organic
BS20 - Open bog: moderately wet fibric organic
BS21 - Tamarack treed fen: wet fibric organic
BS22 - Leatherleaf shrubby poor fen: Very wet fibric organic
BS23 - Willow shrubby rich fen: wet fibric organic
BS24 - Graminoid fen: very wet humic organic
BS25 - Open fen: wet mesic organic
BS26 - Rush sandy shore: very moist sand

Source: McLaughlan et al. 2010.
ELC = Ecological Land Classification.

13.2.6.1.3 Riparian Ecosystem Mapping

Riparian ecosystems are zones of interaction between aquatic and terrestrial environments within watersheds that function in linking terrestrial ecosystems to watercourses, stabilizing streambanks and floodplains, regulating stream temperatures, and providing a source of large woody debris and organic matter for aquatic ecosystems (Tschaplinski and Pike 2010). Riparian ecosystems in the RSA, which includes the LSA, were defined as the subset of upland and wetland cover types with riparian potential that intersected buffered watercourses and waterbodies. The identification of riparian ecosystems following this definition was completed spatially in a geographic information system platform. Riparian potential was assigned to the subset of upland forested land cover types with moist or wet soil moisture regimes and dominated by tree species associated with high soil moisture (i.e., balsam poplar, black spruce, and paper birch) and/or with a wet soil moisture regime dominated by white spruce. For upland non-forested cover types, riparian potential was assigned to a subset of land cover types with moist or wet soil moisture regimes that were dominated by shrubs, river sediments, or unspecified cover sub-types. Riparian potential was assigned to the subset of wetland cover types that were vegetated (i.e., excluded non-vegetated exposed land, anthropogenic areas, and water within wetlands).

Land cover types in the RSA with riparian potential were spatially intersected with a buffer surrounding natural watercourses and waterbodies based on the CanVec 1:50,000 spatial data (NRCan 2019) to capture the spatial correlation between land cover types with riparian potential and watercourses and waterbodies. Guidelines from Environment Canada (2013) recommend that streams be buffered by 30 m of naturally vegetated riparian area on both sides. Therefore, a 30 m buffer was applied around natural waterbodies (e.g., ponds) and to each side of watercourse features (e.g., creeks), which resulted in 60 m wide corridors. The ELC units identified within this initial buffer were further refined to more accurately capture the riparian influenced communities such as active floodplains and exclude ELC units that provide limited riparian interaction (i.e., bedrock outcrops, dry upland sandy coniferous sites). Riparian ELC unit distribution was considered continuous for individual ELC unit polygons, even where polygon edges exceeded the buffer width (i.e., polygons were not clipped at a 30 m buffer if riparian influenced vegetation communities extend beyond this distance). Polygons for ELC units with riparian potential were excluded where they were completely outside the buffer. Polygons for ELC units with no riparian potential that occurred in the buffer were also excluded. The method used to identify riparian ecosystems likely overestimates the outer edge of active floodplains for many of the smallest watercourses and waterbodies in the RSA and appropriately captures the active floodplains for the largest watercourses in the RSA. Vegetated ELC units with riparian potential are listed in Table 13.2-5.

Table 13.2-5: Riparian Ecological Land Classification Units within the Local and Regional Study Areas

Riparian Ecosystem ELC Units
Boreal Plain
BP07 - Trembling aspen - white birch/sarsaparilla: fresh loamy sand
BP11 - White birch - white spruce - balsam fir: fresh sandy clay loam
BP12 - Jack pine - spruce/feathermoss: fresh loamy sand
BP14 - Black spruce/Labrador tea/feathermoss: very moist sandy clay loam
BP16 - Balsam poplar - trembling aspen/prickly rose: fresh clay loam
BP18 - Black spruce - tamarack treed swamp: wet humic organic
BP19 - Black spruce treed bog: moderately wet fibric organic
BP20 - Labrador tea shrubby bog: wet fibric organic
BP21 - Graminoid bog: wet fibric organic
BP22 - Open bog: wet humic organic
BP23 - Tamarack treed fen: wet fibric organic
BP24 - Leatherleaf shrubby poor fen: wet fibric organic
BP25 - Willow shrubby rich fen: wet humic organic
BP26 - Graminoid fen: wet humic organic
BP27 - Open fen: wet fibric organic
BP28 - Seaside arrow-grass marsh: very moist humic organic
Boreal Shield
BS06 - Jack pine - trembling aspen/green alder: moderately fresh loamy sand
BS09 - Black spruce - jack pine/feathermoss: moderately fresh sandy loam
BS10 - Black spruce - white birch/feathermoss: fresh sand
BS13 - White birch - black spruce - trembling aspen: moderately fresh sand
BS15 - Trembling aspen - white birch/green alder: moderately fresh loamy sand
BS17 - Black spruce treed bog: very moist mesic organic
BS18 - Labrador tea shrubby bog: moderately wet mesic organic
BS19 - Graminoid bog: very wet humic organic
BS20 - Open bog: moderately wet fibric organic
BS21 - Tamarack treed fen: wet fibric organic
BS22 - Leatherleaf shrubby poor fen: very wet fibric organic
BS23 - Willow shrubby rich fen: wet fibric organic
BS24 - Graminoid fen: very wet humic organic
BS25 - Open fen: wet mesic organic
BS26 - Rush sandy shore: very moist sand

Source: McLaughlan et al. 2010.
ELC = Ecological Land Classification.

13.2.6.1.4 Fire Mapping

Fire disturbance data were applied to the RSA based on a 40-year fire history period (1981 to 2020; ECCC 2020). Burn severity data were determined by the Wildfire Management Branch (ENV 2018) using a normalized burn ratio calculation to classify burn severity and identify residuals within burned patches. Where available (1988 to 2018), the Wildfire Management Branch burn severity data were used to replace coarse polygon mapping associated with the Wildfire History data (SPSA 2020). Burn severity data used differentiated normalized burn ratio to back-cast fire (i.e., estimating past fire extents through historical remote sensing data) and post-fire residuals with greater accuracy than Wildfire History mapping. Burn severity data were not available for fire years 1981 to 1987, nor 2019 and 2020. In the absence of burn severity data, Wildfire History data were used to delineate fire extents.

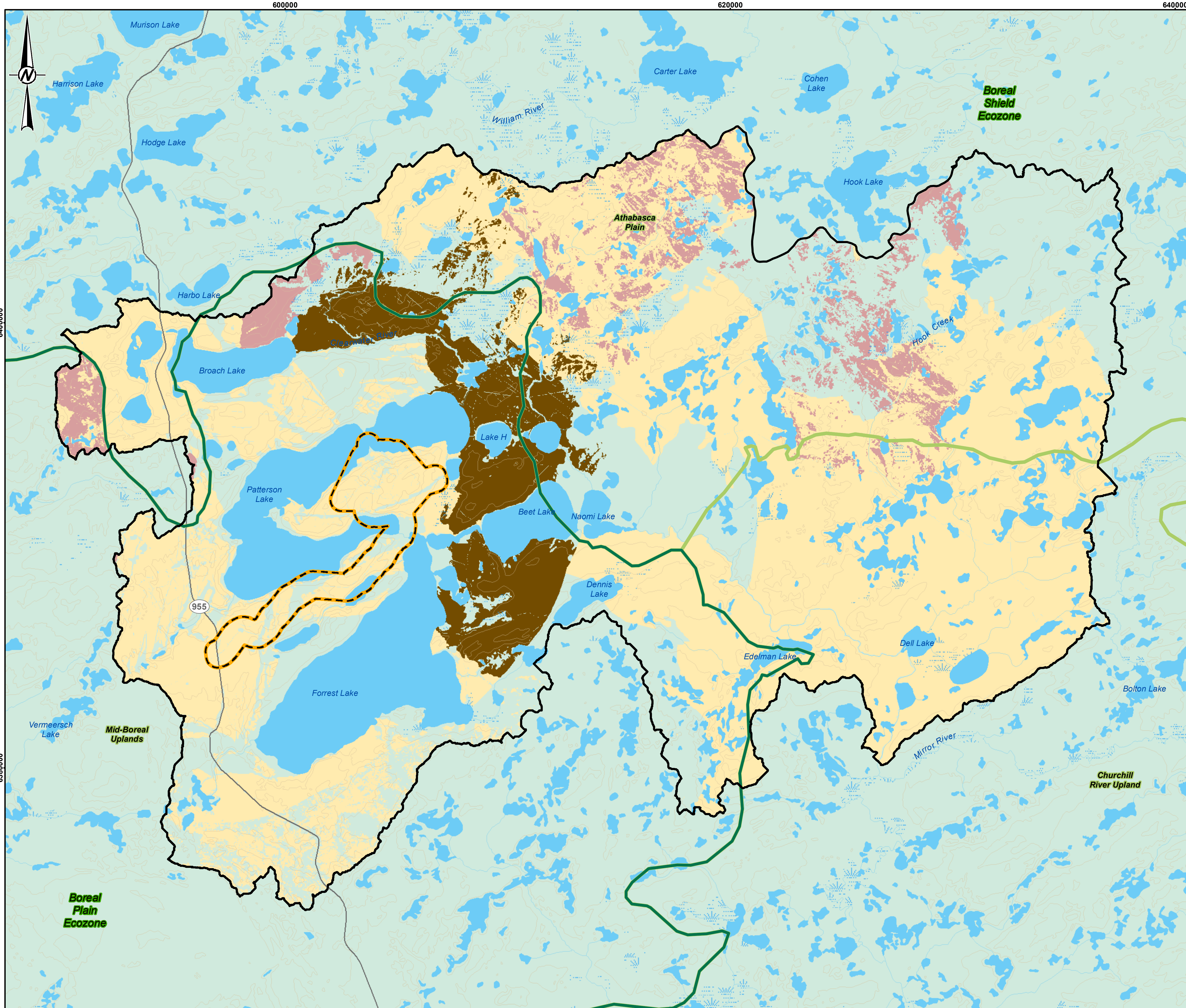
Fire disturbance data were overlaid onto the ELC mapping to provide an estimate of the amount and distribution of burns across the RSA and the types of ELC units affected by fire. Ecological Land Classification units within fire-disturbed areas were assigned a modifier (i.e., BU) to indicate the occurrence of previous fire disturbance. Burned areas five years old or less were grouped within a Recent Burn classification, as baseline surveys indicated post-fire conditions of recent burns were devoid of vegetation and could not be assigned to an ecosite (Annex VII.1). Burned ELC units more than five years old were assigned an additional burn modifier to indicate early-stage (i.e., BU/E; 6 to 20 years post-fire) and late-stage (i.e., BU/L; 21 to 40 years post-fire) regeneration classes based on the year of fire disturbance (Table 13.2-6).

Early- and late-stage modifiers for burned ELC units were used to further describe and inform the habitat suitability index models developed for wildlife VCs as early- and late-stage regeneration ELC units, which can provide habitat of different quality (Section 14; Appendix 14B, Wildlife Habitat Models). However, the approach for the vegetation assessment used two age groups to identify burned ELC units. The Recent Burn classification was used to describe general upland and wetland burns less than five years old (i.e., Recent Burn Upland, Recent Burn Wetland). Early- and late-stage burns were combined into a single burn category (i.e., Burned [BU]) for each affected ELC unit (e.g., BP04[BU]). The ELC for the vegetation assessment is consistent with the *Field Guide to the Ecosite of the Saskatchewan's Provincial Forests* (McLaughlan et al. 2010), which describes ecosites based on the average natural, mature site conditions (i.e., greater than 40 years old). Over the last 40 years, 65,296 ha (61%) of RSA has been burned in historical fires. However, historical fire extents overlap each other within the RSA; therefore, the amount of area within the RSA classified as burned is 61,997 ha (58%) (Figure 13.2-5).

Table 13.2-6: Fire Disturbance Ecological Land Classification Units within the Local and Regional Study Areas

Fire Disturbance ELC Units	ELC Modifier	Year	Fire Name	Extent of Fire within the RSA (ha)
Recent Burn (1-5 years)	n/a	2017	17BN-Vision	2,037
Recent Burn (1-5 years)	n/a	2016	16BN-Koop	0.7
Recent Burn (1-5 years)	n/a	2016	16BN-Brian	0.1
Early-Stage Regeneration (6-20 years)	BU/E	2015	15BN-Eagle	3,381
Early-Stage Regeneration (6-20 years)	BU/E	2012	12BN-Jet	498
Early-Stage Regeneration (6-20 years)	BU/E	2009	09LL-Patterson	670
Early-Stage Regeneration (6-20 years)	BU/E	2006	06LL-Murzin	586
Late-Stage Regeneration (21-40 years)	BU/L	1995	Tocker	6,216
Late-Stage Regeneration (21-40 years)	BU/L	1993	Sheep	225
Late-Stage Regeneration (21-40 years)	BU/L	1990	Jules	2,476
Late-Stage Regeneration (21-40 years)	BU/L	1981	Bigfish	4,688
Late-Stage Regeneration (21-40 years)	BU/L	1981	Sally	38,036
Late-Stage Regeneration (21-40 years)	BU/L	1981	October	6,482

Source: ENV 2018; SPSA 2020.
RSA = regional study area; ELC = Ecological Land Classification; n/a = not applicable.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED AREA
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- LOCAL STUDY AREA
- REGIONAL STUDY AREA

FIRE DISTURBANCE

- RECENT BURN (1-5 YEARS)
- EARLY-STAGE REGENERATION (6-20 YEARS)
- LATE-STAGE REGENERATION (21-40 YEARS)

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)

1. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. ECOZONES OBTAINED FROM AGRICULTURE AND AGRI-FOOD CANADA (AAFC).

PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

EXISTING FIRE DISTURBANCE IN THE LOCAL STUDY AREA AND THE REGIONAL STUDY AREA

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08	**FIGURE 13.2-5**	
CHECK	HH	2023-02-08		
REVIEW	JV	2023-02-08		

25mm

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

13.2.6.1.5 Anthropogenic Features Mapping

A baseline anthropogenic disturbance layer for the LSA and RSA was constructed from available datasets including:

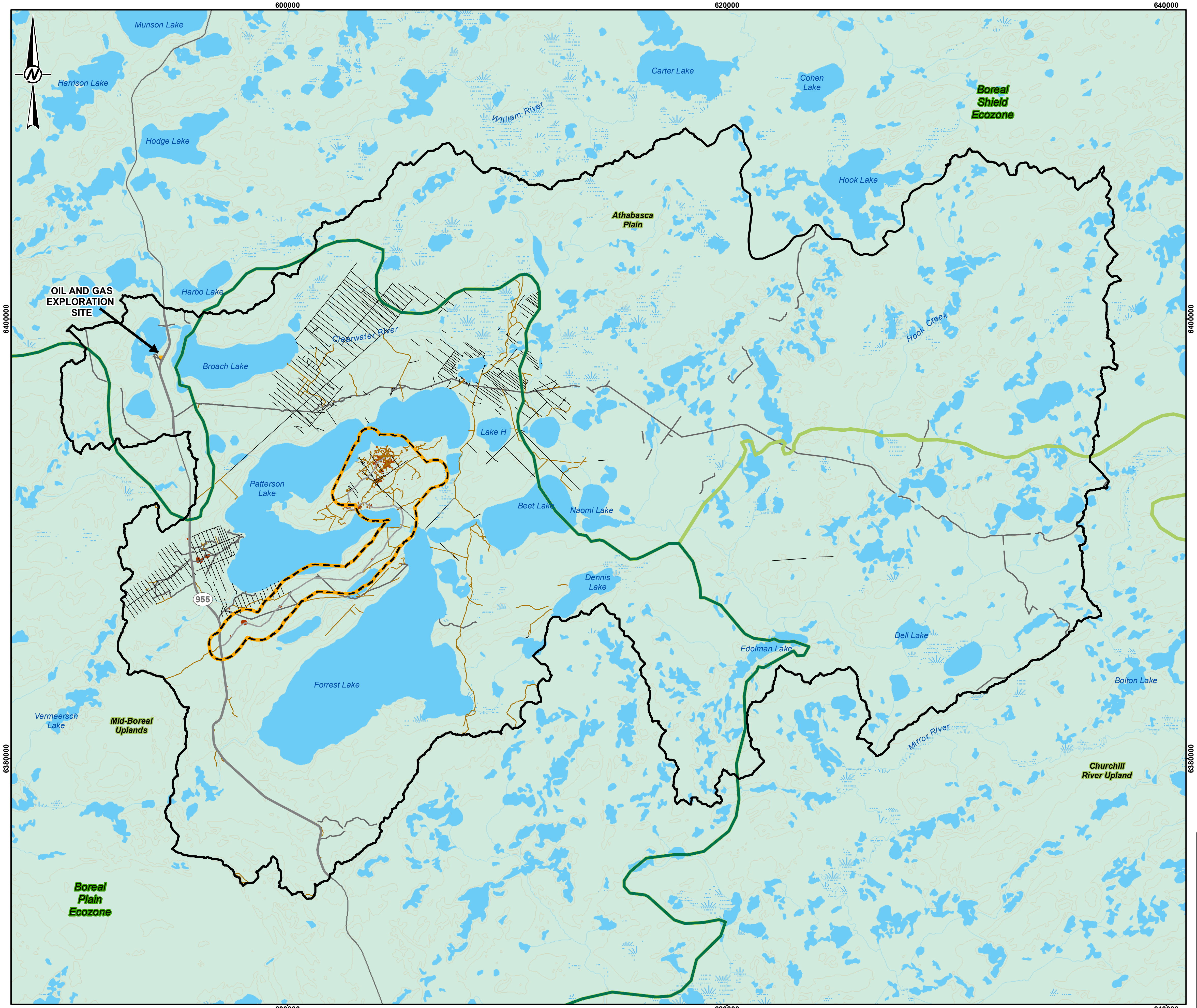
- Axiom orthorectified aerial map (4.88 cm pixel; June 2019) of the existing exploration camp and access road;
- anthropogenic features included in the Omnia baseline PEM (Annex VII.1);
- ENV SK2 West Caribou Administration Unit anthropogenic disturbance layer (2019); and
- Environment and Climate Change Canada anthropogenic disturbance layer (Environment Canada 2015).

Axiom orthorectified aerial mapping was used to complete the delineation of NexGen's existing exploration camp and access road. Visible disturbances were mapped within the exploration lease boundary at a scale of 1:5,000. Disturbance data mapped by Environment and Climate Change Canada, ENV, and Omnia were classified as either linear (e.g., roads and trails) or polygonal (e.g., outfitting camp, and oil and gas development) features. To calculate the amount of human disturbance in the study areas, buffers were applied to create footprints for each linear feature type (Table 13.2-7). The resulting disturbance layer was overlaid on the land cover map to characterize existing anthropogenic disturbance in the LSA and RSA (Figure 13.2-6).

Table 13.2-7: Existing Anthropogenic Disturbance Types within the Local and Regional Study Areas

Type of Disturbance	Feature Type	Footprint Width (m)
Cutlines/seismic lines	Linear/Polygon[(a)]	2 / Actual[(b)]
Trail	Linear/Polygon[(a)]	6 / Actual[(b)]
Rough road	Linear	12
Existing access road	Linear/Polygon[(a)]	Actual / Actual[(b)]
Highway 955	Linear	30
Existing exploration disturbance	Polygon	Actual[(b)]
Oil and gas development	Polygon	Actual[(b)]
Clearing	Polygon	Actual[(b)]
Outfitting (fishing) camp	Polygon	Actual[(b)]
Unknown disturbance[(c)]	Linear/Polygon[(a)]	15 / Actual[(b)]

a) Includes data from ENV and Environment and Climate Change Canada (i.e., linear) as well as digitized disturbance data (i.e., polygon) taken from the Axiom orthorectified aerial map.
b) Disturbance as identified in the Axiom orthorectified aerial map (4.88 cm pixel; June 2019) of the existing exploration camp and access road. Outside of the Axiom orthorectified aerial map extent disturbance types were assigned footprint widths as indicated.
c) Classified as unknown disturbance according to Environment and Climate Change Canada disturbance layer (Section 13.2.6.1, Ecological Land Classification) and may be characterized by infrastructure, unvegetated areas, and areas adjacent to settlements (e.g., reservoirs next to communities, gravel pits, and adjacent residential dwellings).
ENV = Saskatchewan Ministry of Environment.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED AREA
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- LOCAL STUDY AREA
- REGIONAL STUDY AREA

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

0 5 10
1:175,000 KILOMETRES

REFERENCE(S)

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PROJECT
NexGen Energy Ltd.
ROOK I PROJECT

TITLE
EXISTING ANTHROPOGENIC DISTURBANCE IN THE LOCAL STUDY AREA AND THE REGIONAL STUDY AREA

CONSULTANT
wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08	**FIGURE 13.2-6**	
CHECK	HH	2023-02-08		
REVIEW	JV	2023-02-08		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

13.2.6.2 Traditional Use Plant Species

As noted in Section 13.2.2, traditional use plant species and gathering activities are an important part of the culture and traditional ways of life of Indigenous Groups. Plant use varies and includes food, ceremonial, medicinal, and other purposes. Traditional use plant species were identified in the IKTLU Studies (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD VI: YNLR) and comments from CRDN (2019a) on the Cluff Lake Mine licence renewal.

Traditional use plant species included both specific and generic plant references and were cross-referenced against the Saskatchewan Conservation Data Centre vascular taxa list (SKCDC 2021a) to determine appropriate genera and species names. Where multiple potential species names were associated with a single traditional use plant species, the list of traditional use plant species was analyzed against those species observed during baseline surveys (Annex VII.1; Annex VII.2) to identify all related candidate species (Table 13.2-8).

Table 13.2-8: Traditional Use Plant Species Identified through Indigenous and Local Knowledge

Traditional Use Plant Species[a]	Scientific Name[b]	SKCDC Common Name[b]
Berries	*Rubus arcticus* ssp. *acaulis*	Nagoon berry
	Rubus pubescens	Dewberry
Birch	*Betula glandulosa*	Dwarf birch
	Betula occidentalis	River birch
	Betula papyrifera	Paper birch
	Betula pumila	Swamp birch
Blueberry	*Vaccinium myrtilloides*	Blueberry
Bulrushes	*Juncus alpinoarticulatus*	Northern green rush
	Juncus nodosus var. *nodosus*	Knotted rush
	Schoenoplectus acutus var. *acutus*	Hard-stemmed bulrush
Chokecherry	*Prunus virginiana* var. *viriginiana*	Chokecherry
Cloudberry	*Rubus chamaemorus*	Cloudberry
Cranberry	*Vaccinium oxycoccos*	Small cranberry
Cranberry, bog	*Vaccinium vitis-idaea*	Bog cranberry
Cranberry, low bush	*Viburnum edule*	Low-bush cranberry
Cranberry, high bush	*Viburnum opulus* var. *americanum*	High-bush cranberry
Dogwood	*Cornus sericea* ssp. *sericea*	Red-osier dogwood
Frog tail	*Sarracenia purpurea* ssp. *gibbosa*	Pitcherplant
Gooseberry	*Ribes americanum*	Wild black currant
	Ribes glandulosum	Skunk currant
	Ribes hudsonianum	Northern black currant
	Ribes oxyacanthoides var. *oxyacanthoides*	Bristly gooseberry
	Ribes triste	Swamp red currant
Jack pine	*Pinus banksiana*	Jack pine
Kinnikinnick	*Arctostaphylos uva-ursi*	Bearberry
Labrador tea	*Rhododendron groenlandicum*	Common Labrador tea
	Rhododendron tomentosum	Labrador tea
Mint	*Mentha canadensis*	Wild mint
Mosses[c]	n/a	n/a
Mushrooms[c]	n/a	n/a

Table 13.2-8: Traditional Use Plant Species Identified through Indigenous and Local Knowledge

Traditional Use Plant Species[(a)]	Scientific Name[(b)]	SKCDC Common Name[(b)]
Poplar	*Populus balsamifera* ssp. *balsamifera*	Balsam poplar
	Populus tremuloides	Trembling aspen
Raspberry	*Rubus idaeus* ssp. *strigosus*	American red raspberry
Rat root	*Acorus americanus*	Sweet flag
Saskatoon	*Amelanchier alnifolia* var. *alnifolia*	Saskatoon
Spruce	*Picea glauca*	White spruce
	Picea mariana	Black spruce
Strawberry	*Fragaria vesca* ssp. *americana*	American wild strawberry
	Fragaria virginiana ssp. *glauca*	Smooth wild strawberry
Sweetgrass	*Anthoxanthum hirtum* ssp. *arcticum*	Sweet grass
Tamarack	*Larix laricina*	Tamarack
Willow[(d)]	*Salix* spp.	Willow species

a) TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD VI: YNLR; CRDN 2019a.
b) SKCDC 2021a.
c) Traditional use plant species name reflects a broad group of plant or fungi species; therefore, the scientific name, SKCDC common name, and habitat information are not described.
d) Saskatchewan has over 40 willow species (*Salix* sp.*;* Harms 2017); therefore, the scientific name and SKCDC common name of all potential willow species are not described.
n/a = not applicable.

The availability of traditional use plant species in the LSA and RSA was estimated using the relative frequency and percent cover for each species recorded during baseline field surveys (Annex VII.1; Annex VII.2). For each species, the relative frequency (i.e., the proportion of the total number of observations recorded) was calculated for each upland and wetland ELC unit sampled, which provided an estimate of the potential to encounter a species within an ELC unit. The average percent cover of each traditional use plant species was also calculated based on the percent cover estimated from sample plots (Appendix 13A, Vegetation Ecosystem Availability in the Base Case, Application Case, and Reasonably Foreseeable Development Case). The relative frequency was multiplied by the average percent cover to provide an index of the relative availability (i.e., occupancy) for each traditional use plant species for each ELC unit sampled. The total availability of each species was then estimated by multiplying the relative availability by the area of each upland and wetland ELC unit for the Base Case, Application Case, and RFD Case within the LSA and RSA. An example with respect to blueberry (*Vaccinium myrtilloides*) is provided below.

Blueberry was observed 29 times within BS03 ELC units during the baseline surveys, and the average cover of blueberry observed across those plots was 5.7%. In total, 32 vegetation plots were completed in BS03 ELC units during the baseline surveys. Therefore, blueberry was encountered with a relative frequency of 90.6%. The average cover and relative frequency of blueberry in BS03 ELC units were multiplied (i.e., 0.0565 x 0.906) to determine the occupancy index (i.e., the anticipated cover of a species within an ELC unit based on its observed cover and the frequency it was encountered in the field) of blueberry within BS03 ELC units (i.e., 0.051). The occupancy index was then multiplied by the available area of BS03 ELC units within the LSA and RSA to estimate the potential area blueberry may occupy within a specific ELC unit (0.051 x 4,991.4 ha [available BS03 ELC units within the RSA] = 255.6 ha; (Appendix 13B, Traditional Use Plant Availability in the Base Case, Application Case, and Reasonably Foreseeable Development Case, Table 13B-2).

13.2.7 Project Interactions and Mitigations

Interactions (i.e., linkages) between Project components or activities, and the corresponding potential changes to measurement indicators, were identified by a pathway analysis that was then used to focus the residual effects assessment for the vegetation VCs (Section 6.7, Pathways Analysis). The first part of the analysis was to identify all potential effects pathways for all phases of the Project (Section 6.7.1, Identification of Project Interactions). Each pathway was initially considered to have a linkage to potential effects on vegetation VCs.

Potential pathways from Project activities to vegetation VCs were identified using the following:

- review of the Project description (Section 5) and potential effects scoping by the project development, environmental, and socio-economic teams for the Project;
- input from Indigenous, regulatory, and public engagement (Section 2), and Indigenous and Local Knowledge (Section 3);
- scientific knowledge;
- previous experience with mining projects; and
- consideration of potential effects identified from the Terms of Reference (Section 1; Appendix 1A).

Potential adverse effects of the Project were then identified, and practical mitigation was applied to avoid, minimize, and/or rehabilitate effects on vegetation VCs (Section 6.7.2, Identification of Mitigation). Avoidance and minimization are widely recognized as the most important approach for biodiversity conservation (BBOP 2021). Avoidance designs and actions integrated into the Project were developed iteratively between the Project's environmental and project development teams. Minimization techniques and technology were also identified and implemented collaboratively between Project teams.

Each potential effect pathway was evaluated using the proposed mitigation to predict whether the pathway had the potential to cause residual adverse effects (Section 6.7.3, Pathway Screening). A screening-level assessment was applied using Indigenous and Local Knowledge, scientific knowledge, logic, experience with similar developments, and an understanding of the effectiveness of mitigation (i.e., the level of certainty that mitigation would work) to assign each pathway to one of the following categories:

- **No pathway:** Analysis reveals that the pathway could be removed (i.e., the effect is avoided) by mitigation so that the Project would result in no measurable environmental change relative to existing conditions or guideline values and, therefore, would have no residual effect on vegetation.
- **Secondary pathway:** The pathway could result in a measurable but minor environmental change relative to existing conditions or guideline values, but this change would be sufficiently small that it would have a negligible residual effect on vegetation. Therefore, the pathway is not expected to contribute to effects of RFDs to cause a significant effect.
- **Primary pathway:** The pathway is likely to result in an environmental change relative to existing conditions or guideline values that could cause a greater than negligible effect on vegetation.

Project interactions determined as no pathway or secondary pathway were not carried forward for further assessment (Section 6.7.3). Primary pathways that could result in changes to the environment with one or more associated measurement indicator and have the potential to cause a greater than negligible effect on vegetation VCs were carried forward to the residual effects analysis and residual effects classification (Section 12.5, Residual Effects Analysis).

Reclamation was considered as a mitigation for removal of natural soils and vegetation. However, the time lag between Project effects and the reclamation of disturbed areas meant that an effect could be present, potentially for a long period of time before reclamation would be effective. Therefore, reclamation mitigation did not lead to a determination of no pathway.

Offsetting aims to achieve no net loss or potentially a net gain for vegetation VCs by addressing residual effects not already mitigated by avoiding, minimizing, and restoring. Offsets can include land purchases or land management decisions that avert loss and other kinds of conservation actions implemented outside of the direct and indirect Project effects, such as off-site ecosystem improvements or restoration. In general, an offset requirement is not expected for vegetation because the Project has been designed to avoid wetlands, and reclamation is anticipated to provide sufficient mitigation. However, if wetlands cannot be sufficiently reclaimed, offsets may be required to meet the *Federal Policy on Wetland Conservation* (Government of Canada 1991). Because offsetting is associated with uncertainty in terms of the specific actions that might be undertaken and, like reclamation, takes time to implement, offsets were not assumed to remove pathways. Instead, offsets, if required, were considered in the follow-up actions identified for each VC after residual effects were analyzed and characterized, and significance was determined (Section 13.7, Monitoring, Follow-Up, and Adaptive Management).

13.2.8 Residual Effects Analysis

The residual effects analysis measures and describes the effects of the Project on vegetation VCs relative to existing conditions. The residual effects analysis was conducted using the spatial boundaries (Section 13.2.3, Spatial Boundaries) and temporal boundaries (Section 13.2.4, Temporal Boundaries) identified for the assessment. Residual effects are described for each of the measurement indicators for the primary pathways identified for vegetation VCs in the LSA and RSA (Section 13.4.3, Primary Pathways). The residual effects analysis was completed for the Application Case and the RFD Case (Section 6.8, Residual Effects Analysis).

The residual effects analysis was completed by quantitively, where possible, and qualitatively, where necessary, predicting changes to vegetation VC measurement indicators in the LSA and RSA.

- **Ecosystem availability:** Changes in ecosystem availability were estimated quantitatively by calculating the change in ELC units associated with each ecosystem.
- **Ecosystem distribution:** Changes in ecosystem distribution, including effects on connectivity, were estimated qualitatively by examining changes to the size and distribution of ecosystem patches, and estimates were supported by the scientific literature.
- **Ecosystem condition:** Changes in the ecosystem condition were estimated qualitatively using the scientific literature on the potential effects of human developments primarily associated with dust deposition, changes in the amount of moisture and sunlight, and competition with invasive species.
- **Habitat availability for traditional use plants:** Changes in habitat availability for traditional use plants were estimated quantitatively by calculating differences in the occupancy of each traditional use plant species.
- **Habitat distribution for traditional use plants:** Changes in habitat distribution for traditional use plants, including the effects on connectivity, were estimated qualitatively by examining changes to the size and distribution of habitat patches, and estimates were supported by the scientific literature.

In addition, ecological health risks were examined for three terrestrial plant species/groups or receptors (i.e., lichen, blueberry, and Labrador tea [*Rhododendron tomentosum*]) and one aquatic receptor (i.e., macrophytes, such as sedges and bulrush) to determine the sensitivity of plants from exposure to COPCs through contact with surface water, soil, and sediment (TSD XXI). Results from the ecological health risk assessment were used to support the assessment of vegetation VCs.

13.2.9 Residual Effects Classification and Determination of Significance

The residual effects analysis uses a reasoned narrative to describe anticipated changes to each measurement indicator caused by the proposed Project and the associated effects on each VC. The residual effects analysis also considers effects from both the Project and RFDs. These narrative descriptions of anticipated effects represent the foundation for the residual effects classification and significance determination. Residual effects are summarized or classified in tabular form using effects criteria, which is intended to provide structure and comparability across VCs and intermediate components assessed for the Project (Section 6.9.1, Residual Effects Classification).

The residual effects classification uses direction, magnitude, geographic extent, duration, reversibility, frequency, and probability of occurrence as criteria. The approach to classify each residual effect criterion is provided in Table 13.2-9.

Table 13.2-9: Definitions Applied to Effects Criteria Classifications for the Assessment of Vegetation Valued Components

Criterion	Rating	Definition
Direction	Positive	Change in measurement indicator results in net improvement or benefit to the vegetation VC
	Neutral	Change in measurement indicator results in net balance to the vegetation VC
	Negative	Change in measurement indicator results in net degradation or loss to the vegetation VC
Magnitude	Qualitative narrative or numeric quantification	Qualitative narrative or numeric quantification supported by a reasoned narrative (e.g., change in measurement indicator is described by effect size)
Geographic extent	Maximum disturbance area	Change in measurement indicator is confined to the maximum disturbance area
	Local	Change in measurement indicator extends outside the Project footprint but within the LSA
	Regional	Change in measurement indicator extends beyond the LSA but is confined to the RSA
	Beyond regional	Change in measurement indicator extends beyond the RSA
Duration	Qualitative narrative or numeric quantification	Change in measurement indicator is described by effect duration (e.g., months, years, decades, or permanent)
Reversibility	Reversible	Change in measurement indicator is reversible within a clearly defined time period
	Irreversible	Change in measurement indicator is predicted to influence the vegetation VC indefinitely
Frequency	Occasional	Change in measurement indicator is expected to occur rarely (e.g., once or a few times)
	Periodic	Change in measurement indicator is expected to occur consistently at regular intervals or associated with temporal events (e.g., during dry summers)
	Continuous	Change in measurement indicator is expected to occur all the time
Probability of occurrence	Unlikely	Change in measurement indicator is not expected to occur, but is not impossible
	Possible	Change in measurement indicator may occur, but is not likely
	Probable	Change in measurement indicator is likely to occur, but is uncertain
	Certain	Change in measurement indicator will occur

LSA = local study area; RSA = regional study area; VC = valued component.

While most criteria could be assigned categorical ratings for vegetation VCs, predicted effect sizes were provided in specific terms (i.e., narrative or numeric quantification) in the residual effects characterization (Table 13.2-9). Similarly, duration was described in specific terms (e.g., years). Applying a category rating to a criterion such as magnitude might lead to confusion or misinterpretation of the effects assessment or result in the criterion not being easily categorized in a meaningful way. For example, characterizing magnitude solely using an ordinal scale (i.e., low, moderate, or high) for vegetation VCs is often not appropriate as additional context is required to properly characterize the effects. Universal effect size boundaries, such as a 20% change in a measurement indicator at the RSA or LSA scale used to define a high-magnitude effect, work poorly because these size boundaries fail to consider context. Ecological context can include ecosystems and plant species status and trends, current threats, the amount of historical disturbance in and beyond the RSA, resilience, and adaptability. Depending on the ecological context, and the context from the cumulative effects from previous and existing developments and activities that also interact with a VC, a 20% change from existing conditions in the study area may be required to cause a high magnitude effect on one VC, whereas a 2% change in the study area may be sufficient to cause a high magnitude effect for another VC (Section 6.9.1).

The significance of adverse residual effects on vegetation VCs was evaluated using the assessment endpoints as significance thresholds and followed the approach described in Section 6.9.2, Significance Determination. The significance of effects was predicted as a binary response, with effects classified as significant or not significant. Adverse residual effects were determined to be significant if the vegetation VC is not expected to be self-sustaining or ecologically effective at the scale of the RSA. The RSA was defined using ecological and watershed boundaries and is at a scale suitable for the application of cumulative effects and management strategies for most terrestrial VCs (Section 13.2.3.2, Environmental Assessment Boundaries); it is therefore an appropriate and relevant scale for evaluating ecosystem and population integrity for vegetation VCs.

Self-sustaining ecosystems are ecosystems that will be maintained into the future. They are healthy, functioning, and robust ecosystems that are capable of withstanding environmental change and accommodating stochastic processes (i.e., random or unpredictable changes in variables). Similarly, self-sustaining populations are not populations on the brink of extirpation (i.e., becoming locally extinct); they are healthy, robust populations with an ability to remain viable under changing environmental conditions and population processes (Reed et al. 2003). Ecologically effective ecosystems are those that can support the range of native species and ecological and evolutionary processes normally provided by the ecosystem (Noss 1990). These processes vary by ecosystem type and are not easily quantified.

Most ecosystems can adapt to, or otherwise accommodate, some changes without altering the functional state of the system, and some changes, positive or negative, to ecosystem availability, distribution, or condition would have little effect on self-sustaining and ecologically effective ecosystems at scales typically considered for conservation planning (Swift and Hannon 2010). However, the amount of change required to cause a significant adverse effect is heavily dependent on context, including ecological resilience and the effects of previous and existing developments on ecosystems. Both factors were considered when determining significance of the effects on vegetation VCs.

Ecosystem resilience is the capacity of an ecosystem to cope with disturbances without shifting into a qualitatively different state (Holling 1973). A resilient ecosystem can tolerate change and, if disturbed, can renew itself. This renewal can be accelerated with reclamation practices. If an ecosystem has limited resilience, it is vulnerable to the effects of disturbance such that it may shift into a different state and become functionally different (Folke et al. 2004). Ecosystem resilience can vary by VC, and this variation has important implications for assessing effects on ecosystem function (Peterson et al. 1998; Folke et al. 2004; Thompson et al. 2009).

Like ecosystems, plant populations can also adapt to disturbance through changes in physiology or reproductive characteristics (e.g., increased seed production) such that the integrity of the population remains unchanged. Adaptable species can accommodate substantial disturbance and sometimes thrive in highly modified environments, whereas species with low adaptability can accommodate little or no disturbance (Clarke et al. 2013; Elmqvist et al. 2003). As with ecosystems, plant populations exhibit variation in resilience or the ability to recover or bounce back from disturbance. Highly resilient plant species may recover quickly, whereas species with low resilience recover more slowly or may not recover at all.

Resilience, adaptability, and existing conditions provide important ecological context for the determination of significance. Existing conditions represent the combined effects of previous and current human activities and natural factors that have shaped the observed condition or patterns of each VC in the LSA and RSA. These conditions represent the starting point for assessing Project effects and were considered as context to help define how close each VC may be to its resilience limits when making the significance determination for the Project and RFDs.

Critical thresholds, such as the amount or distribution of ecosystems required to maintain ecosystem function or the ability of an ecosystem to accommodate changes in condition, are rarely known with certainty for ecosystem VCs. Similar challenges exist in defining the threshold for the amount and distribution of habitat required for self-sustaining traditional use plant populations. Moreover, ecological thresholds vary by community composition, landscape type, and spatial scale (Environment Canada 2013; Swift and Hannon 2010).

A detailed and transparent account of whether the predicted effects from the Project and other developments would cause the defined significance threshold to be exceeded was prepared for each VC by combining residual effects criteria, available scientific literature, data collected in the study areas, and logical reasoning (i.e., a weight of evidence or reasoned narrative approach). Using ecological context combined with residual effects criteria in a reasoned narrative, or rationale, to determine significance is a method accepted by the CEA Agency (2018). The determination of significance was also placed in context of how changes from the Project could influence biodiversity (Section 6.3.5, Biodiversity). Vegetation VCs and measurement indicators were reviewed holistically to evaluate potential for effects on biodiversity.

Confidence in the significance threshold prediction was identified and discussed for each VC as part of the reasoned narrative. If the threshold for where a significant effect would occur in the range of potential values had high uncertainty, and if the effect could be assessed as significant or not significant, a precautionary approach was applied, and the effect was identified as significant. The greater the uncertainty, the earlier a significant effect would be identified on the continuum of cumulative change from the Project and RFDs, where applicable.

13.2.10 Prediction Confidence and Uncertainty

The purpose of the assessment is to predict the future conditions for vegetation with the addition of the Project and the Fission Patterson Lake South Property and climate change. As with all predictions of future conditions, the predictions made in this assessment embody some degree of uncertainty. The assessment applied a precautionary (i.e., conservative) approach to address uncertainty by identifying the greatest magnitude, duration, and geographic extent of potential adverse effects when a range of outcomes were possible. Consequently, uncertainty was addressed in a manner that increased the level of confidence that residual effects were conservatively estimated. The key uncertainties for vegetation and the way they were addressed are presented as part of this assessment (Section 13.6).

13.2.11 Monitoring, Follow-Up, and Adaptive Management

Monitoring programs are proposed to address the uncertainties associated with the effects predictions and to evaluate the performance of mitigation. In general, monitoring is used to verify the effects predictions. Monitoring is also used to identify any unanticipated effects and to support the implementation of adaptive management to limit these effects. Typically, monitoring includes one or both of the following categories that may be applied during the Project lifespan:

- **Regulatory compliance monitoring:** monitoring activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation and conditions of approval, and NexGen commitments (e.g., monitoring for the introduction of invasive species).
- **Follow-up monitoring:** programs designed to test the accuracy of effects predictions, reduce or address uncertainties, determine the effectiveness of mitigation, or provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices (e.g., implementation of adaptive management). Results from these programs can be used to increase the certainty of effect predictions in future EAs.

Where relevant, conceptual monitoring programs would be proposed to confirm predictions and to address the uncertainties associated with the effects predictions and mitigation, and upon Project approval, would be included in the Integrated Management System.

The implementation of robust, long-term environmental testing and monitoring has also been requested by Indigenous Groups to verify protection of the environment, including community-led monitoring during Construction and Operations of the proposed Project (TSD IV: MN-S; TSD V.2: CRDN; TSD VI: YNLR).

In addition to environmental monitoring programs typically implemented for projects (i.e., as noted above), NexGen is working with local Indigenous Groups to implement independent environmental monitoring. In combination with standard Project monitoring processes, independent Indigenous monitoring would be used to verify Project performance and to determine if mitigations and controls are effective in protecting the receiving environment.

Adaptive management measures may also be proposed to address the uncertainties associated with the effects predictions and mitigation. The process for determining when, how, and where to use adaptive management would be described within the Integrated Management System Manual.

13.3 Existing Conditions

This subsection characterizes the existing conditions, or the Base Case, of vegetation ecosystems and traditional use plants VCs in the LSA and RSA, which provides context for assessing incremental and cumulative effects from the Project and RFDs (i.e., the Fission Patterson Lake South Property).

13.3.1 Upland Ecosystems

13.3.1.1 Ecosystem Availability

Upland ecosystems provide a diversity of ecological structure and function for plants and wildlife occupying the landscape. In the Base Case, uplands cover 2,172.6 ha (76.7%) within the LSA and 74,821.7 ha (69.6%) within the RSA (Table 13.3-1; Figure 13.3-1; Figure 13.3-2). Over half of upland vegetation ELC units in the LSA and RSA have been burned by forest fires in the last 40 years and are composed of regenerating forest vegetation, which is supported by observations from the CRDN about several forest fires occurring at Patterson and Forrest lakes in recent years (TSD V.2: CRDN). Burned uplands cover 1,803.0 ha (63.7%) of the LSA and 55,663.4 ha (51.8%) of the RSA. Undisturbed (i.e., ELC units that have not been burned in the last 40 years and have not been anthropogenically modified) uplands cover 369.6 ha (13.1%) of the LSA and 19,158.2 ha (17.8%) of the RSA.

The Jack pine/lichen (BP02) ELC unit is the most common undisturbed upland ELC unit within the LSA and covers 199.9 ha (7.1%) of the LSA. The Jack pine - black spruce/feathermoss (BS04) is the most common undisturbed upland ELC unit within the RSA and covers 6,158.9 ha (5.7%) of the RSA. Black spruce/Labrador tea/feathermoss (BP14) covers 19.1 ha (0.7%) and Jack pine - trembling aspen/feathermoss (BP04) covers 16.9 ha (0.6%) of the LSA and are the least abundant undisturbed upland types within the LSA. Several undisturbed upland ELC units within the RSA cover less than 0.1% (33.3 ha or less) of the RSA in the Base Case (Table 13.3-1). The BNDN and BRDN have also noted that jack pine dominates the Patterson Lake area, along with "rock" and "sand", and around Dyck Lake, the forest is not as thick as in other areas (TSD II: BNDN; TSD III: BRDN).

Early- to late-stage regenerating (i.e., burned in the last 6 to 40 years; Burned) ELC units within the LSA are anticipated to regenerate towards a Jack pine/lichen (BP02) ELC unit. Jack pine/lichen (Burned) (BP02[BU]) ELC units cover 1,641.2 ha (58.0%) of the LSA. Similarly, the burned ELC units within the RSA are associated with jack pine dominant ELC units including Jack pine/blueberry/lichen (Burned) (BS03[BU]), Jack pine - black spruce/feathermoss (Burned) (BS04[BU]), and Jack pine/lichen (Burned) (BP02[BU]), which cover 23,172.8 ha (21.6%), 9,065.2 ha (8.4%), and 8,990.9 ha (8.4%) of the RSA, respectively (Table 13.3-1). These results are supported by observations from the CRDN who noted that a recent forest fire at Patterson and Forrest lakes has removed a stand of large Jack pine that had survived several earlier fires (TSD V.2: CRDN). ELC units disturbed by fire in the last five years (i.e., Recent Burn Upland) are not found in the LSA and represent 6.6% (7,041.6 ha) of the RSA.

Table 13.3-1: Upland Ecosystem Availability in the Local and Regional Study Areas in the Base Case

Upland ELC Unit[a]	LSA		RSA	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
BP02 - Jack pine/lichen	199.9	7.1	2,791.3	2.6
BP03 - Jack pine/feathermoss	133.6	4.7	3,712.1	3.5
BP04 - Jack pine - trembling aspen/feathermoss	16.9	0.6	1,000.7	0.9
BP06 - Trembling aspen/beaked hazel/sarsaparilla	0.0	0.0	0.3	<0.1
BP07 - Trembling aspen - white birch/sarsaparilla	0.0	0.0	5.1	<0.1
BP11 - White birch - white spruce - balsam fir	0.0	0.0	3.2	<0.1
BP12 - Jack pine - spruce/feathermoss	0.0	0.0	219.2	0.2
BP14 - Black spruce/Labrador tea/feathermoss	19.1	0.7	129.8	0.1
BP16 - Balsam poplar - trembling aspen/prickly rose	0.0	0.0	33.3	<0.1

Table 13.3-1: Upland Ecosystem Availability in the Local and Regional Study Areas in the Base Case

Upland ELC Unit[(a)]	LSA		RSA	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
BS02 - Lichen/felsenmeer - bedrock	0.0	0.0	<0.1	<0.1
BS03 - Jack pine/blueberry/lichen	0.0	0.0	4,991.4	4.6
BS04 - Jack pine - black spruce/feathermoss	0.0	0.0	6,158.9	5.7
BS05 - Jack pine - white birch/feathermoss	0.0	0.0	1.1	<0.1
BS06 - Jack pine - trembling aspen/green alder	0.0	0.0	0.3	<0.1
BS07 - Black spruce/blueberry/lichen	0.0	0.0	2.6	<0.1
BS08 - Black spruce - white birch/lichen	0.0	0.0	<0.1	<0.1
BS09 - Black spruce - jack pine/feathermoss	0.0	0.0	23.1	<0.1
BS10 - Black spruce - white birch/feathermoss	0.0	0.0	0.1	<0.1
BS13 - White birch - black spruce - trembling aspen	0.0	0.0	11.9	<0.1
BS14 - White birch/lingonberry - Labrador tea	0.0	0.0	74.0	0.1
BS15 - Trembling aspen - white birch/green alder	0.0	0.0	<0.1	<0.1
Undisturbed upland subtotal	*369.6*	*13.1*	*19,158.2*	*17.8*
BP02(BU) - Jack pine/lichen (Burned)	1,641.2	58.0	8,990.9	8.4
BP03(BU) - Jack pine/feathermoss (Burned)	0.0	0.0	4,846.6	4.5
BP04(BU) - Jack pine - trembling aspen/feathermoss (Burned)	0.0	0.0	1,274.5	1.2
BP06(BU) - Trembling aspen/beaked hazel/sarsaparilla (Burned)	0.0	0.0	0.3	<0.1
BP07(BU) - Trembling aspen - white birch/sarsaparilla (Burned)	0.0	0.0	10.4	<0.1
BP11(BU) - White birch - white spruce - balsam fir (Burned)	0.0	0.0	0.9	<0.1
BP12(BU) - Jack pine - spruce/feathermoss (Burned)	0.0	0.0	4.4	<0.1
BP14(BU) - Black spruce/Labrador tea/feathermoss (Burned)	0.0	0.0	25.2	<0.1
BP16(BU) - Balsam poplar - trembling aspen/prickly rose (Burned)	161.9	5.7	1,070.4	1.0
BS02(BU) - Lichen/felsenmeer - bedrock (Burned)	0.0	0.0	0.7	<0.1
BS03(BU) - Jack pine/blueberry/lichen (Burned)	0.0	0.0	23,172.8	21.6
BS04(BU) - Jack pine - black spruce/feathermoss (Burned)	0.0	0.0	9,065.2	8.4
BS05(BU) - Jack pine - white birch/feathermoss (Burned)	0.0	0.0	5.1	<0.1
BS06(BU) - Jack pine - trembling aspen/green alder (Burned)	0.0	0.0	0.9	<0.1
BS07(BU) - Black spruce/blueberry/lichen (Burned)	0.0	0.0	5.6	<0.1
BS08(BU) - Black spruce - white birch/lichen (Burned)	0.0	0.0	0.1	<0.1
BS09(BU) - Black spruce - jack pine/feathermoss (Burned)	0.0	0.0	50.1	<0.1
BS13(BU) - White birch - black spruce - trembling aspen (Burned)	0.0	0.0	57.7	0.1
BS14(BU) - White birch/lingonberry - Labrador tea (Burned)	0.0	0.0	39.9	<0.1
BS15(BU) - Trembling aspen - white birch/green alder (Burned)	0.0	0.0	0.2	<0.1
Recent burn upland	0.0	0.0	7,041.6	6.6
Burned upland subtotal	*1,803.0*	*63.7*	*55,663.4*	*51.8*
Upland total	**2,172.6**	**76.7**	**74,821.7**	**69.6**
Summary				
Upland total	**2,172.6**	**76.7**	**74,821.7**	**69.6**
Wetland total	**553.2**	**19.5**	**32,211.3**	**30.0**
Anthropogenic disturbance	**104.7**	**3.7**	**457.8**	**0.4**
Grand Total	**2,831.6**	**100.0**	**107,490.7**	**100.0**

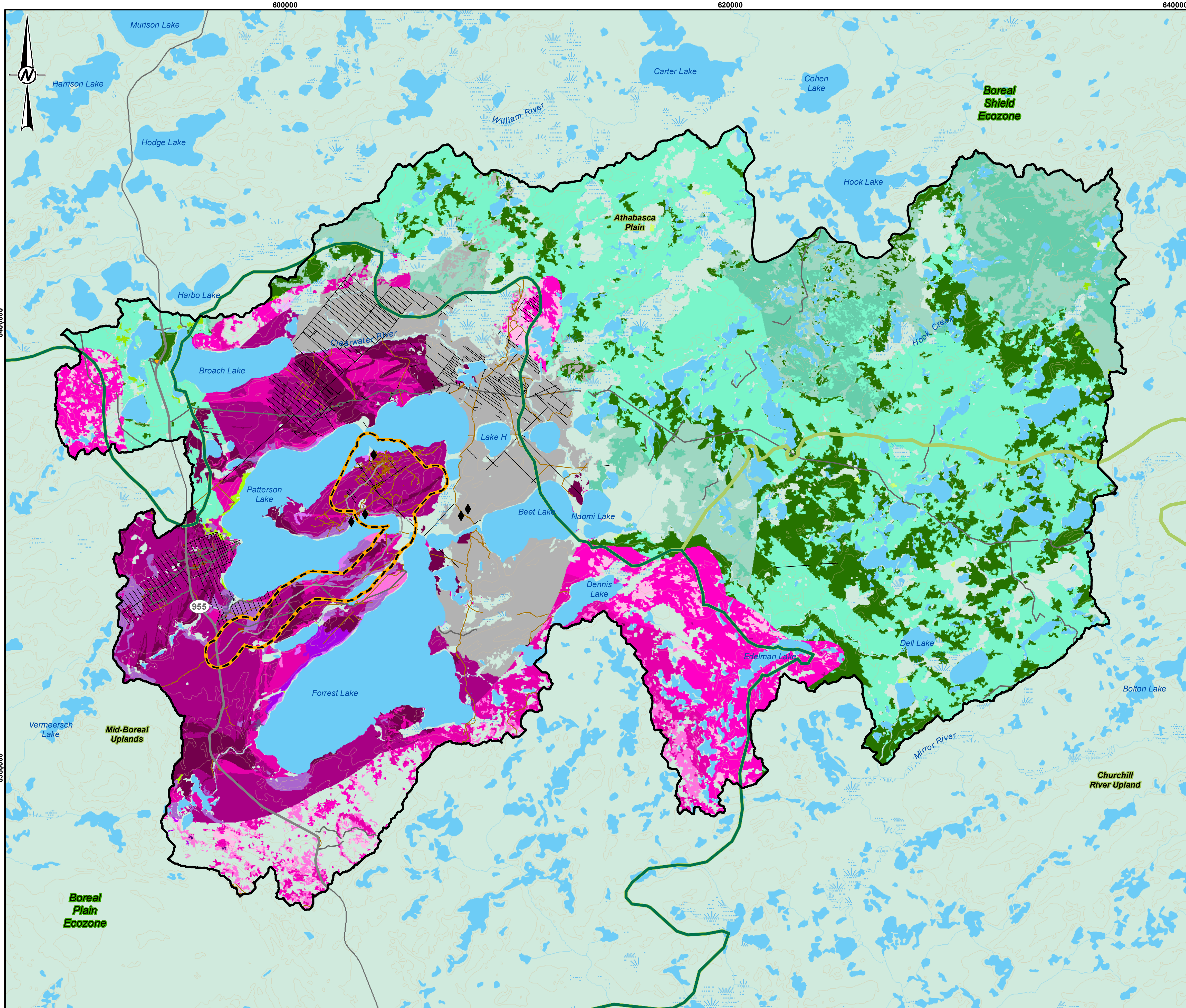
Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
a) McLaughlan et al. 2010.
ELC = Ecological Land Classification; LSA = local study area; RSA = regional study area; < = less than.

Existing anthropogenic disturbance covers 104.7 ha (3.7%) of the LSA and 457.8 ha (0.4%) of the RSA and includes Highway 955, a small amount of oil and gas development, the existing exploration camp, and the existing access road, trails, rough roads, and seismic lines/cutlines (Table 13.3-2). Disturbance in the Patterson Lake area by roads and cutlines was noted by the CRDN (TSD V.2: CRDN). Anthropogenic disturbance is discussed within the context of upland and wetland ecosystems; however, it is measured exclusive from either ecosystem (i.e., a cutline is not classified as either a wetland or an upland ecosystem). Highway 955 is an important transportation corridor within the RSA and covers 78.2 ha (0.1%). Clearings are largely adjacent to Highway 955.

Table 13.3-2: Existing Anthropogenic Disturbance in the Local and Regional Study Areas in the Base Case

Disturbance Type	LSA		RSA	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Clearing	33.0	1.2	46.1	<0.1
Cutline/seismic line	2.4	0.1	55.1	0.1
Highway 955	4.1	0.1	78.2	0.1
Existing exploration disturbance	2.8	0.1	5.9	<0.1
Oil and gas development	0.0	0.0	0.8	<0.1
Existing access road	23.2	0.8	24.6	<0.1
Rough road	6.6	0.2	136.9	0.1
Outfitting (fishing) camp	0.0	0.0	0.8	<0.1
Trail	32.6	1.2	102.1	0.1
Unknown	0.0	0.0	7.3	<0.1
Total	**104.7**	**3.7**	**457.8**	**0.4**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
LSA = local study area; RSA = regional study area; < = less than.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- LOCAL STUDY
- REGIONAL STUDY

UPLAND VASCULAR RARE PLANT SPECIES

- BEAUTIFUL SEDGE

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

UPLAND ECOLOGICAL LAND CLASSIFICATION UNIT

BP02	BP14	BS07
BP02 (BU)	BP14 (BU)	BS07 (BU)
BP03	BP16	BS08
BP03 (BU)	BP16 (BU)	BS08 (BU)
BP04	BS02	BS09
BP04 (BU)	BS02 (BU)	BS09 (BU)
BP06	BS03	BS10
BP06 (BU)	BS03 (BU)	BS13
BP07	BS04	BS13 (BU)
BP07 (BU)	BS04 (BU)	BS14
BP11	BS05	BS14 (BU)
BP11 (BU)	BS05 (BU)	BS15
BP12	BS06	BS15 (BU)
BP12 (BU)	BS06 (BU)	RECENT BURN (UPLAND)

0 5 10
1:175,000 KILOMETRES

REFERENCE(S)

1. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. ECOZONES OBTAINED FROM AGRICULTURE AND AGRI-FOOD CANADA (AAFC).

PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

UPLAND ECOSYSTEMS AND RARE PLANT SPECIES IN THE REGIONAL STUDY AREA, BASE CASE

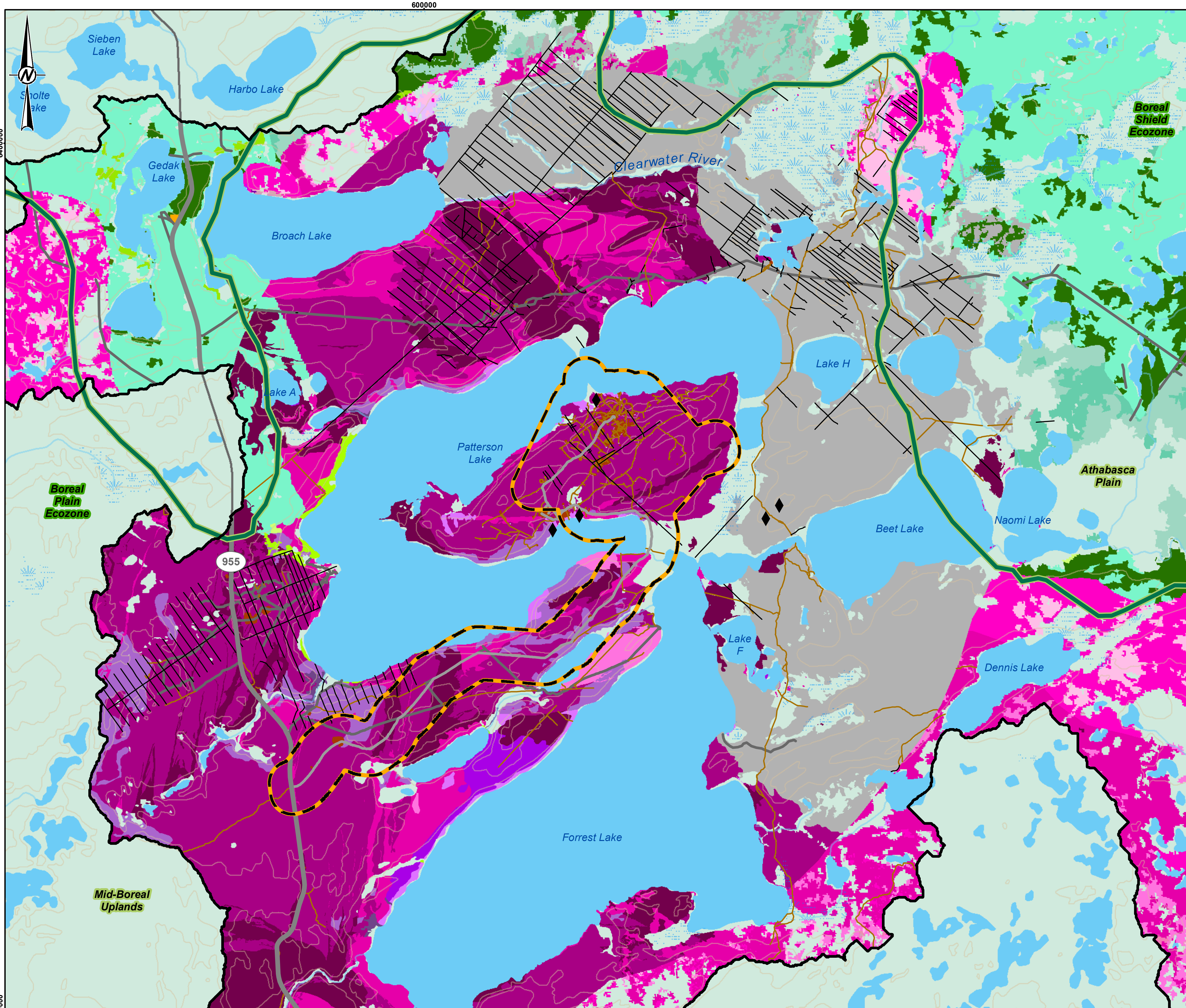
CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08	**FIGURE 13.3-1**	
CHECK	HH	2023-02-08		
REVIEW	JV	2023-02-08		

25mm

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- LOCAL STUDY
- REGIONAL STUDY

UPLAND VASCULAR RARE PLANT SPECIES

- BEAUTIFUL SEDGE

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

UPLAND ECOLOGICAL LAND CLASSIFICATION UNIT

- BP02
- BP02 (BU)
- BP03
- BP03 (BU)
- BP04
- BP04 (BU)
- BP06
- BP06 (BU)
- BP07
- BP07 (BU)
- BP11 (BU)
- BP12
- BP12 (BU)
- BP14
- BP14 (BU)
- BP16
- BP16 (BU)
- BS02 (BU)
- BS03
- BS03 (BU)
- BS04
- BS04 (BU)
- BS06 (BU)
- BS07 (BU)
- BS09
- BS09 (BU)
- BS13
- BS13 (BU)
- BS14
- BS14 (BU)
- RECENT BURN (UPLAND)

0 3 6
1:90,000 KILOMETRES

REFERENCE(S)

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PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

UPLAND ECOSYSTEMS AND RARE PLANT SPECIES IN THE LOCAL STUDY AREA, BASE CASE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08	FIGURE 13.3-2	
REVIEW	JV	2023-02-08		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

13.3.1.2 Ecosystem Distribution

The boreal forest landscape is heterogeneous, having been influenced by a variety of historical natural disturbance regimes, including fire, floods, insects, forest pathogens, and wind (NRCan 2020). Wildfire is considered the most important factor driving broad-scale forest patterns within the boreal forest (Urquizo et al. 2000; NRCan 2020). Large fires leave portions of the landscape unburned, resulting in a mosaic of burned and unburned areas and a complex arrangement of seral (i.e., intermediate successional community) stages or habitats that are fragmented and disconnected. Fires have played a dominant role structuring landscape patterns in the RSA and the Boreal Shield north of the Project site (Kansas et al. 2016; Skatter et al. 2017), and are representative of the conditions within the LSA.

Forests within the Boreal Shield Ecozone are mostly in a natural state, affected mainly by fire disturbance, whereas human activities, such as timber harvesting, road construction, and fire suppression, are greater in the Boreal Plain Ecozone. In Saskatchewan, forest management practices, including suppression practices, over the last number of decades have shifted the distribution of forested ELC units towards undisturbed or mature ELC units relative to what is expected under natural boreal forest conditions (ENV 2019d). In the Boreal Shield Ecozone, where fire suppression has been less intensive, the distribution of burned and early-stage regenerating ELC units is more common. Overall, the area burned in Canadian forests has increased over the past several decades because of various factors, including climate change (Gillett et al. 2004; Girardin et al. 2013).

Indigenous Groups have observed an increase in the frequency and magnitude of wildfires across their traditional lands in northern Saskatchewan in recent years (TSD V.1: CRDN; TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S). Birch Narrows Dene Nation reported that wildfires have played a role in decreasing wildlife populations and availability for hunting and trapping because of the removal of vegetation and availability of food sources for wildlife (TSD II: BNDN).

> Too many roads and lots of activity going on . . . . Plus, on top of that, they just let the fires burn in the north. And moose move on. They came back when they get some plants grow back to a certain height for new growth. Some areas don't – because all this area here, lots of it burned, like maybe four or five times. It keeps on burning and there's nothing that will grow back. The trees growing so tall before they get seedlings and they burn. And there's no topsoil. Just sand. They don't regenerate. And up north there, it takes forever to grow – trees to grow, eh? Because it's so far north . . . . So, that's why lots of animals don't go back to that kind of area. (TSD II: BNDN)

> Beaver is different. With the burnt country, they don't stay around. They move toward the green area, so the beavers are gone. (TSD II: BNDN)

> This used to be good trap line country before fires . . . . Now that's all burnt out. Larson Lake, Moss Lake, all those areas . . . . It burned over and over every year. (TSD II: BNDN)

> Yeah [ability to trap has changed over time]. Because of all the exploration and that, I have to switch routes once in a while or all the burns that are happening up there. . . . Less animals. Gas prices are going higher. Weather is unpredictable nowadays . . . . (TSD II: BNDN)

Over 80% of the upland ecosystems within the LSA are regenerating from forest fires that occurred in the last 40 years (Table 13.3-1; Figure 13.3-1; Figure 13.3-2). As a result of the fires, there are four undisturbed upland ELC units within the LSA. The Jack pine/lichen (BP02) and the Jack pine/feathermoss (BP03) ELC units are moderately well distributed within the LSA. In contrast, the Jack pine - trembling aspen/feathermoss (BP04) and the Black spruce/Labrador tea/feathermoss (BP14) ELC units are uncommon on the landscape (i.e., each covering less than 0.7% [19.1 ha]), which is a consequence of the frequent wildfires in the region, as fires favour the spread of jack pine (Acton et al. 1998). This predominance in the LSA of young, pine-leading forests aligns with knowledge shared by members of the BNDN, and their observations of the long-term effects of wildfires on vegetation and food sources for wildlife because of the slow rate of vegetation regrowth and lack of topsoil for plants to re-establish (TSD II: BNDN).In the absence of fire, the forest will tend to transition towards a black spruce dominated cover type, as the jack pine component eventually decreases (McLaughlan et al. 2010). Due to the high fire disturbance, black spruce forest is a less common or abundant cover type and is generally limited to islands, peninsulas, and other areas less prone to wildfire effects.

Natural fire regimes have the largest influence on ELC unit distribution in the RSA in the Base Case. Similar to the LSA, most upland ecosystems within the RSA are regenerating from forest fires that occurred within the last 40 years (Table 13.3-1; Figure 13.3-1; Figure 13.3-2). This is consistent with the wider Boreal Shield Ecozone (i.e., 47.0% being burned in the last 40 years; McLoughlin et al. 2019). Despite the presence of frequent and widespread fire events, other more common and well-distributed undisturbed upland ELC units in the RSA include Jack pine/lichen (BP02), Jack pine/feathermoss (BP03), Jack pine/blueberry/lichen (BS03), and Jack pine - black spruce/feathermoss (BS04). Undisturbed black spruce ELC units and many upland burned and undisturbed ELC units are not abundant on the landscape (i.e., each covering less than 0.1% [about 50 ha] of the RSA) and may be susceptible to further disturbance and fragmentation.

The RSA and Boreal Shield Ecozone to the north of the Project have some of the lowest levels of anthropogenic disturbance in the Canadian boreal forest (Kansas et al. 2016). Within the LSA, there are disturbances such as small roads, trails, and seismic lines that contribute to fragmentation of forest uplands. Linear disturbance within the LSA was determined to be 2.9 km/km^2, and 0.6 km/km^2 for the RSA. McLoughlin et al. (2019) describe the overall density of linear features within Saskatchewan's Boreal Shield as very low (0.1 km/km^2). In the RSA, existing human disturbance is aggregated in the northwest portion of the study area and includes infrastructure and activities such as Highway 955, oil and gas development, the existing exploration camp, and the existing access road, trails, and seismic lines / cutlines (Figure 13.3-1). In addition, a seasonal trail (i.e., rough road) to the Bolton Lake Wilderness Retreat Resort Lodge passes through the RSA in an east–west direction originating from Highway 955 and extending east on the north side of Patterson Lake, following the Cree Lake Trail, before turning south to extend to the lodge, which is located outside of the RSA (Bolton Lake Wilderness Retreat 2021). Access to the lodge via this trail occurs during the winter season (Figure 13.3-1).

Overall, fire is the primary driver of existing conditions on the landscape and has resulted in relatively few common well-distributed undisturbed ELC units across the LSA and RSA (i.e., 17.8% of the RSA has been undisturbed by fire in last 40 years). Approximately 7% (7,000 ha) of upland ELC units in the RSA have been disturbed by fire in the last 5 years, and about 45% (48,000 ha) have burned in the previous 6 to 40 years. Some common early- to late-stage regenerating ELC units (e.g., Jack pine/lichen [Burned] and Jack pine/feathermoss [Burned]) are well distributed in the RSA, but most of the burned ELC units within the RSA (i.e., 34,784.4 ha; 32.4%) is composed of small patches of regenerating ELC units with immature vegetation (i.e., average patch size of less than 13.7 ha).

13.3.1.3 Ecosystem Condition

In addition to direct loss of upland ecosystems, previous and existing anthropogenic disturbances (as discussed in Section 13.3.1.2) may have affected upland composition through adjacency or edge effects (e.g., ingress of invasive species and changes in moisture and sunlight; Foley et al. 2005). Dust deposition from road traffic can negatively affect surrounding vegetation by physically smothering the plant and altering processes such as photosynthesis, transpiration, growth, and germination (Farmer 1993). Dust deposition can also negatively affect vegetation by changing the soil chemistry, inhibiting the ability for plants to grow in the soil (Farmer 1993; Chen et al. 2017). Bryophytes and lichen are particularly sensitive to road dust, as the dust particles are readily trapped on their surfaces (Farmer 1993; Chen et al. 2017). Vehicles contribute to airborne pollutants, including metals and nitrogen, that are eventually deposited onto soils and plants (Bobbink et al. 1998; Peachey et al. 2009). The deposition of nitrogen from airborne pollutants can alter species composition and species diversity by changing soil nutrient availability and soil pH (Bobbink et al. 1998).

Indigenous Groups indicated that they are experiencing the effects of air and water pollution from existing or previous industrial developments, including from the Alberta oilsands region and the Cluff Lake Mine, which have impacted the health of the landscape and vegetation in the region (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; CRDN-JWG 2020a; MN-S-JWG 2019b). A BRDN member commented on how half the trees are different colours now, and every time it rains the trees look different, which was attributed to acid rain from Alberta (BRDN-JWG 2019b). Another BRDN member noted that the trees are dying from the “top down” which was perceived as a sign of poor air quality (BRDN-JWG 2019a). The MN-S described how fewer wildflowers, butterflies, and grasshoppers are observed now, which they attribute to pollution from the oil sands region near Fort McMurray (MN-S-JWG 2019b). The CRDN commented that they consider the area around the historic Cluff Lake Mine, and Patterson Lake where exploration activities have occurred in the past to have “unclean conditions” because of contamination, which has affected their ability to gather plants and berries in these areas (TSD V.2: CRDN).

NexGen understands the concerns of Indigenous Groups regarding existing air and water quality on vegetation and would implement environmental design features and mitigation to minimize potential Project effects (Section 13.4, Project Interactions and Mitigations). The EA approach for the Project includes predicted changes to air and water quality within the vegetation assessment in consideration of Indigenous Group concerns.

Existing edge effects from existing anthropogenic disturbances recorded at baseline provide an opportunity for changes in microclimate and non-native species to influence and degrade ecosystem condition (Haddad et al. 2015).

Fire is a widespread and common natural disturbance in the boreal forest, with fire cycles shorter than the lifespan of the dominant trees (Johnson et al. 2001). Large, stand-replacing crown fires (i.e., fires that spread through the forest canopy) are common in the boreal forest and are intense enough to burn through young and old stands (Johnson et al. 2001). A large proportion of the upland ELC units within the RSA have been burned within the last 40 years, reflecting a natural fire regime with little human involvement in fire suppression. The Jack pine/blueberry/lichen (BS03) and the Jack pine - black spruce/feathermoss (BS04) ELC units are the most common undisturbed upland ELC units with mature jack pine trees that are at least 60 years old (Annex VII.1). The Jack pine/blueberry/lichen (BS03) ELC units located within the RSA are composed of an average of 21 plant and lichen species and the Jack pine - black spruce/feathermoss (BS04) ELC unit was composed of an average of 18 plant and lichen species (Annex VII.1).

Baseline surveys found that the undisturbed Jack pine/blueberry/lichen (BS03) ELC unit has a characteristically pure canopy of jack pine, a scattered ericaceous (i.e., plants belonging to the *Ericaceae* family) shrub understory, a near continuous carpet of green reindeer and other lichens, and a substantial cover of needle litter (Annex VII.1). The Jack pine - black spruce/feathermoss (BS04) ELC unit was dominated by pure stands of jack pine or jack pine stands with small inclusions of trembling aspen and spruce. The understory consists mainly of ericaceous shrubs and green alder. The forest floor is predominantly feathermoss (Schreber's moss [*Pleurozium schreberi*]). This ELC unit is approximately 70 years old (Annex VII.1).

Mature deciduous-dominant ELC units (White birch/lingonberry - Labrador tea [BS14]) were observed during baseline surveys having a characteristically pure canopy of white birch. However, black spruce, white spruce, jack pine, and trembling aspen were also observed as part of the canopy. The understory consisted of ericaceous shrubs and scattered green alder, and sometimes willow, rose, and pin cherry. A moderate herbaceous layer was usually observed in combination with patches of Schreber's moss and scattered lichens. Generally, leaf litter tended to be high due to the abundance of birch in the overstory. This ELC unit is approximately 50 years old (Annex VII.1).

All undisturbed upland ELC units within the RSA were classified as mature (i.e., greater than 40 years old) based on tree core data from Annex VII.1 or McLaughlan et al. (2010). The age of undisturbed forested stands within the RSA varies from a minimum observed age of 50 years (BS14; BP11) to a maximum of 142 years (BS02), with an average age of undisturbed upland ELC units of 72 years. The most common ELC unit types (i.e., Jack pine/blueberry/lichen [BS03] and Jack pine - black spruce/feathermoss [BS04]) were observed to be 60 to 70 years old.

The most common burned ELC units within the RSA are Jack pine/blueberry/lichen (BS03[BU]) and Jack pine - black spruce/feathermoss (BS04[BU]). These results are supported by observations by the CRDN who noted that a recent forest fire at Patterson and Forrest lakes has removed a stand of large Jack pine that had survived several earlier fires (TSD V.2: CRDN). Baseline surveys observed that these sites were either early pioneer regenerating stage forest following a forest fire and dominated by low shrub understory or were late-stage regenerating forest dominated by a thick cover of tall jack pine shrubs (Annex VII.1). Blueberry and jack pine were the most common low shrub species observed, although leatherleaf was found in some plots. Scattered tall shrubs or residual stands of jack pine may be present within these sites. The ground cover was generally characterized by a high percentage cover of bare soil and litter (i.e., greater than 70%). Forbs, graminoids, mosses, and lichens were virtually absent in early-stage regenerating sites. Blueberry and reindeer lichen were more commonly observed in late-stage regenerating forests (Annex VII.1). Late-stage regeneration deciduous ELC units (e.g., BS13[BU]) were observed to be predominantly led by white birch. Low shrub layers supported blueberry, green alder, or Labrador tea, and ground cover consisted largely of litter and a sporadic distribution of a variety of lichen and bryophyte species (Annex VII.1).

No federally listed plant species (SARA or COSEWIC) were observed during the baseline plant community surveys conducted in 2018 by Omnia (Annex VII.1) and CanNorth (Annex VII.2). Five observations of one provincially tracked vascular plant species were documented in upland ecosystems (Annex VII.1; Annex VII.2; SKCDC 2021b), namely, beautiful sedge, an S3 ranked species (i.e., vulnerable - at moderate risk of extinction or elimination due to a restricted range, relatively few populations, or recent and widespread declines; NatureServe 2012). Beautiful sedge was found at five upland locations during the 2018 terrestrial surveys, including two individuals within a Black spruce/Labrador tea/feathermoss (BP14) ELC unit, 50 individuals within a Jack pine/lichen (BP02[BU]), and one individual within a Balsam poplar - trembling aspen/prickly rose

(BP16[BU]) ELC unit. Two observations without occurrence data were recorded within Recent Burn Upland ELC units (Annex VII.1; Annex VII.2; Figure 13.3-2).

Human-disturbed areas are susceptible to the introduction and establishment of invasive or non-native plant species (Andrews 1990; Bradley and Mustard 2006). No prohibited weed species designated under *The Weed Control Act* were identified within upland ecosystems in the LSA during the 2018 terrestrial baseline surveys (Annex VII.1; Annex VII.2). One nuisance species, dandelion (*Taraxacum officinale*), and one noxious species, narrow-leaved hawk's beard (*Crepis tectorum*), were observed in areas associated with existing or reclaimed anthropogenic disturbances (e.g., road rights-of-way) during 2018 field surveys (Annex VII.1). The distribution and infestation rank of the occurrences were not recorded (Annex VII.1). Additional introduced species (i.e., non-native species not designated under *The Weed Control Act*) were observed in association with anthropogenic disturbances and areas that have been actively seeded during reclamation (Annex VII.1). American mistletoe (*Arceuthobium americanum*), a widespread parasitic flowering plant of Saskatchewan's provincial forests, was observed by CanNorth (Annex VII.2) in several locations within and adjacent to the LSA. This species parasitizes trees and causes widespread stand death, which can increase the likelihood of fire and affect the ecological balance of the forest (Government of Saskatchewan 2016).

13.3.2 Wetland Ecosystems

13.3.2.1 Ecosystem Availability

Wetlands are ecosystems containing soils that are saturated with moisture either permanently or seasonally and are further characterized by the presence of hydrophytic (i.e., water-adapted) vegetation (National Wetlands Working Group 1997). Wetlands contribute to fish and wildlife habitat and recreational activities such as birding, store carbon from the atmosphere, and act as natural filters. Several different types of wetlands are mapped within the LSA and RSA, including swamps, bogs, fens, and water.

Medicinal plants, and some types of berries, are often found near wetlands or open water where traditional plant gathering takes place, as noted by a member of Ya'thi Néné Lands and Resources (YNLR): "I picked Labrador tea. It is all over in this area, in the country, in the muskegs, and eskers" (TSD VI: YNLR). The CRDN also commented on the importance of wetlands for supporting medicinal plants (TSD V.2: CRDN).

Although the amount of wetland ecosystems available before any human-related development in the LSA and RSA is not precisely known, minor changes to wetland ecosystem availability has likely occurred due to disturbances such as roads, trails, and seismic activity. In the Base Case, wetlands, including open water, cover 553.2 ha (19.5%) of the LSA and 32,211.3 ha (30.0%) of the RSA (Table 13.3-3; Figure 13.3-3; Figure 13.3-4). Open water covers 395.3 ha (14.0%) within the LSA and 18,821.8 ha (17.5%) within the RSA. Excluding open water, undisturbed wetlands represent 122.5 ha (4.3%) and 7,056.4 ha (6.6%) of the LSA and RSA, respectively. The Labrador tea shrubby bog (BP20) ELC unit is the most common or abundant undisturbed wetland ELC unit within the LSA and covers 57.6 ha (2.0%). The Black spruce treed bog (BP19) is the most abundant undisturbed wetland ELC unit within the RSA and covers 1,708.0 ha (1.6%). Most of the RSA consists of small patches of undisturbed wetlands, with an average patch size of 6.0 ha or less.

Over half of the LSA and RSA have been burned by forest fires in the last 40 years and are composed of regenerating forest vegetation. ELC units disturbed by fire in the last five years (i.e., Recent Burn Wetland) are not found in the LSA and represent 96.8 ha (0.1%) of the RSA. Early- to late-stage regenerating (i.e., burned in the last 6 to 40 years; Burned) wetland ELC units cover 35.5 ha (1.3%) of the LSA and 6,236.3 ha (5.8%) of the RSA. Some common early- to late-stage regenerating ELC units (e.g., Jack pine/lichen [Burned] and Jack pine/feathermoss [Burned]) are well distributed in the RSA, but most of the RSA is composed of small patches of regenerating ELC units with immature vegetation (i.e., average patch size of less than 9.0 ha).

Table 13.3-3: Wetland Ecosystem Availability in the Local and Regional Study Areas in the Base Case

Wetland ELC Units[(a)]	LSA		RSA	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
BP18 - Black spruce - tamarack treed swamp	0.0	0.0	21.9	<0.1
BP19 - Black spruce treed bog	52.9	1.9	1,708.0	1.6
BP20 - Labrador tea shrubby bog	57.6	2.0	1,254.7	1.2
BP21 - Graminoid bog	0.0	0.0	25.2	<0.1
BP22 - Open bog	0.0	0.0	7.8	<0.1
BP23 - Tamarack treed fen	0.8	<0.1	40.4	<0.1
BP24 - Leatherleaf shrubby poor fen	6.2	0.2	54.5	0.1
BP25 - Willow shrubby rich fen	4.5	0.2	317.1	0.3
BP26 - Graminoid fen	0.2	<0.1	263.3	0.2
BP27 - Open fen	0.0	0.0	32.8	<0.1
BP28 - Seaside arrow-grass marsh	0.0	0.0	64.3	0.1
BS17 - Black spruce treed bog	0.0	0.0	1,517.3	1.4
BS18 - Labrador tea shrubby bog	0.0	0.0	1,481.3	1.4
BS19 - Graminoid bog	0.0	0.0	0.2	<0.1
BS20 - Open bog	0.0	0.0	0.9	<0.1
BS21 - Tamarack treed fen	0.0	0.0	0.3	<0.1
BS22 - Leatherleaf shrubby poor fen	0.0	0.0	205.0	0.2
BS23 - Willow shrubby rich fen	0.0	0.0	4.5	<0.1
BS24 - Graminoid fen	0.0	0.0	41.8	<0.1
BS25 - Open fen	0.0	0.0	<0.1	<0.1
BS26 - Rush sandy shore	0.2	<0.1	15.2	<0.1
Undisturbed wetland subtotal	*122.5*	4.3	*7,056.4*	*6.6*
BP18(BU) - Black spruce - tamarack treed swamp (Burned)	0.0	0.0	49.9	<0.1
BP19(BU) - Black spruce treed bog (Burned)	35.5	1.3	2,240.8	2.1
BP20(BU) - Labrador tea shrubby bog (Burned)	0.0	0.0	82.2	0.1
BP21(BU) - Graminoid bog (Burned)	0.0	0.0	0.3	<0.1
BP23(BU) - Tamarack treed fen (Burned)	0.0	0.0	25.3	<0.1
BP24(BU) - Leatherleaf shrubby poor fen (Burned)	0.0	0.0	11.6	<0.1
BP25(BU) - Willow shrubby rich fen (Burned)	0.0	0.0	142.0	0.1
BP26(BU) - Graminoid fen (Burned)	0.0	0.0	401.6	0.4
BP28(BU) - Seaside arrow-grass marsh (Burned)	0.0	0.0	109.9	0.1
BS16(BU) - Black spruce/balsam poplar/river alder swamp (Burned)	0.0	0.0	<0.1	<0.1
BS17(BU) - Black spruce treed bog (Burned)	0.0	0.0	1,540.3	1.4
BS18(BU) - Labrador tea shrubby bog (Burned)	0.0	0.0	1,052.9	1.0
BS19(BU) - Graminoid bog (Burned)	0.0	0.0	0.1	<0.1
BS20(BU) - Open bog (Burned)	0.0	0.0	2.2	<0.1

Table 13.3-3: Wetland Ecosystem Availability in the Local and Regional Study Areas in the Base Case

Wetland ELC Units[a]	LSA		RSA	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
BS21(BU) - Tamarack treed fen (Burned)	0.0	0.0	7.0	<0.1
BS22(BU) - Leatherleaf shrubby poor fen (Burned)	0.0	0.0	411.4	0.4
BS23(BU) - Willow shrubby rich fen (Burned)	0.0	0.0	33.1	<0.1
BS24(BU) - Graminoid fen (Burned)	0.0	0.0	89.1	0.1
BS25(BU) - Open fen (Burned)	0.0	0.0	0.1	<0.1
BS26(BU) - Rush sandy shore (Burned)	0.0	0.0	36.6	<0.1
Recent burn wetland	0.0	0.0	96.8	0.1
Burned wetland subtotal	*35.5*	1.3	*6,333.1*	*5.9*
Water	395.3	14.0	18,821.8	17.5
Wetland total	**553.2**	**19.5**	**32,211.3**	**30.0**
Summary				
Wetland total	**553.2**	**19.5**	**32,211.3**	**30.0**
Upland total	**2,172.6**	**76.7**	**74,821.7**	**69.6**
Anthropogenic disturbance	**104.7**	**3.7**	**457.8**	**0.4**
Grand total	**2,831.6**	**100.0**	**107,490.7**	**100.0**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
a) McLaughlan et al. 2010.
LSA = local study area; RSA = regional study area; < = less than.

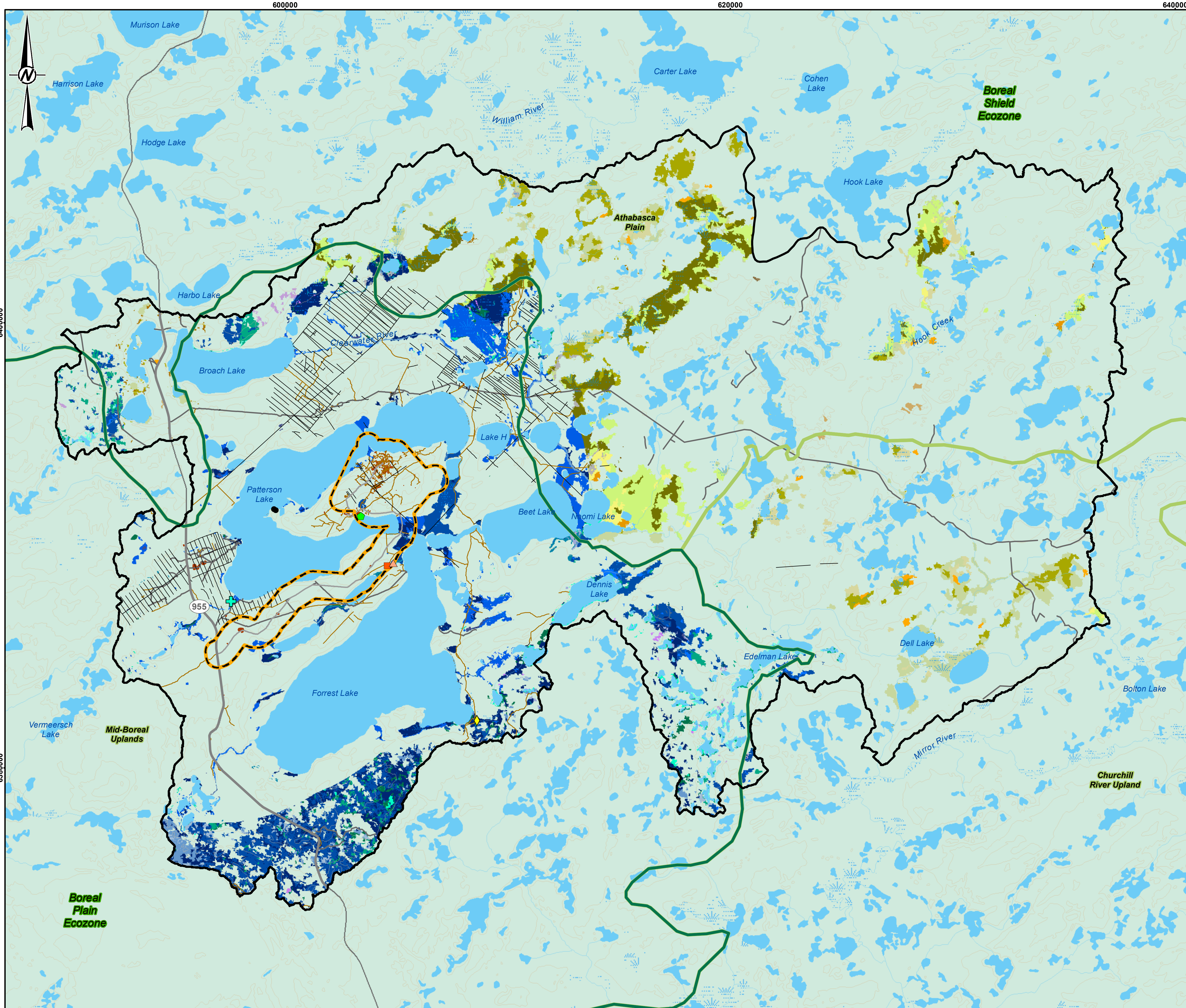
13.3.2.2 Ecosystem Distribution

Wetland ecosystems are limited in distribution within the LSA but are well distributed across the RSA (Figure 13.3-3; Figure 13.3-4). It is probable that wetland ecosystems within the LSA had greater connectivity prior to human development activities and disturbances such as roads, trails, and seismic activity. The effects of human development activities on wetland ecosystem distribution are associated with water flow interception and culverts for roads and with changes in water quantity, which may have caused smaller wet areas to dry out, thereby reducing wetland connectivity. The RSA and Boreal Shield Ecozone to the north of the Project site have some of the lowest levels of anthropogenic disturbance in the Canadian boreal forest (Kansas et al. 2016). As a result, most wetlands within the RSA are distributed naturally across the landscape and have had minimal reductions in connectivity associated with human development activities. Environment Canada (2013) states that priorities should be made to maintain wetlands in close proximity to one another and to reduce fragmentation of wetland habitat. Fragmentation of wetlands can lead to reduced habitat for species that require contiguous patches and may inhibit effective dispersal (Environment Canada 2013).

Two undisturbed wetland ELC units are common and more frequently distributed within the LSA: the Black spruce treed bog (BP19) and the Labrador tea shrubby bog (BP20) ELC units. There are five additional wetland ELC units found within the LSA (i.e., Tamarack treed fen [BP23], Leatherleaf shrubby poor fen [BP24], Willow shrubby rich fen [BP25], Graminoid fen [BP26], and Rush sandy shore [BS26]) and though they are uncommon on the landscape, these five wetland ELC units are distributed in close proximity to each other and to lakes.

Fire is a widespread and common natural disturbance within the RSA. However, wetland ELC units are generally less prone to wildfire compared to uplands. Within the LSA, 35.5 ha (1.3%) has been affected by previous wildfire events and is limited to Black spruce treed bog (BP19[BU]) ELC units. Within the RSA, fire has affected a wider diversity of wetland ELC units and a greater proportion of the total wetland area (i.e., 6,331 ha; 5.9%). Following wildfire disturbance, many wetland ELC units will typically return to their former condition (McLaughlan et al. 2010) and are anticipated to be structurally and compositionally similar to their undisturbed counterparts.

Common and well-distributed undisturbed wetland ELC units in the RSA include the Black spruce treed bog (BP19), Labrador tea shrubby bog (BP20), Black spruce treed bog (BS17), and Labrador tea shrubby bog (BS18). These observations align with knowledge shared by a member of YNLR about the abundance of Labrador tea in the area, particularly in the muskegs and eskers (TSD VI: YNLR). Members of the BRDN also described a large muskeg area approximately 50 square miles in size just outside of Dillon, and muskeg near Patterson Lake (TSD III: BRDN). However, similar to upland ELC units, most of the RSA is composed of small patches of regenerating wetland ELC units with immature vegetation (i.e., each covering less than 1.0% [about 1,000 ha] of the RSA), which may make these ELC units susceptible to further disturbance and fragmentation.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- LOCAL STUDY
- REGIONAL STUDY

WETLAND VASCULAR RARE PLANT SPECIES

- ENGLISH SUNDEW
- HUDSON BAY SEDGE
- NORTHERN LADY-FERN
- SCHEUCHZER COTTON-GRASS
- WATER LOBELIA
- HEART-LEAVED TWAYBLADE

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

WETLAND ECOLOGICAL LAND CLASSIFICATION UNIT

BP18	BP25 (BU)	BS20 (BU)
BP18 (BU)	BP26	BS21
BP19	BP26 (BU)	BS21 (BU)
BP19 (BU)	BP27	BS22
BP20	BP28	BS22 (BU)
BP20 (BU)	BP28 (BU)	BS23
BP21	BS16 (BU)	BS23 (BU)
BP21 (BU)	BS17	BS24
BP22	BS17 (BU)	BS24 (BU)
BP23	BS18	BS25
BP23 (BU)	BS18 (BU)	BS25 (BU)
BP24	BS19	BS26
BP24 (BU)	BS19 (BU)	BS26 (BU)
BP25	BS20	RECENT BURN (WETLAND)

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)

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PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

WETLAND ECOSYSTEMS AND RARE PLANT SPECIES IN THE REGIONAL STUDY AREA, BASE CASE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08	FIGURE 13.3-3	
REVIEW	JV	2023-02-08		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

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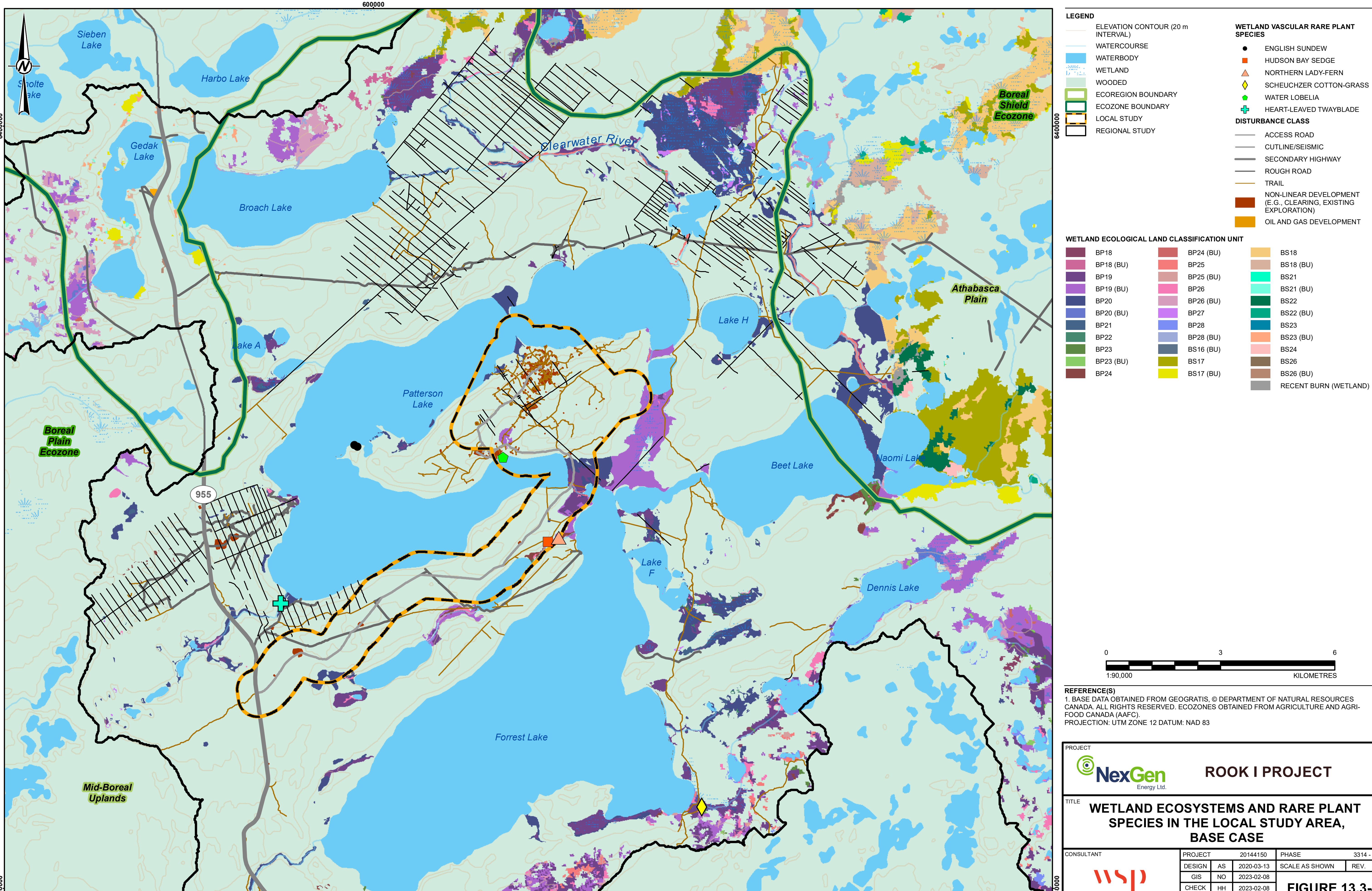

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1. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. ECOZONES OBTAINED FROM AGRICULTURE AND AGRI-FOOD CANADA (AAFC).
PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT
NexGen Energy Ltd.
ROOK I PROJECT

TITLE
WETLAND ECOSYSTEMS AND RARE PLANT SPECIES IN THE LOCAL STUDY AREA, BASE CASE

CONSULTANT
wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08	FIGURE 13.3-4	
CHECK	HH	2023-02-08		
REVIEW	JV	2023-02-08		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
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13.3.2.3 Ecosystem Condition

The hydrological regime is one of the most important factors determining wetland ecosystem function and the health of associated wetland plants (Welsh et al. 1995; Carter 1997; Sheldon et al. 2005). The composition and richness of species in a wetland plant community is influenced by the duration, timing, and frequency of saturation and the depth of water (Sheldon et al. 2005). Disturbance to one or all of these factors can result in changes to the distribution and richness of plant and wildlife species in wetlands, although individual species will respond differently to changes in the hydrological regime.

Natural disturbance events such as fires and floods are the primary factors affecting wetland condition within the LSA and RSA. Some wetland types do not burn regularly because of their inherent wet nature and a lack of flammable materials. However, peatlands and other forested wetlands can accumulate organic fuels and can burn, particularly where black spruce and lichen are dominant portions of the community (Smith and D'Eon 2006; Whitman et al. 2010).

Construction of transportation routes, including seasonal roads and trails, has likely degraded a small number of wetland ecosystems in the LSA and RSA through clearing vegetation, removing riparian forests, destabilizing banks, and altering upstream and downstream geomorphology. Additionally, vehicle traffic can contribute to airborne nitrogen pollutants, which are eventually deposited onto soil and vegetation adjacent to transportation routes (Bobbink et al. 1998). Wetland ecosystems such as bogs are particularly sensitive to nitrogen pollutants since the plant species that grow within them are adapted to low levels of nitrogen and a change in nitrogen availability may cause a shift in the species composition (Bobbink et al. 1998). However, anthropogenic disturbances cover only 104.7 ha (3.7%) within the LSA and 457.8 ha (0.4%) within the RSA and have not likely resulted in ecologically measurable changes to wetland condition.

Existing anthropogenic disturbance (as discussed in Section 13.3.1.2) and edge effects likely result in reduced ecosystem condition, as forest and wetland edges are typically exposed to more sunlight and are drier, windier, and warmer than the forest interior (Chen et al. 1999). Edge effects from existing anthropogenic disturbances recorded at baseline provide an opportunity for changes in microclimate and non-native species to influence and degrade the ecosystem condition (Haddad et al. 2015).

The Black spruce treed bog (BP19) ELC unit accounts for the largest proportion of both burned and unburned wetland ELC units in the RSA. The Black spruce treed bog (BP19) ELC units found within the RSA are characterized by mature black spruce stands, which are at least 80 years old, and a Labrador tea (*Rhododendron groenlandicum*) and sphagnum moss (*Sphagnum* spp.) understory; these ELC units are, on average, composed of 21 plant and lichen species (Annex VII.1).

Baseline surveys found that the Black spruce treed bog (BP19) ELC unit has low tree and shrub species richness but often contains a high diversity of moss and lichen species (Annex VII.1). Overall structural diversity is moderate. Black spruce on these sites usually represents all ages as the sphagnum moss layer encourages vegetative reproduction by branch layering. Sphagnum is also a suitable seed bed for black spruce germination provided that the moss is not Girgensohn's (*Sphagnum girgensohnii*) or another fast-growing peat moss that can outcompete and smother black spruce seedlings. Despite the wet conditions, black spruce can remain free from rot for long periods. In the absence of disturbance, these sites would likely remain a treed bog (Annex VII.1).

Stand age for wetland ELC units within the RSA was based on tree core data from Omnia (Annex VII.1) or McLaughlan et al. (2010). Tree age of undisturbed wetland ELC units within the RSA varies from a minimum observed age of 27 years (BP25, BS23) to a maximum of 168 years (BS25), with an average age of undisturbed wetland ELC units of 67 years. However, age for wetland ELC units was restricted to forested wetland ELC units, as some wetlands support only limited tree or shrub cover (e.g., Graminoid bog [BP21]). The most common treed wetland ELC units (i.e., Black spruce treed bog [BP19] and Black spruce treed bog [BS17]) were observed to be 80 years old.

A review of the provincial HABISask database (SKCDC 2021b) identified one element occurrence of the provincially tracked species heart-leaved twayblade (*Listera cordata* var. *cordata*) in a wetland ELC unit within the RSA, with 17 individuals observed (Figure 13.3-4). Heart-leaved twayblade is an S2 ranked species (i.e., imperiled - at high risk of extinction or elimination due to restricted range, few populations, or steep declines; NatureServe 2012).

No federally listed plant species (SARA or COSEWIC) were observed in wetland ecosystems during the baseline surveys conducted in 2018 (Annex VII.1; Annex VII.2). However, six observations of five provincially tracked vascular plant species were documented in wetland ecosystems (Annex VII.1; Annex VII.2). The provincially tracked vascular plant species documented within wetland ecosystems were English sundew (*Drosera anglica*), Hudson Bay sedge (*Carex heleonastes*), northern lady-fern (*Athyrium filix-femina* var. *angustum*), Scheuchzer cotton-grass (*Eriophorum scheuchzeri*), and water lobelia (*Lobelia dortmanna*). English sundew, Hudson Bay sedge, northern lady-fern, and water lobelia are ranked as S3 species (i.e., vulnerable - at moderate risk of extinction or elimination due to a restricted range, relatively few populations, recent and widespread declines, or other factors; NatureServe 2012). Scheuchzer cotton-grass is ranked as an S2 species (i.e., imperiled - at high risk of extinction or elimination due to restricted range, few populations, or steep declines).

Provincially tracked vascular plant species were observed within three different ELC units as well as in open water during the 2018 baseline surveys (Annex VII.1[3], Annex VII.2) (Figure 13.3-4). English sundew was documented in two Open fen (BP27) ELC units. An individual Hudson Bay sedge plant was found by CanNorth (Annex VII.2) within a Willow shrubby rich fen (BP25) ELC unit. Omnia (Annex VII.1) recorded an observation of northern lady-fern in a Willow shrubby rich fen (BP25) ELC unit. Scheuchzer cotton-grass was documented within a Black spruce treed bog (BP19) ELC unit. A single water lobelia plant was observed floating on the shoreline of Patterson Lake during an aquatic vegetation inventory survey point (Annex VII.2).

Disturbance can lead to an increase in invasive species abundance and distribution on the landscape (Environment Canada 2013). Wetland ecosystems can be particularly sensitive to invasive species and changes in species composition can affect local wetland structure and function (Zedler and Kercher 2004). However, no prohibited, noxious, or nuisance weed species designated under *The Weed Control Act* were identified within wetland ecosystems within or adjacent to the LSA during the 2018 baseline surveys (Annex VII.1; Annex VII.2). The wetland habitats in the LSA and RSA are predicted to have maintained overall function in terms of ability to perform hydrological functions and support regional biodiversity in the Base Case.

[3] Lesser duckweed (*Lemna minor*) was recorded as observed in Section 6.3 of Annex VII.1 (Vegetation Baseline Report 1 [Mapping]). However, taxonomic changes to the *Lemna* genus have resulted in most, if not all, lesser duckweed observations in Saskatchewan to now be recognized as common duckweed (*Lemna turionifera*), a species that is not provincially tracked (Harms et al. 2018; SKCDC 2023). Lesser duckweed has not been verified as occurring in the province (Harms et al. 2018); therefore, the species recorded in Annex VII.1 is assumed to be common duckweed.

13.3.3 Riparian Ecosystems

13.3.3.1 Ecosystem Availability

Riparian habitat is a transition zone between aquatic and terrestrial ecosystems (Austin et al. 2008). Riparian habitat is defined as areas adjacent to rivers and lakes, or ephemeral, intermittent, or perennial streams that differ from the surrounding uplands in plant and animal diversity and productivity (Environment Canada 2013). Indigenous Groups have identified several gathering sites for berries, medicines, and other traditional plants near lakes and along creeks and rivers in the RSA (TSD V.1: CRDN; TSD II: BNDN; TSD IV: MN-S; TSD VI: YNLR).

> There is a lot of medicine, my dad and I use to collect them. Ts'aili Teli. (Frog Tail) on the side of the road, it looks like red rose, that is medicine. They pay respect to the lake and plants when they harvested the plants . . . . He used to bring it to mom, and mom would drink it. It is good for body aches, made into tea. She mixed it with another plant, and made it into a tea. (TSD VI: YNLR)

Several lakes were identified in the RSA by Indigenous Groups where berries, medicines and other traditional plants are gathered (TSD V.1: CRDN; TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD VI: YNLR). Indigenous Groups described the importance of the Patterson Lake area in particular for traditional activities, including plant gathering.

For the purposes of the assessment, riparian ecosystems were defined as the subset of upland and wetland cover types with riparian potential that intersected buffered watercourses and waterbodies (i.e., disturbance to riparian ecosystems are inclusive of effects to upland and wetland ecosystems).

Riparian ecosystems are distributed throughout the LSA and RSA, and are associated with watercourses and waterbodies. In the Base Case, the total area of riparian habitat within riparian buffers covers 205.4 ha of the LSA (7.3%) and 9,612.5 ha of the RSA (8.9%; Table 13.3-4; Figure 13.3-5; Figure 13.3-6). Undisturbed riparian habitat covers 116.6 ha (4.1%) of the LSA and 5,456.3 ha (5.1%) of the RSA. The most common undisturbed riparian ELC unit in the LSA is the Black spruce treed bog (BP19) ELC unit, which covers 51.4 ha (1.8%). Labrador tea shrubby bog (BS18) is the most abundant undisturbed riparian ELC unit in the RSA, covering 1,302.8 ha (1.2%). This classification aligns with observations from a member from YNLR who commented on the abundance of Labrador tea in the region: "I picked Labrador tea. It is all over in this area, in the country, in the muskegs, and eskers" (TSD VI: YNLR). Riparian habitat disturbed by fire in the last five years (i.e., Recent Burn Wetland) is not found in the LSA and represents less than 0.1% (23.7 ha) of the RSA. Early- to late-stage regenerating (i.e., burned in the last 6 to 40 years; Burned) riparian areas cover 88.8 ha (3.1%) of the LSA and 4,132.5 ha (3.9%) of the RSA.

Overall, riparian habitats are uncommon on the landscape relative to upland and wetland ecosystems, and all riparian ELC units represent less than 10% of the LSA and RSA. Generally, less abundant riparian ELC units are also uncommon in their respective upland and wetland ecosystems (e.g., Trembling aspen – white birch/sarsaparilla [BP07]), several (n=16) of which cover less than 1.0 ha in the RSA.

Previous and existing human disturbances such as roads, and trails have likely been the primary factors contributing to changes in riparian habitat availability. The construction of roads, culverts, and access trails would have altered riparian habitat in the RSA through vegetation clearing and the removal of riparian forests.

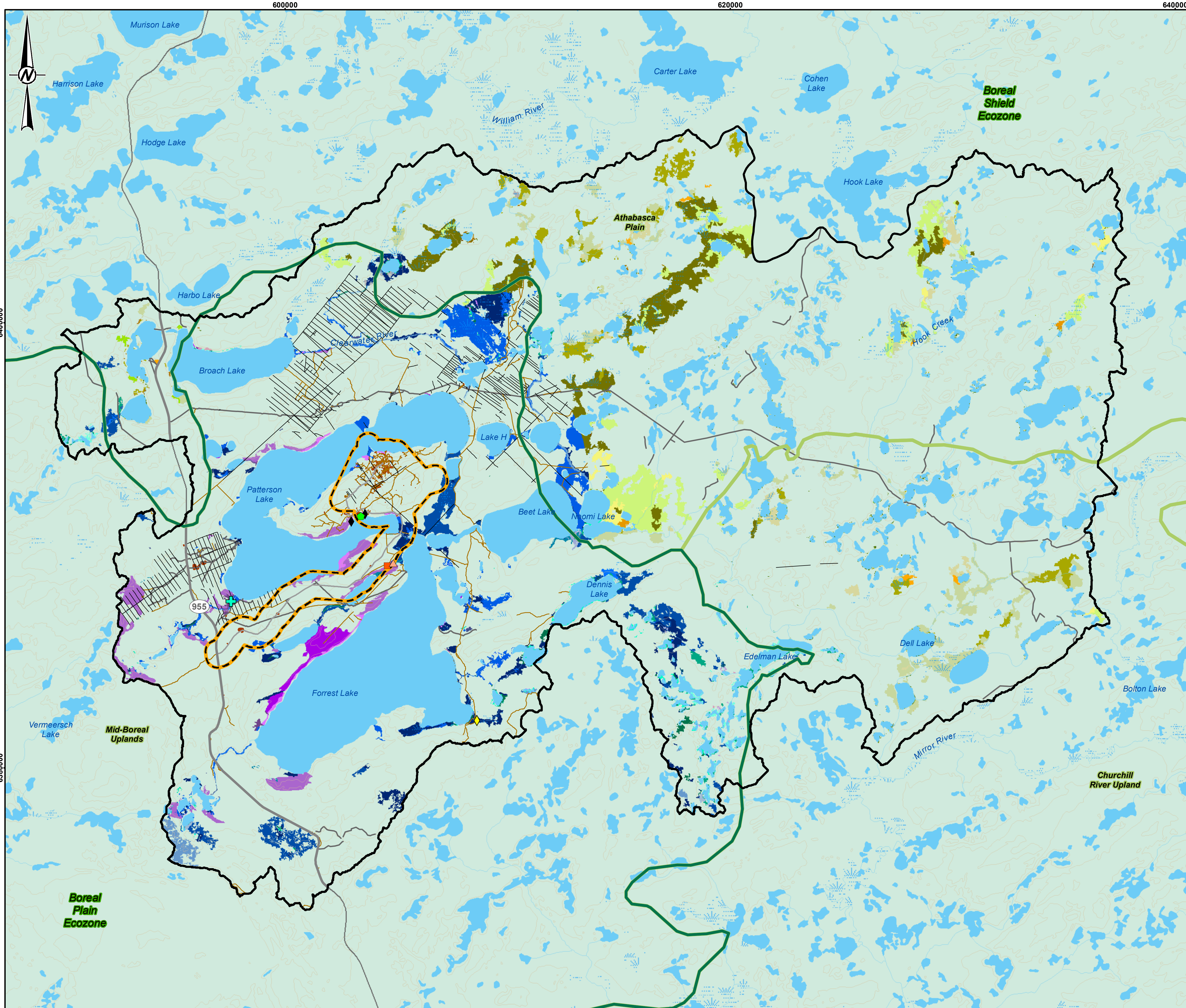
Table 13.3-4: Riparian Ecosystems Availability in the Local and Regional Study Areas in the Base Case

Riparian ELC Unit[a]	LSA		RSA	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
BP07 - Trembling aspen - white birch/sarsaparilla	0.0	0.0	<0.1	<0.1
BP12 - Jack pine - spruce/feathermoss	0.0	0.0	216.2	0.2
BP14 - Black spruce/Labrador tea/feathermoss	17.3	0.6	96.7	0.1
BP16 - Balsam poplar - trembling aspen/prickly rose	0.0	0.0	32.4	<0.1
BP18 - Black spruce - tamarack treed swamp	0.0	0.0	3.6	<0.1
BP19 - Black spruce treed bog	51.4	1.8	822.2	0.8
BP20 - Labrador tea shrubby bog	35.1	1.2	1,003.6	0.9
BP21 - Graminoid bog	0.0	0.0	12.3	<0.1
BP22 - Open bog	0.0	0.0	3.6	<0.1
BP23 - Tamarack treed fen	0.7	<0.1	27.3	<0.1
BP24 - Leatherleaf shrubby poor fen	6.2	0.2	36.8	<0.1
BP25 - Willow shrubby rich fen	4.5	0.2	216.5	0.2
BP26 - Graminoid fen	1.2	<0.1	97.5	0.1
BP27 - Open fen	0.0	0.0	15.6	<0.1
BP28 - Seaside arrow-grass marsh	0.0	0.0	46.0	<0.1
BS06 - Jack pine - trembling aspen/green alder	0.0	0.0	0.3	<0.1
BS09 - Black spruce - jack pine/feathermoss	0.0	0.0	23.1	<0.1
BS10 - Black spruce - white birch/feathermoss	0.0	0.0	0.1	<0.1
BS13 - White birch - black spruce - trembling aspen	0.0	0.0	0.5	<0.1
BS15 - Trembling aspen - white birch/green alder	0.0	0.0	<0.1	<0.1
BS17 - Black spruce treed bog	0.0	0.0	1,281.4	1.2
BS18 - Labrador tea shrubby bog	0.0	0.0	1,302.8	1.2
BS19 - Graminoid bog	0.0	0.0	0.2	<0.1
BS20 - Open bog	0.0	0.0	0.7	<0.1
BS21 - Tamarack treed fen	0.0	0.0	<0.1	<0.1
BS22 - Leatherleaf shrubby poor fen	0.0	0.0	171.9	0.2
BS23 - Willow shrubby rich fen	0.0	0.0	2.7	<0.1
BS24 - Graminoid fen	0.0	0.0	30.8	<0.1
BS25 - Open fen	0.0	0.0	<0.1	<0.1
BS26 - Rush sandy shore	0.2	<0.1	11.9	<0.1
Undisturbed riparian subtotal	*116.6*	*4.1*	*5,456.3*	*5.1*
BP16(BU) - Balsam poplar - trembling aspen/prickly rose (Burned)	64.4	2.3	729.1	0.7
BP18(BU) - Black spruce - tamarack treed swamp (Burned)	0.0	0.0	6.8	<0.1
BP19(BU) - Black spruce treed bog (Burned)	24.4	0.9	871.2	0.8
BP20(BU) - Labrador tea shrubby bog (Burned)	0.0	0.0	25.2	<0.1
BP23(BU) - Tamarack treed fen (Burned)	0.0	0.0	12.2	<0.1
BP25(BU) - Willow shrubby rich fen (Burned)	0.0	0.0	20.7	<0.1
BP26(BU) - Graminoid fen (Burned)	0.0	0.0	105.8	0.1

Table 13.3-4: Riparian Ecosystems Availability in the Local and Regional Study Areas in the Base Case

Riparian ELC Unit[a]	LSA		RSA	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
BP28(BU) - Seaside arrow-grass marsh (Burned)	0.0	0.0	98.5	0.1
BS06(BU) - Jack pine - trembling aspen/green alder (Burned)	0.0	0.0	0.7	<0.1
BP07(BU) - Trembling aspen - white birch/sarsaparilla (Burned)	0.0	0.0	5.3	<0.1
BP11(BU) - White birch - white spruce - balsam fir (Burned)	0.0	0.0	0.5	<0.1
BP12(BU) - Jack pine - spruce/feathermoss (Burned)	0.0	0.0	0.5	<0.1
BP14(BU) - Black spruce/Labrador tea/feathermoss (Burned)	0.0	0.0	<0.1	<0.1
BS09(BU) - Black spruce - jack pine/feathermoss (Burned)	0.0	0.0	47.8	<0.1
BS13(BU) - White birch - black spruce - trembling aspen (Burned)	0.0	0.0	26.6	<0.1
BS15(BU) - Trembling aspen - white birch/green alder (Burned)	0.0	0.0	0.1	<0.1
BS17(BU) - Black spruce treed bog (Burned)	0.0	0.0	1,189.3	1.1
BS18(BU) - Labrador tea shrubby bog (Burned)	0.0	0.0	665.0	0.6
BS19(BU) - Graminoid bog (Burned)	0.0	0.0	0.1	<0.1
BS20(BU) - Open bog (Burned)	0.0	0.0	1.3	<0.1
BS21(BU) - Tamarack treed fen (Burned)	0.0	0.0	3.3	<0.1
BS22(BU) - Leatherleaf shrubby poor fen (Burned)	0.0	0.0	266.1	0.2
BS23(BU) - Willow shrubby rich fen (Burned)	0.0	0.0	16.4	<0.1
BS24(BU) - Graminoid fen (Burned)	0.0	0.0	37.4	<0.1
BS25(BU) - Open fen (Burned)	0.0	0.0	0.1	<0.1
Recent burn wetland	0.0	0.0	23.7	<0.1
Burned riparian subtotal	*88.8*	*3.1*	*4,156.2*	*3.9*
Total Riparian	**205.4**	**7.3**	**9,612.5**	**8.9**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values. Riparian ecosystems are a subset of upland and wetland ecosystems. ELC units described as riparian do not match upland or wetland ecosystem totals.
a) McLaughlan et al. 2010.
ELC = Ecological Land Classification; LSA = local study area; RSA = regional study area; < = less than.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- LOCAL STUDY
- REGIONAL STUDY

RIPARIAN VASCULAR RARE PLANT SPECIES

- BEAUTIFUL SEDGE
- HUDSON BAY SEDGE
- NORTHERN LADY-FERN
- SCHEUCHZER COTTON-GRASS
- WATER LOBELIA
- HEART-LEAVED TWAYBLADE

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

RIPARIAN ECOLOGICAL LAND CLASSIFICATION UNIT

BP07	BP24	BS18
BP07 (BU)	BP25	BS18 (BU)
BP11 (BU)	BP25 (BU)	BS19
BP12	BP26	BS19 (BU)
BP12 (BU)	BP26 (BU)	BS20
BP14	BP27	BS20 (BU)
BP14 (BU)	BP28	BS21
BP16	BP28 (BU)	BS21 (BU)
BP16 (BU)	BS06	BS22
BP18	BS06 (BU)	BS22 (BU)
BP18 (BU)	BS09	BS23
BP19	BS09 (BU)	BS23 (BU)
BP19 (BU)	BS10	BS24
BP20	BS13	BS24 (BU)
BP20 (BU)	BS13 (BU)	BS25
BP21	BS15	BS25 (BU)
BP22	BS15 (BU)	BS26
BP23	BS17	RECENT BURN (WETLAND)
BP23 (BU)	BS17 (BU)	

0 5 10
1:175,000 KILOMETRES

REFERENCE(S)

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PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

RIPARIAN ECOSYSTEMS AND RARE PLANT SPECIES IN THE REGIONAL STUDY AREA, BASE CASE

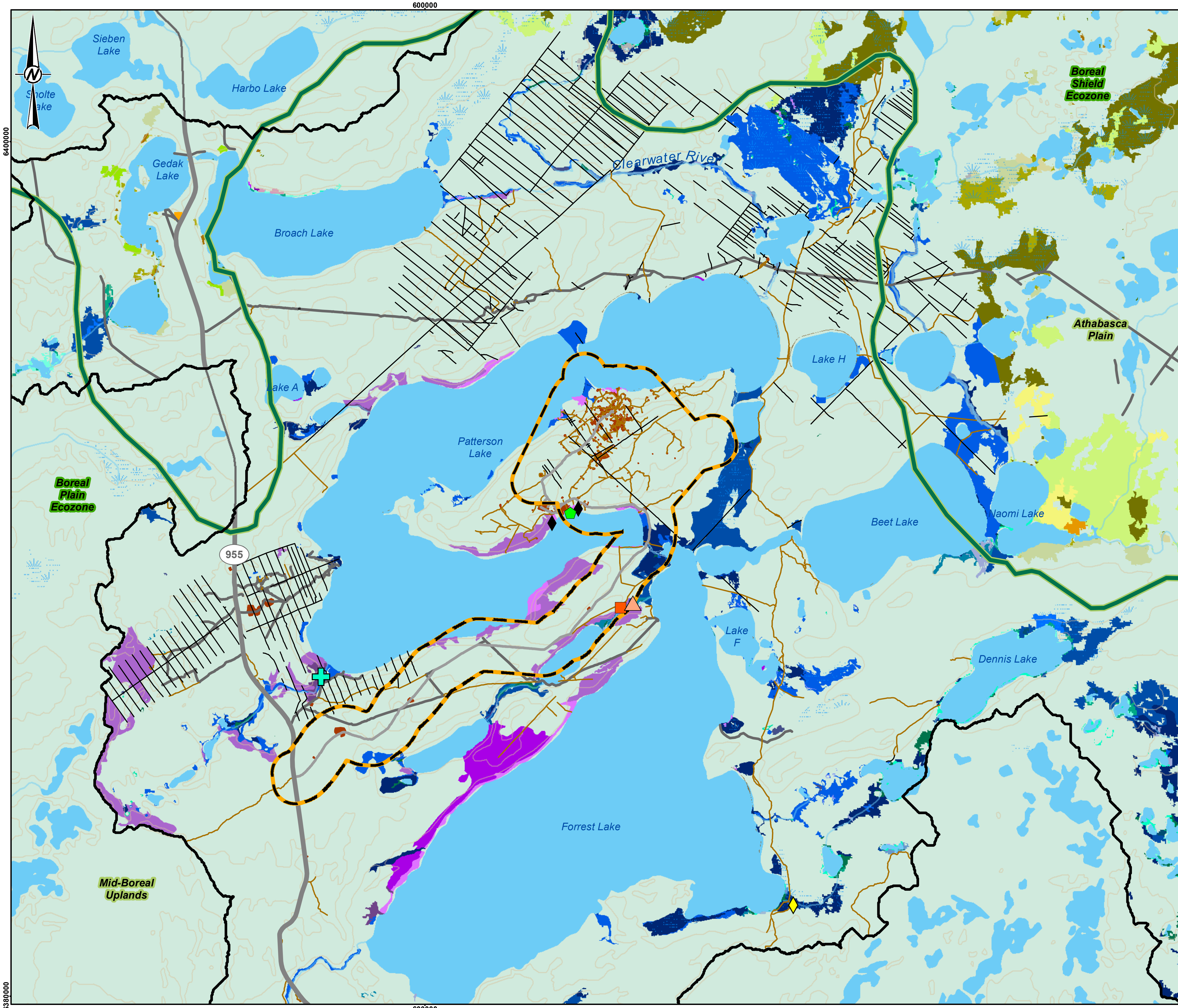
CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08	FIGURE 13.3-5	
REVIEW	JV	2023-02-08		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm



LEGEND

ELEVATION CONTOUR (20 m INTERVAL)
WATERCOURSE
WATERBODY
WETLAND
WOODED
ECOREGION BOUNDARY
ECOZONE BOUNDARY
LOCAL STUDY
REGIONAL STUDY

RIPARIAN VASCULAR RARE PLANT SPECIES

BEAUTIFUL SEDGE
HUDSON BAY SEDGE
NORTHERN LADY-FERN
SCHEUCHZER COTTON-GRASS
WATER LOBELIA
HEART-LEAVED

DISTURBANCE CLASS

ACCESS ROAD
CUTLINE/SEISMIC
SECONDARY HIGHWAY
ROUGH ROAD
TRAIL
NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
OIL AND GAS DEVELOPMENT

RIPARIAN ECOLOGICAL LAND CLASSIFICATION UNIT

BP07	BP22	BS13 (BU)
BP07 (BU)	BP23	BS17
BP11 (BU)	BP23 (BU)	BS17 (BU)
BP12	BP24	BS18
BP12 (BU)	BP25	BS18 (BU)
BP14	BP25 (BU)	BS21
BP16	BP26	BS21 (BU)
BP16 (BU)	BP26 (BU)	BS22
BP18	BP27	BS22 (BU)
BP18 (BU)	BP28	BS23
BP19	BP28 (BU)	BS23 (BU)
BP19 (BU)	BS06 (BU)	BS24
BP20	BS09	BS26
BP20 (BU)	BS09 (BU)	RECENT BURN (WETLAND)
BP21	BS13	

0 3 6

1:90,000 KILOMETRES

REFERENCE(S)

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PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

RIPARIAN ECOSYSTEMS AND RARE PLANT SPECIES IN THE LOCAL STUDY AREA, BASE CASE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08	FIGURE 13.3-6	
REVIEW	JV	2023-02-08		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

13.3.3.2 Ecosystem Distribution

Changes to riparian distribution are caused by the same disturbances as those described above for availability. Regional connectivity of riparian habitat is important for dispersal of plants and for movement of fish and wildlife species (Environment Canada 2013). A member of the BRDN also commented on the importance of the interconnectedness of lakes for facilitating travel during the winter to access traditional use areas, and particularly the Dyck Lake area, which is in the RSA (TSD III: BRDN).

> Yeah, it's really good trapping areas [around Dyck Lake] because of the terrain, the lakes, they are close, interconnected, and you can get trails into them as you go along without really doing any kind of major trail cutting. You can get around obstacles and keep going instead of just cutting that tree down, cutting that tree down and it's [not] thick forest as here, it's a lot more spread out. (TSD III: BRDN)

The distribution of riparian habitat in the LSA and RSA is likely within the range of natural historical conditions (i.e., where natural events such as flooding would have caused regular shifts in distribution), except in areas affected by roads and trails, where riparian systems have been lost or permanently altered (Figure 13.3-5; Figure 13.3-6). Overall, riparian ecosystems are well distributed and connected over the LSA and RSA in the Base Case.

13.3.3.3 Ecosystem Condition

Riparian trees provide habitat for wildlife and shade to buffer temperature within watercourses. Riparian habitat also maintains water quality of watercourses by filtering out nutrients and contaminants. Human disturbances have the potential to accelerate the establishment of invasive plant species in native ecosystems through the introduction of seeds or disturbance of soils (Mack et al. 2000; Bradley and Mustard 2006). Disturbances such as roads, trails, and seismic lines have likely caused habitat fragmentation, barriers, or partial barriers to wildlife movement and can lead to increased invasive species on the landscape (Parendes and Jones 2000; Reichard and White 2001; Lafortezza et al. 2010).

No federally listed plant species (SARA or COSEWIC) were observed in riparian ecosystems during the baseline plant community surveys conducted in 2018 (Annex VII.1; Annex VII.2). However, there were five recorded occurrences of four provincially tracked vascular plant species in riparian ecosystems (Annex VII.1[4], Annex VII.2; Figure 13.3-6). The provincially tracked vascular plant species documented within riparian ecosystems were beautiful sedge, Hudson Bay sedge, northern lady-fern, and water lobelia. All these occurrences, except water lobelia, are also classified in the upland or wetland ELC units (Sections 13.3.1.3 and 13.3.2.3, Ecosystem Condition). A single water lobelia plant was observed floating on the shoreline of Patterson Lake (Annex VII.2). Additionally, the Saskatchewan Conservation Data Centre (SKCDC 2021b) historical element occurrence of heart-leaved twayblade occurs within ELC units classified as riparian ecosystem in the RSA.

No prohibited, noxious, or nuisance weed species designated under *The Weed Control Act* were identified in riparian ecosystems within the LSA during the 2018 baseline terrestrial surveys (Annex VII.1; Annex VII.2). The

[4] Lesser duckweed was recorded as observed in Section 6.3 of Annex VII.1 (Vegetation Baseline Report 1 [Mapping]). However, taxonomic changes to the *Lemna* genus have resulted in most, if not all, lesser duckweed observations in Saskatchewan to now be recognized as common duckweed, a species that is not provincially tracked (Harms et al. 2018; SKCDC 2023). Lesser duckweed has not been verified as occurring in the province (Harms et al. 2018); therefore, the species recorded in Annex VII.1 is assumed to be common duckweed.

riparian habitats in the LSA and RSA are predicted to have maintained overall function in terms of ability to perform hydrological functions and support regional biodiversity in the Base Case.

13.3.4 Traditional Use Plant Species

13.3.4.1 Traditional Use Plant Species Availability

Traditional use plant species are used by Indigenous Groups for food, medicinal, spiritual, and ceremonial purposes, and plant gathering is an important cultural activity that contributes to well-being. The CRDN and MN-S have described the importance of berries, medicinal and other traditional plants for the promotion of health and community wellbeing (TSD IV: MN-S; TSD V.2 CRDN):

> Berries, such as blueberries, strawberries and raspberries, are another important traditional food source, as they are full of antioxidants and promote heart and brain health. The Patterson Lake area provides a bounty for harvest which is also important for the collection of natural medicines . . . . Rat root and birch bark are collected and used for medicine, as is birch syrup, the harvesting of which continues to be passed down in the area. In early spring, the men tap the trees and collect the sap; the women boil and bottle the syrup. Some members make tea for medicine. Members, for example, makes medicinal green tea and cranberry tea which promote bladder health. When sick, some members visit the medicine people for remedy because they know every plant and their medicinal use. There is also sweet grass that grows in the territory and most lake water is used for drinking. (TSD IV: MN-S)

> We've got all kinds of berries there. They are all used for medicine. Even the leaves from the trees are used for medicine, you know. We get rat root from there. Rat root is used for everything from mental illness to physical pain . . . . In the summer there's beautiful blueberries, raspberries, all kinds of berries there. And if somebody had kidney problems or something, my mom said "You just go out in the bush, grab some cranberries." And now the mainstream society is figuring it out . . . . And gooseberries, you know, is good for your eyes. Like all these things. We know that stuff. (TSD V.2: CRDN)

Indigenous Groups have reported that plant gathering activities have, and continue to occur, in the Patterson Lake area (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN). The CRDN reported that the Patterson Lake has historically, and is currently "recognized as good for everything harvesting grounds which have sustained CRDN members through time, beyond living memory" because of its abundance of resources, including berries and medicines (TSD V.1: CRDN; TSD V.2: CRDN). The YNLR identified the Patterson Lake area as an important area for plants in general (TSD VI: YNLR).

Twenty-eight traditional use plant species were identified in the IKTLU Studies (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD VI: YNLR) and from comments from CRDN (2019a) on the Cluff Lake Mine licence renewal. Baseline surveys (Annex VII.1; Annex VII.2) recorded 1,214 observations of 34 species or genera that can be potentially described as one of the identified traditional use plant species (Table 13.3-5).

Table 13.3-5: Traditional Use Plant Species Recorded during Baseline Surveys

Traditional Use Plant Species[a]	Scientific Name[b]	SKCDC Common Name[b]	Habitat[c]	Number of Observations during Baseline[d]
Berries	*Rubus arcticus* ssp. *acaulis*	Nagoon berry	Moist-wet woods, shrub thickets, muskegs, and meadows	10
	Rubus pubescens	Dewberry	Moist rich woods, stream banks, bogs, and swamps	7
Birch	*Betula glandulosa*	Dwarf birch	Muskegs, peat bogs and fens, stream banks, and rocky slopes	5
	Betula occidentalis	River birch	Stream and lake shores, marsh edges, wet swales, bluff slopes, ridges, and moist open woods	1
	Betula papyrifera	Paper birch	Often codominant trees in moist, mostly riparian, deciduous and mixedwood forest	87
	Betula pumila	Swamp birch	Moist woods, muskegs, swamps, bogs, fens, and shore thickets	15
Blueberry	*Vaccinium myrtilloides*	Blueberry	Dry-moist, often sandy, coniferous (often jack pine) woods, forest edges and clearings	124
Bulrushes	*Juncus alpinoarticulatus*	Northern green rush	Wet meadows, sandy or gravelly, often calcareous shores and fens	1
	Juncus nodosus var. *nodosus*	Knotted rush	Sandy or muddy shores of lakes, rivers and streamlets, swamps, fens marshes, and wet fields, often calcareous or saline	1
	Schoenoplectus acutus var. *acutus*	Hard-stemmed bulrush	Wet depressions, fens, and marshy lake and stream margins, often emergent aquatics to 1.5 m depths	1
Chokecherry	*Prunus virginiana* var. *viriginiana*	Chokecherry	Sandy stream banks, open woods and borders, prairie shrub thickets, and roadsides	n/o
Cloudberry	*Rubus chamaemorus*	Cloudberry	Moist-wet mossy spruce woods and muskegs, sphagnum bogs and fens, and wet meadows	57
Cranberry	*Vaccinium oxycoccos*	Small cranberry	Sphagnum hummocks in wet bogs, fens, and muskegs	55
Cranberry, bog	*Vaccinium vitis-idaea*	Bog cranberry	Dry-fresh pine and spruce woods, exposed slopes, drier bogs, and various habitats	129
Cranberry, low bush	*Viburnum edule*	Low-bush cranberry	Woods	1
Cranberry, high bush	*Viburnum opulus* var. *americanum*	High-bush cranberry	Moist, rich woods, shrub thickets, open or semi-shaded shores	n/o
Dogwood	*Cornus sericea* ssp. *sericea*	Red-osier dogwood	Rich shore woods on river-bank alluvium and lower bluff slopes	n/o
Frog tail	*Sarracenia purpurea* ssp. *gibbosa*	Pitcherplant	Peaty fens and bogs	n/o
Gooseberry	*Ribes americanum*	Wild black currant	Mesic-moist shrub-thickets, open woods, woodland edges, ravine-slopes, and stream banks	1
	Ribes glandulosum	Skunk currant	Moist woods, clearings, shrubland, and rocky shores	2
	Ribes hudsonianum	Northern black currant	Rich moist woods	7
	Ribes oxyacanthoides var. *oxyacanthoides*	Bristly gooseberry	Mesic-moist woods, shrub-thickets, and clearings	4
	Ribes triste	Swamp red currant	Moist-wet woods and boggy sites	2

Table 13.3-5: Traditional Use Plant Species Recorded during Baseline Surveys

Traditional Use Plant Species[(a)]	Scientific Name[(b)]	SKCDC Common Name[(b)]	Habitat[(c)]	Number of Observations during Baseline[(d)]
Jack pine	*Pinus banksiana*	Jack pine	Dominant or codominant trees in dry-mesic, sandy-gravelly, coniferous or mixedwood forests	151
Kinnikinnick	*Arctostaphylos uva-ursi*	Bearberry	Dry(-moist), sandy, open woods, forest clearings, and exposed rocky areas	72
Labrador tea	*Rhododendron groenlandicum*	Common Labrador tea	Moist-wet, spruce woods, acidic peat bogs, meadows, stream margins, and talus slopes	115
	Rhododendron tomentosum	Labrador tea	Wet black spruce woods, muskegs, and treed/open bogs	11
Mint	*Mentha canadensis*	Wild mint	Marshy shores, moist sedge meadows, and other damp places	1
Mosses[(e)]	n/a	n/a	Various habitats	113
Mushrooms[(e)]	n/a	n/a	Various habitats	n/o
Poplar	*Populus balsamifera* ssp. *balsamifera*	Balsam poplar	Moist, lake/river/stream shores, often dominant or codominant trees in rich, riparian woods	5
	Populus tremuloides	Trembling aspen	Usually dominant or codominant trees in dry-mesic (-moist) woodlands	11
Raspberry	*Rubus idaeus* ssp. *strigosus*	American red raspberry	Dry-mesic, open woods (especially after fire), forest clearings, roadsides, and disturbed open sites	3
Rat root	*Acorus americanus*	Sweet flag	River and stream banks, lake shores, woodland margins, mesic woods, and shrub-thickets	n/o
Saskatoon	*Amelanchier alnifolia* var. *alnifolia*	Saskatoon	Dominant or codominant trees in coniferous and mixedwood forest	n/o
Spruce	*Picea glauca*	White spruce	Dominant or codominant trees in moist-wet woods, muskegs, fens, and bogs	30
	Picea mariana	Black spruce	Rocky woods, riparian forests, forest edges, clearings, along trails and roadsides, and sandy/gravelly shores	72
Strawberry	*Fragaria vesca* ssp. *americana*	American wild strawberry	Mesic-moist, open riparian, and upland deciduous/mixed/coniferous woods, forest edges and clearings, sandy shores, roadsides, and disturbed sites	1
	Fragaria virginiana ssp. *glauca*	Smooth wild strawberry	Moist-wet open marshes, swales, and edges of quiet water	1
Sweetgrass	*Anthoxanthum hirtum* ssp. *arcticum*	Sweet grass	Mesic-wet meadows, semi-open shores, sloughs, and marsh edges	n/o
Tamarack	*Larix laricina*	Tamarack	Dominant or codominant trees with black spruce in wet woods, treed bogs, and some fens	25
Willow[(f)]	*Salix* spp.	Willow species	Various habitats	93

a) TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD VI: YNLR; CRDN 2019a.
b) SKCDC 2021a.
c) Harms 2017.
d) Annex VII.1; Annex VII.2.
e) Traditional use plant species name reflects a broad group of plant or fungi species; therefore, the scientific name, SKCDC common name, and habitat information are not described.
f) Saskatchewan has over 40 willow species (*Salix* sp.; Harms 2017); therefore, the scientific name, SKCDC common name, and habitat information of all potential willow species are not described.
n/a = not applicable; n/o = not observed.

The availability of traditional use plant species in the LSA and RSA was determined using the relative frequency and percent cover (Section 13.2.6.2, Traditional Use Plant Species) for each species recorded during baseline field surveys (Annex VII.1; Annex VII.2). The most available traditional use plant species within both the LSA and RSA are jack pine, mosses, blueberry, and bog cranberry (*Vaccinium vitis-idaea*) (Table 13.3-6; Figure 13.3-7; Figure 13.3-8). The prevalence of jack pine in the LSA and RSA aligns with knowledge shared by the BNDN and the BRDN (TSD II: BNDN; TSD III: BRDN) of jack pine dominating the Patterson Lake area. The CRDN also commented on the availability of jack pine in the Patterson Lake area (TSD V.2; CRDN). The relatively high availability of blueberry in the LSA and RSA was reflected by the three blueberry gathering sites identified by the BNDN in the RSA and the blueberry harvesting sites identified by the YNLR in the LSA and RSA (TSD II: BNDN; TSD VI: YNLR). The availability of several species is low within the RSA as they were observed infrequently during baseline surveys (e.g., strawberry) or are generally smaller species with limited cover (e.g., small cranberry [*Vaccinium oxycoccos*]).

Table 13.3-6: Traditional Use Plant Species Availability in the Local and Regional Study Areas in the Base Case

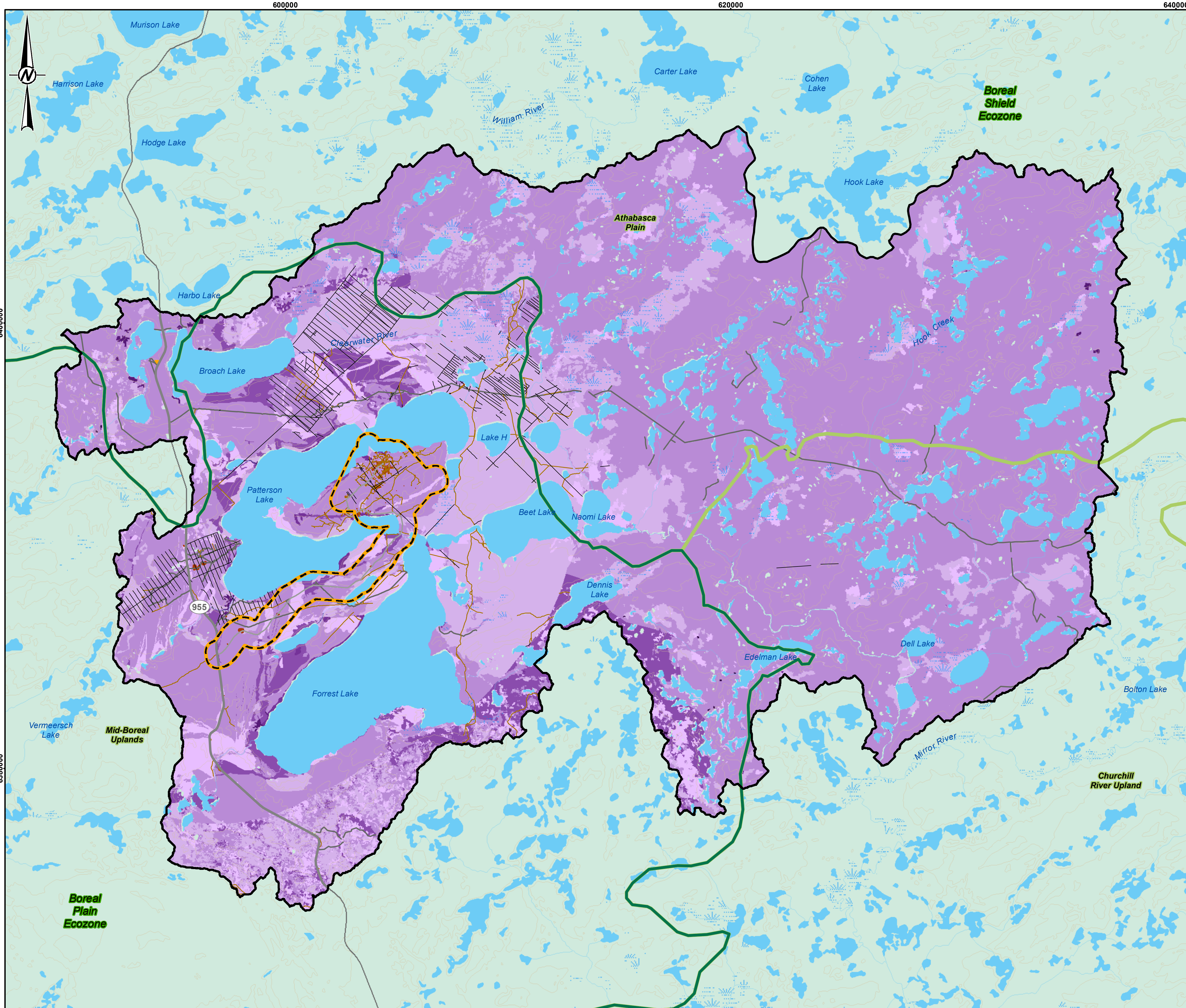
Traditional Use Plant Species[a]	Scientific Name[b]	SKCDC Common Name[b]	LSA		RSA	
			Area (ha)	Percent (%)	Area (ha)	Percent (%)
Berries	*Rubus arcticus* ssp. *acaulis*	Nagoon berry	<0.1	<0.1	2.2	<0.1
	Rubus pubescens	Dewberry	<0.1	<0.1	1.4	<0.1
Birch	*Betula glandulosa*	Dwarf birch	<0.1	<0.1	5.8	<0.1
	Betula occidentalis	River birch	0.1	<0.1	0.6	<0.1
	Betula papyrifera	Paper birch	30.8	1.1	764.9	0.7
	Betula pumila	Swamp birch	1.7	0.1	70.8	0.1
Blueberry	*Vaccinium myrtilloides*	Blueberry	225.3	8.0	6,230.4	5.8
Bulrushes	*Juncus alpinoarticulatus*	Northern green rush	<0.1	<0.1	0.6	<0.1
	Juncus nodosus var. *nodosus*	Knotted rush	0.0	0.0	0.8	<0.1
	Schoenoplectus acutus var. *acutus*	Hard-stemmed bulrush	<0.1	<0.1	0.5	<0.1
Chokecherry	*Prunus virginiana* var. *viriginiana*	Chokecherry	n/o	n/o	n/o	n/o
Cloudberry	*Rubus chamaemorus*	Cloudberry	2.6	0.1	176.7	0.2
Cranberry	*Vaccinium oxycoccos*	Small cranberry	3.3	0.1	230.0	0.2
Cranberry, bog	*Vaccinium vitis-idaea*	Bog cranberry	72.2	2.5	3,148.3	2.9
Cranberry, low bush	*Viburnum edule*	Low bush-cranberry	0.0	0.0	0.4	<0.1
Cranberry, high bush	*Viburnum opulus* var. *americanum*	High bush-cranberry	n/o	n/o	n/o	n/o
Dogwood	*Cornus sericea* ssp. *sericea*	Red-osier dogwood	n/o	n/o	n/o	n/o
Frog tail	*Sarracenia purpurea* ssp. *gibbosa*	Pitcherplant	n/o	n/o	n/o	n/o
Gooseberry	*Ribes americanum*	Wild black currant	<0.1	<0.1	0.8	<0.1
	Ribes glandulosum	Skunk currant	0.0	0.0	0.2	<0.1
	Ribes hudsonianum	Northern black currant	<0.1	<0.1	2.7	<0.1
	Ribes oxyacanthoides var. *oxyacanthoides*	Bristly gooseberry	<0.1	<0.1	2.4	<0.1
	Ribes triste	Swamp red currant	0.0	0.0	0.2	<0.1
Jack pine	*Pinus banksiana*	Jack pine	203.4	7.2	8,931.3	8.3
Kinnikinnick	*Arctostaphylos uva-ursi*	Bearberry	36.7	1.3	1,225.4	1.1
Labrador Tea	*Rhododendron groenlandicum*	Common Labrador tea	40.8	1.4	2,036.5	1.9

Table 13.3-6: Traditional Use Plant Species Availability in the Local and Regional Study Areas in the Base Case

Traditional Use Plant Species[a]	Scientific Name[b]	SKCDC Common Name[b]	LSA		RSA	
			Area (ha)	Percent (%)	Area (ha)	Percent (%)
	Rhododendron tomentosum	Labrador tea	2.2	0.1	111.7	0.1
Mint	*Mentha canadensis*	Wild mint	0.5	<0.1	13.0	<0.1
Mosses[c]	n/a	n/a	40.2	1.4	3,439.5	3.2
Mushrooms[c]	n/a	n/a	n/o	n/o	n/o	n/o
Poplar	*Populus balsamifera* ssp. *balsamifera*	Balsam poplar	0.0	0.0	13.3	<0.1
	Populus tremuloides	Trembling aspen	24.8	0.9	530.5	0.5
Raspberry	*Rubus idaeus* ssp. *strigosus*	American red raspberry	0.0	0.0	1.1	<0.1
Rat root	Acorus americanus	Sweet flag	n/o	n/o	n/o	n/o
Saskatoon	*Amelanchier alnifolia* var. *alnifolia*	Saskatoon	n/o	n/o	n/o	n/o
Spruce	*Picea glauca*	White spruce	22.3	0.8	981.0	0.9
	Picea mariana	Black spruce	31.0	1.1	1,171.8	1.1
Strawberry	*Fragaria vesca* ssp. *americana*	American wild strawberry	0.0	0.0	0.3	<0.1
	Fragaria virginiana ssp. *glauca*	Smooth wild strawberry	0.0	0.0	<0.1	<0.1
Sweetgrass	*Anthoxanthum hirtum* ssp. *arcticum*	Sweet grass	n/o	n/o	n/o	n/o
Tamarack	*Larix laricina*	Tamarack	0.5	<0.1	35.5	<0.1
Willow[d]	*Salix* sp.	Willow species	10.6	0.4	318.5	0.3
Total			**748.9**	**26.4**	**29,449.0**	**27.4**

a) TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD VI: YNLR; CRDN 2019a.
b) SKCDC 2021a.
c) Traditional use plant species name reflects broad group of plant or fungi species; therefore, the scientific name and SKCDC common name are not described.
d) Saskatchewan has over 40 willow species (*Salix* sp.; Harms 2017); therefore, the scientific name and SKCDC common name of all potential willow species are not described.
LSA = local study area; RSA = regional study area; < = less than; n/a = not applicable; n/o = not observed during baseline surveys.

Members of the CRDN noted that tree clearing in some areas has removed navigational landmarks for land users, (TSD V.1: CRDN). Indigenous Groups have commented that previous and existing developments have affected traditional use plants in the region, which they attribute to dust settling on plants and berries and from the effects of forestry activities and clearing for other industrial developments and exploration activities (TSD III BRDN; TSD II: BNDN; TSD IV: MN-S; TSD V.2: CRDN). NexGen understands the concerns of Indigenous Groups regarding effects from air quality changes to traditional plants and would implement environmental design features and mitigation to minimize potential Project effects (Section 13.4, Project Interactions and Mitigations).



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- LOCAL STUDY
- REGIONAL STUDY

TRADITIONAL USE PLANT SPECIES OCCUPANCY

- 0.00 TO 0.16
- 0.17 TO 0.32
- 0.33 TO 0.48
- 0.49 TO 0.64
- 0.65 TO 0.80
- 0.81 TO 0.96
- 0.97 TO 1.12
- 1.13 TO 1.28

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)

1. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. ECOZONES OBTAINED FROM AGRICULTURE AND AGRI-FOOD CANADA (AAFC).

PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

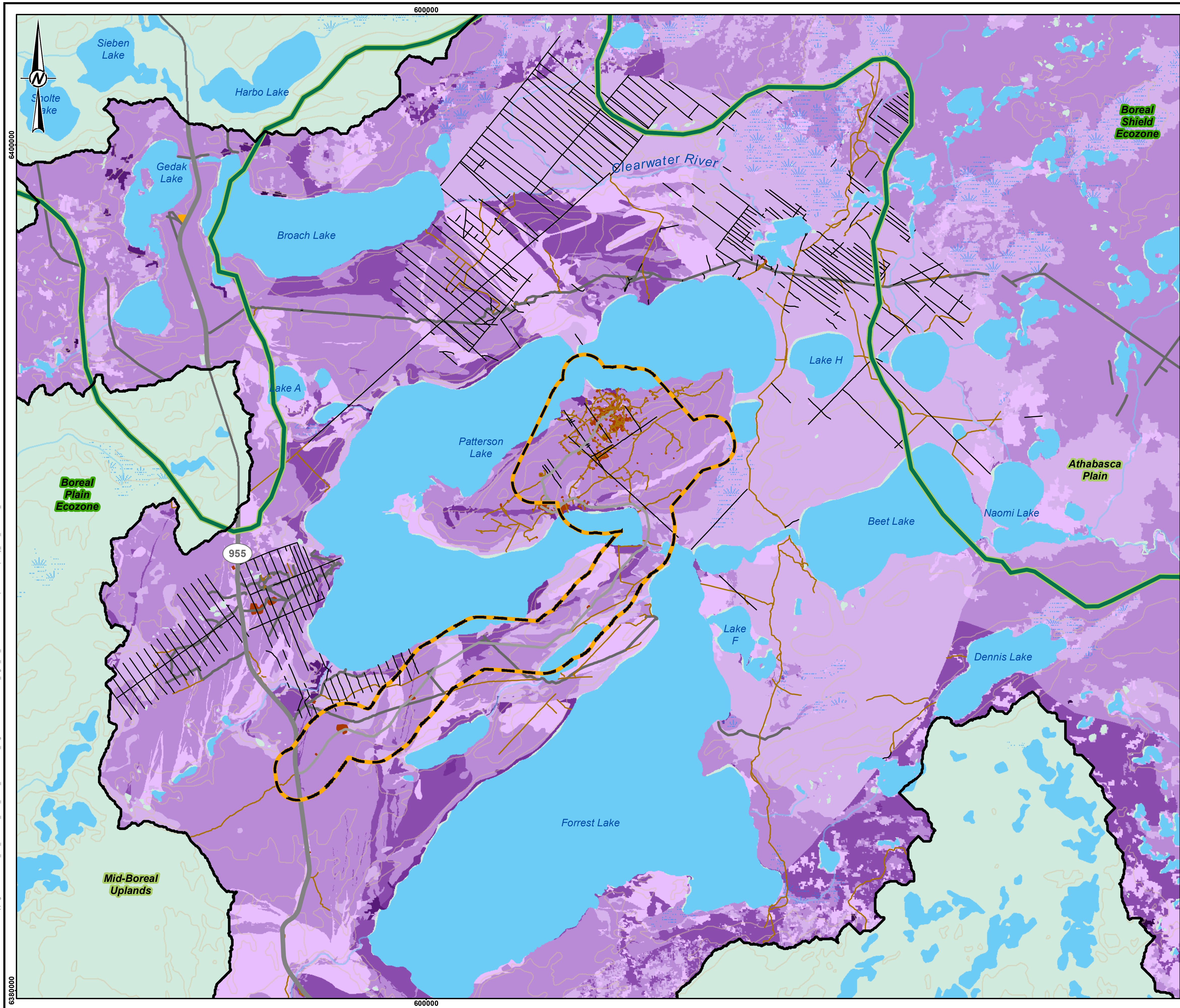
TRADITIONAL USE PLANT SPECIES OCCUPANCY IN THE REGIONAL STUDY AREA, BASE CASE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08	**FIGURE 13.3-7**	
REVIEW	JV	2023-02-08		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- LOCAL STUDY
- REGIONAL STUDY

TRADITIONAL USE PLANT SPECIES OCCUPANCY

- 0.00 TO 0.16
- 0.17 TO 0.32
- 0.33 TO 0.48
- 0.65 TO 0.80
- 0.81 TO 0.96
- 0.97 TO 1.12
- 1.13 TO 1.28

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

0 3 6

1:90,000 KILOMETRES

REFERENCE(S)

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PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

TRADITIONAL USE PLANT SPECIES OCCUPANCY IN THE LOCAL STUDY AREA, BASE CASE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08		
REVIEW	JV	2023-02-08		

FIGURE 13.3-8

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm 0

13.3.4.2 Traditional Use Plant Species Distribution

Indigenous Groups have described the importance of the Patterson Lake area for traditional activities in general, including for plant gathering. The MN-S reported that the Patterson Lake area has both historic and current value and was noted as providing “a bounty for harvest which is also important for the collection of natural medicines” (TSD IV: MN-S). The MN-S continue to live off the land “tapping trees for birch syrup, and gathering berries, mint and medicine all over the north, especially near Patterson Lake” (TSD IV: MN-S).

Several areas in the LSA and RSA were identified by Indigenous Groups as gathering sites for medicines, berries, and other plants (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YNLR). In the RSA, the CRDN have mapped “other harvesting areas” south of Patterson Lake, south of Forrest Lake, and west of Gedak lake (TSD V.2: CRDN, Figure 17). The MN-S identified several areas in the RSA where berries, medicines and other traditional plants are gathered, including Gedak Lake and Dennis Lake (TSD IV: MN-S, Table 1), as well as general harvesting areas east of Patterson Lake (TSD IV: MN-S, Figure C).

The BRDN have identified two sites in the RSA that are used for firewood gathering, one of which is mapped at Dyck Lake (TSD III: BRDN, Figure 2). A BRDN member also noted that there is good access to wild rice areas near Patterson Lake (BRDN-JWG 2021b). The BNDN have identified three blueberry gathering sites in the RSA, two of which are within 250 m of the proposed Project footprint (TSD II: BNDN). The YNLR identified the entire RSA as an important plant area, though plant gathering is not currently practiced in the RSA (TSD VI: YNLR, Figure 13).

Traditional use plant species are associated with a variety of ELC units depending on species-specific habitat requirements. Some species are able to occupy a wide ecological niche or are found within common ELC units and terrain features (e.g., jack pine on upland sandy soils), while other species have limited distribution or grow under restricted habitat requirements (e.g., pitcherplant [*Sarracenia purpurea* ssp. *gibbosa*]). In the Base Case, traditional use plant species are associated with several ELC units in the LSA. The greatest distribution of traditional use plant species is associated with the burned Jack pine/lichen (BP02[BU]) ELC unit as some common species were frequently observed in these sites (i.e., jack pine and blueberry). The Black spruce - tamarack treed swamp (BP18), burned Black spruce - tamarack treed swamp (BP18[BU]), and burned Black spruce/balsam poplar/river alder swamp (BS16[BU]) ELC units supported the highest diversity of traditional use plant species (24 species each) but within the LSA only account for total occupancy of 21.9 ha, 49.9 ha, and <0.1 ha, respectively. Overall, a higher frequency of traditional use plant species was observed within wetland ecosystems; however, species within wetland habitats were generally observed with lower percent cover and therefore occupy a small area within those ELC units.

Species such as blueberry are common in most upland ELC units within the LSA and RSA (i.e., BP02, BP03, BP04, BP12, BP14, BS03, BS04, and BS13) (Section 13.3.1.1, Ecosystem Availability; Appendix 13A). Berries, including low bush-cranberry (*Viburnum edule*), raspberries (*Rubus* spp.), and strawberries (*Fragaria* spp.), are common within deciduous or mixedwood ELC units (i.e., BP06, BP07, BP11, BP16, BS13, BS14), which are not present in the LSA and not abundant in the RSA (Table 13.3-7). ELC units associated with birch trees (i.e., BP07, BP11, BS13, and BS14) are not present in the LSA and are uncommon in the RSA (Section 13.3.1.1).

Wetland and riparian areas within the LSA and RSA are used as gathering sites by Indigenous Groups for medicines and berries (TSD II: BNDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YNLR). Black spruce treed bog (BP19) ELC units are commonly associated with berries (e.g., cranberry [*Vaccinium* spp.] and cloudberry [*Rubus chamaemorus*]; McLaughlan et al. 2010; Annex VII.1). Berries are common within most wetland ELC units (i.e., BP18, BP19, BP20, BP21, BP22, BP23, BP24, and BP27); however, these ELC units have low abundance in the LSA and RSA (Section 13.3.2.1, Ecosystem Availability).

Shoreline habitat associated with lakes is abundant in the LSA and RSA, but riparian ELC units with open water (e.g., BP22, BP24, and BP25), where medicinal shoreline and aquatic plants could be found, are relatively uncommon (Section 13.3.3.1, Ecosystem Availability). Berries are common within most riparian ELC units (e.g., BP14, BP19, BP20, and BP24); however, these ELC units are uncommon in the LSA and RSA. Nevertheless, Indigenous Groups have identified several gathering sites for berries, medicines, and other traditional plants near lakes and along creeks and rivers in the LSA and RSA, including Patterson Lake; however, it is unknown how close to the shoreline these plants are gathered and it is possible that plants are gathered farther upland in these areas (TSD V.1: CRDN; TSD II: BNDN; TSD IV: MN-S; TSD VI: YNLR).

Table 13.3-7: Traditional Use Plant Species Habitat Availability per Ecological Land Classification Unit

Traditional Use Plant Habitat ELC Unit[(a)]	Traditional Use Plant Species Richness	Habitat Availability LSA (ha)	ELC Unit Area LSA (ha)	Habitat Availability RSA (ha)	ELC Unit Area RSA (ha)
BP02 - Jack pine/lichen	8	24.2	199.9	337.6	2,791.3
BP03 - Jack pine/feathermoss	13	89.4	133.6	2,483.4	3,712.1
BP04 - Jack pine - trembling aspen/feathermoss	7	1.9	16.9	113.0	1,000.7
BP06 - Trembling aspen/beaked hazel/sarsaparilla	14	0.0	0.0	0.3	0.3
BP07 - Trembling aspen - white birch/sarsaparilla	14	0.0	0.0	5.8	5.1
BP11 - White birch - white spruce - balsam fir	14	0.0	0.0	1.3	3.2
BP12 - Jack pine - spruce/feathermoss	10	0.0	0.0	90.7	219.2
BP14 - Black spruce/Labrador tea/feathermoss	16	17.3	19.1	117.7	129.8
BP16 - Balsam poplar - trembling aspen/prickly rose	12	0.0	0.0	31.3	33.3
BS02 - Lichen/felsenmeer - bedrock	3	0.0	0.0	<0.1	<0.1
BS03 - Jack pine/blueberry/lichen	11	0.0	0.0	1,625.0	4,991.4
BS04 - Jack pine - black spruce/feathermoss	10	0.0	0.0	2,549.1	6,158.9
BS05 - Jack pine - white birch/feathermoss	8	0.0	0.0	0.8	1.1
BS06 - Jack pine - trembling aspen/green alder	9	0.0	0.0	0.3	0.3
BS07 - Black spruce/blueberry/lichen	5	0.0	0.0	1.5	2.6
BS08 - Black spruce - white birch/lichen	8	0.0	0.0	<0.1	<0.1
BS09 - Black spruce - jack pine/feathermoss	9	0.0	0.0	8.2	23.1
BS10 - Black spruce - white birch/feathermoss	8	0.0	0.0	<0.1	0.1
BS13 - White birch - black spruce - trembling aspen	14	0.0	0.0	12.2	11.9
BS14 - White birch/lingonberry - Labrador tea	14	0.0	0.0	23.2	74.0
BS15 - Trembling aspen - white birch/green alder	14	0.0	0.0	<0.1	<0.1
BP02(BU) - Jack pine/lichen (Burned)	14	527.5	1641.2	2,889.7	8,990.9
BP03(BU) - Jack pine/feathermoss (Burned)	10	0.0	0.0	2,005.9	4,846.6
BP04(BU) - Jack pine - trembling aspen/feathermoss (Burned)	14	0.0	0.0	409.6	1,274.5
BP06(BU) - Trembling aspen/beaked hazel/sarsaparilla (Burned)	14	0.0	0.0	0.4	0.3
BP07(BU) - Trembling aspen - white birch/sarsaparilla (Burned)	14	0.0	0.0	11.7	10.4
BP11(BU) - White birch - white spruce - balsam fir (Burned)	14	0.0	0.0	0.4	0.9
BP12(BU) - Jack pine - spruce/feathermoss (Burned)	10	0.0	0.0	1.8	4.4
BP14(BU) - Black spruce/Labrador tea/feathermoss (Burned)	16	0.0	0.0	23.2	25.2

Table 13.3-7: Traditional Use Plant Species Habitat Availability per Ecological Land Classification Unit

Traditional Use Plant Habitat ELC Unit[(a)]	Traditional Use Plant Species Richness	Habitat Availability LSA (ha)	ELC Unit Area LSA (ha)	Habitat Availability RSA (ha)	ELC Unit Area RSA (ha)
BP16(BU) - Balsam poplar - trembling aspen/prickly rose (Burned)	11	38.4	161.9	253.8	1,070.4
BS02(BU) - Lichen/felsenmeer - bedrock (Burned)	3	0.0	0.0	<0.1	0.7
BS03(BU) - Jack pine/blueberry/lichen (Burned)	14	0.0	0.0	7,447.7	23,172.8
BS04(BU) - Jack pine - black spruce/feathermoss (Burned)	10	0.0	0.0	3,752.0	9,065.2
BS05(BU) - Jack pine - white birch/feathermoss (Burned)	8	0.0	0.0	3.7	5.1
BS06(BU) - Jack pine - trembling aspen/green alder (Burned)	14	0.0	0.0	0.3	0.9
BS07(BU) - Black spruce/blueberry/lichen (Burned)	14	0.0	0.0	1.8	5.6
BS08(BU) - Black spruce - white birch/lichen (Burned)	14	0.0	0.0	<0.1	0.1
BS09(BU) - Black spruce - jack pine/feathermoss (Burned)	9	0.0	0.0	17.8	50.1
BS13(BU) - White birch - black spruce - trembling aspen (Burned)	14	0.0	0.0	59.4	57.7
BS14(BU) - White birch/lingonberry - Labrador tea (Burned)	11	0.0	0.0	9.5	39.9
BS15(BU) - Trembling aspen - white birch/green alder (Burned)	14	0.0	0.0	0.2	0.2
Recent burn upland	11	0.0	0.0	1,823.3	7,041.6
BP18 - Black spruce - tamarack treed swamp	24	0.0	0.0	2.7	21.9
BP19 - Black spruce treed bog	10	23.6	52.9	763.1	1,708.0
BP20 - Labrador tea shrubby bog	11	15.1	57.6	329.6	1,254.7
BP21 - Graminoid bog	9	0.0	0.0	9.0	25.2
BP22 - Open bog	4	0.0	0.0	2.5	7.8
BP23 - Tamarack treed fen	14	0.3	0.8	13.0	40.4
BP24 - Leatherleaf shrubby poor fen	6	0.9	6.2	8.0	54.5
BP25 - Willow shrubby rich fen	19	0.9	4.5	65.8	317.1
BP26 - Graminoid fen	11	0.0	0.2	19.8	263.3
BP27 - Open fen	4	0.0	0.0	6.5	32.8
BP28 - Seaside arrow-grass marsh	2	0.0	0.0	13.1	64.3
BS17 - Black spruce treed bog	10	0.0	0.0	433.3	1,517.3
BS18 - Labrador tea shrubby bog	14	0.0	0.0	270.2	1,481.3
BS19 - Graminoid bog	6	0.0	0.0	0.1	0.2
BS20 - Open bog	7	0.0	0.0	0.3	0.9
BS21 - Tamarack treed fen	14	0.0	0.0	0.1	0.3
BS22 - Leatherleaf shrubby poor fen	6	0.0	0.0	30.1	205.0
BS23 - Willow shrubby rich fen	19	0.0	0.0	0.9	4.5
BS24 - Graminoid fen	11	0.0	0.0	3.1	41.8
BS25 - Open fen	4	0.0	0.0	<0.1	<0.1
BS26 - Rush sandy shore	3	<0.1	0.2	0.3	15.2
BP18(BU) - Black spruce - tamarack treed swamp (Burned)	24	0.0	0.0	6.2	49.9
BP19(BU) - Black spruce treed bog (Burned)	11	9.2	35.5	580.2	2,240.8
BP20(BU) - Labrador tea shrubby bog (Burned)	14	0.0	0.0	15.0	82.2
BP21(BU) - Graminoid bog (Burned)	9	0.0	0.0	0.1	0.3

Table 13.3-7: Traditional Use Plant Species Habitat Availability per Ecological Land Classification Unit

Traditional Use Plant Habitat ELC Unit[(a)]	Traditional Use Plant Species Richness	Habitat Availability LSA (ha)	ELC Unit Area LSA (ha)	Habitat Availability RSA (ha)	ELC Unit Area RSA (ha)
BP23(BU) - Tamarack treed fen (Burned)	14	0.0	0.0	8.1	25.3
BP24(BU) - Leatherleaf shrubby poor fen (Burned)	6	0.0	0.0	1.7	11.6
BP25(BU) - Willow shrubby rich fen (Burned)	19	0.0	0.0	29.5	142.0
BP26(BU) - Graminoid fen (Burned)	11	0.0	0.0	30.3	401.6
BP28(BU) - Seaside arrow-grass marsh (Burned)	2	0.0	0.0	22.4	109.9
BS16(BU) - Black spruce/balsam poplar/river alder swamp (Burned)	24	0.0	0.0	<0.1	<0.1
BS17(BU) - Black spruce treed bog (Burned)	11	0.0	0.0	398.8	1,540.3
BS18(BU) - Labrador tea shrubby bog (Burned)	14	0.0	0.0	192.1	1,052.9
BS19(BU) - Graminoid bog (Burned)	6	0.0	0.0	0.1	0.1
BS20(BU) - Open bog (Burned)	7	0.0	0.0	0.8	2.2
BS21(BU) - Tamarack treed fen (Burned)	14	0.0	0.0	2.4	7.0
BS22(BU) - Leatherleaf shrubby poor fen (Burned)	6	0.0	0.0	60.4	411.4
BS23(BU) - Willow shrubby rich fen (Burned)	19	0.0	0.0	6.9	33.1
BS24(BU) - Graminoid fen (Burned)	11	0.0	0.0	6.6	89.1
BS25(BU) - Open fen (Burned)	4	0.0	0.0	<0.1	0.1
BS26(BU) - Rush sandy shore (Burned)	3	0.0	0.0	0.7	36.6
Recent burn wetland	5	0.0	0.0	1.3	96.8
Total		**748.8**	**2,330.6**	**29,449.0**	**88,211.2**

Note: Traditional use plant habitat totals do not include disturbance or water ELC units.
a) McLaughlan et al. 2010.
ELC = Ecological Land Classification; LSA = local study area; RSA = regional study area.

13.4 Project Interactions and Mitigations

The pathways analysis identifies potential adverse effects of the Project on vegetation VCs, identifies practicable mitigation for these potential effects, and determines whether any of the potential effects could be sufficiently mitigated such that they are not expected to cause a residual adverse effect. As described in Section 13.2.7, Project Interactions and Mitigations, the pathways analysis assigned each potential effect as:

- no pathway (i.e., mitigation results in no effect on vegetation VCs);
- secondary pathway (i.e., mitigation results in a negligible effect on vegetation VCs); or
- primary pathway (i.e., an effect that is greater than negligible and carried forward for further assessment).

The pathway analysis is summarized in Table 13.4-1. The subsections following the table provide the rationale used to assign potential effects to the no pathway and secondary pathway categories and list the primary pathways. Each Project interaction identified as a primary pathway was carried forward for detailed assessment in Section 13.5, Residual Effects Analysis. Effects pathways apply to all Project phases and all vegetation VCs unless otherwise noted.

The environmental design features and mitigations in Table 13.4-1 represent the list of key actions used to inform the pathway analysis as part of preparing the EIS. In addition to this list of key actions, NexGen would implement the Environmental Protection Program, which would describe the processes required to monitor and characterize effects from Project facilities and activities. This program would be used to periodically evaluate mitigation performance and identify additional mitigation, where required, and prompt potential adaptive management measures (Section 13.7, Monitoring, Follow-Up, and Adaptive Management). Where relevant, adaptive management measures may also be proposed to address uncertainties associated with effects predictions and mitigation. The process for determining when, how, and where to use adaptive management would be described within the Integrated Management System Manual.

Potential accidents and malfunctions that have the capability to influence biophysical or human environments are discussed in Section 21, Accidents and Malfunctions.

Table 13.4-1: Potential Effects Pathways for Vegetation

Pathway ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
V-01	Project components or activities that contribute to the Project footprint during **all Project phases**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ additional infrastructure (e.g., roads, airstrip, camp, maintenance shop, and offices) ▪ handling and storage of waste rock, special waste rock, and ore ▪ sewage treatment plant and water storage and effluent monitoring ponds ▪ removal of infrastructure ▪ restoration and revegetation of facilities and infrastructure	**Direct loss:** ▪ Direct loss, alteration, and fragmentation of upland, wetland, and riparian ecosystems and traditional use plants as a result of the Project	▪ **Site access road** between gatehouse and mine terrace realigned during Project design **to avoid a wetland** ▪ **Limit the Project footprint** to the extent practical using practices such as: o optimizing the use of cleared areas for Project activity o using existing road infrastructure, including existing access road and bridge crossing o storing tailings underground o designing an efficient infrastructure footprint (i.e., buildings clustered together) ▪ **Minimize areas of vegetation clearing** and soil disturbance ▪ **Minimize steepness and length of slopes of disturbed areas** and stockpiled soils ▪ Mark clearly with an applicable **set-back distance and avoid known rare plants**, where feasible. Where disturbance to rare plants is unavoidable, compensation would be considered following discussion with and guidance from regulators ▪ To the extent practical, **work in sensitive areas** (i.e., erosive soils, wetland features, and fish habitats) would be scheduled **to avoid periods that may result in high flow volumes and/or increase erosion and sedimentation** (e.g., spring freshet) ▪ **Use clearing equipment that minimizes surface disturbance, soil compaction, and topsoil loss** (e.g., equipment with low ground pressure tracks or tires, blade shoes, and brushes), where feasible ▪ Implement **progressive reclamation and revegetation** of disturbed areas no longer required ▪ **Reclaim and revegetate areas** where non-permanent Project facilities have been decommissioned ▪ Implement a Project-specific **Environmental Protection Program** that includes actions to avoid and limit invasive plant species ▪ Develop and implement a **Detailed Decommissioning and Reclamation Plan** to decommission and transfer the site to the province under the Institutional Control Program	Primary pathway

Table 13.4-1: Potential Effects Pathways for Vegetation

Pathway ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
V-02	Project components or activities that alter soil conditions or final terrain (i.e., topography) conditions during **all Project phases**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ additional infrastructure (e.g., roads, airstrip, camp, maintenance shop, and offices) ▪ handling and storage of waste rock, special waste rock, and ore ▪ sewage treatment plant and water storage and effluent monitoring ponds ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure	**Terrain alteration:** ▪ Alteration of final terrain, soil conditions, and/or plant species composition could change the types of ecosystems and traditional use plants that can be reclaimed on the landscape and adversely affect vegetation ecosystem availability, distribution, and condition	▪ **Minimize areas of vegetation clearing** and soil disturbance ▪ **Minimize steepness and length of slopes of disturbed** areas and stockpiled soils ▪ As part of reclamation activities, complete **contouring of disturbed areas** to minimize erosion, re-establish drainage, and encourage the growth of vegetation ▪ Use stockpiled overburden and NPAG mine rock as fill to meet decommissioning requirements ▪ Fill and **contour the site to blend with the natural surrounding topography**, to the extent practical ▪ Use **native species** or non-aggressive, non-native species appropriate for the conditions for revegetation ▪ To the extent practical, **work in sensitive areas** (i.e., erosive soils, wetland features, and fish habitats) would be scheduled **to avoid periods that may result in high flow volumes and/or increase erosion and sedimentation** (e.g., spring freshet) ▪ Implement a Project-specific **Environmental Protection Program** that includes actions to avoid and limit invasive plant species ▪ Implement **progressive reclamation and revegetation** of disturbed areas no longer required ▪ **Reclaim and revegetate areas** where non-permanent Project facilities have been decommissioned ▪ Develop and implement a **Detailed Decommissioning and Reclamation Plan** to decommission and transfer the site to the province under the Institutional Control Program ▪ Adhere to the *Federal Policy on Wetland Conservation* (Government of Canada 1991) to have **no net loss of wetland functions**	Primary pathway
V-03	Project activities that change access for Indigenous and other land users during **all Project phases**: ▪ development and improvement of access road and site roads ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure	**Public access affecting vegetation:** ▪ Changes in public access to gathering areas and increased density of people (i.e., Project staff and contractors) in the area may alter traditional use plant availability and distribution	▪ **Use existing road** infrastructure, including existing access road and bridge crossing to further develop access road to meet Project requirements ▪ **Install a gate at the site entrance** (i.e., gatehouse) to control public access ▪ Implement **progressive reclamation and revegetation** of disturbed areas no longer required ▪ **Reclaim and revegetate areas** where non-permanent Project facilities have been decommissioned ▪ Develop and implement a **Detailed Decommissioning and Reclamation Plan** to decommission and transfer the site to the province under the Institutional Control Program	Secondary pathway

Table 13.4-1: Potential Effects Pathways for Vegetation

Pathway ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
V-04	Project components or activities that contribute to deposition of fugitive dust and radon emissions during **all Project phases**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ underground shaft and mine development ▪ handling and storage of waste rock, special waste rock, and ore ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure ▪ site traffic ▪ transportation of personnel and material to and from the site	**Fugitive dust and constituent emissions:** ▪ Deposition of fugitive dust emissions and associated constituents (e.g., metals and radionuclides) may adversely change soil quality and affect the availability, distribution, and condition of vegetation ecosystems and traditional use plants	▪ Establish and enforce **speed limits** on site and access roads to reduce dust production ▪ **Limit vehicle speed** on unpaved site roads to reduce fugitive dust during Construction and Operations ▪ **Optimize haul routes** to reduce fuel consumption and emissions from equipment ▪ Limit total suspended particulate emissions during Construction by enforcing a **25 km/h speed limit for heavy equipment** involved in material movement and earthworks on the mine/mill terrace. This speed limit does not apply to site road traffic or the haul route from the headworks to the waste rock piles ▪ **Apply water and/or suppressants to site roads, access road, and airstrip**, as necessary. Use dust suppressants that minimize environmental risk and are government approved for use ▪ Implement a Project-specific **Environmental Monitoring Plan** that includes soil quality and ambient air monitoring ▪ Implement a Project-specific **Environmental Protection Program**	Secondary pathway
V-05	Project components or activities that contribute to criteria air contaminant emissions during **all Project phases**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ underground shaft and mine development ▪ power generation ▪ process plant buildings and underground operations ▪ handling and storage of waste rock, special waste rock, and ore ▪ additional infrastructure (e.g., camp, maintenance shop, and offices) ▪ waste incineration ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure ▪ site traffic ▪ transportation of personnel and materials to and from the site	**Particulates and acid emissions:** ▪ Deposition of criteria air contaminant emissions (e.g., particulates, potential acid inputs) may change soil chemistry or plant physiology and affect the availability, distribution, and condition of vegetation ecosystems and traditional use plants	▪ Evaluate opportunities to **reduce fuel combustion** requirements of infrastructure and equipment, to the extent practical, during detailed design ▪ **Optimize haul routes** to reduce fuel consumption and emissions from equipment ▪ Primarily **use liquified natural gas for power** generation ▪ Identify and implement **procurement criteria** to confirm stationary and mobile engines meet applicable performance standards ▪ Use and **maintain emissions control devices** on combustion-based equipment ▪ **Limit idling** of vehicles to the extent practical ▪ **Maintain mobile mining equipment and vehicles** and operate the equipment within parameters for engine exhaust system design ▪ Conduct **regular equipment maintenance** ▪ Implement a Project-specific **Environmental Monitoring Plan** that includes air monitoring ▪ Implement a Project-specific **Environmental Protection Program**	Secondary pathway

Table 13.4-1: Potential Effects Pathways for Vegetation

Pathway ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
V-06	Project components or activities that alter vegetation ecosystems during **Construction**: ▪ fibre optics line	**Loss from fibre optic line:** ▪ Direct loss, alteration, and fragmentation of upland, wetland, and riparian ecosystems and traditional use plants due to the installation of the fibre optic line	▪ Align the fibre optic line **right-of-way adjacent to existing highway and access road** ▪ **Clearing of vegetation** would be kept to the existing highway and site access road, to the extent possible ▪ Implement **sedimentation and erosion control** best practices and standard mitigation (e.g., temporary sediment ponds, silt curtains, sediment traps) during all Project phases ▪ Implement best management practices and mitigation such as **spill prevention** ▪ **Promote natural propagation and regeneration** to enhance reclamation along the access road and other Project rights-of-way	Secondary pathway
V-07	Project components or activities that contribute to the introduction of designated weed species during **all Project phases**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ roads and airstrip ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure	**Invasive species:** ▪ Introduction of weed species can affect the condition of upland, wetland, and riparian ecosystems and traditional use plants	▪ Use **native species** or non-aggressive, non-native species appropriate for the conditions for revegetation ▪ **Inspect construction equipment** prior to arriving at site and clean, if required o Utilize maintenance shop to support cleaning, once constructed and as required ▪ Procure clean construction materials and procure seed mixes that work to **avoid the introduction of noxious weeds** ▪ Implement a Project-specific **Environmental Protection Program** that includes actions to prevent, detect, control (i.e., remove), and monitor areas with prohibited, noxious, and nuisance weed / invasive species (e.g., along the access road, airstrip, and loading or staging site), following best practice guidance	Secondary pathway
V-08	Project components or activities that contribute to changes in site surface water quality and affect soil chemistry and vegetation during **all Project phases**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ handling and storage of waste rock, special waste rock, and ore	**Surface water flow changes:** ▪ Changes in surface water levels and flows can affect soils and alter waterbodies and watercourses and affect the availability, distribution, and condition of upland, wetland, and riparian ecosystems and traditional use plants	▪ Implement **progressive reclamation and revegetation** of disturbed areas no longer required ▪ **Reclaim and revegetate areas** where non-permanent Project facilities have been decommissioned ▪ Implement a Project-specific **Mine Waste Management Plan** ▪ Implement a Project-specific **Environmental Protection Program** ▪ Develop and implement a **Detailed Decommissioning and Reclamation Plan** to decommission and transfer the site to the province under the Institutional Control Program	Secondary pathway

Table 13.4-1: Potential Effects Pathways for Vegetation

Pathway ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
V-09	▪ additional infrastructure (e.g., roads, airstrip, camp, maintenance shop, and offices) ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure	**<u>Surface water quality from runoff:</u>** ▪ Changes in surface water quality from contact with surface facilities and additional infrastructure could adversely affect the condition of upland, wetland, and riparian ecosystems and traditional use plants		Secondary pathway
V-10	Project components or activities that may change surface water and sediment quality through treated effluent release during **all Project phases**: ▪ underground shaft and mine development ▪ process plant buildings and underground operations ▪ handling and storage of waste rock, special waste rock, and ore ▪ effluent treatment plant and treated effluent discharge ▪ sewage treatment plant and treated effluent discharge ▪ additional infrastructure (e.g., roads, airstrip, and camp) ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure	**<u>Treated effluent discharge:</u>** ▪ Release of treated effluent can alter surface water and sediment quality in Patterson Lake and farther downstream and adversely affect aquatic plants, traditional use plants, and the condition of wetland and riparian ecosystems	▪ Site-specific **effluent treatment** plant designed to reduce constituents of potential concern ▪ Design the treated effluent diffuser and treated sewage outfall to **provide effective mixing and dilution of the effluent** to limit the area of the receiving environment affected by mine discharge ▪ Design outfall(s) such that **discharged flow does not interact with sediment** ▪ Design discharge points to **avoid sensitive or unique habitats**, to the extent practical ▪ Collect, store, and routinely **monitor contact water** to confirm discharge water meets water quality criteria appropriate for release ▪ **Monitor treated effluent and treated** sewage flow and quality ▪ Implement a Project-specific **Environmental Monitoring Plan** that includes monitoring water quality and sediment quality and applying adaptive management if necessary ▪ Implement a Project-specific **Mine Waste Management Plan** ▪ Implement a Project-specific **Environmental Protection Program** ▪ Develop and implement a **Detailed Decommissioning and Reclamation Plan** to decommission and transfer the site to the province under the Institutional Control Program	Secondary pathway

Table 13.4-1: Potential Effects Pathways for Vegetation

Pathway ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
V-11	Project components or activities that potentially change groundwater quality **following Closure**: ▪ WRSAs ▪ the UGTMF and backfilled stopes	**Surface water quality from WRSAs and UGTMF after Closure:** ▪ Runoff and seepage from the WRSAs and groundwater flow from the UGTMF may alter surface water quality in Patterson Lake after Closure and adversely affect the condition of wetland and riparian ecosystems and traditional use plants	▪ Use **engineered cemented paste backfill and tailings** to control source concentrations ▪ **Apply binder** to reduce permeability in backfill and tailings ▪ Install **engineered cover system** on PAG and NPAG material during reclamation ▪ Implement site water management procedures under an **Environmental Protection Program** that include monitoring seepage from WRSAs and applying adaptive management, if necessary	Secondary pathway
V-12	Project components or activities that contribute to deposition of fugitive dust and radon emissions during **all Project phases**: ▪ land clearing, site preparation, and construction of facilities and infrastructure ▪ underground shaft and mine development ▪ handling and storage of waste rock, special waste rock, and ore ▪ removal of infrastructure ▪ reclamation and revegetation of facilities and infrastructure ▪ site traffic ▪ transportation of personnel and material to and from the site	**Radon emissions:** ▪ Radon emissions may adversely change soil quality and affect the availability, distribution, and condition of vegetation ecosystems and traditional use plants	▪ Implement a Project-specific **Environmental Monitoring Plan** that includes monitoring ambient air	No pathway

Table 13.4-1: Potential Effects Pathways for Vegetation

Pathway ID	Project Components/Activities	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
V-13	Project components or activities that potentially change groundwater quality during **all Project phases**: ▪ handling and storage of waste rock, special waste rock, and ore	**Groundwater and soil quality changes from seepage:** ▪ Seepage and runoff from the WRSAs may cause changes in groundwater quality and soil quality, and adversely affect the condition of upland, wetland, and riparian ecosystems and traditional use plants	▪ Design, maintain, and monitor a mine dewatering system to manage the flow of **groundwater inflow** ▪ **Segregate PAG material** from NPAG material and store separately ▪ **Contain and divert runoff and seepage from PAG** waste rock, special waste rock, and ore to the effluent treatment plant ▪ Implement a Project-specific **Mine Waste Management Plan** ▪ Implement site water management procedures under an **Environmental Protection Program** that include monitoring seepage from WRSAs and applying adaptive management, if necessary ▪ Develop and implement a **Detailed Decommissioning and Reclamation Plan** to decommission and transfer the site to the province under the Institutional Control Program	No pathway

Bolded text represents the key topic of the environmental design features and mitigation.
WRSAs = waste rock storage areas; NPAG = non-potentially acid generating; PAG = potentially acid generating; UGTMF = underground tailings management facility.

13.4.1 No Pathways

The following Project interactions were predicted to result in no pathway to vegetation VCs and were not carried forward in the assessment.

V-12: Radon emissions:

- Radon emissions may adversely affect soil quality and affect the availability, distribution, and condition of vegetation ecosystems and traditional use plants.

Radon emissions would be released as a gas from the process plant, underground operations, ore stockpiles, and WRSAs. The CRDN, BNDN, and YNLR expressed concerns related to radiation from the Project on the environment in general, which are in part, based on their observations and experiences from previous mining developments (i.e., the Cluff Lake Mine) and their belief that the Cluff Lake Mine was not properly decommissioned (TSD II: BNDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; CRDN 2019a; CRDN 2019b). For example, members of the BNDN expressed concerns about controlling radon gas and how far chemical emissions (e.g., radon) from the Project travel, as well as the effects of radon gas on terrestrial resources and how it would be monitored (BNDN-JWG 2020; BNDN-JWG 2021a; BNDN-JWG 2021c).

Soils in the maximum disturbance area are not expected to absorb radon gas and cause measurable changes to soil quality (Section 12.4.1, No Pathways). Radon atoms are released through radium decay and, once released into soil pore space, are able to emanate into the atmosphere. Once released, radon atoms travel via air or water within soil pore space and are dispersed to the atmosphere, and do not reabsorb into the soil particle. Radon emissions are not expected to change soil quality (Section 12.4.1, No Pathways) and are predicted to have no effect on the vegetation ecosystems and traditional use plants; the pathway is removed from the assessment.

V-13: Groundwater and soil quality changes from seepage:

- Seepage and runoff from the WRSAs may cause changes in groundwater quality and soil quality, and adversely affect the condition of upland, wetland, and riparian ecosystems, and traditional use plants.

Indigenous Groups expressed concerns related to the effects of Project activities in general, including of mine waste materials on underground water quality and environmental health (TSD II: BNDN; TSD V.2: CRDN; BRDN-JWG 2020; MN-S-JWG 2019a). NexGen understands the concerns raised by Indigenous Groups and recognizes the importance of designing the UGTMF and the PAG WRSA in a manner that minimizes potential effects to groundwater and soils. The effects of mine waste and tailings on underground water quality is assessed in Section 8, Hydrogeology, and effects to soil quality are assessed in Section 12, Terrain and Soils.

Extracted ore, special waste rock, and waste rock would be stored at surface in designated areas or WRSAs (Section 5.4.4 Mine Rock Management). Seepage and runoff from these storage areas during all Project phases could cause changes to groundwater quality, which has the potential to change soil quality and adversely affect vegetation VCs.

Seepage from the WRSAs during the Project lifespan would be mitigated by a number of proven engineering design features and techniques. Management of waste rock would begin when materials are hoisted from the underground mine to the surface. Ore, special waste rock, PAG and NPAG material would be separated and stored separately. Ore stockpiles, special waste stockpiles and the PAG WRSA would be lined with high density polyethylene to prevent seepage (Mine Waste Management Plan). The NPAG WRSA would be unlined and used for short- and long-term storage of NPAG waste rock. Runoff from the ore stockpiles, special waste stockpiles, and PAG WRSA would be contained and diverted to the effluent treatment plant and released to the environment after meeting discharge criteria. Runoff from the NPAG WRSA would be collected for containment and if it meets discharge criteria would be released to the environment. Water not meeting discharge criteria would be considered mineralized contact water and diverted to the effluent treatment plant prior to release. As part of the Environmental Protection Program, WRSAs would be monitored for seepage to support groundwater protection and to confirm the Mine Waste Management Plan is effective. A Detailed Decommissioning and Reclamation Plan would also be developed to decommission and transfer the Project to the Province under the Institutional Control Program.

Groundwater potentially affected by seepage from WRSAs is not expected to interact with the top layers of soils that support the establishment and growth of vegetation. Any changes to groundwater from the WRSAs would occur below the surficial soil layers (Section 12.4.1, No Pathways). In the ecological health risk assessment, direct contact or uptake exposure pathways associated with groundwater were predicted to be incomplete, as it was assumed that groundwater is inaccessible to ecological receptors (e.g., terrestrial plants and earthworms) or negligible relative to other pathways (TSD XXI, Section 6.1.4 Selection of Exposure Pathways). Therefore, there are no predicted residual effects on the condition of vegetation ecosystems and traditional use plants and the pathway was removed from further assessment.

13.4.2 Secondary Pathways

The following Project interactions were predicted to result in secondary pathways to vegetation VCs and were not carried forward in the assessment.

V-03: Public access affecting vegetation:

- Changes in public access to gathering areas and increased density of people (i.e., Project staff and contractors) in the area may alter traditional use plant species availability and distribution.

Indigenous Groups expressed concerns about being displaced from their traditional lands because of the Project, and about the ability to continue accessing areas in the vicinity of the Project site to practice traditional activities, including gathering medicinal plants or berries (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN). Increased density of people on the Project site may lead to changes in the availability of traditional use plant species and limit opportunities for Indigenous Group members to gather and harvest. Access roads provide increased opportunities for humans to use an area, which can result in increased harvesting pressure since linear features facilitate ease of movement into previously inaccessible areas. However, given that existing roads already provide public access, improvement of the access road to the Project is unlikely to affect traditional use plant species through additional harvest. The access road would also have a gatehouse to restrict public vehicle access to the main mine and process plant area.

Alternatively, employees and contractors working on the Project may use the opportunity to harvest plants and berries adjacent to the Project site, which could decrease the availability and distribution of traditional use plants relative to existing conditions. However, the changes are expected to be minor and localized and have a negligible residual effect on traditional use plants, and so the pathway was determined to be secondary and not carried forward in the assessment. Ecosystem services (i.e., the benefits people gain from the environment) provided by traditional use plant species are assessed in Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use, and Section 17, Other Land and Resource Use, and are not considered during pathway analysis in this section.

V-04: Fugitive dust and constituent emissions:

- Deposition of fugitive dust emissions and associated constituents (e.g., metals and radionuclides) may adversely change soil quality and affect the availability, distribution, and condition of vegetation ecosystems and traditional use plants.

Activities such as land clearing, site preparation, construction of facilities, site traffic, handling of waste rock during Construction and Operations, and removal of infrastructure and reclamation during Closure, would generate fugitive dust. Indigenous Groups expressed concerns about the effects of dust from Project activities on vegetation, including on berry patches. Concerns were raised specifically related to uranium dust generated from Project activities affecting the air, water, soil, and vegetation, which are based in part on their experience with other mining developments (i.e., Cluff Lake Mine) (TSD II: BNDN; TSD IV: MN-S; TSD V.2: CRDN). For example, the MN-S commented that uranium dust 'covers everything' because of its ability to "travel hundreds of kilometres with the wind" (TSD IV: MN-S). Accumulation of airborne dust produced by the Project may result in local and direct changes to vegetation. Dust can have a physical effect on plants by smothering plant leaves or blocking stomata openings (i.e., pores in the epidermis of the leaf of a plant) (Farmer 1993). Crusts that form on leaves can reduce net photosynthesis (Brandt and Rhoades 1973). After many cycles of crusting, the annual growth rate of plants can be reduced or cease and may lead to plant death (Brandt and Rhoades 1973). Decreased photosynthetic rates and less ground coverage in sphagnum moss (*Sphagnum* spp.) were observed when dust deposition from an adjacent gravel road was from 1.0 to 2.5 g/m^2/d (Farmer 1993).

Plant community changes can result if dustfall upsets the competitive balance among plants (Brandt and Rhoades 1973; Farmer 1993). For example, the abundances of tolerant species such as haircap moss (*Polytrichum* spp.), Bryum moss (*Bryum* spp.), cotton-grass (*Eriophorum* spp.), and willow (*Salix* spp.) increase, whereas sensitive species such as sphagnum moss and conifer species decrease in areas of high dustfall (Farmer 1993; Auerbach et al. 1997). Walker and Everett (1987) reported that few vascular plant species showed physiological effects from dust, except where vegetation was subject to high dust loading (e.g., 2.4 g/m^2/d or 7.2 mg/cm^2/30 d), in which case ericaceous shrubs and conifers were more affected.

In terms of spatial extent, Walker and Everett (1987) found effects on vegetation from dust were primarily within 50 m of a road in one Alaskan study, while in another study, Meininger and Spatt (1988), detected stronger effects within 50 m and weaker changes within 50 to 500 m from a road. At the Ekati Mine in the Northwest Territories, dust generated from a high-traffic, 28 km haul road was found to decrease lichen cover up to 1 km (Chen et al. 2017). At the nearby Diavik Mine, measured changes to plant communities were within 500 m of the mine and coincided with annual dust deposition rates of 0.283 to 0.848 mg/cm^2/30 d during underground and open pit mining (Watkinson et al. 2021). Therefore, spatial extents for the deposition of fugitive dust emissions are anticipated to be concentrated within 500 m of the Project footprint.

Air quality modelling was completed to predict the amount and spatial extent of dust deposition and associated constituents as a result of the Project during Construction and Operations (Section 7.2; Appendix 7A, Air Dispersion Modelling Report). Results indicate that the dust deposition rate was higher during Operations than Construction, which is a function of the type of dust, the height that dust is released, and the fraction of coarse particulate matter in total suspended particulates (i.e., particulate matter greater than PM_{10} [particulate matter with a diameter of 10 µm or less]). Rates of dust deposition and accumulation also depend on the rate of supply from the source, wind speed, precipitation events, topography, and vegetation cover (Brown and Berg 1980; Rusek and Marshall 2000).

The annual dust deposition rate during Operations was 0.095 mg/cm^2/30 d at the boundary of the maximum disturbance area, which is well below the Ontario human health guideline of 0.46 mg/cm^2/30 d (MECP 2020) (Section 7.2; Appendix 7A). The dust deposition rate equivalent to the Ontario guideline value was located a minimum of 314 m inside the boundary of the maximum disturbance area. Dust deposition rates during Construction (i.e., 0.072 mg/cm^2/30 d) and Operations are also much lower than the rates reported above (i.e., 0.3 to 7.2 mg/cm^2/30 d); therefore, vegetation community changes are anticipated be localized, with negligible effects beyond the maximum disturbance area. Changes to soil chemistry from dust containing metals and radionuclides were also predicted to result in negligible effects on soil quality (Section 12.4.2).

Metals in dust can also affect plants, either indirectly through the soil (Section 12.4.2, Secondary Pathways) or directly through the surface of the plant (Farmer 1993; Rusek and Marshall 2000). The indirect responses of vegetation to changes in soil quality depend on the chemical compositions of dust and its source (Grantz et al. 2003). The toxicity of metals absorbed through leaves (i.e., from dust) varies with the type of metals present and with plant species tolerance (Shahid et al. 2017). In some cases, plant exposure to metals can cause oxidative stress, damage plant tissues and DNA (deoxyribonucleic acid), impede plant metabolism (e.g., photosynthesis and respiration) and growth, or lead to plant death (John et al. 2009; Li et al. 2016; Rahul and Jain 2016). However, plant species display various tolerances due to specific defense mechanisms by which they cope with metals toxicity (Shahid et al. 2017). These mechanisms can lead instead to accumulation of metals in living plant tissues (Ghori et al. 2019).

Uranium radionuclides may cause toxicity to plants and inhibit photosynthesis (Weiersbye et al. 1999). However, plants can store uranium radionuclides in the roots, with little accumulation in plant shoots, which may protect against toxicity effects (Mitchell et al. 2013). Radionuclide concentrations are generally high in bryophyte and lichen species because these species have high dust interception and retention periods, but fungi have been observed to have the highest concentrations of radionuclides from dust (IAEA 1996). For vascular plants, ericaceous dwarf shrubs appear to have the highest uptake of radionuclides from dust, followed by herbs, grasses, and then shrubs and trees (IAEA 1996).

Mitigation in the Environmental Protection Program is expected to be effective at reducing the magnitude and spatial extent of fugitive dust deposition (Table 13.4-1). Water and/or dust suppressants would be applied to the airstrip, site roads, and the access road as necessary (i.e., during dry conditions in the non-winter period). Speed limits would be enforced and are expected to reduce the production of dust emissions. After implementing mitigation, dust deposition is expected to result in minor changes in the availability, distribution, and condition of upland, wetland, and riparian ecosystems and traditional use plants. However, these changes are predicted to be confined to the maximum disturbance area and have a negligible residual effect on vegetation VCs, so the pathway was not carried forward in the assessment.

V-05: Vegetation changes from particulates and acid emissions:

- Deposition of criteria air contaminant emissions (e.g., particulates, potential acid inputs) may change soil chemistry or plant physiology and affect the availability, distribution, and condition of vegetation ecosystems and traditional use plants.

Deposition of criteria air contaminants emissions associated with Project activities are expected to occur from the combustion of fossil fuels in large equipment, aircraft, trucks, vehicles, power generation, and the burning of non-hazardous waste materials (e.g., food garbage). Criteria air contaminants include particulate matter less than 2.5 µm in diameter ($PM_{2.5}$) and less than 10 µm in diameter (PM_{10}), total suspended particulates, carbon monoxide, sulphuric acid, sulphur dioxide, and nitrogen dioxide.

Air particulate emissions can change soil quality and subsequently lead to effects on vegetation by altering soil pH, nutrient content, and the composition of soil organisms (Rusek and Marshall 2000; Jung et al. 2011; Chen et al. 2017). Air particulates may also affect cation and anion exchange in soil, nutrient uptake by vegetation, decomposition rate of organic matter, and nutrient cycling (John et al. 2009; Jung et al. 2011). Deposition of sulphur dioxide and nitrogen dioxide could lead to acidification of soils (Holowaychuck and Fessenden 1987; Bobbink et al. 1998).

Indigenous Groups and LPA community members have expressed concerns about changes in air quality from Project activities and effects to terrestrial environmental health (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; BRDN-JWG 2020; CRDN-JWG 2021; NexGen 2019). For example, a member of the CRDN commented that they will not eat berries from the Cluff Lake Mine area because of their belief that the area is contaminated (TSD V.2; CRDN; CRDN-JWG 2020a), and the MN-S stated that the trees on the side of the road were dying near the Cluff Lake Mine, which they attributed to carbon emissions or dust from increased traffic, and that plants are dying from what they attributed to the effects of oil sands mining (MN-S-JWG 2019a). MN-S also raised concerns about the effects of dust from Project activities on vegetation, including berry patches (TSD IV: MN-S).

NexGen understands the concerns of Indigenous Groups regarding existing air quality on vegetation and would implement environmental design features and mitigation to minimize potential Project effects (Section 13.4, Project Interactions and Mitigations).

Short-term exposures (e.g., 24-hour) to high concentrations of sulphur dioxide may also result in dead or chlorotic (i.e., nutrient deficient) plant tissue. However, long-term exposures (e.g., annual) to lower concentration levels of sulphur dioxide may or may not result in visible injury to plants (Alberta Environment 2004). Mineral (i.e., clay) and organic matter colloid content (i.e., particle size of 2 µm in diameter or less) of soil and pH level affect the sensitivity of soil to acidification (Holowaychuck and Fessenden 1987) and therefore can also affect the sensitivity of vegetation ecosystems to acidification.

Air quality modelling was used to predict maximum ground-level concentrations of criteria air contaminant emissions during Construction and Operations (Section 7.2.2.8, Residual Effects Analysis). Cumulative concentrations were calculated by adding values for the Base Case to maximum predicted values for Construction and Operations. The Saskatchewan Ambient Air Quality Standards (ENV 2021) were developed to minimize human health and ecosystem health risks. Results indicate that concentrations of criteria air contaminants beyond the maximum disturbance area are well within Saskatchewan Ambient Air Quality Standards (ENV 2021) during Construction and Operations (Table 13.4-2), including carbon monoxide and sulphuric acid (Section 7.2.5, Residual Effects Analysis). The exception is PM_{10}, which exceeds the air quality guideline value during both Project phases. During Construction, most of the area of exceedance (279 ha) overlaps Patterson Lake North Arm and extends north from the boundary of the maximum disturbance area to approximately 1.2 km (Section 7.2.5). In contrast, during Operations, the area of exceedance is substantially reduced (9 ha) and extends north 203 m from the boundary of the maximum disturbance area. Since exceedances would occur mostly over Patterson Lake North Arm, it is anticipated that there would be minimal changes to terrestrial vegetation VCs.

Table 13.4-2: Annual Criteria Air Contaminant Emissions as a result of the Rook I Project during Construction and Operations

Criteria Air Contaminant	Construction (µg/m^3)	Operations (µg/m^3)	Guideline (Annual)[(a)]
Total suspended particulates	13.2	11.2	60
PM_{10}	**147.0**	**65.4**	50[(b)]
$PM_{2.5}$	4.1	3.7	10
Nitrogen dioxide	9.7	6.7	45
Sulphur dioxide	0.0	0.1	20

Bold values indicate exceedance of guideline.
a) ENV 2021.
b) 24-hour average period.
PM_{10} = particulate matter 10 µm or less in diameter; $PM_{2.5}$ = particulate matter 2.5 µm or less in diameter.

The World Health Organization has established that vegetation growth and community composition characteristics may be altered with sulphur oxide emissions of 20 µg/m^3 as an annual mean (WHO 2000). The critical level for lichens and bryophytes is species dependent. Sensitive lichen and bryophyte species are damaged or eradicated by annual average levels of sulphur dioxide of 8 µg/m^3 to 30 µg/m^3, and few lichens can tolerate levels exceeding 125 µg/m^3 (Blett et al. 2003). The World Health Organization has established a critical level for lichens of 10 µg/m^3 because community changes have been observed at these levels (WHO 2000). Results of the air quality modelling indicate that annual sulphur dioxide emissions as a result of the Project are predicted to be 0.0 µg/m^3 and 0.1 µg/m^3 for Construction and Operations, respectively (Section 7.2.5), which are well below levels believed to be harmful to vegetation.

Changes in the amount of nitrogen in an ecosystem can affect soil nutrient balance through the amount of litter produced and the rates of ammonification (i.e., release of ammonia from the soil surface) and nitrification (i.e., conversion of ammonia to nitrate) (Grantz et al. 2003). Oxidization of nitrogen dioxide can produce nitrate, which is typically limited in nutrient-poor environments and can be taken up by vegetation. Nitrogen dioxide at low concentration can stimulate plant growth, while higher concentrations may adversely effect plants (WHO 2000). Biological uptake can reduce effects of nitrogen deposition on other components of the environment by storing nitrogen compounds in plants (WHO 2000).

The World Health Organization has established annual critical levels at which vegetation growth and community composition characteristics may be altered due to nitrogen oxide emissions (WHO 2000). The critical level where direct effects are anticipated on plant species or ecosystems is 30 µg/m^3 as an annual mean (WHO 2000). Air quality modelling for the Project predicted that nitrogen dioxide emissions would be 9.7 µg/m^3 and 6.7 µg/m^3 during Construction and Operations, respectively (Section 7.2.5), which are below the values expected to be harmful to vegetation.

Environmental protection and monitoring plans developed for the Project, which include adaptive management, are expected to limit the emissions of criteria air contaminants and the associated effects on soils, vegetation ecosystems, and traditional use plants (Effluent and Emissions Plan, Environmental Monitoring Plan). Project designs and mitigation measures include the primary use of liquid natural gas for power generation, emission control devices on combustion-based equipment and vehicles, regular maintenance of equipment, and procurement criteria specifying that stationary and mobile equipment are to meet applicable performance standards (Table 13.4-1).

After implementation of environmental design features, mitigation, and monitoring changes to soil quality (i.e., productivity), effects from criteria air contaminants are predicted to be minor and confined to the maximum disturbance area for all criteria air contaminants, except particulate matter less than 10 µm, which would extend into the LSA (Section 12.4.2). Emissions of sulphur dioxide and sulphuric acid were predicted to have no effect on soil quality. Deposition of criteria air contaminant emissions could result in a minor change to the availability, distribution, and condition of upland, wetland, and riparian ecosystems and traditional use plants within the maximum disturbance area, but most changes are likely to be not measurable relative to existing conditions. Any changes were predicted to have a negligible residual effect on vegetation VCs, and the pathway was not carried forward in the assessment.

V-06: Loss from fibre optic line;

- Direct loss, alteration, and fragmentation of upland, wetland, and riparian ecosystems and traditional use plants due to installation of the fibre optic line.

Depending on final Project design, an approximately 155 km fibre optic line may be installed from La Loche, Saskatchewan, to the Project. Should the development of a fibre optic line progress, all construction is expected to occur in previously disturbed road allowances of Highway 955 and the Project access road, which would avoid loss and fragmentation of natural vegetation ecosystems and traditional use plants that occupy those habitats. Given that plough-in construction methods are anticipated to be used, the disturbance width would be minimal (i.e., approximately 1 m based on existing construction practices), and natural plant regeneration is expected to adequately reclaim the disturbance. Dust deposition would be limited to the installation of the fibre optic line and is predicted to result in small changes to the condition of natural ecosystems and to be reversible shortly after construction. It is expected that best management practices would be implemented to mitigate effects on the environment during construction (e.g., erosion control practices and spill prevention measures). Therefore, changes to the availability and distribution of upland, wetland, and riparian ecosystems and habitats for traditional use plant species from installation of the fibre optic line are predicted to be minor relative to existing conditions and result in negligible residual effects on vegetation VCs, and the pathway was not carried forward in the assessment.

V-07: Invasive species:

- Introduction of weed species can affect the condition of upland, wetland, and riparian ecosystems and traditional use plants.

In Saskatchewan, weeds are designated as prohibited, noxious, or nuisance species under *The Weed Control Act*. Weed species primarily have the potential to alter ecosystem condition in areas adjacent to new disturbances, particularly where the edge-to-interior ratio is high (Honnay et al. 2002). Ecosystems with undisturbed soils that occur away from disturbances are relatively resistant to invasion by weed species. However, habitat edges are prone to invasion in part because of the increased likelihood of soil disturbance.

Anthropogenic activities have the potential to accelerate the invasion of native ecosystems by weeds through the introduction of seeds or disturbance of soils (Hobbs and Humphries 1995).

An Environmental Protection Program would be implemented to prevent, detect, control (i.e., remove), and monitor areas with prohibited, noxious, and nuisance weed species (e.g., along the access road, airstrip, and loading or staging site). Construction equipment would be cleaned prior to arriving on site, if required. Once the maintenance shop is built, vehicles would be cleaned in a wash bay with containment and a sump. Clean construction materials and seed mixes would be procured that work to avoid the introduction of noxious weeds.

The implementation of best management practices and mitigation is expected to avoid and minimize the introduction and spread of weed species in the maximum disturbance area of the Project and result in minor changes to the condition of upland, wetland, and riparian ecosystems and traditional use plants. Any changes are predicted to have a negligible residual effect on vegetation VCs, and so the pathway not carried forward in the assessment.

V-08: Surface water flow changes:

- Changes in surface water levels, flows, and drainage areas can affect soils and the availability, distribution, and condition of upland, wetland, and riparian ecosystems and traditional use plants.
- Changes in surface water levels and flows can alter waterbodies and watercourses and affect the availability, distribution, and condition of upland, wetland, and riparian ecosystems and traditional use plants.

Changes in the volume or rate of surface water flows due to the Project may adversely affect vegetation ecosystems and traditional use plants through desiccation or inundation (van der Valk 1994; Hudon et al. 2005). Wetland and riparian ecosystems experience water level fluctuations as part of natural variability, and riparian ecosystems can recover relatively quickly from flooding (van der Valk 1994; Drinkard 2012; Vale et al. 2015). Fluctuating water levels typically influence plant species composition, community structure, and species richness (van der Valk 1994; Drinkard 2012; Vale et al. 2015). Preventing changes in wetland water levels can cause a decrease in aquatic plant community diversity (Nielsen et al. 2013). Alternatively, changes in the amplitude, frequency, and timing of flood or drought compared to historical levels can cause adverse effects on wetlands (Hudon et al. 2005). For example, Drinkard (2012) found that unpredictable short-term flooding of small-order riparian floodplain systems resulted in lower plant biodiversity. If wetland plants experience a reduction in water input leading to dehydration, they may die (Sheldon et al. 2005).

Changes in water flow regimes that persist for many successive years can also facilitate the invasion of introduced and exotic species while reducing the growth and survival of native aquatic macrophytes, with conditions favouring generalist species that could form highly resilient monocultures (i.e., growth consisting of a single species) (van der Valk 1994; Bunn and Arthington 2002; Zedler and Kercher 2004; Vale et al. 2015). Indigenous Groups raised concerns over potential effects on vegetation from changes in surface water and they indicated the importance of connections between waterways, rivers, and peatland vegetation communities (BRDN-JWG 2019a; BRDN-JWG 2019b). Further, several riparian and wetland traditional use plant species (i.e., willow, bulrush, and Labrador tea), which were identified in the IKTLU Studies (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD VI: YNLR) and in comments from CRDN (2019a) on the Cluff Lake Mine licence, may be susceptible to changes to surface water within wetland and riparian ecosystems.

Sediment in surface runoff also has the potential to affect vegetation. The effects of surface runoff sedimentation on vegetation may be similar to the effects of dust deposition on vegetation, which can have physical and chemical effects indirectly through the soil or directly through the surface of the plant (Farmer 1993; Rusek and Marshall 2000). Effects may include reduced net photosynthesis, reduced or stagnated growth, or plant death (Brandt and Rhoades 1973; Rahul and Jain 2016). Relative to the existing conditions, the potential for erosion, surface water runoff, and sediment release to wetland and riparian ecosystems from Project activities is expected to be highest during Construction and the Active Closure Stage and then decrease with the establishment of vegetation through the Transitional Monitoring Stage.

A regional hydrological model was used to characterize and predict changes from Project activities to water surface levels and watercourse flow rates for the RSA (Section 9.6, Residual Effects Analysis). Outputs from the regional hydrological model were used as inputs to stream channel relationships and a fluvial sediment transport model. The model predicted surface water flows and levels from the start of Construction to the end of Closure. The results indicate that the net discharge of water to Patterson Lake from Project activities is expected to create small changes such as increasing water surface elevation by 5 cm, increasing flows in the Clearwater River downstream of Patterson Lake by less than 5%, and changing stream channel parameters (i.e., wetted area) by less than 1%. Erosional losses in the Clearwater River Upper Reach and subsequent sediment deposition in the lower reach may increase by a non-detectable margin and the net balance of sediment transported to Forrest Lake is expected to remain unchanged. Changes in surface water patterns as a result of the Project are predicted to have a negligible residual effect on soils in the LSA (Section 12.4.2).

Surface water in the receiving environment downstream of the Project would be protected and managed through the Environmental Monitoring Plan. Site contact water would be intercepted and managed in ways to reduce effects on the surrounding environment in accordance with the Environmental Protection Program. The Project footprint is designed to minimize areas of vegetation clearing and soil disturbance and optimize the use of the existing access road and disturbed areas. The tailings management facility (i.e., UGTMF) would be located underground, which avoids permanent disturbance to vegetation (i.e., natural control for soil erosion) and considers the concerns raised by Indigenous Groups regarding surface deposition of mine wastes (Section 2).

In addition, work required in areas that may be more prone to erosion from surface water runoff and changes in surface water levels, flows, and drainage areas would be scheduled to avoid the time of year when erosion is most likely (e.g., spring freshet). The rate of discharge from the effluent treatment plant would be managed by having adequate surface water storage capacity to allow for controlled release rates if required. A minimum 150 m buffer between soil stockpiles and waterbodies or drainages would be maintained (unless temporary soil storage is required) and all containment and conveyance structures (i.e., ditches and culverts) would be routinely inspected and maintained to limit the risk of road washout or sediment release. Progressive reclamation and revegetation would also be implemented as disturbed areas are no longer required, and non-permanent features would be reclaimed and revegetated as they are removed. The Environmental Monitoring Plan includes monitoring surface water levels and flows. A Detailed Decommissioning and Reclamation Plan would also be developed with the provincial government and Indigenous Groups to decommission and transfer the Project site to the Province per the Institutional Control Program.

Overall, environmental design features, mitigation, and monitoring are anticipated to minimize changes in surface water levels and flows, drainage areas, and channel parameters (Section 9.5, Project Interactions and Mitigations) and result in a minor increase in soil erosion within the maximum disturbance area and LSA relative to existing conditions (Section 12.4.2). The predicted changes in surface water patterns and soil erosion as a result of the Project could result in minor alterations to the availability, distribution, and condition of upland, wetland, and riparian ecosystems and traditional use plants. However, the changes are predicted to have a negligible residual effect on vegetation VCs, and so the pathway was not carried forward in the assessment.

V-09: Surface water quality from runoff:

- Changes in surface water quality from contact with surface facilities and additional infrastructure could adversely affect the condition of upland, wetland, and riparian ecosystems and traditional use plants.

Rain and snowfall that contacts Project facilities and infrastructure (e.g., WRSAs, the process plant, and roads) may alter surface water quality through collection of metals and radionuclides in dust deposited on infrastructure and soils. Precipitation runoff from ore, NPAG, PAG, and special waste rock would also alter surface water quality. Changes in surface water quality have the potential to alter soil chemistry (i.e., quality) and affect vegetation ecosystems and traditional use plants.

Indigenous Groups and LPA communities have expressed concerns related to effects of the Project to water quality in general and subsequent effects on the aquatic and terrestrial environment. This includes concerns about Project-related contaminants entering the food chain within the Clearwater River watershed through effects to water quality in Patterson Lake, and adversely affecting the health of vegetation and wildlife (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; BNDN-JWG 2019; BRDN-JWG 2019a; BRDN-JWG 2020; MN-S-JWG 2019b; NexGen 2019).

Mitigation in the Environmental Protection Program is expected to be effective at reducing the amount and spatial extent of fugitive dust deposition (Table 13.4-1). Concentrations of metals and radionuclides in dust are predicted to be well below soil quality guideline values (Section 12.4.2). Dust deposition (i.e., total suspended particulates) is predicted to be largely confined to the maximum disturbance area, as discussed previously in the secondary pathway analysis for the effects of radon emissions and the deposition of fugitive dust emissions on soil quality and the availability, distribution, and condition of vegetation ecosystems and traditional use plants.

A Mine Waste Management Plan and Environmental Protection Program would be implemented to avoid and minimize changes in surface water quality during all Project stages, which would also mitigate effects on vegetation VCs. Site precipitation events (e.g., rain and snowmelt) that occur and contact Project facilities and infrastructure (i.e., contact water) would be captured, collected, and directed to respective site runoff ponds or collection areas. Contact water would be collected from the mine terrace, mill terrace, NPAG and PAG WRSAs, ore storage stockpile, special waste rock stockpile, camp area, and conventional waste management area (Section 5.4.5, Site Water Management).

Diversion ditches and perimeter berms are designed to divert clean non-contact water away from any disturbed areas, facilities, or works where that water may become contaminated. Design of water management facilities, processes, and activities that enable safe, secure, and environmentally responsible contact and non-contact water management through the Project lifespan would be determined by water characteristics. Present design focuses on modelled characteristics of contact water that would be confirmed or adjusted through monitoring if the Project is approved and developed. To maintain integrity, diversion ditches and collection ditches would be provided with erosion control measures reflective of ditch slopes and flow rates, where required. Swales (i.e., broad, shallow depressions that facilitate drainage) would be constructed on surface-graded pads where ditches are not possible, and where the initial anticipated contributing precipitation would not warrant a full ditch (Section 5.15). Surface water quality would also be monitored using the principles of adaptive management (Environmental Monitoring Plan). Disturbed areas that are no longer needed would be progressively reclaimed and revegetated, which would reduce the areas generating site contact water.

Environmental design features, mitigation, and monitoring are anticipated to minimize changes in surface water quality. Changes in surface water quality as a result of the Project could result in a measurable minor change to the condition of upland, wetland, and riparian ecosystems and traditional use plants relative to existing conditions. However, any changes would be limited to the maximum disturbance area and have negligible residual effects on wetland and riparian ecosystems, and would be considered reversible following the Active Closure Stage, so the pathway was not carried forward in the assessment.

V-10: Treated effluent discharge:

- Release of treated effluent can alter surface water and sediment quality in Patterson Lake and farther downstream and adversely affect aquatic plants and traditional use plants and the condition of wetland and riparian ecosystems.

Water from site runoff (i.e., contact water) and the UGTMF would be collected, contained, controlled, treated (if necessary), and monitored to protect the receiving environment (i.e., Patterson Lake). Similarly, domestic waste water would be treated and discharged to Patterson Lake after meeting discharge criteria. The release of treated effluent may alter surface water and sediment quality and affect aquatic plants and traditional use plants and the condition of wetland and riparian ecosystems.

As noted above, Indigenous Groups raised concerns about potential Project-related effects on the water quality of Patterson Lake, which could affect other nearby lakes, and by extension, downstream the Clearwater River and the entire Clearwater River watershed, including aquatic and terrestrial health (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; BNDN-JWG 2019; BRDN-JWG 2019a; BRDN-JWG 2020; MN-S-JWG 2019b; NexGen 2019).

Surface water quality changes in Patterson Lake and lakes farther downstream of the aquatic LSA from the start to the end of Operations were assessed using a nearfield model and regional receiving environment model. Operations represents the period of maximum expected changes to surface water quality from the discharge of treated effluent and treated sewage as a result of the Project. The expected magnitude, spatial extent, and duration of Project effects in the aquatic LSA was assessed using the regional model, while the nearfield model was used to assess potential effects in the immediate areas of the effluent treatment plant diffuser and sewage treatment plant outfall (Section 10.2.6.1, Surface Water Quality). Water quality thresholds were developed based on the Canadian Environmental Quality Guidelines for the Protection of Aquatic Life (CCME 2021) and provincial or federal objectives when no Canadian Council of Ministers of the Environment guidelines were available (Section 10.2.6.1).

Results indicate that no modelled water quality constituents or parameters exceeded their respective threshold values during Operations for the nearfield and regional assessments (Section 10.5, Residual Effects Analysis). Results for the upper bound scenario (i.e., a more conservative, or precautionary, model) for the regional assessment indicate that most modelled constituents were below threshold values during Operations. The exception was chloride, which showed a slight localized exceedance (approximately 10 mg/L) for a brief period (i.e., approximately two years) and was limited to the Patterson Lake North Arm – West Basin.

An ecological risk assessment was completed to determine the health risks to aquatic plant receptors from changes in surface water quality due to the Project. The risk assessment applied the modelled concentrations of water quality constituents as input values for the toxicological exposure model for each receptor during Operations and for the upper bound scenario. Results indicated that predicted changes in surface water quality for the upper bound scenario would not cause adverse effects on the health of aquatic plants (i.e., macrophytes, such as sedges and bulrush, and phytoplankton) (TSD XXI).

An Environmental Protection Program would be implemented to avoid and minimize changes in surface water quality during all Project phases, which would also mitigate effects on aquatic plants and vegetation VCs (Table 13.4-1). Routine monitoring of water quality parameters would be conducted to confirm discharge criteria are met before release into Patterson Lake. The outfalls for the effluent treatment and sewage treatment plants would be designed to provide effective initial mixing and avoid sensitive aquatic habitat. The designs would also avoid direct interactions with lake sediments.

With the implementation of environmental design features, mitigation, monitoring, and adaptive management, water quality in Patterson Lake and farther downstream is expected to result in minor or non-measurable influences on aquatic plant health and diversity and have negligible residual effects on wetland and riparian ecosystems. Thus, the pathway was not carried forward in the assessment.

V-11: Surface water quality from WRSAs and UGTMF after Closure:

- Runoff and seepage from the WRSAs and groundwater flow from the UGTMF may alter surface water quality in Patterson Lake after Closure and adversely affect the condition of wetland and riparian ecosystems and traditional use plants.

Indigenous Groups expressed concerns related to the effects of mine waste and tailings on surface and underground water quality, and risks to terrestrial environmental health (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; BNDN-JWG 2019; BNDN-JWG 2020; BNDN-JWG 2021b; BRDN-JWG 2021b; CRDN-JWG 2020b; CRDN-JWG 2021; MN-S-JWG 2019a). These concerns are based, in part, on observations from Indigenous Groups of the effects of contamination from previous mining developments (i.e., Cluff Lake Mine) on the health of the landscape (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; CRDN-JWG 2020a; MN-S-JWG 2019b; BRDN-JWG 2021a). NexGen understands the concerns of Indigenous Groups regarding changes in surface water quality from runoff and seepage from the WRSAs and groundwater flow from the UGTMF on vegetation and would implement environmental design features and mitigation to minimize potential Project effects (Section 13.4, Project Interactions and Mitigations).

Following Closure, runoff and seepage from the WRSAs and groundwater flow from the UGTMF may alter surface water quality in Patterson Lake and affect wetland and riparian ecosystems and traditional use plants. Proven engineered designs would be applied to the Project to limit runoff and seepage from WRSAs, such as installing a cover on PAG and NPAG material. Potentially acid generating waste rock would be separated from NPAG waste rock. Special waste rock would also be stored separately. Special waste stockpiles and the PAG WRSA would be lined with high density polyethylene to prevent seepage (Mine Waste Management Plan). Alternating lifts of PAG waste rock and engineered source control layers would be placed at the PAG WRSA. The engineered source control design concept includes the use of prescribed waste rock and control layer placement such that oxygen ingress to the waste rock is reduced compared to conventional construction. Engineered paste tailings would be used in the UGTMF to control sources of constituents of potential concern (Table 13.4-1). A Detailed Decommissioning and Reclamation Plan would also be developed with the provincial government and Indigenous Groups to decommission and transfer the Project site to the Province per the Institutional Control Program.

Surface water quality changes in Patterson Lake and lakes farther downstream of the aquatic LSA after Closure were assessed using a far-future scenario. The far-future scenario includes two stages totalling 357 years (Section 10.2.4, Temporal Boundaries). The first stage (157 years) includes natural hydrological and hydrogeological processes as a result of the Project during post-Closure, such as seepage from the UGTMF and the WRSAs, and surface runoff from the covered and reclaimed areas. The first stage continues for at least three climate cycles to examine the effects of climate on water quality. The second stage (200 years beyond the 157 years of the first stage) includes natural hydrological and hydrogeological processes where maximum mass loadings associated with seepage to groundwater are applied to the Patterson Lake North Arm – West Basin to examine maximum potential effects on Patterson Lake and lakes farther downstream until steady-state conditions are achieved.

The far-future scenario was assessed using the regional model and included an upper bound scenario (Section 10.2.8.1, Water Quality Models). Most modelled parameters remained below their respective threshold values in the far-future scenario, except for cobalt and copper. In this scenario, cobalt exceedances were predicted for Patterson Lake North Arm – West Basin and Patterson Lake South Arm. Copper exceedances were predicted for Patterson Lake North Arm – West Basin (Section 10.5.1.2, Regional Surface Water Quality Model). For the upper bound scenario, cobalt exceedances were predicted for Patterson Lake North Arm – West Basin, Patterson Lake South Arm, Forrest Lake – North Basin, and Beet Lake. Copper exceedances were predicted for Patterson Lake North Arm – West Basin and Patterson Lake South Arm (Section 10.5.2.1).

An ecological risk assessment was completed to determine the health risks to aquatic plant receptors from changes in surface water quality due to the Project. The risk assessment applied the modelled concentrations of water quality constituents as input values for the toxicological exposure model for each aquatic plant receptor for the far-future and upper bound scenario. Results indicated that predicted changes in surface water quality for the upper bound scenario would not cause adverse effects on the health of aquatic plants (i.e., macrophytes and phytoplankton) (TSD XXI).

Project designs, such as incorporating physical liners and providing a cover for waste rock storage, and the design, maintenance, and monitoring of a mine dewatering system, are anticipated to minimize changes in surface water quality in Patterson Lake due to seepage from the WRSAs and groundwater flow from the UGTMF in the far-future beyond Closure. Cobalt and copper are predicted to exceed their Project thresholds for water quality in the far-future projection (i.e., risk to aquatic and terrestrial life; Section 10.5.1.2, Regional Surface Water Quality Model). Alterations in surface water quality in Patterson Lake could result in a minor change to the condition of wetland and riparian ecosystems and traditional use plants that occupy those ecosystems relative to existing conditions. However, the environmental risk assessment (TSD XXI) showed that in the far future only copper has the potential to exceed the Project hazard quotient threshold of 1, which is limited spatially to the near-field in Patterson Lake and limited in magnitude to just above the benchmark for the upper bound sensitivity scenario. These exceedances of the hazard quotient benchmark were predicted for some groups of aquatic animals (i.e., lake whitefish, aquatic invertebrates, and zooplankton) but not for aquatic plants. Therefore, any minor changes are predicted to have a negligible residual effect on vegetation VCs, and the pathway was not carried forward in the assessment.

13.4.3 Primary Pathways

The following Project interactions were predicted to be primary pathways to vegetation VCs (Table 13.4-1) and were advanced for further assessment in the residual effects analysis (Section 13.5):

V-01: Direct loss:

- Direct loss, alteration, and fragmentation of upland, wetland, and riparian ecosystems and traditional use plants as a result of the Project.

V-02: Terrain alteration:

- Alteration of the final terrain, soil conditions, and/or plant species composition could change the types of ecosystems and traditional use plants that can be reclaimed on the landscape and adversely affect ecosystem availability, distribution, and condition.

13.5 Residual Effects Analysis

Project activities and components would alter upland, wetland, and riparian ecosystems (i.e., availability, distribution, and condition) and traditional use plant species (i.e., availability and distribution); this alteration could subsequently adversely affect vegetation productivity and the types of vegetation communities that can be re-established on the landscape through reclamation. Project activities that would affect ecosystem availability and distribution include: land clearing and site preparation for infrastructure and facilities during Construction; hauling and deposition of ore, waste rock, and other materials during Operations; and removal of infrastructure and facilities and associated restoration and revegetation of non-permanent Project components during Closure.

The residual effects analysis considers the primary pathways expected to result in effects on vegetation after implementing mitigation (Table 13.4-1) and was structured using separate subsections for each of the vegetation measurement indicators in the maximum disturbance area. The measurement indicators for vegetation are:

- ecosystem availability;
- ecosystem distribution;
- ecosystem condition;
- traditional use plant habitat availability; and
- traditional use plant distribution.

Residual effects resulting from the Project have been assessed using the assumption that vegetation in the entire maximum disturbance area would be altered (Section 13.2.3, Spatial Boundaries). The maximum disturbance area is approximately four times larger than the area to be disturbed by the anticipated Project footprint. Therefore, the assessment provides a conservative approach that overestimates Project effects in order to address uncertainty during the assessment.

13.5.1 Upland Ecosystems

The residual effects analysis for upland ecosystems focused on evaluating the following pathways:

- direct loss, alteration, and fragmentation of upland ecosystems as a result of the Project; and
- alteration of final terrain, soil conditions, and/or plant species composition could change the types of ecosystems that can be reclaimed on the landscape and adversely affect ecosystem availability, distribution, and condition.

13.5.1.1 Application Case

13.5.1.1.1 Ecosystem Availability

The assessment of changes to upland ecosystem availability in the Application Case focused on measuring changes from Construction through to Closure and beyond. The Project is predicted to contribute to a loss of 868.4 ha of upland ecosystems in the LSA and RSA (40.0% and 1.2% respectively) from the maximum disturbance area (980.7 ha; Table 13.5-1; Figure 13.5-1; Figure 13.5-2). However, the actual loss is anticipated to be less when considering the Project footprint.

Changes to upland ecosystems are predicted to be limited to five upland ELC units: Jack pine/lichen (BP02), Jack pine/feathermoss (BP03), Black spruce/Labrador tea/feathermoss (BP14), burned Jack pine/lichen (BP02[BU]), and burned Balsam poplar - trembling aspen/prickly rose (BP16[BU]).

The largest absolute change (i.e., difference between calculated values) would be to the burned Jack pine/lichen (BP02[BU]) ELC unit, with a predicted loss of 720.4 ha of 8,270.5 ha (8.0%) within the RSA. The burned Jack pine/lichen (BP02[BU]) ELC unit was the most common ELC unit observed at existing conditions within the LSA (i.e., 1,641.2 ha, or 58% of the LSA). Burned Jack pine/lichen (BP02[BU]) is a frequently encountered ELC unit in both the LSA and RSA, and the change from the Base Case represents an 8.0% change in the ELC unit. Further, an analogous habitat can be found within the unburned Jack pine/lichen habitat, as early- to late-stage regenerating (i.e., burned in the last 6 to 40 years; Burned) ELC units are anticipated to regenerate towards a Jack pine/lichen (BP02) ELC units. Similarly, an analogous habitat can be found in the burned and unburned Boreal Shield synonymous ELC units Jack pine/blueberry/lichen (BS03[BU]; BS03), which occupy a majority of the RSA (i.e., 23,172.8 ha [21.6%] and 4,991.4 ha [4.6%], respectively). Jack pine/lichen (BP02) and Jack pine/feathermoss (BP03) ELC units would also be disturbed, with the maximum disturbance area predicted to remove 52.2 ha and 48.4 ha, respectively. Jack pine communities (i.e., BP02, BP03, and BP02[BU]) are common within both the LSA and RSA. Changes to upland ELC units are predicted to occur primarily within jack pine communities (i.e., BP02, BP03, and BP02[BU]) (821.0 ha of 868.4 ha total upland Project-related alteration).

The largest relative change (i.e., absolute change expressed as a percentage) would be to the Black spruce/Labrador tea/feathermoss (BP14) ELC unit, with a predicted loss of 11.5 ha of 129.8 ha from the Base Case (8.9% change in RSA). Members of CRDN noted that the clearcutting of a stand of large spruce trees from development activities in general at Patterson Lake showed a lack of respect for the trees and for the community who utilize medicines from those same trees (TSD V.1: CRDN). Within the LSA, Black spruce/Labrador tea/feathermoss (BP14) availability would decrease from 19.1 ha to 7.6 ha. The Black spruce/Labrador tea/feathermoss (BP14) ELC unit is uncommon in the LSA and RSA.

A loss of 35.8 ha of burned Balsam poplar - trembling aspen/prickly rose (BP16[BU]) is predicted in the Application Case. Availability within the LSA would decrease from 161.9 to 126.0 ha, and availability within the RSA would decrease 3.3% from 1,070.4 ha to 1,034.6 ha.

Table 13.5-1: Changes to Upland Ecosystem Availability in the Application Case

Upland ELC Unit[a]	RSA		
	Base Case (ha)	Application Case (ha)	Change in Area (ha)
BP02 - Jack pine/lichen	2,791.3	2,739.1	-52.2
BP03 - Jack pine/feathermoss	3,712.1	3,663.7	-48.4
BP04 - Jack pine - trembling aspen/feathermoss	1,000.7	1,000.7	0.0
BP06 - Trembling aspen/beaked hazel/sarsaparilla	0.3	0.3	0.0
BP07 - Trembling aspen - white birch/sarsaparilla	5.1	5.1	0.0
BP11 - White birch - white spruce - balsam fir	3.2	3.2	0.0
BP12 - Jack pine - spruce/feathermoss	219.2	219.2	0.0
BP14 - Black spruce/Labrador tea/feathermoss	129.8	118.3	-11.5
BP16 - Balsam poplar - trembling aspen/prickly rose	33.3	33.3	0.0
BS02 - Lichen/felsenmeer - bedrock	<0.1	<0.1	0.0
BS03 - Jack pine/blueberry/lichen	4,991.4	4,991.4	0.0
BS04 - Jack pine - black spruce/feathermoss	6,158.9	6,158.9	0.0
BS05 - Jack pine - white birch/feathermoss	1.1	1.1	0.0
BS06 - Jack pine - trembling aspen/green alder	0.3	0.3	0.0
BS07 - Black spruce/blueberry/lichen	2.6	2.6	0.0
BS08 - Black spruce - white birch/lichen	<0.1	<0.1	0.0
BS09 - Black spruce - jack pine/feathermoss	23.1	23.1	0.0
BS10 - Black spruce - white birch/feathermoss	0.1	0.1	0.0
BS13 - White birch - black spruce - trembling aspen	11.9	11.9	0.0
BS14 - White birch/lingonberry - Labrador tea	74.0	*74.0*	0.0
BS15 - Trembling aspen - white birch/green alder	0.0	0.0	0.0
Undisturbed upland subtotal	*19,158.2*	*19,046.1*	*-112.1*
BP02(BU) - Jack pine/lichen (Burned)	8,990.9	8,270.5	-720.4
BP03(BU) - Jack pine/feathermoss (Burned)	4,846.6	4,846.6	0.0
BP04(BU) - Jack pine - trembling aspen/feathermoss (Burned)	1,274.5	1,274.5	0.0
BP06(BU) - Trembling aspen/beaked hazel/sarsaparilla (Burned)	0.3	0.3	0.0
BP07(BU) - Trembling aspen - white birch/sarsaparilla (Burned)	10.4	10.4	0.0
BP11(BU) - White birch - white spruce - balsam fir (Burned)	0.9	0.9	0.0
BP12(BU) - Jack pine - spruce/feathermoss (Burned)	4.4	4.4	0.0
BP14(BU) - Black spruce/Labrador tea/feathermoss (Burned)	25.2	25.2	0.0
BP16(BU) - Balsam poplar - trembling aspen/prickly rose (Burned)	1,070.4	1,034.6	-35.8
BS02(BU) - Lichen/felsenmeer - bedrock (Burned)	0.7	0.7	0.0
BS03(BU) - Jack pine/blueberry/lichen (Burned)	23,172.8	23,172.8	0.0
BS04(BU) - Jack pine - black spruce/feathermoss (Burned)	9,065.2	9,065.2	0.0
BS05(BU) - Jack pine - white birch/feathermoss (Burned)	5.1	5.1	0.0
BS06(BU) - Jack pine - trembling aspen/green alder (Burned)	0.9	0.9	0.0
BS07(BU) - Black spruce/blueberry/lichen (Burned)	5.6	5.6	0.0
BS08(BU) - Black spruce - white birch/lichen (Burned)	0.1	0.1	0.0
BS09(BU) - Black spruce - jack pine/feathermoss (Burned)	50.1	50.1	0.0

Table 13.5-1: Changes to Upland Ecosystem Availability in the Application Case

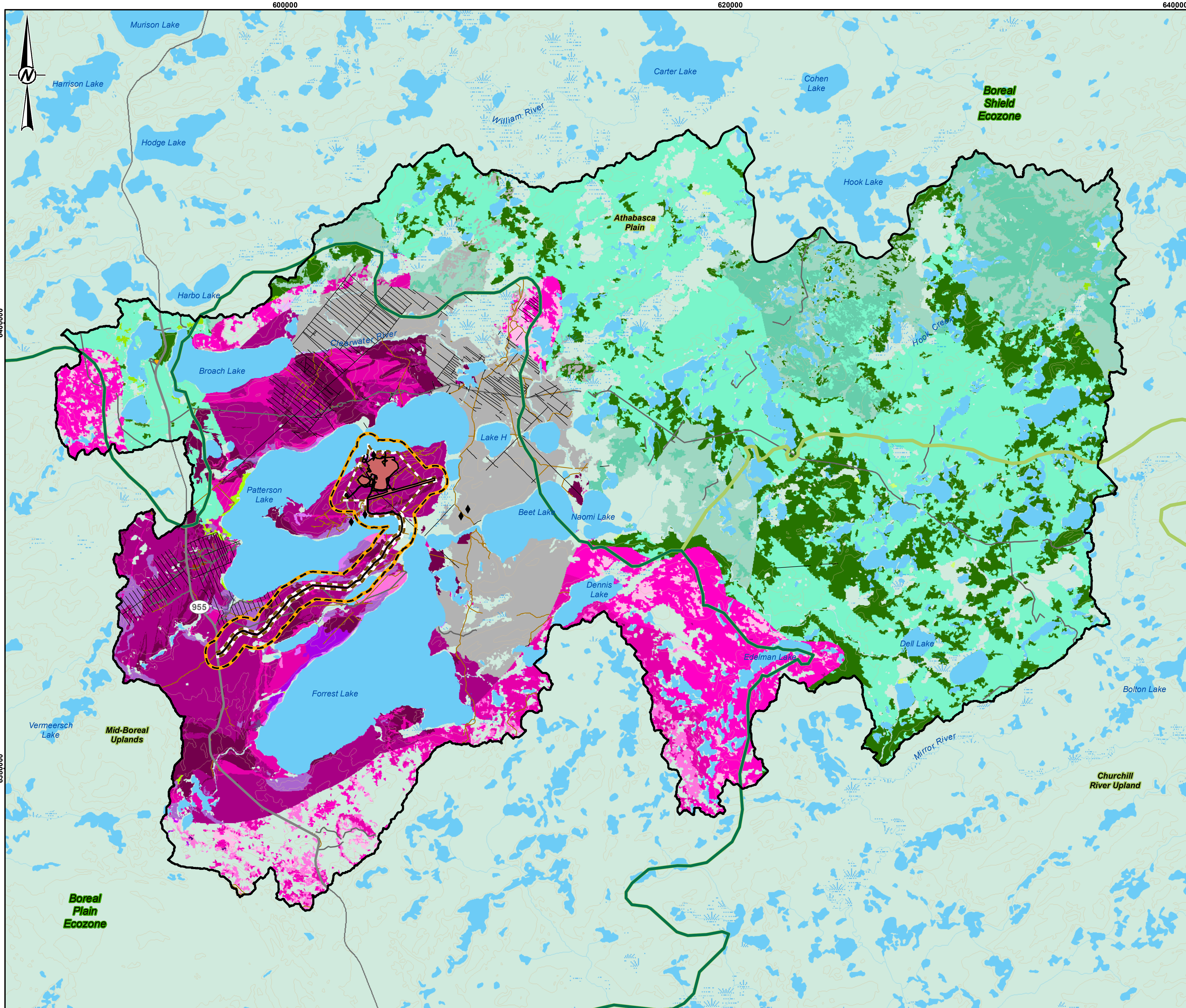
Upland ELC Unit[a]	RSA		
	Base Case (ha)	**Application Case (ha)**	**Change in Area (ha)**
BS13(BU) - White birch - black spruce - trembling aspen (Burned)	57.7	57.7	0.0
BS14(BU) - White birch/lingonberry - Labrador tea (Burned)	39.9	39.9	0.0
BS15(BU) - Trembling aspen - white birch/green alder (Burned)	0.2	0.2	0.0
Recent burn upland	7,041.6	7,041.6	0.0
Burned upland subtotal	*55,663.4*	*54,907.2*	*-756.2*
Upland total	**74,821.7**	**73,953.3**	**-868.4**
Summary			
Upland total	**74,821.7**	**73,953.3**	**-868.4**
Wetland total	**32,211.3**	**32,181.2**	**-30.1**
Anthropogenic disturbance total[b]	**457.8**	**1,356.3**	**898.5**
Total RSA	**107,490.7**	**107,490.7**	**n/a**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
a) McLaughlan et al. 2010.
b) Anthropogenic disturbance total includes the maximum disturbance area for the Project (980.7 ha) minus the existing anthropogenic disturbance within the maximum disturbance area in the Base Case (82.2 ha).
ELC = Ecological Land Classification; RSA = regional study area; < = less than; n/a = not applicable.

Effects on upland ecosystems from Project-related changes to ecosystem availability are certain as physical changes (e.g., vegetation clearing, placement of facilities) would occur as a result of Project development. Effects would be expected to be confined to the maximum disturbance area and be continuous from the start of Construction through to Closure and beyond. While permanent facilities of the Project (e.g., WRSAs) would be reclaimed, vegetation communities anticipated to establish on these features would likely not be representative of the upland ELC units not influenced by the Project; therefore, effects are conservatively considered permanent and irreversible (i.e., approximately 73.1 ha). Progressive reclamation would occur in areas no longer required for Project activities, as well as decommissioning and reclamation of non-permanent facilities and infrastructure, during the Active Closure Stage until regeneration is complete, which is expected to occur beyond Closure. Reclamation is predicted to reverse effects on disturbed ELC units and provide adequate material for the development of productive soils, which would support the establishment and succession of vegetation communities with similar function to natural ecosystems not influenced by the Project; however, upland ecosystems would likely differ from those present before disturbance but reflect plant communities in the boreal forest.

Indigenous Groups have expressed concerns about reclamation and commented that the land should be returned to its former condition after exploration activities in general and during Project Closure, and planted with native vegetation (TSD IV: MN-S; MN-S-JWG 2020; BRDN-JWG 2021a; YNLRO 2019). Vegetation ecosystems that can be returned to the landscape depend on edaphic (i.e., soil-related) conditions determined by topography, cover type, and depth. Reclaimable upland vegetation ecosystems are assumed to be predominantly dry to fresh upland sites, which would emulate common upland vegetation ELC units in the LSA under the existing conditions. The establishment of reclaimed upland vegetation ecosystems is predicted to occur well beyond the Active Closure Stage, particularly for mature forest types (e.g., 60 to 80 years; Section 13.3.1.3, Ecosystem Condition). However, young seral forest communities are anticipated to be established within 6 to 20 years following the Active Closure Stage.

Additional reclamation activities would be implemented during the Project lifespan and focus on the restoration of existing linear anthropogenic disturbances (Omnia 2020). However, to take a conservative assessment approach, potential net benefits from the reclamation of non-Project facilities (i.e., seismic lines) were not included as mitigation in the residual effects analysis. Reclamation of linear anthropogenic features may include seeding, planting, installation of coarse woody debris, tree tipping, and mounding. Investigations completed during the linear feature natural regeneration assessment program (Annex VII.1) and linear feature reclamation pilot program (Omnia 2020) may be used to inform other on-site reclamation activities.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- PROPOSED PROJECT FOOTPRINT
- MAXIMUM DISTURBANCE AREA
- LOCAL STUDY
- REGIONAL STUDY

UPLAND VASCULAR RARE PLANT SPECIES

- BEAUTIFUL SEDGE

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

UPLAND ECOLOGICAL LAND CLASSIFICATION UNIT

BP02	BP14	BS07
BP02 (BU)	BP14 (BU)	BS07 (BU)
BP03	BP16	BS08
BP03 (BU)	BP16 (BU)	BS08 (BU)
BP04	BS02	BS09
BP04 (BU)	BS02 (BU)	BS09 (BU)
BP06	BS03	BS10
BP06 (BU)	BS03 (BU)	BS13
BP07	BS04	BS13 (BU)
BP07 (BU)	BS04 (BU)	BS14
BP11	BS05	BS14 (BU)
BP11 (BU)	BS05 (BU)	BS15
BP12	BS06	BS15 (BU)
BP12 (BU)	BS06 (BU)	RECENT BURN (UPLAND)

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
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PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

UPLAND ECOSYSTEMS AND RARE PLANT SPECIES IN THE REGIONAL STUDY AREA, APPLICATION CASE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08	**FIGURE 13.5-1**	
CHECK	HH	2023-02-08		
REVIEW	JV	2023-02-08		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

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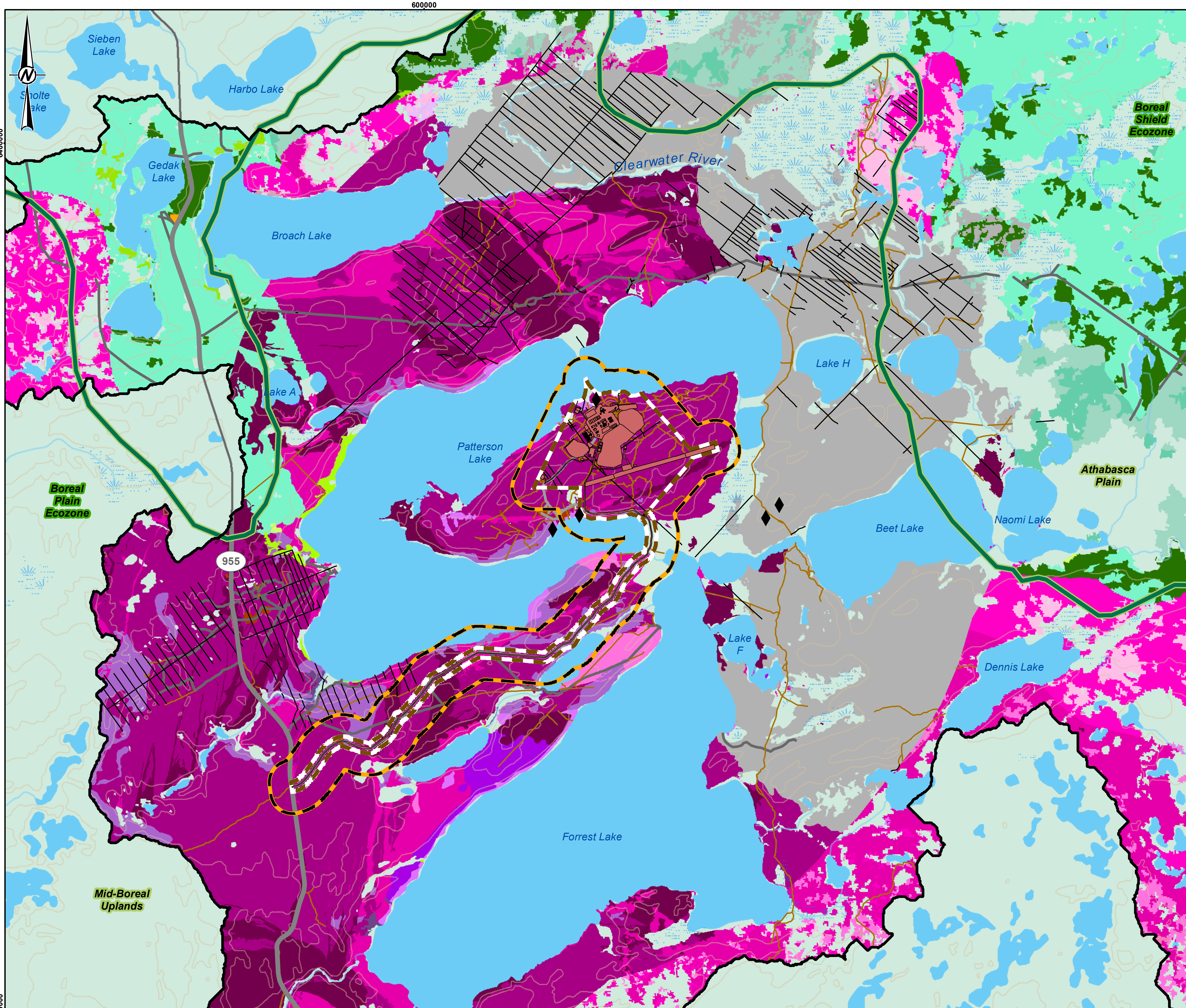

LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- PROPOSED PROJECT FOOTPRINT
- MAXIMUM DISTURBANCE AREA
- LOCAL STUDY
- REGIONAL STUDY

UPLAND VASCULAR RARE PLANT SPECIES

- BEAUTIFUL SEDGE

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

UPLAND ECOLOGICAL LAND CLASSIFICATION UNIT

BP02	BP11 (BU)	BS04
BP02 (BU)	BP12	BS04 (BU)
BP03	BP12 (BU)	BS06 (BU)
BP03 (BU)	BP14	BS07 (BU)
BP04	BP14 (BU)	BS09
BP04 (BU)	BP16	BS09 (BU)
BP06	BP16 (BU)	BS13
BP06 (BU)	BS02 (BU)	BS13 (BU)
BP07	BS03	BS14
BP07 (BU)	BS03 (BU)	BS14 (BU)
		RECENT BURN (UPLAND)

0 3 6

1:90,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
2. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. ECOZONES OBTAINED FROM AGRICULTURE AND AGRI-FOOD CANADA (AAFC).

PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

UPLAND ECOSYSTEMS AND RARE PLANT SPECIES IN THE LOCAL STUDY AREA, APPLICATION CASE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08	**FIGURE 13.5-2**	
CHECK	HH	2023-02-08		
REVIEW	JV	2023-02-08		

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13.5.1.1.2 Ecosystem Distribution

Decreased connectivity of upland ecosystems in the Application Case would occur at the local scale around the maximum disturbance area (Figure 13.5-2). The existing access road would be upgraded to safely accommodate large vehicles and equipment and site roads would be aligned to avoid the wetland west of the proposed airstrip. Most of the existing trails in the Project footprint would be upgraded for site roads and haul roads within the maximum disturbance area. The Project would be in a portion of the RSA that contains an aggregation of existing linear and non-linear features in proximity of Highway 955 (Figure 13.5-1).

Despite some localized fragmentation as a result of the Project, most upland ecosystems remain abundant and well connected across the LSA and RSA. Disturbance to upland ELC units is limited to five ELC units, most of which are widely available and well distributed. The majority (i.e., 77%) of the maximum disturbance area was disturbed by fire in 1990, which has led to a relatively homogenous community of late-stage regenerating Jack pine/lichen forest (BP02[BU]). Jack pine communities within the maximum disturbance area (e.g., BP02, BP03, and BP02[BU]) are well distributed through the LSA. Further, ecozonal synonyms (BS03 and BS04) are widely distributed within the RSA.

The least common ELC unit disturbed by the Project (i.e., Black spruce/Labrador tea/feathermoss [BP14]) is associated with moist sites. Within the LSA, the ELC unit is distributed around the shores of Patterson Lake. Within the RSA, BP14 ELC units are distributed along the shoreline of Forrest Lake, Patterson Lake, Broach Lake, and two smaller unnamed waterbodies (i.e., Lake E and Lake D) near the existing access road. Ecozonal synonyms, as indicated by McLaughlan et al. (2010; BS09 + BS10), appear to have similar distribution within the RSA and are associated with shorelines along lakes. Disturbance to BP14 ELC units within the maximum disturbance area would slightly increase the inter-patch distance in the LSA (i.e., local geographic extent). These changes would result in a minor reduction in the connectivity of ELC units locally but are not predicted to affect connectivity in the RSA. The current density of linear features in the RSA (0.6 km/km^2) is likely causing negligible adverse effects on upland ecosystems, and the Project would not change the density of linear features in the LSA and RSA. Further, the actual loss is anticipated to be less when considering the Project footprint. Effects on upland ecosystem distribution are anticipated to be minor (i.e., low magnitude) as changes are centred on the LSA, with little to no change in fragmentation at the RSA scale.

Burned Balsam poplar - trembling aspen/prickly rose (BP16[BU]) ELC units appear to be well distributed along the existing access road between Patterson Lake and Forrest Lake and with more scattered distribution to the west of both lakes. Balsam poplar - trembling aspen/prickly rose (BP16) ELC units do not have an ecozonal synonym within the Boreal Shield ecoregion; therefore, distribution is restricted to the southwest portion of the RSA. Changes to the distribution of this ELC unit would be largely limited to the realignment and upgrades to the existing access road; therefore, these changes would result in a minor reduction in connectivity from the Base Case. It is anticipated that the remaining Balsam poplar - trembling aspen/prickly rose (BP16) ELC units within the RSA would be maintained on the landscape.

The incremental contribution of the Project to existing effects on upland ecosystem distribution would be small and is predicted to be reversed well beyond Closure (i.e., 60 to 80 years after the Active Closure Stage). Reclamation could provide partial or full restoration of minor changes in upland ecosystem connectivity at the LSA scale relative to the Base Case. Overall, upland ELC units would remain well connected in the Application Case to support healthy and functioning upland ecosystems.

13.5.1.1.3 Ecosystem Condition

Forested areas in closer proximity to any new development may be affected by removal of trees and other edge effects (e.g., ingress of generalist or invasive species, changes in moisture and sunlight) that can adversely influence conditions of ecosystems. Reduced ecosystem condition is a likely outcome of Project activities because of edge effects related to new disturbances. For example, forest edges are typically exposed to more sunlight, and are drier, windier, and warmer than the forest interior (Chen et al. 1999). Plant responses, such as decreases in moss, increases in downed woody material, or higher regeneration of deciduous species can lead to structural changes within forested stands. However, changes to understory vascular plant cover or diversity were observed to be weakly influenced by edge effects (Harper et al. 2015). Generally, edge effects were limited to within 50 m of the disturbance (Ries et al. 2004). Therefore, changes to the ecosystem condition are anticipated to be limited to well within the LSA boundary (i.e., defined as 500 m from the maximum disturbance area).

Data collected during baseline field surveys indicated that jack pine dominant ELC units (e.g., BP02, BP03, and BP02[BU]) had relatively low values and ratings for unique species (e.g., unique observations within an ELC unit) and provincially tracked species observations (Section 13.3.1.3). Species richness was observed as moderate to high; however, these sites have relatively low vascular plant diversity but relatively high lichen species diversity. Early-stage regenerating ELC units (i.e., burned in the last 6 to 20 years) were characterized by a high percentage cover of bare soil and litter (i.e., greater than 70%) with understory strata virtually absent.

Observations from baseline field surveys indicated that Black spruce/Labrador tea/feathermoss (BP14) ELC unit canopies are predominantly black spruce but may contain jack pine, white spruce, or trembling aspen (Section 13.3.1.3). The understory is generally limited to ericaceous shrubs, but low bush-cranberry and green alder may occasionally be found (Annex VII.1). While a large variety of herbs was associated with this ELC unit, only a few species were consistently present. BP14 ELC units were observed to have moderate species richness and received low overall values and rankings for unique species observations and provincially tracked plant species (Section 13.3.1.3, Ecosystem Condition).

Two occurrences of provincially tracked species were identified in upland ecosystems within the LSA, and an additional three occurrences recorded within the RSA (Figure 13.5-2). One occurrence of beautiful sedge was observed within the maximum disturbance area within a burned Jack pine/lichen (BP02[BU]) ELC unit (Section 13.3.1.3). Beautiful sedge was also recorded in four additional upland ELC units that are not predicted to be disturbed by the maximum disturbance area. Known rare plants would be clearly marked and avoided, where feasible (Section 13.4, Project Interactions and Mitigations; Table 13.4-1). The ENV recommends a 30 m setback distance for high disturbance activities (e.g., mining) for species ranked S1 through S3 (ENV 2017). Where disturbance to rare plants is unavoidable, the ENV would be consulted to determine the best course of action. Measures to limit disturbance to rare vascular plants could include the use of temporary access matting, proper salvage of topsoil and seeds, or changes to Project components, where feasible. Mitigation would be dependent on species tolerance to disturbance, species growth habit (i.e., perennial or annual), and species availability and distribution information (i.e., provincial rank).

One species of noxious weed (i.e., narrow-leaved hawk's beard) and one species of nuisance weed (i.e., dandelion) designated under *The Weed Control Act* were identified in anthropogenically disturbed areas during baseline field surveys (Section 13.3.1.3). Project activities involving the movement of machinery or equipment to and from the Project site could introduce regulated weed and invasive species. Regulated weed and invasive plant species could potentially have an adverse effect on the condition of upland ecosystems. As part of mitigation for Project effects, construction equipment would arrive at the site in a clean condition, and an

Environmental Protection Program would be implemented that includes actions to prevent, detect, control (i.e., remove), and monitor designated weed species. With effective implementation of mitigation, Project-related effects from regulated weed and invasive plants on upland ecosystem condition are predicted to not be ecologically measurable relative to existing conditions.

Effects on upland ecosystems from Project-related changes to ecosystem condition are considered possible, as the small decrease in habitat abundance would produce few edge effects. Although the Project would disturb one occurrence of rare plant species detected during baseline studies, additional populations were observed in the LSA (Section 13.3.1.3). Overall, changes to the condition of upland ecosystems in the Application Case are predicted to be well within the resilience and adaptability limits for this VC.

13.5.1.2 Reasonably Foreseeable Development Case

13.5.1.2.1 Ecosystem Availability

The Fission Patterson Lake South Property is predicted to contribute an incremental loss of 1,449.8 ha of upland ecosystems in the RSA (Table 13.5-2, Figure 13.5-3). The Project, as well as additional trails and roads and facilities from the Fission Patterson Lake South Property and existing anthropogenic disturbance (i.e., Highway 955, Bolton Lake trail, and seismic lines) account for 2,390.1 ha of disturbance across upland ecosystem types in the RSA. Cumulative effects would be continuous and occur at the regional scale. Effects are likely to occur but are uncertain (i.e., probable) given that the Fission Patterson Lake South Property has recently entered the formal regulatory application process.

The Fission Patterson Lake South Property would change 239.4 ha of undisturbed upland ELC units and 1,210.4 ha of late-stage regenerating (i.e., burned in the last 21 to 40 years; Burned) upland ELC units into roads and facilities. The Fission Patterson Lake South Property is located within both the Boreal Shield and Boreal Plain ecozones and therefore changes to the availability of Boreal Shield (BS) ELC units in addition to Boreal Plain (BP) ELC units are anticipated.

Disturbance associated with the Fission Patterson Lake South Property to jack pine ELC units is anticipated to be 172.8 ha of Jack pine/lichen (BP02), 1,041.3 ha of burned Jack pine/lichen (BP02[BU]), 40.8 ha of Jack pine/feathermoss (BP03), and 74.2 ha of burned Jack pine/blueberry/lichen (BS03[BU]). Therefore, the Fission Patterson Lake South Property would disturb a total of 1,329.1 ha of mature and late-stage regenerating jack pine forest ELC units. The cumulative predicted loss of unburned and early- and late-stage regenerating jack pine ELC units in the RFD Case is 2,150.1 ha of 66,012.5 ha (3.3%) of available similar ELC units within the RSA. The Fission Patterson Lake South Property is not anticipated to disturb Black spruce/Labrador tea/feathermoss (BP14).

An additional 91.0 ha of BP16(BU) ELC units would be disturbed by the Fission Patterson Lake South Property, resulting in a cumulative disturbance of 126.8 ha of 1,070.4 ha (11.8%) in the RFD Case. However, disturbance to BP16(BU) ELC units was conservatively overestimated. The actual disturbance would depend on the final design of the Project and the Fission Patterson Lake South Property.

Disturbance to White birch/lingonberry - Labrador tea (BS14) and late-stage regenerating White birch/lingonberry - Labrador tea (BS14[BU]) ELC units are specific to the Fission Patterson Lake South Property, which is predicted to remove 25.7 ha of 74.0 ha and 4.0 ha of 39.9 ha of each ELC unit, respectively. It is anticipated that design elements of the Fission Patterson Lake South Property would be reviewed to minimize disturbance to ELC units that may be considered moderately sensitive to additional changes in availability because they are uncommon in the RSA.

Table 13.5-2: Changes to Upland Ecosystem Availability in the Reasonably Foreseeable Development Case

Upland ELC Unit[a]	RSA		
	Base Case (ha)	RFD Case (ha)	Change in Area (ha)
BP02 - Jack pine/lichen	2,791.3	2,566.3	-225.0
BP03 - Jack pine/feathermoss	3,712.1	3,622.8	-89.2
BP04 - Jack pine - trembling aspen/feathermoss	1,000.7	1,000.7	0.0
BP06 - Trembling aspen/beaked hazel/sarsaparilla	0.3	0.3	0.0
BP07 - Trembling aspen - white birch/sarsaparilla	5.1	5.1	0.0
BP11 - White birch - white spruce - balsam fir	3.2	3.2	0.0
BP12 - Jack pine - spruce/feathermoss	219.2	219.2	0.0
BP14 - Black spruce/Labrador tea/feathermoss	129.8	118.3	-11.5
BP16 - Balsam poplar - trembling aspen/prickly rose	33.3	33.3	0.0
BS02 - Lichen/felsenmeer - bedrock	<0.1	<0.1	0.0
BS03 - Jack pine/blueberry/lichen	4,991.4	4,991.4	0.0
BS04 - Jack pine - black spruce/feathermoss	6,158.9	6,158.9	0.0
BS05 - Jack pine - white birch/feathermoss	1.1	1.1	0.0
BS06 - Jack pine - trembling aspen/green alder	0.3	0.3	0.0
BS07 - Black spruce/blueberry/lichen	2.6	2.6	0.0
BS08 - Black spruce - white birch/lichen	<0.1	<0.1	0.0
BS09 - Black spruce - jack pine/feathermoss	23.1	23.1	0.0
BS10 - Black spruce - white birch/feathermoss	0.1	0.1	0.0
BS13 - White birch - black spruce - trembling aspen	11.9	11.9	0.0
BS14 - White birch/lingonberry - Labrador tea	74.0	48.3	-25.7
BS15 - Trembling aspen - white birch/green alder	<0.1	<0.1	0.0
Undisturbed upland subtotal	*19,158.2*	*18,806.8*	*-351.5*
BP02(BU) - Jack pine/lichen (Burned)	8,990.9	7,229.2	-1,761.7
BP03(BU) - Jack pine/feathermoss (Burned)	4,846.6	4,846.6	0.0
BP04(BU) - Jack pine - trembling aspen/feathermoss (Burned)	1,274.5	1,274.5	0.0
BP06(BU) - Trembling aspen/beaked hazel/sarsaparilla (Burned)	0.3	0.3	0.0
BP07(BU) - Trembling aspen - white birch/sarsaparilla (Burned)	10.4	10.4	0.0
BP11(BU) - White birch - white spruce - balsam fir (Burned)	0.9	0.9	0.0
BP12(BU) - Jack pine - spruce/feathermoss (Burned)	4.4	4.4	0.0
BP14(BU) - Black spruce/Labrador tea/feathermoss (Burned)	25.2	25.2	0.0
BP16(BU) - Balsam poplar - trembling aspen/prickly rose (Burned)	1,070.4	943.6	-126.8
BS02(BU) - Lichen/felsenmeer - bedrock (Burned)	0.7	0.7	0.0
BS03(BU) - Jack pine/blueberry/lichen (Burned)	23,172.8	23,098.6	-74.2
BS04(BU) - Jack pine - black spruce/feathermoss (Burned)	9,065.2	9,065.2	0.0
BS05(BU) - Jack pine - white birch/feathermoss (Burned)	5.1	5.1	0.0
BS06(BU) - Jack pine - trembling aspen/green alder (Burned)	0.9	0.9	0.0
BS07(BU) - Black spruce/blueberry/lichen (Burned)	5.6	5.6	0.0
BS08(BU) - Black spruce - white birch/lichen (Burned)	0.1	0.1	0.0
BS09(BU) - Black spruce - jack pine/feathermoss (Burned)	50.1	50.1	0.0

Table 13.5-2: Changes to Upland Ecosystem Availability in the Reasonably Foreseeable Development Case

Upland ELC Unit[a]	RSA		
	Base Case (ha)	RFD Case (ha)	Change in Area (ha)
BS13(BU) - White birch - black spruce - trembling aspen (Burned)	57.7	57.7	0.0
BS14(BU) - White birch/lingonberry - Labrador tea (Burned)	39.9	36.0	-4.0
BS15(BU) - Trembling aspen - white birch/green alder (Burned)	0.2	0.2	0.0
Recent burn upland	7,041.6	7,041.6	0.0
Burned upland subtotal	*55,663.4*	*53,696.7*	*-1,966.7*
Upland total	**74,821.7**	**72,503.5**	**-2,318.2**
Summary			
Upland total	**74,821.7**	**72,503.5**	**-2,318.2**
Wetland total	**32,211.3**	**32,139.3**	**-72.0**
Anthropogenic disturbance total[b]	**457.8**	**2,847.9**	**2,390.1**
Total RSA	**107,490.7**	**107,490.7**	**n/a**

Note**:** Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
a) McLaughlan et al. 2010.
b) Anthropogenic disturbance total includes the maximum disturbance area for the Project (980.7 ha) and the Fission Patterson Lake South Property (1,544.2 ha) minus the existing anthropogenic disturbance within the maximum disturbance areas in the Base Case (134.8 ha).
ELC = Ecological Land Classification; RSA = regional study area; RFD = reasonably foreseeable development; < = less than; n/a = not applicable.

The duration of effects from changes in upland ecosystem availability from the two projects in the RFD Case would be a function of the amount of temporal overlap between the period from the start of Project Construction to the end of the Active Closure Stage and the time required to establish upland ELC units. Incremental effects as a result of the Project were predicted to occur from Construction through the end of the Active Closure Stage and the time required to establish mature upland ELC units (i.e., 60 to 80 years) (Section 13.3.1.3). At a minimum, upland ecosystem loss from the Fission Patterson Lake South Property would occur during a hypothetical or projected three-year construction period, seven-year operating period (production and processing), and active decommissioning (Fission 2019, 2021). The anticipated start of construction and duration of active decommissioning at the Fission Patterson Lake South Property were not publicly available at the time this assessment was completed.

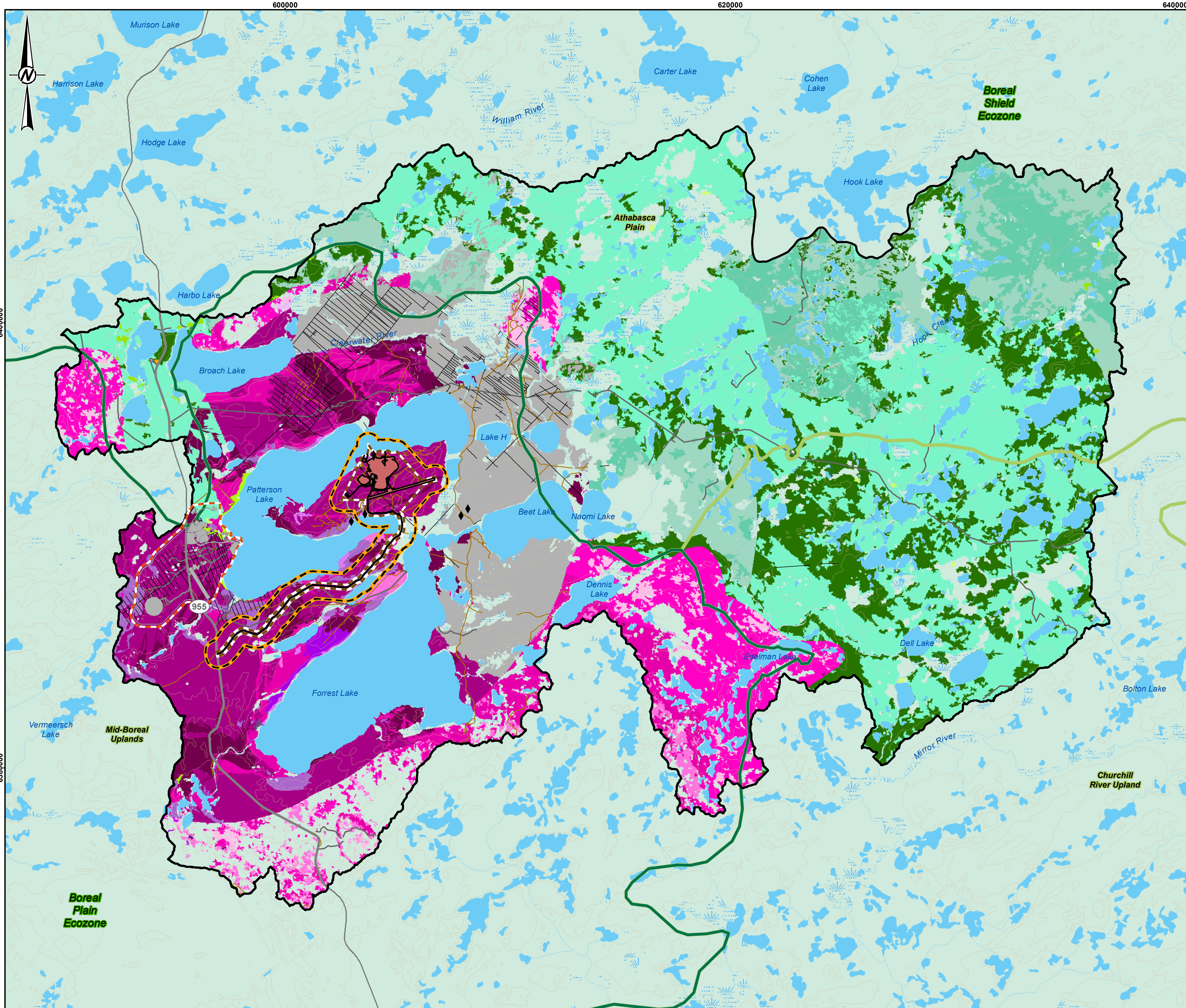
For the assessment, it was assumed that the duration of active decommissioning for the Fission Patterson Lake South Property would be similar to the Active Closure Stage for the Project (i.e., five years). The duration of effects from direct habitat loss for the Fission Patterson Lake South Property was therefore assumed to be from construction to the end of decommissioning (i.e., 15 years) plus 60 to 80 years for mature upland ELC units to be established. If the assumed upland ecosystem loss from the Fission Patterson Lake South Property completely overlapped upland ecosystem loss associated with the Project, the duration of cumulative effects for the RFD Case would be a maximum of 95 years. However, a decrease in temporal overlap of the two projects would result in a shorter duration of cumulative effects.

Climate Change

Section 22, Assessment of Effects of the Environment on the Project, outlines the future climate extreme projections for the Project. From the median (i.e., 50% exceedance probability) values for the 2050s and 2080s, the projected future climate extremes indicate a future that is likely to be warmer and wetter on an annual basis (i.e., increased warm nights and reduced ice and frost days and increased annual total wet-day precipitation, and very wet and extremely wet days). Due to a longer, warmer growing season, forest productivity may increase in the future and alter ecological succession (Sauchyn et al. 2009). Longer growing seasons can increase carbon and nutrient transport to the soil. Increased precipitation can cause groundwater levels to rise, which can increase mobility of solutes and change soil quality (Oni et al. 2017).

Changes to soil quality may alter upland ecosystem availability as ELC units shift to adapt to new nutrient and moisture regimes. Changes are anticipated to be more pronounced within ELC units that are associated with specific nutrient and moisture regimes and therefore may be less resilient to climate change effects (i.e., Black spruce/Labrador tea/feathermoss [BP14], White birch - white spruce - balsam fir [BP11]). Sites with coarse, rapidly drained soils (i.e., jack pine forests [BP02, BP03, BS03, BS04]) are not anticipated to experience large-scale changes from increases in precipitation or nutrient availability. Availability in these ecosystems would likely be driven by changes in the fire regime (i.e., intensity and interval) and would occur beyond the regional (i.e., RSA) scale.

Forest fires occur when fuel, weather, and ignition factors successfully combine. Forest fire characteristics (i.e., frequency and severity) are closely related to weather and climate. Heat waves, droughts, and regional weather patterns (e.g., high-pressure ridges) can increase the risk and alter the behaviour of forest fires and are anticipated to increase fire frequency (Hart et al. 2019). Although projected future climate extremes indicate a future that is likely to be wetter annually (Appendix 22A Climate Change Dataset Summary Report), climate change is still anticipated to increase fire frequency within the RSA (Hart et al. 2019). Changes in climate that affect disturbance regimes and forest resilience would have effects beyond the regional (i.e., RSA) scale. Large, stand-replacing fires are a driver of forest composition, structure, function, and therefore overall availability. However, forests within the RSA may be resilient to fire, particularly with respect to jack pine stands, as self-replacement is the most common post-fire trajectory (Hart et al. 2019). Well-drained black spruce stands (e.g., BP14) tend to be less resilient to fire disturbance and less likely to return to the same state post-fire (Hart et al. 2019). As fire frequency increases, it is predicted that the availability of deciduous ELC units (e.g., BP06 and BP07) would increase as black spruce dominant stands would become less common (Hart et al. 2019).



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- PROPOSED PROJECT FOOTPRINT
- MAXIMUM DISTURBANCE AREA
- FISSION PATTERSON LAKE SOUTH PROPERTY FOOTPRINT
- PATTERSON LAKE SOUTH PROPERTY HYPOTHETICAL MAXIMUM DISTURBANCE AREA
- LOCAL STUDY
- REGIONAL STUDY

UPLAND VASCULAR RARE PLANT SPECIES

- BEAUTIFUL SEDGE

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

UPLAND ECOLOGICAL LAND CLASSIFICATION UNIT

BP02	BP14	BS07
BP02 (BU)	BP14 (BU)	BS07 (BU)
BP03	BP16	BS08
BP03 (BU)	BP16 (BU)	BS08 (BU)
BP04	BS02	BS09
BP04 (BU)	BS02 (BU)	BS09 (BU)
BP06	BS03	BS10
BP06 (BU)	BS03 (BU)	BS13
BP07	BS04	BS13 (BU)
BP07 (BU)	BS04 (BU)	BS14
BP11	BS05	BS14 (BU)
BP11 (BU)	BS05 (BU)	BS15
BP12	BS06	BS15 (BU)
BP12 (BU)	BS06 (BU)	RECENT BURN (UPLAND)

0 5 10
1:175,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
2. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. ECOZONES OBTAINED FROM AGRICULTURE AND AGRI-FOOD CANADA (AAFC).
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

UPLAND ECOSYSTEMS AND RARE PLANT SPECIES IN THE REGIONAL STUDY AREA, REASONABLY FORESEEABLE DEVELOPMENT CASE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08	FIGURE 13.5-3	
REVIEW	JV	2023-02-08		

13.5.1.2.2 Ecosystem Distribution

Despite fragmentation that would occur as a result of the Project and the Fission Patterson Lake South Property, most upland ecosystems are predicted to remain abundant and well connected across the RSA (Figure 13.5-3). It is anticipated that the RFD Case would have a relatively small direct effect on the loss of upland ELC units with an additional loss of 1,449.8 ha relative to the Application Case (Table 13.5-2). However, disturbance to some of the least common ELC units in the RSA (i.e., BP14, BP16[BU], and BS14) is anticipated in the RFD Case (i.e., regional geographic extent). It is also expected that the Fission Patterson Lake South Property would include mitigation to limit cumulative changes to ecosystem availability and distribution.

These changes would result in a minor reduction in the connectivity of ELC units regionally but are not predicted to affect overall connectivity in the RSA. Minor changes in the fragmentation of upland ecosystems would be restricted to the northwest boundary of the RSA, which has an existing aggregation of linear and non-linear disturbances in proximity to Highway 955 (e.g., rough roads, trails, seismic lines / cutlines; Figure 13.5-3). Therefore, the magnitude of changes to ecosystem distribution is anticipated to be low (i.e., little to no change in connectivity in most of the RSA).

Planned mitigation of direct disturbance to upland ecosystems from the Fission Patterson Lake South Property includes minimizing land clearing, reclaiming unused areas, and remediating the site at closure (Fission 2019). The duration effects from direct ecosystem loss for the Fission Patterson Lake South Property was therefore assumed to be from construction to the end of decommissioning (i.e., 15 years) plus 60 to 80 years for mature upland ELC units to be established (Section 13.5.1.2.1, Ecosystem Availability). Therefore, the duration of cumulative effects for the RFD Case would be a maximum of 95 years.

Climate Change

Saskatchewan's Boreal Shield Ecozone is known for a naturally short fire-return interval (Neufeld et al. 2020; Parisien et al. 2004), and species tend to be well adapted to this disturbance regime, as self-replacement of forested stands is the most common post-fire trajectory (Hart et al. 2019). However, where burns are severe enough to remove the organic layer and expose mineral soils, post-fire recovery favours the establishment of deciduous species. Therefore, fire can have a large influence on the distribution of ELC units.

Although projected future climate extremes indicate a future that is likely to be wetter annually (Appendix 22A), climate change is still anticipated to increase fire frequency within the RSA (Hart et al. 2019). As the fire-return interval decreases, forest resilience is reduced, which may potentially lead to changes in structure and composition of forested stands, as well as the overall distribution of forest types (e.g., ELC units). However, fire-return intervals may be limited by self-regulation as young stands burn less frequently due to fuel limitations in early successional vegetation that inhibit ignition (Hart et al. 2019).

13.5.1.2.3 Ecosystem Condition

Five occurrences of beautiful sedge were identified in upland ELC units within the RSA (Figure 13.5-3). One occurrence was observed within the Project maximum disturbance area within a burned Jack pine/lichen (BP02[BU]) ELC unit (Section 13.3.1.3). The four remaining occurrences of beautiful sedge within upland ELC units within the RSA are not predicted to be disturbed by the Project or the Fission Patterson Lake South Property. It is anticipated that rare vascular plant surveys would be completed for the Fission Patterson Lake South Property and that planning would include mitigation to limit disturbance to beautiful sedge and other federally listed or provincially tracked vascular plant species.

Forested areas in close proximity to any new development may be affected by removal of trees and other edge effects (e.g., ingress of generalist or invasive species and changes in moisture and sunlight) that can adversely influence conditions. One nuisance and one noxious weed species designated under *The Weed Control Act*, dandelion and narrow-leaved hawk's beard, respectively, were identified during the field surveys (Section 13.3.1.3). Additional disturbance associated with the proposed RFD Case activities can create increased potential for the introduction or encroachment of designated weed species. Construction equipment for the Project would arrive at the site in a clean condition, and an Environmental Protection Program would be implemented that includes actions to prevent, detect, control (i.e., remove), and monitor designated weed species. No weed management actions were identified in the Fission Patterson Lake South Property prefeasibility study (Fission 2019), but it is anticipated that appropriate mitigation would be implemented to avoid and minimize the introduction of weeds. None of the documented occurrences of rare plant species outside of the Project footprint would be disturbed by activities in the RFD Case. Activities outlined in the Fission Patterson Lake South Property prefeasibility study and project description include designing the project to minimize the amount of area disturbed and remediate the area at decommissioning (Fission 2019, 2021). It is expected that after remediation, the Fission Patterson Lake South Property would have minor, localized, reversible residual effects on ecosystem condition.

Climate Change

Climate-related temperature changes could result in shifts in species composition. The northern boreal forest may experience increased productivity due to warmer temperatures (Sauchyn et al. 2009; Urquizo et al. 2000). Changes to forest structure may occur from increased intensity of fire, insects, and disease, which may cause a loss in forest cover in the boreal forest (Sauchyn et al. 2009). Effects from climate change would likely be permanent. It is uncertain whether climate change would positively or negatively affect the condition of upland ecosystems, but it is unlikely to have a large influence on the predicted small magnitude of Project and RFD-related effects.

Changes in temperature may lead to increased potential for insect invasion, particularly mountain pine beetle (*Dendroctonus ponderosae*). The population dynamics of the mountain pine beetle are driven by the availability of hosts and suitable climatic conditions, with the species' range limited by cold winter temperatures and cool summers (Government of Canada 2021b). To date, there have been no mountain pine beetle detected in the boreal forest monitoring area of Saskatchewan (Government of Saskatchewan 2021). Current pine beetle populations in Alberta are distributed in areas south of Grand Prairie, northwest of Rocky Mountain House, and north of Whitecourt (Government of Alberta 2020). However, mountain pine beetle was observed as far east as Wandering River, Alberta in 2019 (Government of Alberta 2019), approximately 300 km southwest of the Project site. Mountain pine beetles prefer large trees that are typically greater than 80 years old because tree diameter is associated with thicker bark and conductive tissue, which provide protection from weather and predators, and equates to a better mountain pine beetle food source (Safranyik and Carroll 2006). Therefore, jack pine forests within the RSA may be less susceptible to mountain pine beetle infestation due to the short fire-return interval observed within the RSA (i.e., availability of large, mature jack pine stands is limited).

13.5.1.3 Residual Effects Classification and Determination of Significance

13.5.1.3.1 Classification Summary

Residual effects were classified for the Application Case and the RFD Case after the implementation of effective mitigation (Table 13.5-3). Residual effects were summarized according to the direction, magnitude, geographic extent, duration, reversibility, frequency, and probability of the effect occurring following the methods described in Section 13.2.9. Effective implementation of mitigation is summarized in Section 13.4, Project Interactions and Mitigations, (Table 13.4-1), and progressive reclamation and revegetation is expected to reduce the magnitude and duration of residual effects on upland ecosystems. Following the summary of residual effects, the significance of residual effects for the Application Case and the RFD Case was determined according to the methods described in Section 13.2.9.

Table 13.5-3: Classification of Residual Effects on Upland Ecosystem Measurement Indicators for the Application Case and Reasonably Foreseeable Development Case

Measurement Indicator	Criterion	Rating / Effect Size	
		Application Case	RFD Case
Upland ecosystem availability	Direction	▪ Negative	▪ Negative
	Magnitude	▪ Direct physical loss of 868.4 ha (1.2% of the RSA) from the Base Case to the Application Case (i.e., low magnitude)	▪ Loss of 2,318.2 ha (3.1% of RSA) from the Base Case to the RFD Case (i.e., low magnitude)
	Geographic extent	▪ Maximum disturbance area	▪ Regional (Project and Fission Patterson Lake South Property) ▪ Beyond regional (climate change)
	Duration	▪ Permanent: for ELC units covered by permanent facilities (e.g., WRSAs) ▪ Long term (direct loss): 93 to 113 years = 33 years (start of Construction to the end of the Active Closure Stage), or earlier with progressive reclamation, plus 60 years to 80 years to establish mature upland ELC Units	▪ Permanent: ELC units covered by permanent facilities ▪ Permanent: climate change effects ▪ Long term: maximum of 95 years for establishment of mature upland ELC units, depending on the extent of temporal overlap between the Project and the Fission Patterson Lake South Property
	Reversibility	▪ Reversible (reclaimed ELC units) ▪ Irreversible (ELC units covered by permanent facilities)	▪ Reversible (reclaimed ELC units) ▪ Irreversible (ELC units covered by permanent facilities) ▪ Irreversible (climate change effects)
	Frequency	▪ Continuous	▪ Continuous
	Probability of occurrence	▪ Certain	▪ Probable (Project and Fission Patterson Lake South Property) ▪ Possible (climate change)
Upland ecosystem distribution	Direction	▪ Negative	▪ Negative
	Magnitude	▪ Minor net change in upland ecosystem distribution centred on the LSA. Almost no change in fragmentation at the RSA scale (i.e., low magnitude)	▪ Minor increase in fragmentation of upland ecosystems in the RSA near the western boundary in proximity to existing disturbance. Almost no change to connectivity in most of the RSA (i.e., low magnitude)
	Geographic extent	▪ Local to regional	▪ Regional (Project and Fission Patterson Lake South Property) ▪ Beyond regional (climate change)

Table 13.5-3: Classification of Residual Effects on Upland Ecosystem Measurement Indicators for the Application Case and Reasonably Foreseeable Development Case

Measurement Indicator	Criterion	Rating / Effect Size	
		Application Case	RFD Case
Upland ecosystem distribution	Duration	▪ Permanent: for ELC units covered by permanent facilities (e.g., WRSAs) ▪ Long term (direct loss): 93 to 113 years = 33 years (start of Construction to the end of the Active Closure Stage), or earlier with progressive reclamation, plus 60 years to 80 years to establish mature upland ELC Units	▪ Permanent: ELC units covered by permanent facilities ▪ Permanent: climate change effects ▪ Long term: maximum of 95 years for establishment of mature upland ELC units, depending on the extent of temporal overlap between the Project and the Fission Patterson Lake South Property
	Reversibility	▪ Reversible (reclaimed ELC units) ▪ Irreversible (ELC units covered by permanent facilities)	▪ Reversible (reclaimed ELC units) ▪ Irreversible (ELC units covered by permanent facilities) ▪ Irreversible (climate change effects)
	Frequency	▪ Continuous	▪ Continuous
	Probability of occurrence	▪ Certain	▪ Probable (Project and Fission Patterson Lake South Property) ▪ Possible (climate change)
Upland ecosystem condition	Direction	▪ Negative	▪ Negative
	Magnitude	▪ Potential loss of one occurrence of beautiful sedge ▪ Edge effects would result in a minor change in ecosystem structure (i.e., low magnitude)	▪ Potential loss of rare vegetation species ▪ Potential introduction of weed species ▪ Minor change in ecosystem structure from edge effects (i.e., low magnitude)
	Geographic extent	▪ Local	▪ Regional (Project and Fission Patterson Lake South Property) ▪ Beyond regional (climate change)
	Duration	▪ Permanent: for ELC units covered by permanent facilities (e.g., WRSAs) ▪ Long term (direct loss): 93 to 113 years = 33 years (start of Construction to the end of the Active Closure Stage), or earlier with progressive reclamation, plus 60 years to 80 years to establish mature upland ELC Units	▪ Permanent: ELC units covered by permanent facilities ▪ Permanent: climate change effects ▪ Long term: maximum of 95 years for establishment of mature upland ELC units, depending on the extent of temporal overlap between the Project and the Fission Patterson Lake South Property
	Reversibility	▪ Reversible (reclaimed ELC units) ▪ Irreversible (ELC units covered by permanent facilities)	▪ Reversible (reclaimed ELC units) ▪ Irreversible (ELC units covered by permanent facilities) ▪ Irreversible (climate change effects)
	Frequency	▪ Continuous	▪ Continuous
	Probability of occurrence	▪ Possible	▪ Possible (Project, Fission Patterson Lake South Property) ▪ Possible (climate change)

RFD = reasonably foreseeable development; RSA = regional study area; WRSAs = waste rock storage areas; LSA = local study area; ELC = Ecological Land Classification.

13.5.1.3.2 Significance Determination

Upland ecosystems are considered to have ecological resilience and adaptive capacity to changes in abundance, distribution, and condition in the Base Case. Most upland ecosystems are common and well distributed and connected within the LSA and RSA. Previous and existing linear disturbances have resulted in some fragmentation of habitats in the LSA and RSA, but upland ecosystems remain intact on the landscape. Existing human disturbance is largely distributed in the northwest portion of the RSA in proximity to Highway 955. Natural fire disturbance has the largest influence on ELC unit availability, distribution, and condition in the RSA in the Base Case, with 55,663.4 ha (51.8%) of upland ELC units burned within the last 40 years, which is consistent with conditions in the rest of the Boreal Shield Ecozone (i.e., 47.0% being burned in the last 40 years; McLoughlin et al. 2019). Overall, the weight of evidence indicates that upland ecosystems in the RSA are self-sustaining and ecologically effective in the Base Case.

Application Case

In the Application Case, changes in upland ecosystem availability, distribution, and condition as a result of the Project are predicted to be certain, local, long term, and continuous (Table 13.5-3). The exception is for changes to the ecosystem condition, which are classified as possible since the small decrease in habitat abundance may produce few new edge effects. A single rare plant species was detected during baseline studies; however, if possible, the occurrence would be flagged for avoidance. Designated weed species were detected during baseline surveys; however, the Project would implement an Environmental Protection Program that includes actions to avoid and limit the risk of introducing invasive plant species.

The establishment of reclaimed upland vegetation ecosystems is predicted to occur well beyond the Active Closure Stage, particularly for mature forest types (e.g., 60 to 80 years). The loss of 868.4 ha of available uplands as a result of the Project is predicted to have a small influence on ecological structure and function. Disturbance associated with the Project would be limited to five ELC units, three of which are associated with common jack pine forest types (i.e., BP02, BP03, and BP02[BU]). Disturbance to less common ELC units (i.e., BP14 and BP16[BU]) is anticipated to be 47.3 ha (i.e., less than 5% of the maximum disturbance area). The importance of these ELC units were raised by CRDN, as they felt that the clearcutting of large spruce trees (e.g., BP14) from previous development activities in general at Patterson Lake showed a lack of respect for the trees and for the CRDN members who utilize medicines from those trees (TSD V.1: CRDN). Although they comprise a small portion of the maximum disturbance area, disturbance to these ELC units would be minimized to the extent possible. The effects on upland ecosystems are anticipated to be less when considering the smaller size of the anticipated Project footprint relative to the maximum disturbance area applied in the assessment.

One occurrence of beautiful sedge is located in an upland ecosystem within the maximum disturbance area and could be lost or removed by the Project. Four occurrences of the same species were observed outside of the maximum disturbance area where no direct effects are anticipated. Rare plants would be clearly marked and avoided, where feasible. Where disturbance to rare plants is unavoidable, the ENV would be consulted to determine the best course of action. It is anticipated that measures to limit disturbance to rare vascular plants would include the use of temporary access matting, proper salvage of topsoil and seed bank, and/or changes to Project components, where feasible. Mitigation would be dependent on species tolerance to disturbance, species growth habit (i.e., perennial or annual), and species availability and distribution information (i.e., provincial rank). Overall, upland ecosystems are predicted to remain self-sustaining and ecologically effective in the Application Case.

RFD Case

For the RFD Case, the combined effects from the Project and planned Fission Patterson Lake South Property are expected to be regional. Cumulative effects are predicted to be long term, mostly reversible, and continuous (Table 13.5-3). Effects on ELC units covered by permanent facilities (e.g., WRSAs) would be irreversible but localized within the RSA and not predicted to disrupt ELC unit distribution and connectivity. The Project and the Fission Patterson Lake South Property would result in a direct loss of 2,390.1 ha to upland ecosystems, but the implementation of effective mitigation, including reclamation and revegetation, is expected to limit cumulative changes to ecosystem availability, distribution, and condition. Approximately 97% of upland ecosystems would remain intact in the RFD Case and are well connected and distributed across the RSA. Species with upland ecosystems are well adapted to the existing fire disturbance regime, with ELC units generally self-replaced post-fire (Hart et al. 2019). Changes to structure and species composition due to burn frequency and intensity may also be moderated through self-regulation as young stands burn less frequently due to fuel limitations in early successional vegetation that inhibit ignition (Hart et al. 2019). Overall, upland ecosystems are predicted to remain self-sustaining and ecologically effective in the RFD Case.

Climate Change

Climate change is expected to affect ecosystem availability, distribution, and condition continuously at a beyond regional extent (Table 13.5-3). Effects from climate change would likely be permanent, but not certain (i.e., possible) due to the inherent low level of confidence in predicting the magnitude, frequency, and geographic extent of climate-related changes to measurement indicators. However, upland ecosystems are expected to remain resilient, abundant, and well distributed within and adjacent to the RSA and self-sustaining and ecologically effective.

Overall Significance

Based on several lines of evidence, incremental and cumulative effects associated with the Project, previous and existing developments, and the Fission Patterson Lake South Property on upland ecosystems are predicted to be not significant. Effects related to climate change are not expected to significantly influence upland ecosystems and do not alter the assessment of no significant cumulative effects from the Project and Fission Patterson Lake South Property.

13.5.2 Wetland Ecosystems

The residual effects analysis for wetland ecosystems focused on evaluating the following pathways:

- direct loss, alteration, and fragmentation of wetland ecosystems as a result of the Project; and
- alteration of final terrain, soil conditions, and/or plant species composition could change the types of ecosystems that can be reclaimed on the landscape and adversely affect ecosystem availability, distribution, and condition.

13.5.2.1 Application Case

13.5.2.1.1 Ecosystem Availability

The Project is predicted to contribute to a loss of 26.0 ha (i.e., 21.2% in the LSA; 0.3% in the RSA) of undisturbed wetland ecosystems, 1.8 ha of early- and late-stage regeneration (i.e., burned in the last 6 to 40 years; Burned) wetland ecosystems, and 2.4 ha of disturbance in open water. Therefore, the combined loss of burned and unburned wetland ELC units in the RSA is 27.8 ha (0.4%; Table 13.5-4; Figure 13.5-4; Figure 13.5-5). In total, the Project is anticipated to affect only 4 of 42 wetland ELC units in the RSA: Black spruce treed bog (BP19); Labrador tea shrubby bog (BP20); Willow shrubby rich fen (BP25); and burned Black spruce treed bog (BP19[BU]). The largest absolute change (ha) and relative change to a single wetland ELC unit is to the Labrador tea shrubby bog (BP20) ELC unit with a loss of 16.6 ha (i.e., 28.8% change from LSA in the Base Case; 1.3% change from RSA in the Base Case). Because uncertainty was addressed by making assumptions that overestimated the effects (e.g., the maximum disturbance area), the amount of wetland ecosystems lost is expected to be less than estimated. Where avoidance of wetland ELC units is not possible, disturbance would be minimized to the extent possible and additional mitigation would be implemented (i.e., use of erosion control measures, soil handling techniques, and setbacks for soil stockpiles; Section 12.4, Project Interactions and Mitigation). Disturbance associated with permanent facilities of the Project (e.g., WRSAs) is not anticipated to occur within wetland ecosystems.

It is difficult to recreate and/or restore a wetland to full ecological function once it has been disrupted by human development effects. Bog and fen ELC units are slow to recover from disturbance. With restoration, moss and vascular plants can re-establish in areas of disturbance; however, the time for vegetation to recover and the exact composition of the plant cover is unknown (Lucchese et al. 2010; McCarter and Price 2013).

Once wetlands are removed, the loss is considered continuous until functional habitat is reclaimed or offset (i.e., beyond Closure), and effects would be limited to the LSA (i.e., local). Following Closure, it is anticipated that wetland ecosystems would be reclaimed to the extent possible in an attempt to achieve no net loss of wetland functions, consistent with the guideline of the *Federal Policy on Wetland Conservation* (Government of Canada 1991). Wetland ecosystems are assumed to be reclaimed to mineral wetlands consisting of non-forested structural stages (e.g., herb-, sedge-, or shrub-dominated). Although the establishment of functioning wetland ecosystems following the Active Closure Stage is considered possible, restoration of wetland species composition and ecological function similar to the wetland ELC units observed in the Base Case is unlikely. Therefore, for the purpose of this assessment, the loss of all wetland ecosystems is conservatively assumed to be permanent and irreversible.

Wetland ecosystems are less common within the LSA (i.e., 553.2 ha, 19.5%) relative to the RSA (i.e., 32,211.3 ha, 30.0%). Most wetlands are expected to have the capacity to adapt and be resilient to existing natural and anthropogenic disturbances and associated variations in availability. However, some specific wetland ELC units (e.g., BS25) are less common on the landscape and would be likely less resilient to adverse changes in availability. Resilience in wetlands is also a function of soil type, as mineral-based wetlands can be reclaimed and contribute to reversing adverse effects, while there is less confidence in reclaiming peat-bog type wetlands when soils have been disturbed (Environment Canada 2013).

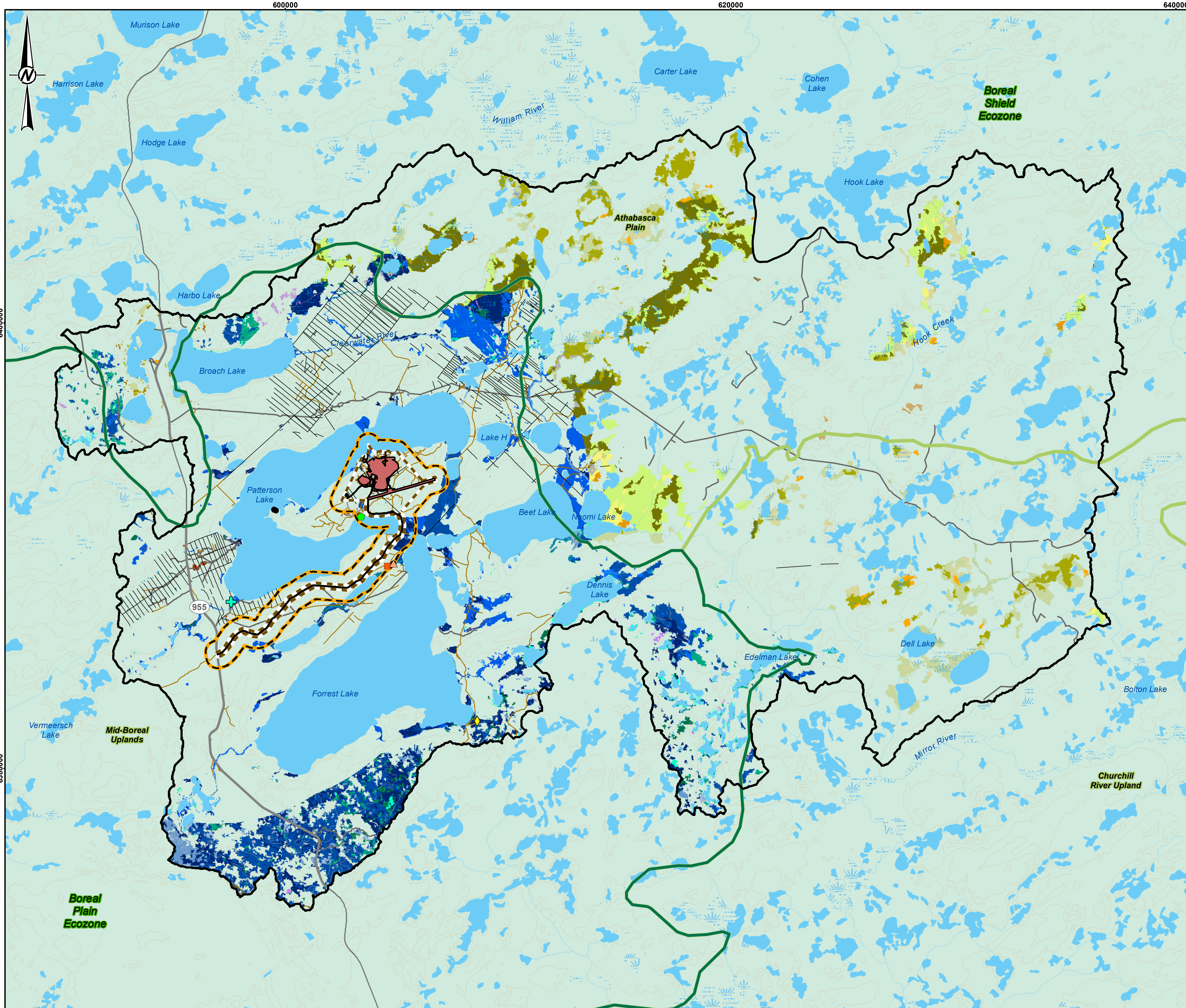
Table 13.5-4: Changes to Wetland Ecosystem Availability in the Application Case

Wetland ELC Unit[a]	RSA		
	Base Case (ha)	Application Case (ha)	Change in Area (ha)
BP18 - Black spruce - tamarack treed swamp	21.9	21.9	0.0
BP19 - Black spruce treed bog	1,708.0	1,699.0	-9.0
BP20 - Labrador tea shrubby bog	1,254.7	1,238.1	-16.6
BP21 - Graminoid bog	25.2	25.2	0.0
BP22 - Open bog	7.8	7.8	0.0
BP23 - Tamarack treed fen	40.4	40.4	0.0
BP24 - Leatherleaf shrubby poor fen	54.5	54.5	0.0
BP25 - Willow shrubby rich fen	317.1	316.7	-0.4
BP26 - Graminoid fen	263.3	263.3	0.0
BP27 - Open fen	32.8	32.8	0.0
BP28 - Seaside arrow-grass marsh	64.3	64.3	0.0
BS17 - Black spruce treed bog	1,517.3	1,517.3	0.0
BS18 - Labrador tea shrubby bog	1,481.3	1,481.3	0.0
BS19 - Graminoid bog	0.2	0.2	0.0
BS20 - Open bog	0.9	0.9	0.0
BS21 - Tamarack treed fen	0.3	0.3	0.0
BS22 - Leatherleaf shrubby poor fen	205.0	205.0	0.0
BS23 - Willow shrubby rich fen	4.5	4.5	0.0
BS24 - Graminoid fen	41.8	41.8	0.0
BS25 - Open fen	<0.1	<0.1	0.0
BS26 - Rush sandy shore	15.2	15.2	0.0
Undisturbed wetland subtotal	*7,056.4*	*7,030.4*	*-26.0*
BP18(BU) - Black spruce - tamarack treed swamp (Burned)	49.9	49.9	0.0
BP19(BU) - Black spruce treed bog (Burned)	2,240.8	2,239.0	-1.8
BP20(BU) - Labrador tea shrubby bog (Burned)	82.2	82.2	0.0
BP21(BU) - Graminoid bog (Burned)	0.3	0.3	0.0
BP23(BU) - Tamarack treed fen (Burned)	25.3	25.3	0.0
BP24(BU) - Leatherleaf shrubby poor fen (Burned)	11.6	11.6	0.0
BP25(BU) - Willow shrubby rich fen (Burned)	142.0	142.0	0.0
BP26(BU) - Graminoid fen (Burned)	401.6	401.6	0.0
BP28(BU) - Seaside arrow-grass marsh (Burned)	109.9	109.9	0.0
BS16(BU) - Black spruce/balsam poplar/river alder swamp (Burned)	<0.1	<0.1	0.0
BS17(BU) - Black spruce treed bog (Burned)	1,540.3	1,540.3	0.0
BS18(BU) - Labrador tea shrubby bog (Burned)	1,052.9	1,052.9	0.0
BS19(BU) - Graminoid bog (Burned)	0.1	0.1	0.0
BS20(BU) - Open bog (Burned)	2.2	2.2	0.0
BS21(BU) - Tamarack treed fen (Burned)	7.0	7.0	0.0
BS22(BU) - Leatherleaf shrubby poor fen (Burned)	411.4	411.4	0.0
BS23(BU) - Willow shrubby rich fen (Burned)	33.1	33.1	0.0
BS24(BU) - Graminoid fen (Burned)	89.1	89.1	0.0
BS25(BU) - Open fen (Burned)	0.1	0.1	0.0
BS26(BU) - Rush sandy shore (Burned)	36.6	36.6	0.0
Recent burn wetland	96.8	96.8	0.0

Table 13.5-4: Changes to Wetland Ecosystem Availability in the Application Case

Wetland ELC Unit[a]	RSA		
	Base Case (ha)	Application Case (ha)	Change in Area (ha)
Burned wetland subtotal	*6,333.1*	*6,331.3*	*-1.8*
Water	18,821.8	18,819.4	-2.4
Wetland total	**32,211.3**	**32,181.2**	**-30.1**
Summary			
Wetland total	**32,211.3**	**32,181.2**	**-30.1**
Upland total	**74,821.7**	**73,953.3**	**-868.4**
Anthropogenic disturbance total[b]	**457.8**	**1,356.3**	**898.5**
Total RSA	**107,490.7**	**107,490.7**	**n/a**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
a) McLaughlan et al. 2010.
b) Anthropogenic disturbance total includes the maximum disturbance area for the Project (980.7 ha) minus the existing anthropogenic disturbance within the maximum disturbance area in the Base Case (82.2 ha).
ELC = Ecological Land Classification; RSA = regional study area; < = less than.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- PROPOSED PROJECT FOOTPRINT
- MAXIMUM DISTURBANCE AREA
- LOCAL STUDY
- REGIONAL STUDY

WETLAND VASCULAR RARE PLANT SPECIES

- ENGLISH SUNDEW
- HUDSON BAY SEDGE
- NORTHERN LADY-FERN
- SCHEUCHZER COTTON-GRASS
- WATER LOBELIA
- HEART-LEAVED TWAYBLADE

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

WETLAND ECOLOGICAL LAND CLASSIFICATION UNIT

BP18	BP25 (BU)	BS20 (BU)
BP18 (BU)	BP26	BS21
BP19	BP26 (BU)	BS21 (BU)
BP19 (BU)	BP27	BS22
BP20	BP28	BS22 (BU)
BP20 (BU)	BP28 (BU)	BS23
BP21	BS16 (BU)	BS23 (BU)
BP21 (BU)	BS17	BS24
BP22	BS17 (BU)	BS24 (BU)
BP23	BS18	BS25
BP23 (BU)	BS18 (BU)	BS25 (BU)
BP24	BS19	BS26
BP24 (BU)	BS19 (BU)	BS26 (BU)
BP25	BS20	RECENT BURN (WETLAND)

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
2. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. ECOZONES OBTAINED FROM AGRICULTURE AND AGRI-FOOD CANADA (AAFC).

PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

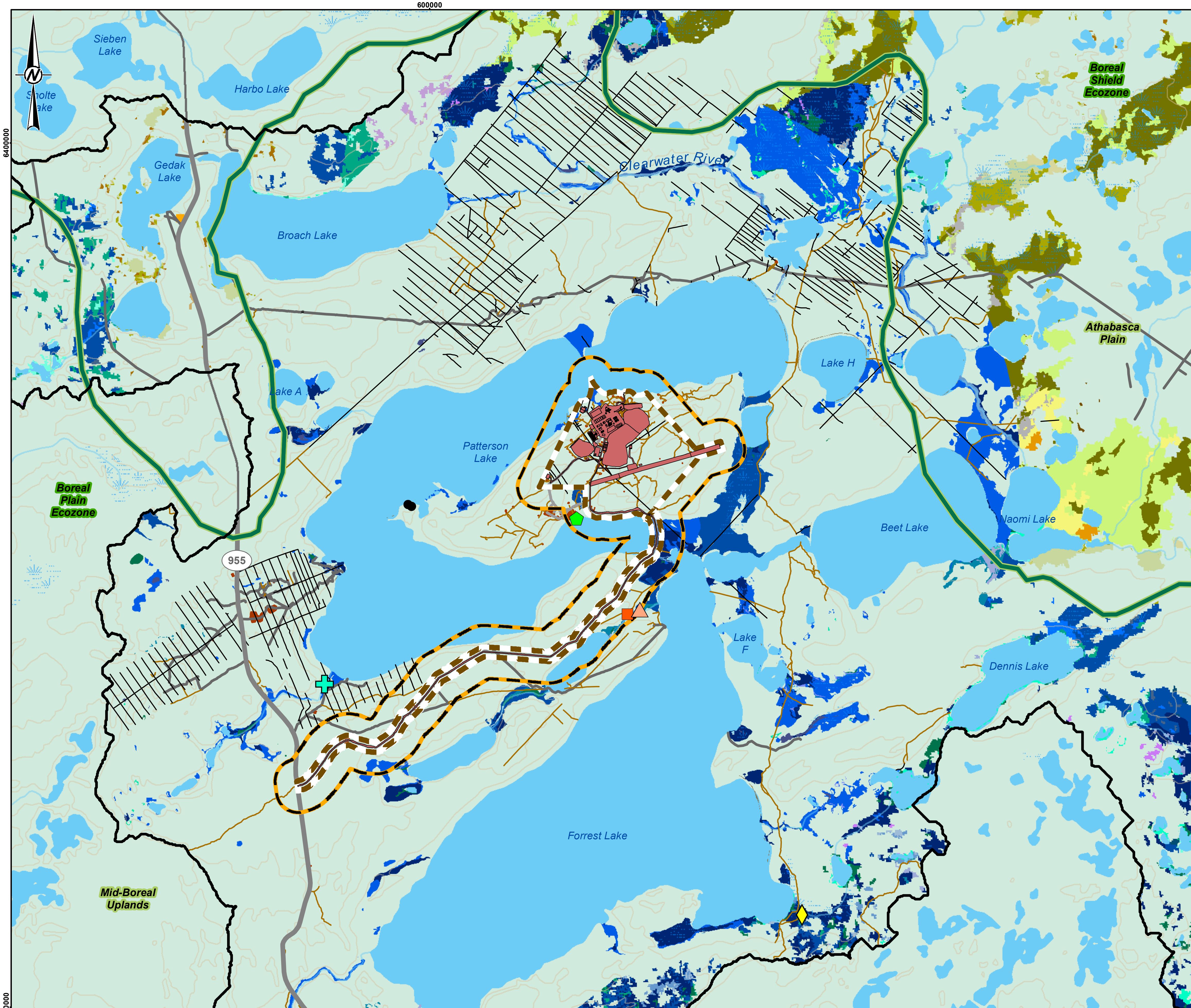
WETLAND ECOSYSTEMS AND RARE PLANT SPECIES IN THE REGIONAL STUDY AREA, APPLICATION CASE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08	FIGURE 13.5-4	
REVIEW	JV	2023-02-08		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- PROPOSED PROJECT FOOTPRINT
- MAXIMUM DISTURBANCE AREA
- LOCAL STUDY
- REGIONAL STUDY

WETLAND VASCULAR RARE PLANT SPECIES

- ENGLISH SUNDEW
- HUDSON BAY SEDGE
- NORTHERN LADY-FERN
- SCHEUCHZER COTTON-GRASS
- WATER LOBELIA
- HEART-LEAVED TWAYBLADE

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

WETLAND ECOLOGICAL LAND CLASSIFICATION UNIT

BP18	BP24 (BU)	BS18
BP18 (BU)	BP25	BS18 (BU)
BP19	BP25 (BU)	BS21
BP19 (BU)	BP26	BS21 (BU)
BP20	BP26 (BU)	BS22
BP20 (BU)	BP27	BS22 (BU)
BP21	BP28	BS23
BP22	BP28 (BU)	BS23 (BU)
BP23	BS16 (BU)	BS24
BP23 (BU)	BS17	BS26
BP24	BS17 (BU)	BS26 (BU)
		RECENT BURN (WETLAND)

0 3 6

1:90,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
2. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. ECOZONES OBTAINED FROM AGRICULTURE AND AGRI-FOOD CANADA (AAFC).

PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

WETLAND ECOSYSTEMS AND RARE PLANT SPECIES IN THE LOCAL STUDY AREA, APPLICATION CASE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08		
REVIEW	JV	2023-02-08		

FIGURE 13.5-5

13.5.2.1.2 Ecosystem Distribution

Environment Canada (2013) states that high priority should be given to maintaining wetlands in close proximity to one another. Fragmentation of wetlands can lead to reduced habitat for species that require contiguous habitat and may inhibit effective dispersal (Environment Canada 2013). Decreased connectivity in the Application Case would occur at the local scale around the maximum disturbance area (Figure 13.5-4; Figure 13.5-5). The existing access road would be upgraded to safely accommodate large vehicles and equipment and realigned to avoid the wetland west of the proposed airstrip. Most of the existing trails in the Project footprint would be upgraded for site roads and haul roads within the maximum disturbance area. The Project would be in a portion of the RSA that contains an aggregation of existing linear and non-linear features in proximity to Highway 955 (Figure 13.5-5).

Project components (i.e., camp location) were redesigned or moved to minimize effects on wetland availability and distribution within the Project footprint, to the extent possible. Existing wetland ecosystems within the LSA are mostly distributed along the shoreline of Patterson Lake and along the Clearwater River below Patterson Lake where an extensive organic wetland (i.e., BP19, BP19[BU], and BP20) has developed to the east of the existing bridge crossing on the existing access road. Changes to wetland distribution are anticipated to be limited as the existing access road would be widened to 10 m, but the existing alignment would be maintained between the gatehouse and Highway 955 (NexGen 2021).

Small changes in distribution are anticipated within the RSA due to Project removal; however, because the ecosystems affected are in close proximity to the existing mine disturbance (i.e., the existing exploration disturbance and existing access road), additional ecosystem fragmentation would be limited and localized such that the Project would result in minor changes (i.e., low magnitude) to wetland ecosystem arrangement and connectivity in the LSA and RSA.

13.5.2.1.3 Ecosystem Condition

Edge effects due to the Project may alter wetland species abundance and richness. Edges can change the natural environment by increasing wind and light and causing small changes in microclimate (e.g., humidity changes) (Foley et al. 2005). The Project is predicted to degrade some wetlands in the LSA due to increased edge effects. However, it is anticipated that any edge effects on wetlands would be limited to wetlands within the maximum disturbance area. Further, some wetland species (e.g., swamp horsetail [*Equisetum fluviatile*]) are adapted to linear environments with high edge-to-area ratios (e.g., roadside ditches), such that they are not likely to be negatively affected by habitat fragmentation (Soomers et al. 2013). Overall changes to the wetland ecosystem condition would be influenced by the sensitivity of local native species to fragmentation and edge effects. New disturbances would occur along the periphery of existing anthropogenic disturbance (i.e., the existing access road), limiting the formation of new habitat edges.

Five rare vascular plant species occurrences were recorded in wetland ecosystems within the RSA (Annex VII.1; Annex VII.2; Figure 13.5-5): English sundew, Hudson Bay sedge, northern lady-fern, Scheuchzer cotton-grass, and water lobelia. None of these observations were recorded within the maximum disturbance area. Known rare plants would be clearly marked and avoided, where feasible. The ENV recommends a 30 m setback distance for high disturbance activities (e.g., mining) for species ranked S1 through S3 (ENV 2017). Where disturbance to rare plants is unavoidable, the ENV would be consulted to determine the best course of action. It is anticipated that measures to limit disturbance to rare vascular plants would include the use of temporary access matting, proper salvage of topsoil and seed bank, and/or changes to Project components, where feasible. Mitigation would be dependent on species tolerance to disturbance, species growth habit (i.e., perennial or annual), and species availability and distribution information (i.e., provincial rank).

No weed species designated under *The Weed Control Act* were identified within wetland ecosystems in the LSA. However, disturbance can create the potential for the introduction or encroachment of designated weed species. Construction equipment would arrive at the site in a clean condition, and an Environmental Protection Program would be implemented that includes actions to prevent, detect, control (i.e., remove), and monitor designated weed species.

Overall, changes in ecosystem condition are likely well within the resilience and adaptability limits for this VC.

13.5.2.2 Reasonably Foreseeable Development Case

13.5.2.2.1 Ecosystem Availability

The RFD Case is predicted to contribute to a loss of 53.9 ha of undisturbed wetland ecosystems and 1.8 ha of early- and late-stage regeneration (i.e., burned in the last 6 to 40 years; Burned) wetland ecosystems (Figure 13.5-5; Figure 13.5-6). Incremental loss is anticipated to Black spruce treed bog (BP19) and Labrador tea shrubby bog (BP20) ELC units as a result of the Fission Patterson Lake South Property, in addition to disturbance to four new wetland ELC units (i.e., Graminoid bog [BP21], Leatherleaf shrubby poor fen [BP24], Graminoid fen [BP26], and Rush sandy shore [BS26]). The actual disturbance would be dependent on the final design of the Fission Patterson Lake South Property. It is estimated that the hypothetical maximum disturbance area used for the Fission Patterson Lake South Property is 6 times larger than the footprint presented in the Fission (2019) prefeasibility study. The largest relative change is to the Leatherleaf shrubby poor fen (BP24) ELC unit, with a 2.9 ha loss from the 54.5 ha available in the Base Case (5.5%). The largest absolute change to the undisturbed wetland ELC units in the RSA is to the Labrador tea shrubby bog (BP20) ELC unit, with 29.3 ha (2.3%) change from the Base Case. Effects are likely to occur but are uncertain (i.e., probable) given that the Fission Patterson Lake South Property has recently entered the formal regulatory application process.

Once wetlands are removed, the loss is considered continuous until functional habitat is reclaimed or offset (i.e., beyond Closure), and effects would be limited to the RSA (i.e., regional) for the RFD Case. Following Closure, it is anticipated that wetland ecosystems would be reclaimed to the extent possible in an attempt to achieve no net loss of wetland functions, consistent with the guideline of the *Federal Policy on Wetland Conservation* (Government of Canada 1991). Although the establishment of functioning wetland ecosystems following the Active Closure Stage is considered possible, restoration of wetland species composition and ecological function similar to the wetland ELC units observed in the Base Case is unlikely. Therefore, the loss of all wetland ecosystems is conservatively assumed to be permanent and irreversible.

Changes to wetland availability by fire are anticipated to be limited as self-replacement of non-forest poorly drained sites is the most common trajectory post-fire (Hart et al. 2019). Further, changes in wetland ecosystem availability due to an increased fire interval under the climate change scenario were also observed to be relatively stable (Hart et al. 2019).

Climate Change

Wetland ecosystem availability may be adversely affected by climate change in the RFD Case. Wetlands are considered one of the ecosystems most sensitive to predicted changes in precipitation, temperature, and the resultant changes in timing and volume of snowmelt. The annual mean temperature and evapotranspiration rate (i.e., rate at which water vapour is released to the atmosphere by plants and soil) are predicted to increase 2.4°C and 9.1%, respectively, under a climate change scenario, with possible changes in surface water elevations in some waterbodies (Section 9.4.1, Water Surface Elevation). However, it is anticipated that increased annual total precipitation would offset potential water deficits within wetland ecosystems associated with increases in temperature and evapotranspiration rate. Although seasonal deficits may occur (i.e., drought), they would be anticipated to occur within the natural variability and resiliency of wetland ecosystems and would not affect overall ecosystem availability. However, because of the large degree of variation in climate change projections, there is uncertainty in predicting climate-related changes to wetland ecosystem availability (Table 13.5-5).

Table 13.5-5: Changes to Wetland Ecosystem Availability in the Reasonably Foreseeable Development Case

Wetland ELC Unit[a]	RSA		
	Base Case (ha)	RFD Case (ha)	Change in Area (ha)
BP18 - Black spruce - tamarack treed swamp	21.9	21.9	0.0
BP19 - Black spruce treed bog	1,708.0	1,688.6	-19.4
BP20 - Labrador tea shrubby bog	1,254.7	1,225.4	-29.3
BP21 - Graminoid bog	25.2	25.1	-0.1
BP22 - Open bog	7.8	7.8	0.0
BP23 - Tamarack treed fen	40.4	40.4	0.0
BP24 - Leatherleaf shrubby poor fen	54.5	51.6	-2.9
BP25 - Willow shrubby rich fen	317.1	316.7	-0.4
BP26 - Graminoid fen	263.3	261.6	-1.7
BP27 - Open fen	32.8	32.8	0.0
BP28 - Seaside arrow-grass marsh	64.3	64.3	0.0
BS17 - Black spruce treed bog	1,517.3	1,517.3	0.0
BS18 - Labrador tea shrubby bog	1,481.3	1,481.3	0.0
BS19 - Graminoid bog	0.2	0.2	0.0
BS20 - Open bog	0.9	0.9	0.0
BS21 - Tamarack treed fen	0.3	0.3	0.0
BS22 - Leatherleaf shrubby poor fen	205.0	205.0	0.0
BS23 - Willow shrubby rich fen	4.5	4.5	0.0
BS24 - Graminoid fen	41.8	41.8	0.0
BS25 - Open fen	<0.1	<0.1	0.0
BS26 - Rush sandy shore	15.2	15.1	-0.1
Undisturbed wetland subtotal	*7,056.4*	*7,002.6*	*-53.9*
BP18(BU) - Black spruce - tamarack treed swamp (Burned)	49.9	49.9	0.0
BP19(BU) - Black spruce treed bog (Burned)	2,240.8	2,239.0	-1.8
BP20(BU) - Labrador tea shrubby bog (Burned)	82.2	82.2	0.0
BP21(BU) - Graminoid bog (Burned)	0.3	0.3	0.0
BP23(BU) - Tamarack treed fen (Burned)	25.3	25.3	0.0
BP24(BU) - Leatherleaf shrubby poor fen (Burned)	11.6	11.6	0.0

Table 13.5-5: Changes to Wetland Ecosystem Availability in the Reasonably Foreseeable Development Case

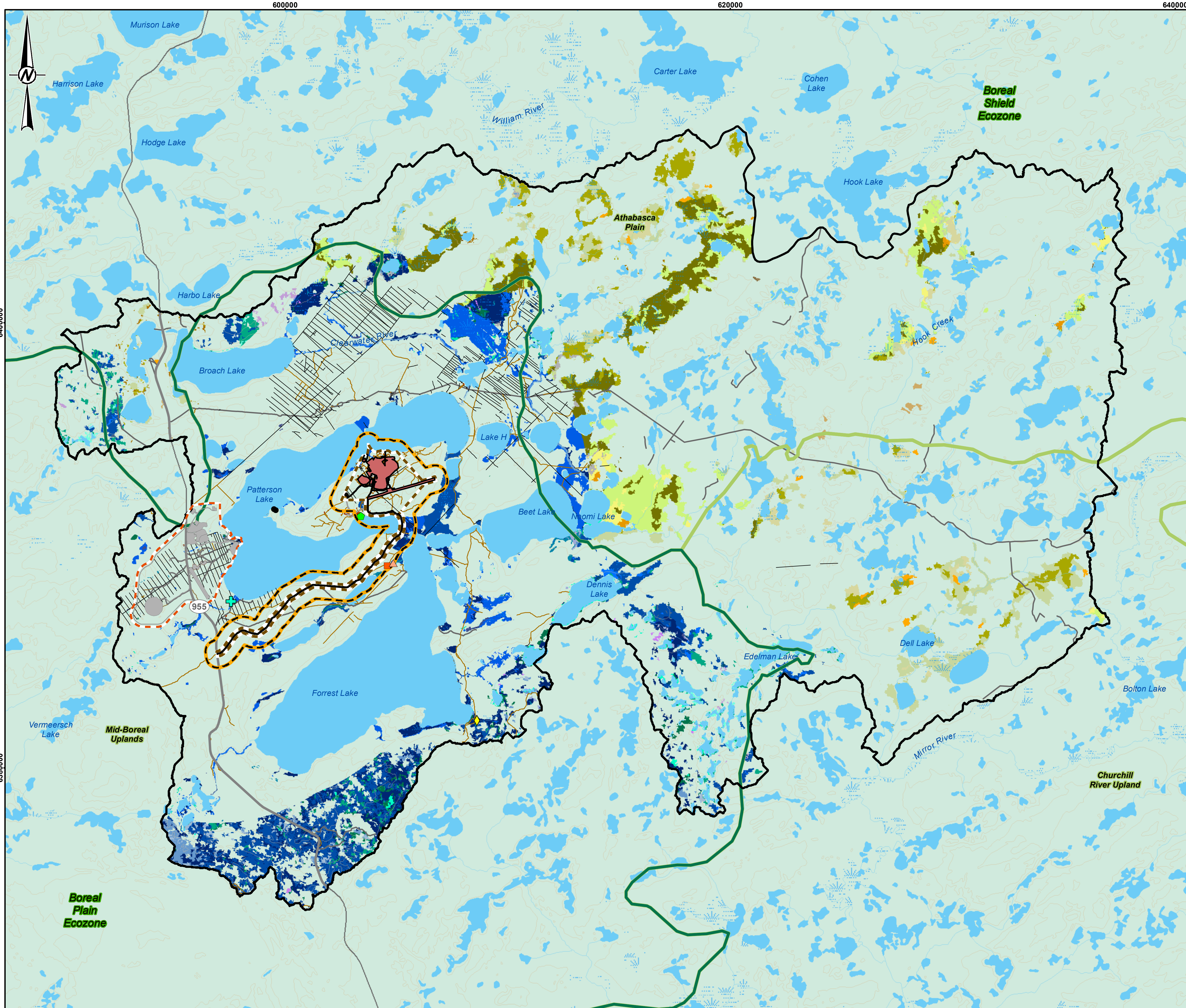
Wetland ELC Unit[(a)]	RSA		
	Base Case (ha)	RFD Case (ha)	Change in Area (ha)
BP25(BU) - Willow shrubby rich fen (Burned)	142.0	142.0	0.0
BP26(BU) - Graminoid fen (Burned)	401.6	401.6	0.0
BP28(BU) - Seaside arrow-grass marsh (Burned)	109.9	109.9	0.0
BS16(BU) - Black spruce/balsam poplar/river alder swamp (Burned)	<0.1	<0.1	0.0
BS17(BU) - Black spruce treed bog (Burned)	1,540.3	1,540.3	0.0
BS18(BU) - Labrador tea shrubby bog (Burned)	1,052.9	1,052.9	0.0
BS19(BU) - Graminoid bog (Burned)	0.1	0.1	0.0
BS20(BU) - Open bog (Burned)	2.2	2.2	0.0
BS21(BU) - Tamarack treed fen (Burned)	7.0	7.0	0.0
BS22(BU) - Leatherleaf shrubby poor fen (Burned)	411.4	411.4	0.0
BS23(BU) - Willow shrubby rich fen (Burned)	33.1	33.1	0.0
BS24(BU) - Graminoid fen (Burned)	89.1	89.1	0.0
BS25(BU) - Open fen (Burned)	0.1	0.1	0.0
BS26(BU) - Rush sandy shore (Burned)	36.6	36.6	0.0
Recent burn wetland	96.8	96.8	0.0
Burned wetland subtotal	*6,333.1*	*6,331.3*	*-1.8*
Water	18,821.8	18,805.5	-16.3
Wetland total	**32,211.3**	**32,139.3**	**-72.0**
Summary			
Wetland total	**32,211.3**	**32,139.3**	**-72.0**
Upland total	**74,821.7**	**72,503.5**	**-2,318.2**
Anthropogenic disturbance total[(b)]	**457.8**	**2,847.9**	**2,390.1**
Total RSA	**107,490.7**	**107,490.7**	**n/a**

Note**:** Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

a) McLaughlan et al. 2010.

b) Anthropogenic disturbance total includes the maximum disturbance area for the Project (980.7 ha) and the Fission Patterson Lake South Property (1,544.2 ha) minus the existing anthropogenic disturbance within the maximum disturbance areas in the Base Case (134.8 ha).

RFD = reasonably foreseeable development; ELC = Ecological Land Classification; RSA = regional study area; < = less than; n/a = not applicable.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- PROPOSED PROJECT FOOTPRINT
- MAXIMUM DISTURBANCE AREA
- LOCAL STUDY
- REGIONAL STUDY
- FISSION PATTERSON LAKE SOUTH PROPERTY FOOTPRINT
- PATTERSON LAKE SOUTH PROPERTY HYPOTHETICAL MAXIMUM DISTURBANCE AREA

WETLAND VASCULAR RARE PLANT SPECIES

- ENGLISH SUNDEW
- HUDSON BAY SEDGE
- NORTHERN LADY-FERN
- SCHEUCHZER COTTON-GRASS
- WATER LOBELIA
- HEART-LEAVED

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

WETLAND ECOLOGICAL LAND CLASSIFICATION UNIT

BP18	BP25 (BU)	BS20 (BU)
BP18 (BU)	BP26	BS21
BP19	BP26 (BU)	BS21 (BU)
BP19 (BU)	BP27	BS22
BP20	BP28	BS22 (BU)
BP20 (BU)	BP28 (BU)	BS23
BP21	BS16 (BU)	BS23 (BU)
BP21 (BU)	BS17	BS24
BP22	BS17 (BU)	BS24 (BU)
BP23	BS18	BS25
BP23 (BU)	BS18 (BU)	BS25 (BU)
BP24	BS19	BS26
BP24 (BU)	BS19 (BU)	BS26 (BU)
BP25	BS20	RECENT BURN (WETLAND)

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
2. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. ECOZONES OBTAINED FROM AGRICULTURE AND AGRI-FOOD CANADA (AAFC).
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

WETLAND ECOSYSTEMS AND RARE PLANT SPECIES IN THE REGIONAL STUDY AREA, REASONABLY FORESEEABLE DEVELOPMENT CASE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08	**FIGURE 13.5-6**	
REVIEW	JV	2023-02-08		

13.5.2.2.2 Ecosystem Distribution

It is anticipated that the RFD Case would have a relatively small direct effect on the loss of wetland ELC units, with a total loss of 55.6 ha of wetland ELC units in the RSA (0.4% of 13,333.9 ha in the RSA [excluding open water]) (Figure 13.5-5; Figure 13.5-6). Fragmentation of wetlands can lead to reduced habitat for species that require contiguous habitat and may inhibit effective dispersal (Environment Canada 2013). Small changes in distribution are anticipated within the RSA due to the Project and the Fission Patterson Lake South Property. Changes are assumed to be permanent but are predicted to be limited to the area around Patterson Lake (i.e., regional). Further, wetland ecosystems affected are in close proximity to the existing disturbance (i.e., cutlines, existing exploration disturbance, and existing access road), and therefore additional ecosystem fragmentation is predicted to be limited such that the Project and the Fission Patterson Lake South Property would result in minor changes (i.e., low magnitude) to wetland ecosystem arrangement and connectivity in the RSA.

The distribution of wetland ecosystems may be further affected in the RFD Case because of changes to hydrology and drainage patterns associated with the Fission Patterson Lake South Property and potential hydrological changes brought on by climate change (Section 9.4, Climate Change Scenarios). However, changes from the Fission Patterson Lake South Property are anticipated to be mitigated by similar measures as for the Project to control and manage potential hydrological pathways (i.e., surface drainage and discharge of water).

Climate Change

Climate change scenarios predict a warmer and wetter climate, conditions that may affect wetland distribution positively through the expansion of existing wetlands and creation of new wetland areas through the accumulation of surface water or saturation of soils. It is anticipated that increased annual total precipitation would offset potential water deficits within wetland ecosystems associated with increases in temperature and evapotranspiration rate (Section 9.4.1, Water Surface Elevation). Although seasonal deficits may occur (i.e., drought), they would be anticipated to occur within the natural variability and resiliency of wetland ecosystems and would not affect overall distribution of wetland ecosystems, but there is uncertainty in this prediction due to variation in climate change projections.

13.5.2.2.3 Ecosystem Condition

Similar to the Application Case, edge effects due to the Project and the Fission Patterson Lake South Property may alter wetland species abundance and richness. Edges can change the natural environment by increasing wind and light, causing small changes in microclimate (e.g., humidity changes; Foley et al. 2005). However, edge effects are predicted to be limited to the maximum disturbance areas for the Project and the Fission Patterson Lake South Property. Project infrastructure is planned to use as much existing disturbance as possible (i.e., approximately 8% of the maximum disturbance area would occur within existing anthropogenic disturbance). Much of the hypothetical maximum disturbance area for the Fission Patterson Lake South Property also overlaps existing disturbance.

As stated under the Application Case, there are no documented rare plant species in wetlands that would be affected by the Project. Six occurrences of five provincially tracked species were observed during baseline terrestrial surveys within the RSA (Annex VII.1; Annex VII.2), none of which is anticipated to be disturbed in the RFD Case. It is anticipated that rare vascular plant surveys would be completed for the Fission Patterson Lake South Property and that planning would include mitigation to limit disturbance to any federally listed or provincially tracked vascular plant species.

No weed species designated under *The Weed Control Act* were identified in wetland ecosystems during the 2018 field surveys (Annex VII.1; Annex VII.2). However, disturbance can create the potential for the introduction or encroachment of designated weed species. Construction equipment for the Project would arrive at the site in a clean condition, and an Environmental Protection Program would be implemented that includes actions to prevent, detect, control (i.e., remove), and monitor designated weed species. No weed management activities were identified in the Fission Patterson Lake South Property prefeasibility study (Fission 2019), but it is anticipated that appropriate mitigation would be implemented to avoid and minimize the introduction of weeds.

The reduction in wetland ecosystem condition in the RFD Case relative to the Base Case is not predicted to greatly alter the ecological function of wetlands within the RSA because most wetlands would remain intact. Less than 55.6 ha of wetlands present in the Base Case (i.e., less than 0.1% of wetlands within the RSA) are predicted to be disturbed in the RSA in the RFD Case. Studies have found that water quality improvement, flood tolerance, and other wetland functions do not decline until large portions of historical wetlands have been removed (Zedler and Kercher 2004; Environment Canada 2013).

Climate Change

Changes to wetland ecosystem condition resulting from fire are anticipated to be limited as wetland ELC units are generally expected to return to a similar pre-fire state (Hart et al. 2019; McLaughlan et al. 2010). Changes to vegetation community structure may occur from increased intensity of fire, insects, and disease, which may cause a loss in vegetation cover in the boreal forest (Sauchyn et al. 2009).

Climate change also may alter the processes that influence the condition of wetland ecosystems and effects would occur beyond the RSA. It is predicted that changes to annual temperature, rainfall, and evapotranspiration could lead to varied results including increased pest and disease persistence or potential increases in primary productivity, which could ultimately result in shifts in species composition (Sauchyn et al. 2009). The annual mean temperature and evapotranspiration rate (i.e., rate at which water vapour is released to the atmosphere by plants and soil) are predicted to increase 2.4°C and 9.1%, respectively, under a climate change scenario (Section 9.4.1, Water Surface Elevation). Effects of increased evapotranspiration are anticipated to be offset by wetter annual conditions; however, seasonal distribution of changes is predicted to be variable within these annual trends, potentially causing periods of stress on wetland vegetation (i.e., summer drought), which may adversely affect the composition and overall condition of wetland ecosystems. Consequently, wetland ecosystem condition could be reduced in the RSA due to climate change, although the magnitude of changes is uncertain due the large degree of variation in climate change projections.

13.5.2.3 Residual Effects Classification and Determination of Significance

13.5.2.3.1 Classification Summary

Residual effects were classified for the Application Case and the RFD Case after the implementation of effective mitigation (Table 13.5-6). Residual effects were summarized according to the direction, magnitude, geographic extent, duration, reversibility, frequency, and probability of the effect occurring following the methods described in Section 13.2.9. Effective implementation of mitigation is summarized in Section 13.4, Project Interactions and Mitigations, (Table 13.4-1), and progressive reclamation and revegetation is expected to reduce the magnitude and duration of residual effects on wetland ecosystems. Following the summary of residual effects, the significance of residual effects for the Application Case and the RFD Case was determined according to the methods described in Section 13.2.9.

Table 13.5-6: Classification of Residual Effects on Wetland Ecosystem Measurement Indicators for the Application Case and Reasonably Foreseeable Development Case

Measurement Indicator	Criterion	Rating / Effect Size	
		Application Case	RFD Case
Wetland ecosystem availability	Direction	▪ Negative	▪ Negative
	Magnitude	▪ Direct physical loss of 27.8 ha (<0.1% of the RSA) from the Base Case to the Application Case (i.e., low magnitude)	▪ Loss of 55.6 ha (0.1% of RSA) from the Base Case to the RFD Case (i.e., low magnitude)
	Geographic extent	▪ Maximum disturbance area	▪ Regional (Project and Fission Patterson Lake South Property) ▪ Beyond regional (climate change)
	Duration	▪ Permanent	▪ Permanent: Project and the Fission Patterson Lake South Property ▪ Permanent: climate change effects
	Reversibility	▪ Irreversible	▪ Irreversible
	Frequency	▪ Continuous	▪ Continuous
	Probability of occurrence	▪ Certain	▪ Probable (Project and Fission Patterson Lake South Property) ▪ Possible (climate change)
Wetland ecosystem distribution	Direction	▪ Negative	▪ Negative
	Magnitude	▪ Minor net change in wetland ecosystem distribution centred on the LSA; almost no change in fragmentation at the RSA scale (i.e., low magnitude)	▪ Minor increase in fragmentation of wetland ecosystems in the RSA near the western boundary in proximity to existing disturbance; almost no change to connectivity in most of the RSA (i.e., low magnitude)
	Geographic extent	▪ Local	▪ Regional (Project and the Fission Patterson Lake South Property) ▪ Beyond regional (climate change)
	Duration	▪ Permanent	▪ Permanent: Project and Fission Patterson Lake South Property ▪ Permanent: climate change effects
	Reversibility	▪ Irreversible	▪ Irreversible
	Frequency	▪ Continuous	▪ Continuous
	Probability of occurrence	▪ Certain	▪ Probable (Project and the Fission Patterson Lake South Property) ▪ Possible (climate change)
Wetland ecosystem condition	Direction	▪ Negative	▪ Negative
	Magnitude	▪ Edge effects would result in a minor change in ecosystem structure (i.e., low magnitude)	▪ Potential loss of rare vegetation species ▪ Potential introduction of weed species ▪ Edge effects would result in a minor change in ecosystem structure (i.e., low magnitude)
	Geographic extent	▪ Maximum disturbance area	▪ Regional (Project and the Fission Patterson Lake South Property) ▪ Beyond regional (climate change)
	Duration	▪ Permanent	▪ Permanent: Project and the Fission Patterson Lake South Property ▪ Permanent: climate change effects
	Reversibility	▪ Irreversible	▪ Irreversible
	Frequency	▪ Continuous	▪ Continuous
	Probability of occurrence	▪ Possible	▪ Possible (Project and the Fission Patterson Lake South Property) ▪ Possible (climate change)

RFD = reasonably foreseeable development; LSA = local study area; RSA = regional study area; < = less than.

13.5.2.3.2 Significance Determination

Wetland ecosystems are considered to have ecological resilience and adaptive capacity to changes in abundance, distribution, and condition in the Base Case. Within the LSA, wetland ELC units are encountered infrequently and are distributed mostly along the shorelines of Patterson Lake, Forrest Lake, and Lake E. Wetland ecosystems in the RSA are relatively more abundant and well distributed. Although previous and existing linear disturbances have resulted in some fragmentation of habitats in the RSA, wetland ecosystems remain intact within the LSA and RSA. Overall, the evidence indicates that wetland ecosystems in the RSA are self-sustaining and ecologically effective in the Base Case.

Application Case

For wetland ecosystems, predicted changes in ecosystem availability, distribution, and condition as a result of the Project are predicted to be certain, local, permanent, and occur continuously in the Application Case (Table 13.5-6). The exception is for changes to ecosystem condition, which are possible as the small decrease in ecosystem abundance is anticipated to produce no or few edge effects and would not disturb any known occurrences of rare plant species detected during baseline studies. Designated weed species were not detected in wetland ecosystems during baseline surveys; however, the Project would implement an Environmental Protection Program that includes actions to avoid and limit the risk of introducing invasive plant species.

Once wetlands are removed, the loss is considered continuous and permanent until functional habitat is reclaimed or offset. For the purpose of this analysis, the loss of all wetland ecosystems is assumed to be irreversible because fen and bog type wetlands cannot be restored with confidence (Environment Canada 2013). The loss of 27.8 ha (excluding open water) of available wetlands (i.e., 0.4% of the RSA) as a result of the Project is predicted to have a small influence on ecological structure and function. Disturbance as a result of the Project would be limited to four ELC units (i.e., BP19, BP20, BP25, and BP19[BU]). However, these wetland ELC units remain available in the LSA and RSA and appear to be well distributed outside of the Project footprint. The least common wetland ELC units (e.g., Graminoid bog [BS19], Open bog [BS20], and Tamarack treed fen [BS21]) within the LSA are not predicted to be disturbed by the Project. Overall, wetland ecosystems are predicted to remain self-sustaining and ecologically effective in the Application Case.

RFD Case

For the RFD Case, the combined effects from the Project and the Fission Patterson Lake South Property in the RSA are expected to remove 55.6 ha of wetland ELC units and be regional in geographic extent. Cumulative effects are predicted to be permanent, irreversible, and continuous (Table 13.5-6). The Project and the Fission Patterson Lake South Property would result in a direct loss to wetland ecosystems, but the implementation of mitigation is expected to limit cumulative changes to ecosystem availability, distribution, and condition.

Persistence of wetland ecosystems on the landscape are tied to their ability to accommodate changes in natural variability, specifically fluctuations in water levels (van der Valk 1994; Drinkard 2012; Vale et al. 2015). Changes are driven by a dynamic climate regime (i.e., drought, flooding), and the ability of wetland ecosystems to adapt to a range of variability indicates generally that resilience limits are high. Overall, the weight of evidence from the analysis predicts that changes to the availability, distribution, and condition of wetland ecosystems that overlap the RSA in the RFD Case would be within the resilience and adaptability limits for this VC. Overall, wetland ecosystems are predicted to remain self-sustaining and ecologically effective in the RFD Case.

Climate Change

Climate change is expected to affect ecosystem availability, distribution, and condition continuously at a beyond regional extent (Table 13.5-6). Effects from climate change would likely be permanent, but not certain (i.e., possible) due to the inherent low level of confidence in predicting the magnitude, frequency, and geographic extent of climate-related changes to measurement indicators. However, wetland ecosystems are expected to remain abundant and well distributed within and adjacent to the RSA and self-sustaining and ecologically effective.

Overall Significance

Based on several lines of evidence, incremental and cumulative effects from the Project, previous and existing developments, and the Fission Patterson Lake South Property on the wetland ecosystems are predicted to be not significant. Effects related to climate change are not expected to significantly influence wetland ecosystems and do not alter the assessment of no significant cumulative effects from the Project and Fission Patterson Lake South Property.

13.5.3 Riparian Ecosystems

The residual effects analysis for riparian ecosystems focused on evaluating the following pathways:

- direct loss, alteration, and fragmentation of riparian ecosystems as a result of the Project; and
- alteration of final terrain, soil conditions, and/or plant species composition could change the types of ecosystems that can be reclaimed on the landscape and adversely affect ecosystem availability, distribution, and condition.

13.5.3.1 Application Case

13.5.3.1.1 Ecosystem Availability

The Project is predicted to remove 39.6 ha of riparian ecosystems (i.e., 19.3% of riparian ecosystems in the LSA and 0.4% of riparian ecosystems in the RSA) from the Base Case (Table 13.5-7; Figure 13.5-7; Figure 13.5-8). In total, the Project is anticipated to affect five riparian ELC units: Black spruce/Labrador tea/feathermoss (BP14), Black spruce treed bog (BP19), Labrador tea shrubby bog (BP20), Willow shrubby rich fen (BP25), and burned Balsam poplar – trembling aspen/prickly rose (BP16[BU]). The largest absolute change to a single riparian ELC unit is to the Labrador tea shrubby bog (BP20) ELC unit, with a loss of 10.4 ha from the 35.1 ha available (i.e., 30% of this ELC unit) in the Base Case. Changes of similar magnitude are anticipated for Black spruce/Labrador tea/feathermoss (BP14) (9.8 ha), Black spruce treed bog (BP19) (9.0 ha) and burned Balsam poplar – trembling aspen/prickly rose (BP16[BU]) (10.0 ha). A smaller change is anticipated for the Willow shrubby fen (BP25), where a loss of only 0.4 ha is predicted. The magnitude of ecosystem loss has been conservatively overestimated when considering the Project footprint. Therefore, the effects on riparian ecosystems as a result of the Project could be much less than predicted.

Riparian ecosystems lost in the Application Case would result from the removal of ELC units along the shore of Patterson Lake and adjacent to the existing access road. Changes to these ELC units are anticipated to be less than predicted as access is expected to use the existing access road alignment. Some upgrades to the road would be required (i.e., widening), but the existing alignment would be maintained between the gatehouse and Highway 955 to minimize new disturbances.

Disturbances associated with permanent facilities of the Project (e.g., WRSAs) are not anticipated to occur within riparian ecosystems. Adverse effects on riparian ecosystems from changes to ecosystem availability would be certain from the addition of the Project. Changes to riparian availability would be confined to the maximum disturbance area, and loss is considered continuous until functional ecosystems are reclaimed (i.e., beyond Closure).

Reclamation is predicted to reverse effects on disturbed ELC units and provide adequate material for the development of productive soils, which would support the establishment and succession of riparian ecosystems (i.e., upland and wetland ELC units with riparian potential) and vegetation communities with similar function to natural ecosystems not influenced by the Project; however, upland ELC units with riparian potential would most likely differ from those present before disturbance. It is anticipated that reclaimed upland ELC units associated with riparian ecosystems would emulate existing common upland vegetation in dry to moist upland ELC units within the LSA. Young seral forest communities are predicted to be established within six to 20 years following the Active Closure Stage. However, it would take 60 to 80 years beyond the Active Closure Stage for upland ELC units with riparian potential to establish mature forest types present at existing conditions (Section 13.3.1.3). Wetland ELC units with riparian potential are assumed to be reclaimed to mineral wetlands consisting of non-forested structural stages (e.g., herb--, sedge--, or shrub-dominated-); however, reclamation prescriptions within riparian ecosystems may include river alder (*Alnus incana*) and paper birch. Although the establishment of functioning wetland ELC units within riparian ecosystems following the Active Closure Stage is considered possible, restoration of riparian species composition and ecological function similar to the riparian ecosystems observed in the Base Case is unlikely. Therefore, the loss of all wetland ELC units associated with riparian ecosystems is conservatively assumed to be permanent and irreversible.

The loss of a maximum of 39.6 ha of riparian ecosystems represents less than 1% of riparian ecosystem in the RSA. Although some riparian ecosystems would be lost due to the Project, these changes are predicted to add no to few adverse effects on riparian ecosystems surrounding Patterson Lake and the Clearwater River watershed throughout the RSA.

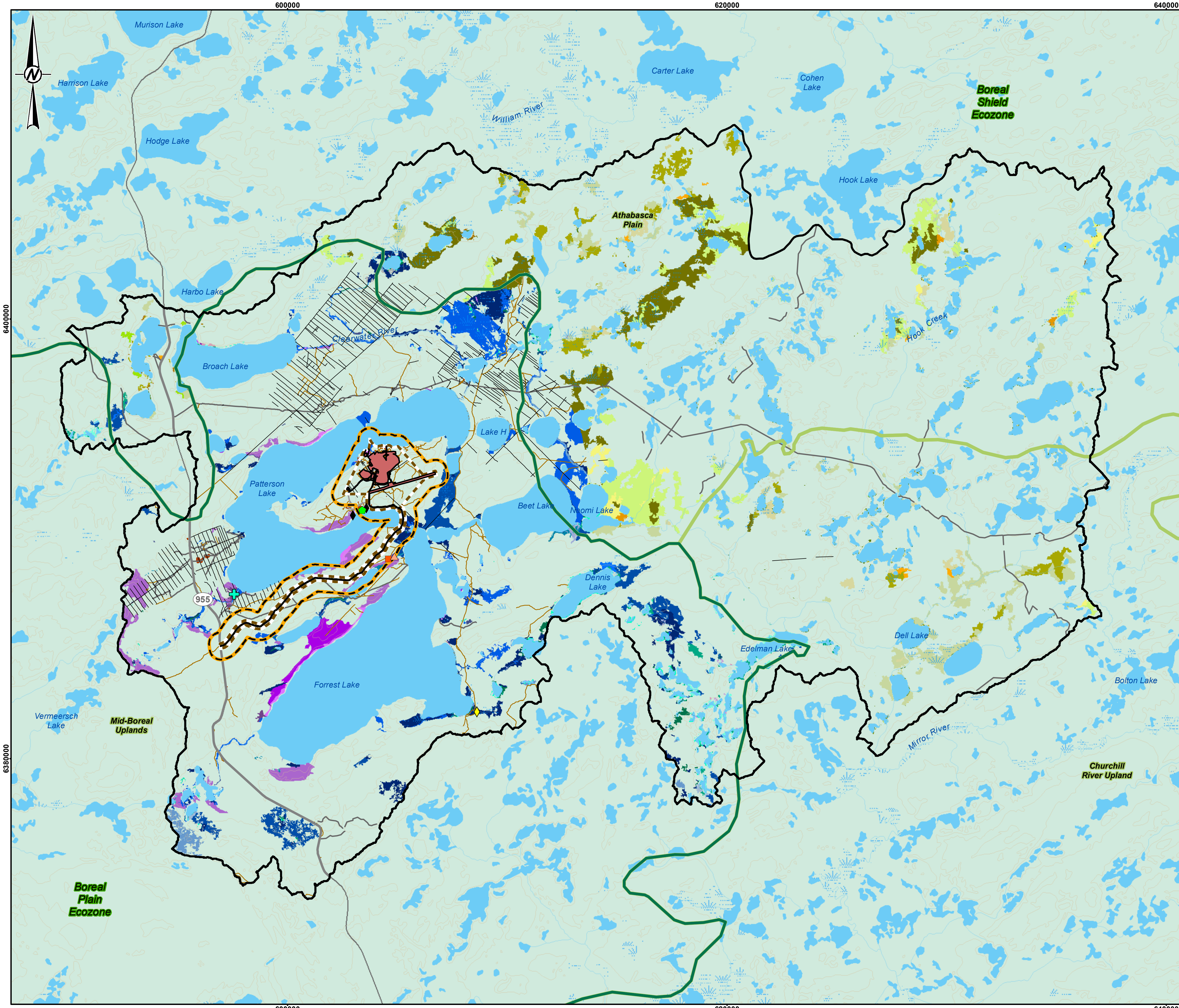
Table 13.5-7: Changes to Riparian Ecosystem Availability in the Application Case

Riparian ELC Unit[a]	RSA		
	Base Case (ha)	Application Case (ha)	Change in Area (ha)
BP07 - Trembling aspen - white birch/sarsaparilla	<0.1	<0.1	0.0
BP12 - Jack pine - spruce/feathermoss	216.2	216.2	0.0
BP14 - Black spruce/Labrador tea/feathermoss	96.7	86.8	-9.8
BP16 - Balsam poplar - trembling aspen/prickly rose	32.4	32.4	0.0
BP18 - Black spruce - tamarack treed swamp	3.6	3.6	0.0
BP19 - Black spruce treed bog	822.2	813.2	-9.0
BP20 - Labrador tea shrubby bog	1,003.6	993.2	-10.4
BP21 - Graminoid bog	12.3	12.3	0.0
BP22 - Open bog	3.6	3.6	0.0
BP23 - Tamarack treed fen	27.3	27.3	0.0
BP24 - Leatherleaf shrubby poor fen	36.8	36.8	0.0
BP25 - Willow shrubby rich fen	216.5	216.1	-0.4
BP26 - Graminoid fen	97.5	97.5	0.0
BP27 - Open fen	15.6	15.6	0.0
BP28 - Seaside arrow-grass marsh	46.0	46.0	0.0
BS06 - Jack pine - trembling aspen/green alder	0.3	0.3	0.0
BS09 - Black spruce - jack pine/feathermoss	23.1	23.1	0.0

Table 13.5-7: Changes to Riparian Ecosystem Availability in the Application Case

Riparian ELC Unit[a]	RSA		
	Base Case (ha)	**Application Case (ha)**	**Change in Area (ha)**
BS10 - Black spruce - white birch/feathermoss	0.1	0.1	0.0
BS13 - White birch - black spruce - trembling aspen	0.5	0.5	0.0
BS15 - Trembling aspen - white birch/green alder	<0.1	<0.1	0.0
BS17 - Black spruce treed bog	1,281.4	1,281.4	0.0
BS18 - Labrador tea shrubby bog	1,302.8	1,302.8	0.0
BS19 - Graminoid bog	0.2	0.2	0.0
BS20 - Open bog	0.7	0.7	0.0
BS21 - Tamarack treed fen	<0.1	<0.1	0.0
BS22 - Leatherleaf shrubby poor fen	171.9	171.9	0.0
BS23 - Willow shrubby rich fen	2.7	2.7	0.0
BS24 - Graminoid fen	30.8	30.8	0.0
BS25 - Open fen	<0.1	<0.1	0.0
BS26 - Rush sandy shore	11.9	11.9	0.0
Undisturbed riparian subtotal	*5,456.3*	*5,426.7*	*-29.6*
BP16(BU) - Balsam poplar - trembling aspen/prickly rose (Burned)	729.1	719.1	-10.0
BP18(BU) - Black spruce - tamarack treed swamp (Burned)	6.8	6.8	0.0
BP19(BU) - Black spruce treed bog (Burned)	873.3	873.3	0.0
BP20(BU) - Labrador tea shrubby bog (Burned)	25.2	25.2	0.0
BP23(BU) - Tamarack treed fen (Burned)	12.2	12.2	0.0
BP25(BU) - Willow shrubby rich fen (Burned)	20.7	20.7	0.0
BP26(BU) - Graminoid fen (Burned)	105.8	105.8	0.0
BP28(BU) - Seaside arrow-grass marsh (Burned)	98.5	98.5	0.0
BS06(BU) - Jack pine - trembling aspen/green alder (Burned)	0.7	0.7	0.0
BP07(BU) - Trembling aspen - white birch/sarsaparilla (Burned)	5.3	5.3	0.0
BP11(BU) - White birch - white spruce - balsam fir (Burned)	0.5	0.5	0.0
BP12(BU) - Jack pine - spruce/feathermoss (Burned)	0.5	0.5	0.0
BP14(BU) - Black spruce/Labrador tea/feathermoss (Burned)	<0.1	<0.1	0.0
BS09(BU) - Black spruce - jack pine/feathermoss (Burned)	47.8	47.8	0.0
BS13(BU) - White birch - black spruce - trembling aspen (Burned)	26.6	26.6	0.0
BS15(BU) - Trembling aspen - white birch/green alder (Burned)	0.1	0.1	0.0
BS17(BU) - Black spruce treed bog (Burned)	1,189.3	1,189.3	0.0
BS18(BU) - Labrador tea shrubby bog (Burned)	665.0	665.0	0.0
BS19(BU) - Graminoid bog (Burned)	0.1	0.1	0.0
BS 20(BU) - Open bog (Burned)	1.3	1.3	0.0
BS21(BU) - Tamarack treed fen (Burned)	3.3	3.3	0.0
BS22(BU) - Leatherleaf shrubby poor fen (Burned)	266.1	266.1	0.0
BS23(BU) - Willow shrubby rich fen (Burned)	16.4	16.4	0.0
BS24(BU) - Graminoid fen (Burned)	37.4	37.4	0.0
BS25(BU) - Open fen (Burned)	0.1	0.1	0.0
Recent burn wetland	23.7	23.7	0.0
Burned riparian subtotal	*4,156.2*	*4,146.3*	*-10.0*
Total Riparian	**9,612.5**	**9,572.9**	**-39.6**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values. Riparian ecosystems are a subset of upland and wetland ecosystems. ELC units described as riparian do not match upland or wetland ecosystem totals.
a) McLaughlan et al. 2010.
RSA = regional study area; ELC = Ecological Land Classification; < = less than.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- PROPOSED PROJECT FOOTPRINT
- MAXIMUM DISTURBANCE AREA
- LOCAL STUDY
- REGIONAL STUDY

RIPARIAN VASCULAR RARE PLANT SPECIES

- BEAUTIFUL SEDGE
- HUDSON BAY SEDGE
- NORTHERN LADY-FERN
- SCHEUCHZER COTTON-GRASS
- WATER LOBELIA
- HEART-LEAVED TWAYBLADE

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

RIPARIAN ECOLOGICAL LAND CLASSIFICATION UNIT

BP07	BP24	BS18
BP07 (BU)	BP25	BS18 (BU)
BP11 (BU)	BP25 (BU)	BS19
BP12	BP26	BS19 (BU)
BP12 (BU)	BP26 (BU)	BS20
BP14	BP27	BS20 (BU)
BP14 (BU)	BP28	BS21
BP16	BP28 (BU)	BS21 (BU)
BP16 (BU)	BS06	BS22
BP18	BS06 (BU)	BS22 (BU)
BP18 (BU)	BS09	BS23
BP19	BS09 (BU)	BS23 (BU)
BP19 (BU)	BS10	BS24
BP20	BS13	BS24 (BU)
BP20 (BU)	BS13 (BU)	BS25
BP21	BS15	BS25 (BU)
BP22	BS15 (BU)	BS26
BP23	BS17	RECENT BURN (WETLAND)
BP23 (BU)	BS17 (BU)	

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
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PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

RIPARIAN ECOSYSTEMS AND RARE PLANT SPECIES IN THE REGIONAL STUDY AREA, APPLICATION CASE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08	**FIGURE 13.5-7**	
REVIEW	JV	2023-02-08		

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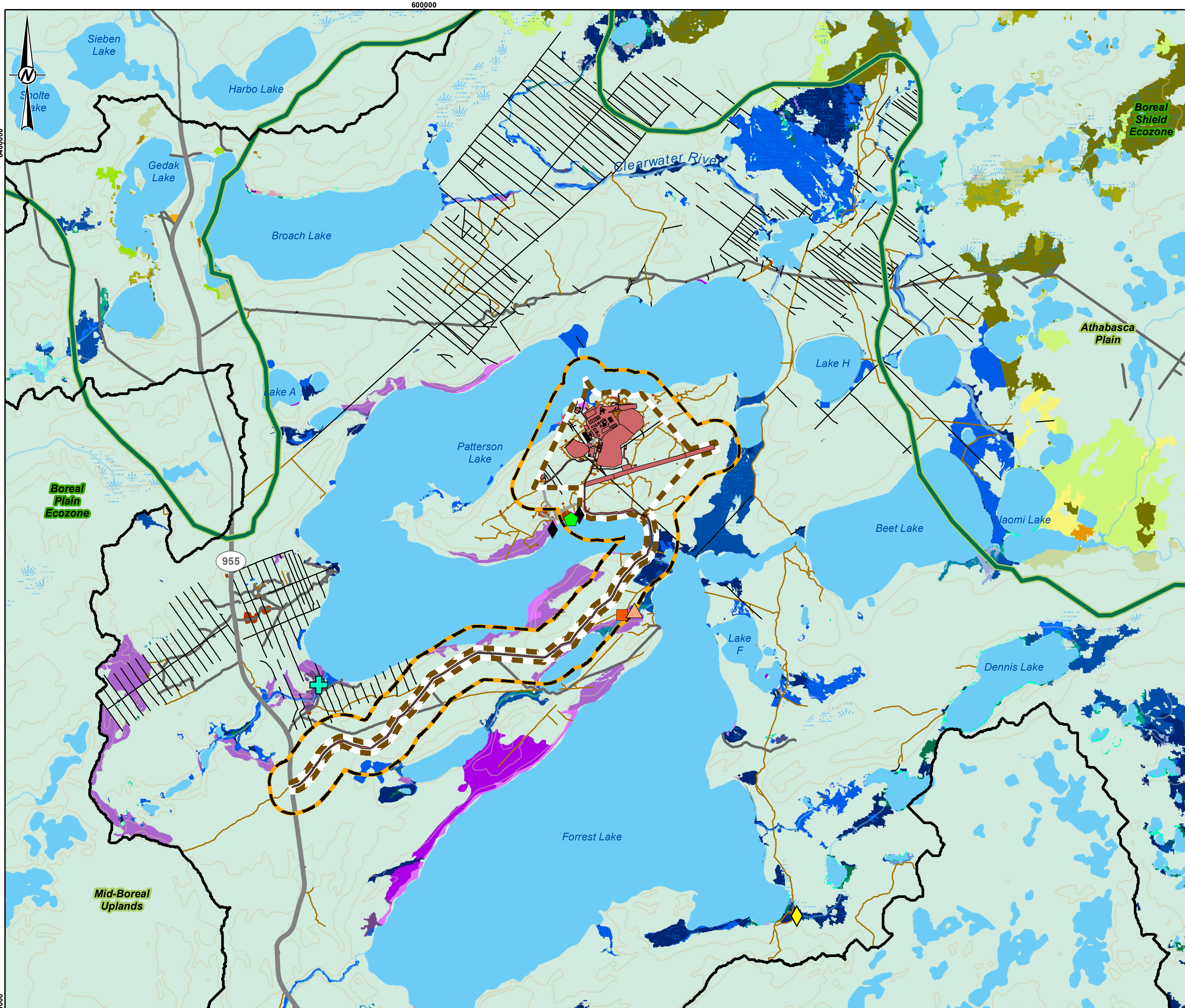

LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- PROPOSED PROJECT FOOTPRINT
- MAXIMUM DISTURBANCE AREA
- LOCAL STUDY
- REGIONAL STUDY

RIPARIAN VASCULAR RARE PLANT SPECIES

- BEAUTIFUL SEDGE
- HUDSON BAY SEDGE
- NORTHERN LADY-FERN
- SCHEUCHZER COTTON-GRASS
- WATER LOBELIA
- HEART-LEAVED TWAYBLADE

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

RIPARIAN ECOLOGICAL LAND CLASSIFICATION UNIT

BP07	BP22	BS13 (BU)
BP07 (BU)	BP23	BS17
BP11 (BU)	BP23 (BU)	BS17 (BU)
BP12	BP24	BS18
BP12 (BU)	BP25	BS18 (BU)
BP14	BP25 (BU)	BS21
BP16	BP26	BS21 (BU)
BP16 (BU)	BP26 (BU)	BS22
BP18	BP27	BS22 (BU)
BP18 (BU)	BP28	BS23
BP19	BP28 (BU)	BS23 (BU)
BP19 (BU)	BS06 (BU)	BS24
BP20	BS09	BS26
BP20 (BU)	BS09 (BU)	RECENT BURN (WETLAND)
BP21	BS13	

0 3 6
1:90,000 KILOMETRES

REFERENCE(S)
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PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT
NexGen Energy Ltd.
ROOK I PROJECT

TITLE
RIPARIAN ECOSYSTEMS AND RARE PLANT SPECIES IN THE LOCAL STUDY AREA, APPLICATION CASE

CONSULTANT
wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08	**FIGURE 13.5-8**	
REVIEW	JV	2023-02-08		

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13.5.3.1.2 Ecosystem Distribution

The Project would result in a 39.6 ha loss in riparian ecosystem availability from the Base Case (Figure 13.5-7; Figure 13.5-8). Loss to riparian ecosystems would result mainly from clearing activities and modifications in topography associated with Construction. Riparian ecosystem loss along Patterson Lake and the Clearwater River are conservatively overestimated as the maximum disturbance area for the Project was selected to follow the shoreline of Patterson Lake; however, the majority of Project infrastructure would be set back from the lake, and the final disturbance as a result of the Project within riparian ELC units would be minimized. Riparian ELC units adjacent to the Clearwater River below Patterson Lake would not be directly disturbed as the existing bridge at this location would be used for future access, though some localized effects may occur from staging material and equipment at the existing bridge location to facilitate crossing (i.e., overweight equipment and material would be lifted by crane). Minor changes in riparian availability may occur as the existing access road would be widened from 5 m to 10 m. Since the ecosystems affected are in close proximity to this existing road, additional ecosystem fragmentation is limited and localized such that the Project would result in minor changes to riparian ecosystem arrangement and connectivity in the LSA and RSA.

Overall, riparian ecosystems would remain well distributed and connectivity across the RSA would be maintained in the Application Case; however, the small changes in the distribution of riparian ecosystems due to the Project are predicted to be permanent and irreversible because restoration of riparian species composition and ecological function similar to the riparian ecosystems observed in the Base Case is unlikely.

13.5.3.1.3 Ecosystem Condition

Edge effects due to the Project may alter vegetation species abundance and richness within riparian ecosystems. Overall, the majority of riparian ecosystem would remain intact in the LSA (80.7%) and RSA (99.6%), and the potential effects on ecosystem condition are expected to be small and localized.

There are six recorded observations of rare plants within riparian areas in the LSA; however, all these plants were observed outside of the maximum disturbance area and consequently would not be affected by the Project.

No weed species designated under *The Weed Control Act* were identified within riparian ecosystems in the RSA. However, disturbance can create the potential for the introduction or encroachment of designated weed species. Construction equipment would arrive at the site in a clean condition, and an Environmental Protection Program would be implemented that includes actions to prevent, detect, control (i.e., remove), and monitor designated weed species.

Changes to water quantity and quality as a result of the Project could have minor, localized effects on riparian ecosystems. However, changes in surface water patterns as a result of the Project were predicted to have a negligible residual effect on vegetation in the LSA (Section 13.4.2, Secondary Pathways).

Overall, the condition of riparian ecosystems in the Application Case is predicted to vary from the Base Case, with changes in availability and distribution; however, changes in ecosystem condition are likely well within the resilience and adaptability limits for this VC.

13.5.3.2 Reasonably Foreseeable Development Case

13.5.3.2.1 Ecosystem Availability

The RFD Case is predicted to remove 102.6 ha (1.1%) of riparian ELC units in the RSA (Table 13.5-8; Figure 13.5-9). The loss of riparian ecosystem in the RFD Case would be due to the direct removal by the Project and the Fission Patterson Lake South Property. When changes because of the Project and planned developments in the RSA are considered in the context of the Base Case, the proportion of remaining naturally vegetated riparian communities (i.e., 98.9%) meets the Environment Canada (2013) recommendation of maintaining natural vegetation communities along 75% of the watercourse length in a given area to protect riparian function. The actual disturbance would be dependent on the final design of the Project and the Fission Patterson Lake South Property. It is estimated that the hypothetical maximum disturbance area used for the Fission Patterson Lake South Property is six times larger than the footprint presented in the Fission (2019) prefeasibility study. Effects are likely to occur but are uncertain (i.e., probable) given that the Fission Patterson Lake South Property has recently entered the formal regulatory application process.

Riparian ecosystems lost in the RFD Case would primarily result from the removal of ELC units along the shore of Patterson Lake and the Clearwater River below Patterson Lake. Changes to these ELC units are conservatively overestimated, as the maximum disturbance areas for the Project and the Fission Patterson Lake South Property were extended up to the shores of Patterson Lake. However, it is anticipated that components for both projects would be set back sufficiently from the water to minimize disturbance to riparian ELC units, except where required (e.g., fresh water intake) and that the actual disturbance would be dependent on the final design of the Fission Patterson Lake South Property.

The duration of effects from changes in riparian ecosystem availability from the Project and the Fission Patterson Lake South Property would be a function of the amount of temporal overlap between the period from the start of Construction to the end of the Active Closure Stage and the time required to establish riparian ELC units (i.e., upland and wetland ELC units with riparian potential). Incremental effects as a result of the Project were predicted to occur from Construction through to the end of the Active Closure Stage and the time required to establish mature upland riparian ELC units (i.e., 60 to 80 years) (Section 13.5.1.2.1, Ecosystem Availability). The duration of effects from direct ecosystem loss for the Fission Patterson Lake South Property was therefore assumed to be from construction to the end of decommissioning (i.e., 15 years) plus 60 to 80 years for mature upland ELC units to be established. If assumed riparian ecosystem loss from the Fission Patterson Lake South Property completely overlapped with the riparian ecosystem loss associated with the Project, the duration of cumulative effects for the RFD Case would be a maximum of 95 years. However, a decrease in temporal overlap of the two projects would result in a shorter duration of cumulative effects. The duration of effects from wetland ELC units associated with riparian ecosystems is conservatively assumed to be permanent (Section 13.5.2.1.1, Ecosystem Availability), as reclaimed wetland ELC units associated with riparian ecosystems may not be restored to an equivalent species composition and ecological function similar to the riparian ecosystems observed in the Base Case. Any permanent facilities associated with the Fission Patterson Lake South Property that disturbed riparian ecosystems would also be considered as permanent and irreversible effects.

Climate Change

Riparian ELC units may be less resilient than upland ecosystems to disturbances associated with fires and climate change. Hart et al. (2019) indicated that poorly drained spruce-dominant sites (e.g., Black spruce/ Labrador tea feathermoss [BP14]) frequently transitioned to a different state post-fire. However, the most likely transition would be to a poorly drained non-forest site (e.g., Graminoid fen [BP21]) and would likely be retained as a riparian ELC unit.

Riparian ecosystem availability may be adversely affected by climate change. Based on a climate change scenario, temperature is projected to increase, resulting in increased warm nights and reduced ice and frost days. Precipitation is also projected to increase, resulting in increased annual total wet-day precipitation and very wet and extremely wet days (Appendix 22A). Overall, it is uncertain if climate change would positively or negatively affect riparian ecosystems availability, but it is expected to have little influence on the small magnitude of Project and RFD-related effects.

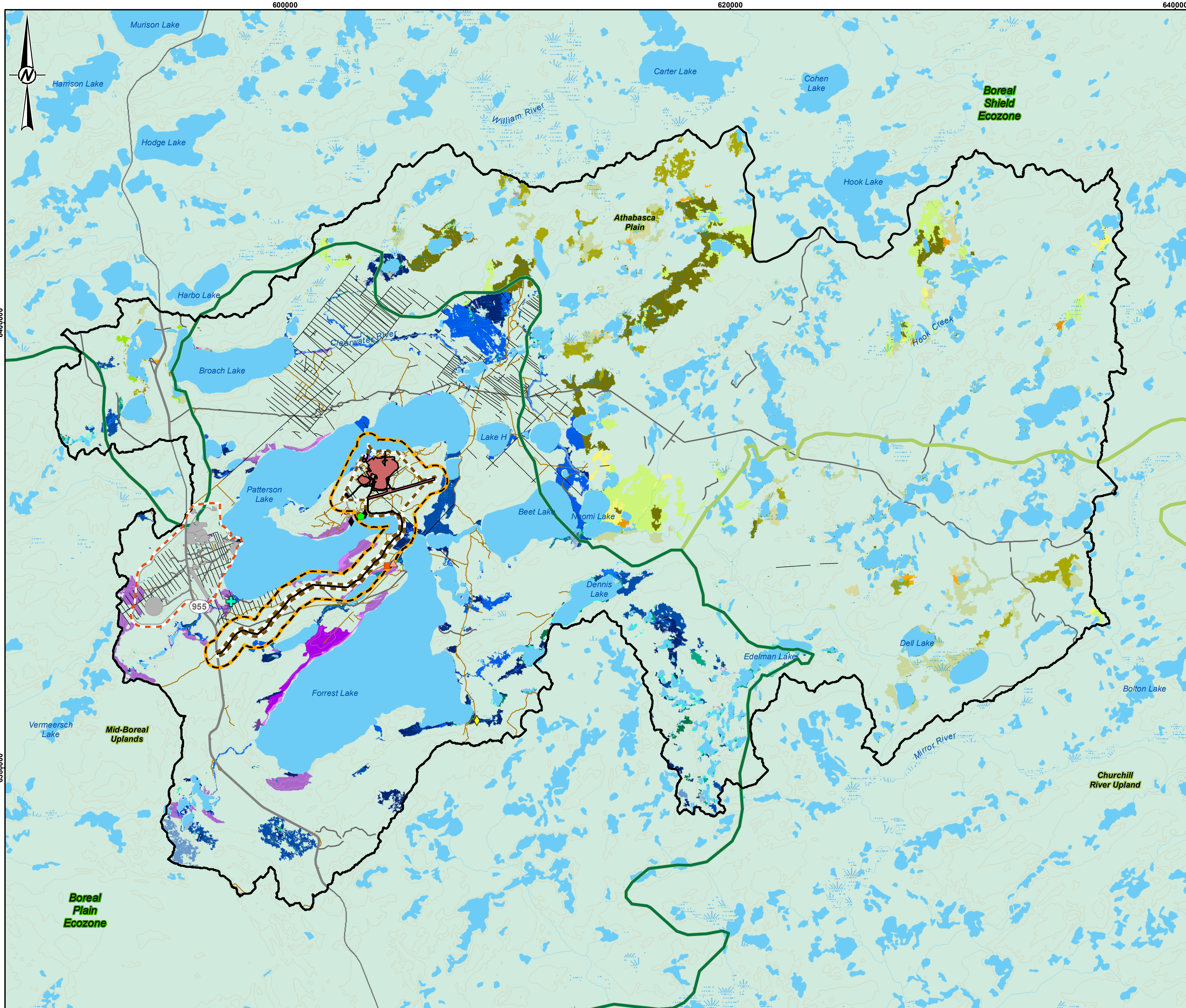
Table 13.5-8: Changes to Riparian Ecosystem Availability in the Reasonably Foreseeable Development Case

Riparian ELC Unit[(a)]	RSA		
	Base Case (ha)	RFD Case (ha)	Change in Area (ha)
BP07 - Trembling aspen - white birch/sarsaparilla	0.0	0.0	0.0
BP12 - Jack pine - spruce/feathermoss	216.2	216.2	0.0
BP14 - Black spruce/Labrador tea/feathermoss	96.7	86.8	-9.8
BP16 - Balsam poplar - trembling aspen/prickly rose	32.4	32.4	0.0
BP18 - Black spruce - tamarack treed swamp	3.6	3.6	0.0
BP19 - Black spruce treed bog	822.2	804.3	-17.8
BP20 - Labrador tea shrubby bog	1,003.6	985.0	-18.6
BP21 - Graminoid bog	12.3	12.2	-0.1
BP22 - Open bog	3.6	3.6	0.0
BP23 - Tamarack treed fen	27.3	27.3	0.0
BP24 - Leatherleaf shrubby poor fen	36.8	35.3	-1.5
BP25 - Willow shrubby rich fen	216.5	216.1	-0.4
BP26 - Graminoid fen	97.5	97.1	-0.5
BP27 - Open fen	15.6	15.6	0.0
BP28 - Seaside arrow-grass marsh	46.0	46.0	0.0
BS06 - Jack pine - trembling aspen/green alder	0.3	0.3	0.0
BS09 - Black spruce - jack pine/feathermoss	23.1	23.1	0.0
BS10 - Black spruce - white birch/feathermoss	0.1	0.1	0.0
BS13 - White birch - black spruce - trembling aspen	0.5	0.5	0.0
BS15 - Trembling aspen - white birch/green alder	0.0	0.0	0.0
BS17 - Black spruce treed bog	1,281.4	1,281.4	0.0
BS18 - Labrador tea shrubby bog	1,302.8	1,302.8	0.0
BS19 - Graminoid bog	0.2	0.2	0.0
BS20 - Open bog	0.7	0.7	0.0
BS21 - Tamarack treed fen	0.0	0.0	0.0
BS22 - Leatherleaf shrubby poor fen	171.9	171.9	0.0
BS23 - Willow shrubby rich fen	2.7	2.7	0.0
BS24 - Graminoid fen	30.8	30.8	0.0

Table 13.5-8: Changes to Riparian Ecosystem Availability in the Reasonably Foreseeable Development Case

Riparian ELC Unit[(a)]	RSA		
	Base Case (ha)	RFD Case (ha)	Change in Area (ha)
BS25 - Open fen	0.0	0.0	0.0
BS26 - Rush sandy shore	11.9	11.8	-0.1
Undisturbed riparian subtotal	*5,456.3*	*5,407.4*	*-48.8*
BP16(BU) - Balsam poplar - trembling aspen/prickly rose (Burned)	729.1	675.3	-53.8
BP18(BU) - Black spruce - tamarack treed swamp (Burned)	6.8	6.8	0.0
BP19(BU) - Black spruce treed bog (Burned)	871.2	871.2	0.0
BP20(BU) - Labrador tea shrubby bog (Burned)	25.2	25.2	0.0
BP23(BU) - Tamarack treed fen (Burned)	12.2	12.2	0.0
BP25(BU) - Willow shrubby rich fen (Burned)	20.7	20.7	0.0
BP26(BU) - Graminoid fen (Burned)	105.8	105.8	0.0
BP28(BU) - Seaside arrow-grass marsh (Burned)	98.5	98.5	0.0
BS06(BU) - Jack pine - trembling aspen/green alder (Burned)	0.7	0.7	0.0
BP07(BU) - Trembling aspen - white birch/sarsaparilla (Burned)	5.3	5.3	0.0
BP11(BU) - White birch - white spruce - balsam fir (Burned)	0.5	0.5	0.0
BP12(BU) - Jack pine - spruce/feathermoss (Burned)	0.5	0.5	0.0
BP14(BU) - Black spruce/Labrador tea/feathermoss (Burned)	0.0	0.0	0.0
BS09(BU) - Black spruce - jack pine/feathermoss (Burned)	47.8	47.8	0.0
BS13(BU) - White birch - black spruce - trembling aspen (Burned)	26.6	26.6	0.0
BS15(BU) - Trembling aspen - white birch/green alder (Burned)	0.1	0.1	0.0
BS17(BU) - Black spruce treed bog (Burned)	1,189.3	1,189.3	0.0
BS18(BU) - Labrador tea shrubby bog (Burned)	665.0	665.0	0.0
BS19(BU) - Graminoid bog (Burned)	0.1	0.1	0.0
BS20(BU) - Open bog (Burned)	1.3	1.3	0.0
BS21(BU) - Tamarack treed fen (Burned)	3.3	3.3	0.0
BS22(BU) - Leatherleaf shrubby poor fen (Burned)	266.1	266.1	0.0
BS23(BU) - Willow shrubby rich fen (Burned)	16.4	16.4	0.0
BS24(BU) - Graminoid fen (Burned)	37.4	37.4	0.0
BS25(BU) - Open fen (Burned)	0.1	0.1	0.0
Recent burn wetland	23.7	23.7	0.0
Burned riparian subtotal	*4,156.2*	*4,102.4*	*-53.8*
Total Riparian	**9,612.5**	**9,509.9**	**-102.6**

Note**:** Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values. Riparian ecosystems are a subset of upland and wetland ecosystems. ELC units described as riparian do not match upland or wetland ecosystem totals.
a) McLaughlan et al. 2010.
RFD = reasonably foreseeable development; RSA = regional study area; ELC = Ecological Land Classification.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- PROPOSED PROJECT FOOTPRINT
- MAXIMUM DISTURBANCE AREA
- LOCAL STUDY
- REGIONAL STUDY
- FISSION PATTERSON LAKE SOUTH PROPERTY FOOTPRINT
- PATTERSON LAKE SOUTH PROPERTY HYPOTHETICAL MAXIMUM DISTURBANCE AREA

RIPARIAN VASCULAR RARE PLANT SPECIES

- BEAUTIFUL SEDGE
- HUDSON BAY SEDGE
- NORTHERN LADY-FERN
- SCHEUCHZER COTTON-GRASS
- WATER LOBELIA
- HEART-LEAVED TWAYBLADE

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

RIPARIAN ECOLOGICAL LAND CLASSIFICATION UNIT

BP07	BP24	BS18
BP07 (BU)	BP25	BS18 (BU)
BP11 (BU)	BP25 (BU)	BS19
BP12	BP26	BS19 (BU)
BP12 (BU)	BP26 (BU)	BS20
BP14	BP27	BS20 (BU)
BP14 (BU)	BP28	BS21
BP16	BP28 (BU)	BS21 (BU)
BP16 (BU)	BS06	BS22
BP18	BS06 (BU)	BS22 (BU)
BP18 (BU)	BS09	BS23
BP19	BS09 (BU)	BS23 (BU)
BP19 (BU)	BS10	BS24
BP20	BS13	BS24 (BU)
BP20 (BU)	BS13 (BU)	BS25
BP21	BS15	BS25 (BU)
BP22	BS15 (BU)	BS26
BP23	BS17	RECENT BURN (WETLAND)
BP23 (BU)	BS17 (BU)	

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
2. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. ECOZONES OBTAINED FROM AGRICULTURE AND AGRI-FOOD CANADA (AAFC).
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

RIPARIAN ECOSYSTEMS AND RARE PLANT SPECIES IN THE REGIONAL STUDY AREA, REASONABLY FORESEEABLE DEVELOPMENT CASE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08		
REVIEW	JV	2023-02-08		

FIGURE 13.5-9

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

13.5.3.2.2 Ecosystem Distribution

The loss of riparian ecosystems in the RSA would result in localized changes in riparian distribution around Patterson Lake, and these effects are assumed to be long term for upland ELC units and permanent for wetland ELC units within riparian ecosystems. It is expected that the Fission Patterson Lake South Property would include mitigation to limit disturbance to riparian ecosystem availability and distribution. Despite some additional fragmentation from the Project and Fission Patterson Lake South Property, most riparian-associated wetland ELC units remain abundant and well connected across the RSA.

Small changes in distribution are anticipated within the RSA due to the Project and the Fission Patterson Lake South Property; however, because the ecosystems affected are in close proximity to the existing disturbance (i.e., the existing exploration disturbance, existing access road, and Highway 955), additional ecosystem fragmentation is limited and localized such that the Project and the Fission Patterson Lake South Property would result in minor changes (i.e., low magnitude) to riparian ecosystem arrangement and connectivity in the RSA.

Climate Change

The distribution of riparian ecosystems may be further affected in the RFD Case because of potential hydrological changes brought on by climate change (Section 9.4). However, changes from the Fission Patterson Lake South Property are anticipated to be mitigated by similar measures to control and manage potential hydrological pathways (i.e., surface drainage and discharge of water). Climate change scenarios predict that the vicinity of the Project site would be warmer and wetter, conditions that may affect riparian distribution positively through the expansion of existing riparian ecosystem and creation of new riparian areas through the accumulation of surface water or saturation of soils. However, increased evapotranspiration rates and more intense rainfall events may inhibit riparian ecosystem development and possibly lead to the reduction of riparian area through persistent drought. The magnitude that riparian ecosystem distribution would be affected by climate change is uncertain due to the large variation in climate change projections.

13.5.3.2.3 Ecosystem Condition

Similar to the Application Case, edge effects due to the Project and the Fission Patterson Lake South Property may alter riparian species abundance and richness. Edges can change the natural environment by increasing wind and light and causing small changes in microclimate (e.g., humidity changes; Foley et al. 2005). However, edge effects are predicted to be limited to the maximum disturbance areas for the Project and the Fission Patterson Lake South Property. Project infrastructure is planned to use as much existing disturbance as possible (i.e., approximately 8% of the maximum disturbance area would occur within existing anthropogenic disturbance). Much of the hypothetical maximum disturbance area for the Fission Patterson Lake South Property also overlaps existing anthropogenic disturbance.

As stated under the Application Case, there are no documented rare plant species in riparian ecosystems that would be affected by the Project. However, six occurrences of provincially tracked species were observed in riparian ecosystems during baseline terrestrial surveys within the RSA (Annex VII.1; Annex VII.2). None of these occurrences are anticipated to be disturbed in the RFD Case. It is anticipated that rare vascular plant surveys would be completed for the Fission Patterson Lake South Property and that planning would include mitigation to limit disturbance to any federally listed or provincially tracked vascular plant species.

No weed species designated under *The Weed Control Act* were identified within riparian ecosystems in the RSA, but disturbance can create the potential for the introduction or encroachment of designated weed species. Construction equipment would arrive at the Project site in a clean condition, and an Environmental Protection Program would be implemented that includes actions to prevent, detect, control (i.e., remove), and monitor designated weed species. No weed management activities were identified in the Fission Patterson Lake South Property prefeasibility study (Fission 2019), but it is anticipated that appropriate mitigation would be implemented to avoid and minimize the introduction of weeds.

The reduction in riparian ecosystem condition in the RFD Case relative to the Base Case is not predicted to greatly alter the ecological function of riparian ecosystems within the RSA because most riparian ELC units would remain intact. Less than 102.6 ha (1.1%) of riparian ecosystems present in the Base Case is predicted to be disturbed in the RSA in the RFD Case, and studies have found that water quality improvement, flood tolerance, and other riparian functions do not decline until large portions of historical habitat (i.e., greater than 60%) have been removed (Zedler and Kercher 2004; Environment Canada 2013).

Climate Change

Climate change may alter the processes that influence the availability, distribution, and condition of riparian ecosystems, and effects would likely occur beyond the RSA. Changes to forest structure and species composition may occur from drought, temperature changes, increased extreme climatic events, increased intensity of fire, and insects and disease (Sauchyn et al. 2009). Overall, it is uncertain whether climate change would positively and/or negatively affect riparian ecosystems.

13.5.3.3 Residual Effects Classification and Determination of Significance

13.5.3.3.1 Classification Summary

Residual effects were classified for the Application Case and the RFD Case after the implementation of effective mitigation (Table 13.5-9). Residual effects were summarized according to the direction, magnitude, geographic extent, duration, reversibility, frequency, and probability of the effect occurring following the methods described in Section 13.2.9. Effective implementation of mitigation is summarized in Section 13.4, Project Interactions and Mitigations, (Table 13.4-1), and progressive reclamation and revegetation is expected to reduce the magnitude and duration of residual effects on riparian ecosystems. Following the summary of residual effects, the significance of residual effects for the Application Case and the RFD Case was determined according to the methods described in Section 13.2.9.

Table 13.5-9: Classification of Residual Effects on Riparian Ecosystem Measurement Indicators for the Application Case and Reasonably Foreseeable Development Case

Measurement Indicator	Criterion	Rating / Effect Size	
		Application Case	RFD Case
Riparian ecosystem availability	Direction	▪ Negative	▪ Negative
	Magnitude	▪ Loss of 39.6 ha (0.4% of the RSA) from the Base Case to the Application Case (i.e., low magnitude)	▪ Loss of 102.6 ha (1.1% of RSA) from the Base Case to the RFD Case (i.e., low magnitude)
	Geographic extent	▪ Maximum disturbance area	▪ Regional (Project and the Fission Patterson Lake South Property) ▪ Beyond regional (climate change)
	Duration	▪ Permanent: for wetland ELC units ▪ Long term (direct loss): 93 to 113 years = 33 years (start of Construction to the end of the Active Closure Stage), or earlier with progressive reclamation, plus 60 years to 80 years to establish mature upland ELC Units	▪ Permanent: wetland ELC units and ecosystems covered by permanent facilities ▪ Permanent: climate change effects ▪ Long term: maximum of 95 years for establishment of mature upland ELC units within riparian ecosystems, depending on extent of temporal overlap between the Project and the Fission Patterson Lake South Property
	Reversibility	▪ Reversible (reclaimed ELC units) ▪ Irreversible (wetland ELC units within riparian ecosystems)	▪ Reversible (reclaimed ELC units) ▪ Irreversible (wetland ELC units and permanent facilities) ▪ Irreversible: climate change effects
	Frequency	▪ Continuous	▪ Continuous
	Probability of occurrence	▪ Certain	▪ Probable (Project and the Fission Patterson Lake South Property) ▪ Possible (climate change)
Riparian ecosystem distribution	Direction	▪ Negative	▪ Negative
	Magnitude	▪ Minor net change in riparian ecosystem distribution centred on the LSA. Almost no change in fragmentation at the RSA scale (i.e., low magnitude)	▪ Minor increase in fragmentation of riparian ecosystems in the RSA near the western boundary in proximity to existing disturbance; almost no change to connectivity in most of the RSA (i.e., low magnitude)
	Geographic extent	▪ Local	▪ Regional (Project and the Fission Patterson Lake South Property) ▪ Beyond regional (climate change)
	Duration	▪ Permanent: for wetland ELC units ▪ Long term (direct loss): 93 to 113 years = 33 years (start of Construction to the end of the Active Closure Stage), or earlier with progressive reclamation, plus 60 years to 80 years to establish mature upland ELC Units	▪ Permanent: wetland ELC units and ecosystems covered by permanent facilities ▪ Permanent: climate change effects ▪ Long term: maximum of 95 years for establishment of mature upland ELC units within riparian ecosystems, depending on extent of temporal overlap between the Project and the Fission Patterson Lake South Property
	Reversibility	▪ Reversible (reclaimed ELC units) ▪ Irreversible (wetland ELC units within riparian ecosystems)	▪ Reversible (reclaimed ELC units) ▪ Irreversible (wetland ELC units and permanent facilities) ▪ Irreversible (climate change effects)
	Frequency	▪ Continuous	▪ Continuous
	Probability of occurrence	▪ Certain	▪ Probable (Project and the Fission Patterson Lake South Property) ▪ Possible (climate change)

Table 13.5-9: Classification of Residual Effects on Riparian Ecosystem Measurement Indicators for the Application Case and Reasonably Foreseeable Development Case

Measurement Indicator	Criterion	Rating / Effect Size	
		Application Case	RFD Case
Riparian ecosystem condition	Direction	▪ Negative	▪ Negative
	Magnitude	▪ Edge effects would result in a minor change in ecosystem structure (i.e., low magnitude)	▪ Potential loss of rare vegetation species ▪ Potential introduction of weed species ▪ Minor to moderate change in ecosystem structure from edge effects (i.e., low magnitude)
	Geographic extent	▪ Maximum disturbance area	▪ Regional (Project and the Fission Patterson Lake South Property) ▪ Beyond regional (climate change)
	Duration	▪ Permanent: for wetland ELC units ▪ Long term (direct loss): 93 to 113 years = 33 years (start of Construction to the end of the Active Closure Stage), or earlier with progressive reclamation, plus 60 years to 80 years to establish mature upland ELC Units	▪ Permanent: wetland ELC units and ecosystems covered by permanent facilities ▪ Permanent: climate change effects ▪ Long term: maximum of 95 years for establishment of mature upland ELC units within riparian ecosystems, depending on extent of temporal overlap between the Project and the Fission Patterson Lake South Property
	Reversibility	▪ Reversible (reclaimed ELC units) ▪ Irreversible (wetland ELC units within riparian ecosystems)	▪ Reversible (reclaimed ELC units) ▪ Irreversible (wetland ELC units and permanent facilities) ▪ Irreversible (climate change effects)
	Frequency	▪ Continuous	▪ Continuous
	Probability of occurrence	▪ Possible	▪ Possible (Project, Fission Patterson Lake South Property) ▪ Possible (climate change)

RFD = reasonably foreseeable development; LSA = local study area; RSA = regional study area; ELC = Ecological Land Classification.

13.5.3.3.2 Significance Determination

Riparian ecosystems are considered to have ecological resilience and adaptive capacity to changes in abundance, distribution, and condition in the Base Case. Riparian ELC units are uncommon on the landscape relative to upland and wetland ecosystems. Within the LSA, riparian ELC units have a scattered distribution around the margins of Patterson Lake, Clearwater River, and Forrest Lake. Distribution is similar in the RSA, with ELC units scattered around the margins of waterbodies. Larger contiguous blocks of riparian ecosystem are available where organic wetland ELC units have developed within low-relief or floodplain areas. Although previous and existing linear disturbances have resulted in some fragmentation of habitats in the LSA, riparian ecosystems remain intact within the LSA and RSA. Overall, the evidence indicates that riparian ecosystems in the RSA are self-sustaining and ecologically effective in the Base Case.

Application Case

For riparian ecosystems, the effects as a result of the Project due to changes in ecosystem availability, distribution, and condition are predicted to be certain and local in the Application Case (Table 13.5-9). The exception is for changes to ecosystem condition, which are possible since a small decrease in ecosystem abundance is expected to produce no to few edge effects; the Project would not disturb occurrences of rare plant species detected in riparian ecosystems during baseline studies. Designated weed species were not detected in riparian ecosystems during baseline surveys; however, the Project would implement an

Environmental Protection Program that includes actions to avoid and limit the risk of introducing invasive plant species.

The duration of effects from changes to riparian ecosystems is considered long term and reversible for upland ELC units and permanent and irreversible for wetland ELC units within riparian ecosystems. Permanent facilities (i.e., WRSAs) would not disturb riparian ecosystems. The loss of 39.6 ha in the LSA and RSA of available riparian areas as a result of the Project is predicted to have a small influence on ecological structure and function; 80.7% of undisturbed riparian ecosystems present in the LSA and 99.6% in the RSA in the Base Case are predicted to remain in the Application Case. The least common undisturbed riparian ELC units in the LSA (i.e., BP23, BP24, BP25, and BP26) would either not be disturbed by the Project or disturbance would be limited to less than 0.4 ha per ELC unit. Seven occurrences of rare plant species were observed in riparian ecosystems in the RSA, none of which would be disturbed by the Project. Overall, riparian ecosystems are predicted to remain self-sustaining and ecologically effective in the Application Case.

RFD Case

For the RFD Case, the combined effects from the Project and planned Fission Patterson Lake South Property development on riparian ecosystems in the RSA are expected to be regional. Cumulative effects are predicted to be continuous and long-term for upland ELC units with riparian potential and permanent and irreversible for wetland ELC units within riparian ecosystems (Table 13.5-9). The Project and the Fission Patterson Lake South Property in the RSA would result in a direct loss to riparian ecosystems, but the implementation of mitigation is expected to limit cumulative changes to ecosystem availability, distribution, and condition.

The establishment of reclaimed upland ELC units within riparian vegetation ecosystems is predicted to occur well beyond the Active Closure Stage (i.e., the cumulative effects for the RFD Case would be a maximum of 95 years). A decrease in temporal overlap of the two projects would result in a shorter duration of cumulative effects. The duration of effects from wetland ELC units associated with riparian ecosystems are conservatively assumed to be permanent (Section 13.5.2.1.1, Ecosystem Availability), as reclaimed wetland ELC units associated with riparian ecosystems may not be restored to an equivalent species composition and ecological function similar to the wetland ELC units observed in the Base Case.

Riparian ecosystems are highly resilient and their persistence on the landscape is tied to their ability to adapt to the natural variability of a dynamic climate regime, specifically fluctuations in water levels (i.e., drought, flooding) (van der Valk 1994; Drinkard 2012; Vale et al. 2015). Overall, the weight of evidence from the analysis predicts that changes to the availability, distribution, and condition of riparian ecosystems that overlap the RSA in the RFD Case would be within the resilience and adaptability limits for these VCs. Riparian ecosystems are predicted to remain self-sustaining and ecologically effective in the RFD Case.

Climate Change

Climate change is expected to affect riparian ecosystem availability, distribution, and condition continuously at a beyond regional extent (Table 13.5-9). Effects from climate change would likely be permanent but not certain (i.e., possible) due to the inherent low level of confidence in predicting the magnitude, frequency, and geographic extent of climate-related changes to measurement indicators. However, riparian ecosystems are expected to remain abundant and well distributed within and adjacent to the RSA and self-sustaining and ecologically effective.

Overall Significance

Based on several lines of evidence, incremental and cumulative effects associated with the Project, previous and existing developments, and the Fission Patterson Lake South Property on the riparian ecosystems are predicted to be not significant. Effects related to climate change are not expected to significantly influence riparian ecosystems and do not alter the assessment of no significant cumulative effects from the Project and Fission Patterson Lake South Property.

13.5.4 Traditional Use Plant Species

The residual effects analysis for traditional use plant species focused on evaluating the following pathways:

- direct loss, alteration, and fragmentation of traditional use plants as a result of the Project; and
- alteration of final terrain, soil conditions, and/or plant species composition could change the types of ecosystems and traditional use plants that can be reclaimed on the landscape and adversely affect ecosystem availability, distribution, and condition.

13.5.4.1 Application Case

13.5.4.1.1 Habitat Availability

The total amount of traditional use plant habitat in the Application Case within the LSA is 450.7 ha (15.9%) and within the RSA is 29,152 ha (27.1% of the RSA; Table 13.5-10; Figure 13.5-10; Figure 13.5-11). Availability in the Application Case is expected to be decreased by approximately 298.2 ha (1.0%) in the RSA. The largest predicted changes in availability are associated with common boreal forest plant species (i.e., blueberry [loss of 96.1 ha], jack pine [loss of 83.0 ha], and bog cranberry [loss of 29.4 ha]). Occupancy is most commonly associated with jack pine dominant ELC units BP02, BP03, and BP02(BU) which are widespread throughout the LSA and RSA, as well as black spruce dominant BP14, and balsam poplar dominant BP16(BU) ELC units. Small changes in occupancy were observed within less common ELC units (i.e., Labrador tea shrubby bog [BP20; loss of 4.4 ha]); however, BP20 sites were observed to support a large diversity of traditional use plant species within the LSA (n=11). The largest relative changes in occupancy are river birch (*Betula occidentalis*) and northern green rush (*Juncus alpinoarticulatus*), where less than 0.1 ha of 0.6 ha habitat would be lost in the Application Case (6.9%) for both species. Within the LSA, it is predicted that the occupancy of 24 traditional use plant species would be reduced based on the removal of the maximum disturbance area. Changes to traditional use plant species availability due to the maximum disturbance area have been conservatively overestimated.

Once traditional use plant species habitat is removed, the loss is considered continuous until functional habitat is reclaimed or offset (i.e., beyond Closure). It is anticipated that many traditional use plant species would re-establish quickly following the removal of the disturbance (e.g., raspberry, jack pine). However, where traditional use plant species occupy wetland ELC units (e.g., pitcherplant), loss of habitat due to the Project is assumed to be permanent and irreversible, as the restoration of wetland ecosystems with similar species composition and ecological function to wetland ELC units observed in the Base Case is uncertain. Habitat loss due to permanent features (i.e., WRSAs) would also be irreversible.

Indigenous Groups have expressed concerns related to Project activities and potential effects on traditional use plants, their health, and availability for gathering (TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD VI: YNLR). Concerns were also expressed about the ability to access habitats in the vicinity of the Project site for collecting medicinal plants or berries and how the ability to harvest traditional use plant species is reduced by the cumulative effects of existing disturbances and the Project. The assessment endpoints for traditional use plant species are defined as self-sustaining and ecologically effective plant populations. Ecosystem services (i.e., the benefits people gain from the environment) provided by traditional use plant species are assessed in Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use, and Section 17, Other Land and Resource Use, and are not considered during the residual effects classification and determination of significance in this section.

In the Application Case, the Project would reduce the availability of traditional use plant species by removing habitat that is overlapped by the maximum disturbance area; however, the traditional use plant habitat is predicted to remain abundant across the RSA. Incremental effects as a result of the Project and previous and existing developments are expected to be well within the adaptive and resilience limits of traditional use plant species.

Table 13.5-10: Changes to Traditional Use Plant Species Availability in the Application Case

Traditional Use Plant Species[(a)]	Scientific Name[(b)]	SKCDC Common Name[(b)]	RSA		
			Base Case (ha)	Application Case (ha)	Change in Area (ha)
Berries	*Rubus arcticus* ssp. *acaulis*	Nagoon berry	2.2	2.2	0.0
	Rubus pubescens	Dewberry	1.4	1.4	0.0
Birch	*Betula glandulosa*	Dwarf birch	5.8	5.8	0.0
	Betula occidentalis	River birch	0.6	0.5	-<0.1
	Betula papyrifera	Paper birch	764.9	755.3	-9.6
	Betula pumila	Swamp birch	70.8	70.3	-0.5
Blueberry	*Vaccinium myrtilloides*	Blueberry	6,230.4	6,134.3	-96.1
Bulrushes	*Juncus alpinoarticulatus*	Northern green rush	0.6	0.5	-<0.1
	Juncus nodosus var. *nodosus*	Knotted rush	0.8	0.8	0.0
	Schoenoplectus acutus var. *acutus*	Hard-stemmed bulrush	0.5	0.5	0.0
Chokecherry	*Prunus virginiana* var. *viriginiana*	Chokecherry	n/o	n/o	n/o
Cloudberry	*Rubus chamaemorus*	Cloudberry	176.7	176.1	-0.6
Cranberry	*Vaccinium oxycoccos*	Small cranberry	230.0	229.1	-0.9
Cranberry, bog	*Vaccinium vitis-idaea*	Bog cranberry	3,148.3	3,119.0	-29.4
Cranberry, low bush-	*Viburnum edule*	Low bush-cranberry	0.4	0.4	0.0
Cranberry, high bush	*Viburnum opulus* var. *americanum*	High bush-cranberry	n/o	n/o	n/o
Dogwood	*Cornus sericea* ssp. *sericea*	Red-osier dogwood	n/o	n/o	n/o
Frog tail	*Sarracenia purpurea* ssp. *gibbosa*	Pitcherplant	n/o	n/o	n/o
Gooseberry	*Ribes americanum*	Wild black currant	0.8	0.8	-<0.1
	Ribes glandulosum	Skunk currant	0.2	0.2	0.0
	Ribes hudsonianum	Northern black currant	2.7	2.7	-<0.1
	Ribes oxyacanthoides var. *oxyacanthoides*	Bristly gooseberry	2.4	2.4	-<0.1
	Ribes triste	Swamp red currant	0.2	0.2	0.0
Jack pine	*Pinus banksiana*	Jack pine	8,931.3	8,848.3	-83.0
Kinnikinnick	*Arctostaphylos uva-ursi*	Bearberry	1,225.4	1,209.9	-15.5
Labrador tea	*Rhododendron groenlandicum*	Common Labrador tea	2036.5	2024.0	-12.5
	Rhododendron tomentosum	Labrador tea	111.7	111.0	-0.7

Table 13.5-10: Changes to Traditional Use Plant Species Availability in the Application Case

Traditional Use Plant Species[(a)]	Scientific Name[(b)]	SKCDC Common Name[(b)]	RSA		
			Base Case (ha)	Application Case (ha)	Change in Area (ha)
Mint	*Mentha canadensis*	Wild mint	13.0	12.7	-0.2
Mosses[(c)]	n/a	n/a	3,439.5	3,425.0	-14.4
Mushroom[(c)]	n/a	n/a	n/o	n/o	n/o
Poplar	*Populus balsamifera* ssp. *balsamifera*	Balsam poplar	13.3	13.3	0.0
	Populus tremuloides	Trembling aspen	530.5	519.7	-10.9
Raspberry	*Rubus idaeus* ssp. *strigosus*	American red raspberry	1.1	1.1	0.0
Rat root	*Acorus americanus*	Sweet flag	n/o	n/o	n/o
Saskatoon	*Amelanchier alnifolia* var. *alnifolia*	Saskatoon	n/o	n/o	n/o
Spruce	*Picea glauca*	White spruce	981.0	972.8	-8.2
	Picea mariana	Black spruce	1,171.8	1,160.0	-11.9
Strawberry	*Fragaria vesca* ssp. *americana*	American wild strawberry	0.3	0.3	-<0.1
	Fragaria virginiana ssp. *glauca*	Smooth wild strawberry	<0.1	<0.1	-<0.1
Sweetgrass	*Anthoxanthum hirtum* ssp. *arcticum*	Sweet grass	n/o	n/o	n/o
Tamarack	*Larix laricina*	Tamarack	35.5	35.3	-0.2
Willow[(d)]	*Salix* spp.	Willow species	318.5	314.9	-3.6
Total			**29,449.0**	**29,151.0**	**-298.1**

Note: Ecosystem services provided by traditional use plant species are assessed in Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use, and Section 17, Other Land and Resource Use.

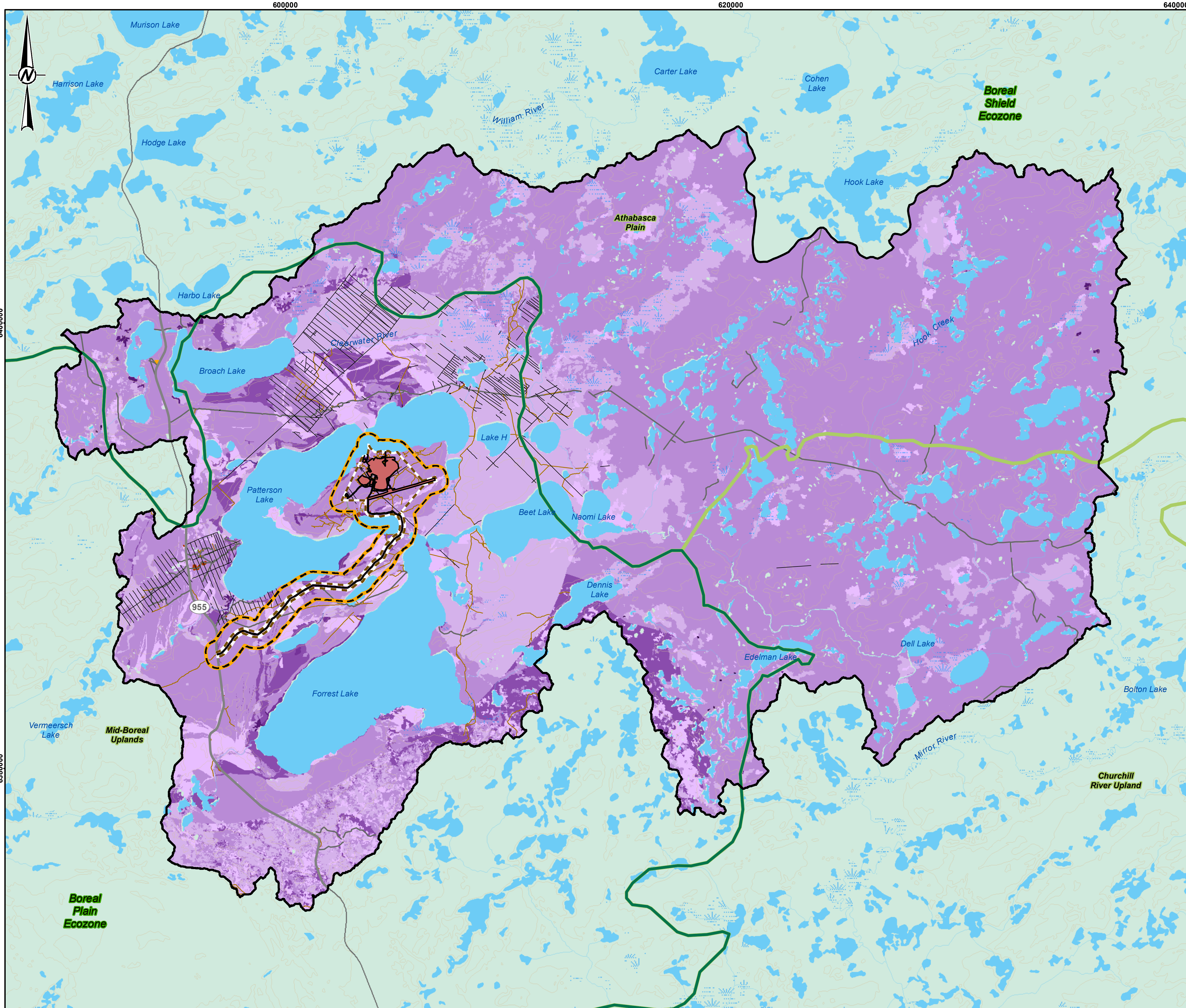
a) TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD VI: YNLR; CRDN 2019a.

b) SKCDC 2021b.

c) Traditional use plant species name reflects broad group of plant or fungi species; therefore, the scientific name and SKCDC common name are not described.

d) Saskatchewan has over 40 willow species (*Salix* sp.; Harms 2017); therefore, the scientific name and SKCDC common name of all potential willow species are not described.

RFD = reasonably foreseeable development; RSA = regional study area; < = less than; n/o = not observed during baseline surveys; n/a = not applicable.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- PROPOSED PROJECT FOOTPRINT
- MAXIMUM DISTURBANCE AREA
- LOCAL STUDY
- REGIONAL STUDY

TRADITIONAL USE PLANT SPECIES OCCUPANCY

- 0.00 TO 0.16
- 0.17 TO 0.32
- 0.33 TO 0.48
- 0.49 TO 0.64
- 0.65 TO 0.80
- 0.81 TO 0.96
- 0.97 TO 1.12
- 1.13 TO 1.28

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
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PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

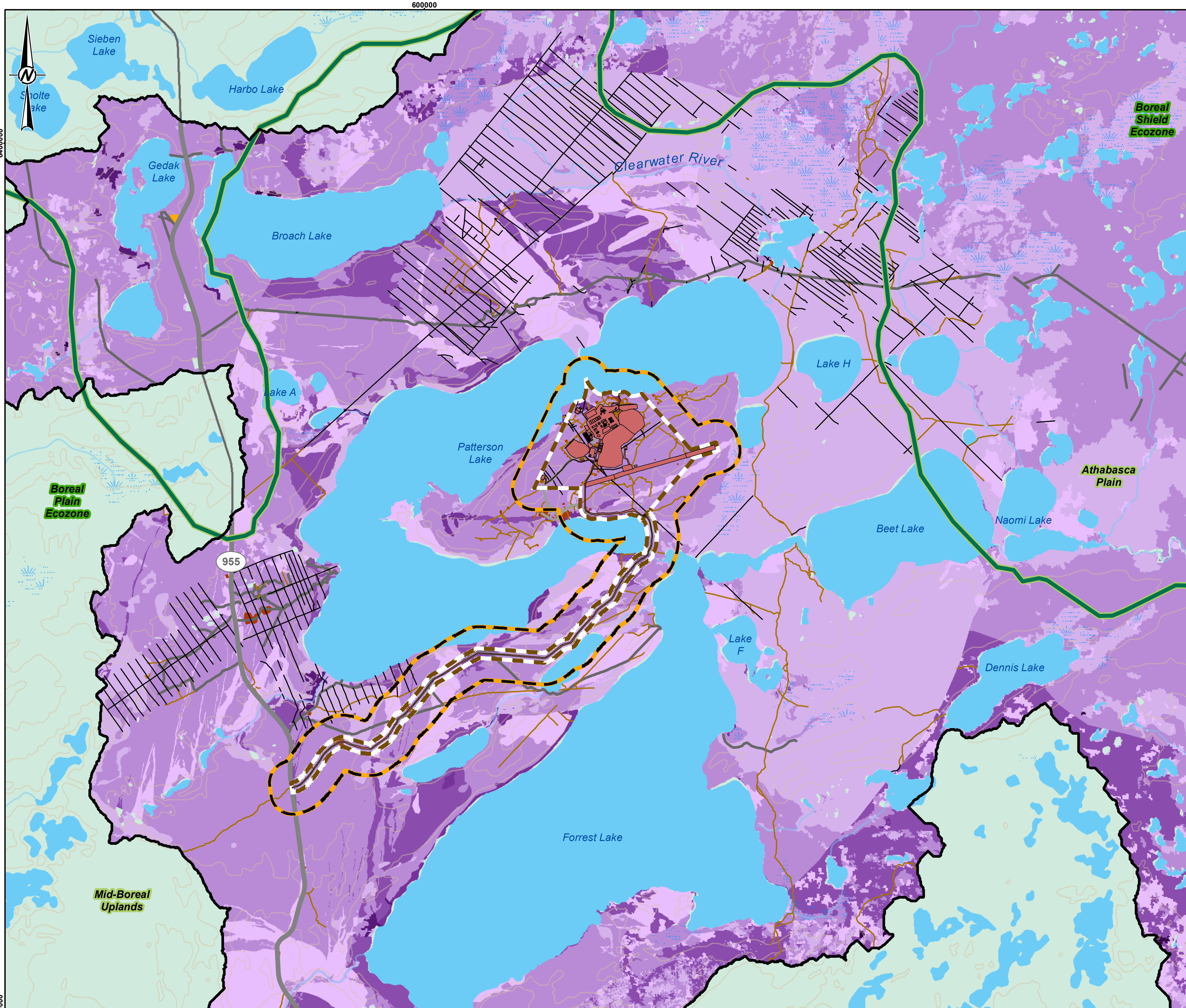
TRADITIONAL USE PLANT SPECIES OCCUPANCY IN THE REGIONAL STUDY AREA, APPLICATION CASE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08	**FIGURE 13.5-10**	
REVIEW	JV	2023-02-08		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- PROPOSED PROJECT FOOTPRINT
- MAXIMUM DISTURBANCE AREA
- LOCAL STUDY
- REGIONAL STUDY

TRADITIONAL USE PLANT SPECIES OCCUPANCY

- 0.00 TO 0.16
- 0.17 TO 0.32
- 0.33 TO 0.48
- 0.65 TO 0.80
- 0.81 TO 0.96
- 0.97 TO 1.12
- 1.13 TO 1.28

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

0 3 6
1:90,000 KILOMETRES

REFERENCE(S)

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PROJECTION: UTM ZONE 12 DATUM: NAD 83

PROJECT

NexGen Energy Ltd.

ROOK I PROJECT

TITLE

TRADITIONAL USE PLANT SPECIES OCCUPANCY IN THE LOCAL STUDY AREA, APPLICATION CASE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08	**FIGURE 13.5-11**	
REVIEW	JV	2023-02-08		

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

13.5.4.1.2 Habitat Distribution

In the Base Case, habitats that support traditional use plant species are well distributed across the RSA and LSA, and although there has been some change in connectivity because of previous and existing developments and activities, there is sufficient connectivity between occurrences to support healthy traditional use plant habitat in both the RSA and LSA. In the Application Case, the Project would decrease the connectivity and configuration of traditional use plant habitat through removal due to the Project footprint. Changes in distribution to traditional use plant species in the Application Case are most commonly predicted within BP02(BU) and BP03 ELC units (Table 13.5-11), as these sites support traditional use plant species with wide abundant cover (e.g., jack pine and blueberry). However, moderate changes in distribution are also associated with Project disturbance to BP14 and BP16[BU] ELC units. During baseline studies, both ELC units were observed to have a higher traditional use plant occupancy index and therefore support a greater abundance of traditional use plant species, although the BP14 ELC unit is less common within the LSA. Disturbance to ELC units with a higher occupancy index (Appendix 13B) would result in a proportionally greater loss of traditional use plant availability.

The Project would result in increased distance between patches of habitat. Because changes in connectivity are localized and traditional use plant habitat is well distributed across the RSA, these changes in habitat distribution are expected to be well within the resilience and adaptability limits of traditional use plant species.

Table 13.5-11: Changes to Traditional Use Plant Species Habitat Availability per ELC Unit in the Application Case

Traditional Use Plant Habitat ELC Unit[a]	RSA			
	ELC Unit Area (ha)	Habitat Availability Base Case (ha)	Habitat Availability Application Case (ha)	Change in Area (ha)
BP02 - Jack pine/lichen	2,791.3	337.6	331.3	-6.3
BP03 - Jack pine/feathermoss	3,712.1	2,483.4	2,451.0	-32.4
BP04 - Jack pine - trembling aspen/feathermoss	1,000.7	113.0	113.0	0.0
BP06 - Trembling aspen/beaked hazel/sarsaparilla	0.3	0.3	0.3	0.0
BP07 - Trembling aspen - white birch/sarsaparilla	5.1	5.8	5.8	0.0
BP11 - White birch - white spruce - balsam fir	3.2	1.3	1.3	0.0
BP12 - Jack pine - spruce/feathermoss	219.2	90.7	90.7	0.0
BP14 - Black spruce/Labrador tea/feathermoss	129.8	117.7	107.2	-10.4
BP16 - Balsam poplar - trembling aspen/prickly rose	33.3	31.3	31.3	0.0
BS02 - Lichen/felsenmeer - bedrock	<0.1	<0.1	<0.1	0.0
BS03 - Jack pine/blueberry/lichen	4,991.4	1,625.0	1,625.0	0.0
BS04 - Jack pine - black spruce/feathermoss	6,158.9	2,549.1	2,549.1	0.0
BS05 - Jack pine - white birch/feathermoss	1.1	0.8	0.8	0.0
BS06 - Jack pine - trembling aspen/green alder	0.3	0.3	0.3	0.0
BS07 - Black spruce/blueberry/lichen	2.6	1.5	1.5	0.0
BS08 - Black spruce - white birch/lichen	<0.1	<0.1	<0.1	0.0
BS09 - Black spruce - jack pine/feathermoss	23.1	8.2	8.2	0.0
BS10 - Black spruce - white birch/feathermoss	0.1	0.0	0.0	0.0
BS13 - White birch - black spruce - trembling aspen	11.9	12.2	12.2	0.0
BS14 - White birch/lingonberry - Labrador tea	74.0	23.2	23.2	0.0
BS15 - Trembling aspen - white birch/green alder	<0.1	<0.1	<0.1	0.0
BP02(BU) - Jack pine/lichen (Burned)	8,990.9	2,889.7	2,658.1	-231.5
BP03(BU) - Jack pine/feathermoss (Burned)	4,846.6	2,005.9	2,005.9	0.0

Table 13.5-11: Changes to Traditional Use Plant Species Habitat Availability per ELC Unit in the Application Case

Traditional Use Plant Habitat ELC Unit[(a)]	RSA			
	ELC Unit Area (ha)	Habitat Availability Base Case (ha)	Habitat Availability Application Case (ha)	Change in Area (ha)
BP04(BU) - Jack pine - trembling aspen/feathermoss (Burned)	1,274.5	409.6	409.6	0.0
BP06(BU) - Trembling aspen/beaked hazel/sarsaparilla (Burned)	0.3	0.4	0.4	0.0
BP07(BU) - Trembling aspen - white birch/sarsaparilla (Burned)	10.4	11.7	11.7	0.0
BP11(BU) - White birch - white spruce - balsam fir (Burned)	0.9	0.4	0.4	0.0
BP12(BU) - Jack pine - spruce/feathermoss (Burned)	4.4	1.8	1.8	0.0
BP14(BU) - Black spruce/Labrador tea/feathermoss (Burned)	25.2	23.2	23.2	0.0
BP16(BU) - Balsam poplar - trembling aspen/prickly rose (Burned)	1,070.4	253.8	245.3	-8.5
BS02(BU) - Lichen/felsenmeer - bedrock (Burned)	0.7	<0.1	<0.1	0.0
BS03(BU) - Jack pine/blueberry/lichen (Burned)	23,172.8	7,447.7	7,447.7	0.0
BS04(BU) - Jack pine - black spruce/feathermoss (Burned)	9,065.2	3,752.0	3,752.0	0.0
BS05(BU) - Jack pine - white birch/feathermoss (Burned)	5.1	3.7	3.7	0.0
BS06(BU) - Jack pine - trembling aspen/green alder (Burned)	0.9	0.3	0.3	0.0
BS07(BU) - Black spruce/blueberry/lichen (Burned)	5.6	1.8	1.8	0.0
BS08(BU) - Black spruce - white birch/lichen (Burned)	0.1	<0.1	<0.1	0.0
BS09(BU) - Black spruce - jack pine/feathermoss (Burned)	50.1	17.8	17.8	0.0
BS13(BU) - White birch - black spruce - trembling aspen (Burned)	57.7	59.4	59.4	0.0
BS14(BU) - White birch/lingonberry - Labrador tea (Burned)	39.9	9.5	9.5	0.0
BS15(BU) - Trembling aspen - white birch/green alder (Burned)	0.2	0.2	0.2	0.0
Recent burn upland	7,041.6	1,823.3	1,823.3	0.0
BP18 - Black spruce - tamarack treed swamp	21.9	2.7	2.7	0.0
BP19 - Black spruce treed bog	1,708.0	763.1	759.0	-4.0
BP20 - Labrador tea shrubby bog	1,254.7	329.6	325.2	-4.4
BP21 - Graminoid bog	25.2	9.0	9.0	0.0
BP22 - Open bog	7.8	2.5	2.5	0.0
BP23 - Tamarack treed fen	40.4	13.0	13.0	0.0
BP24 - Leatherleaf shrubby poor fen	54.5	8.0	8.0	0.0
BP25 - Willow shrubby rich fen	317.1	65.8	65.8	-0.1
BP26 - Graminoid fen	263.3	19.8	19.8	0.0
BP27 - Open fen	32.8	6.5	6.5	0.0
BP28 - Seaside arrow-grass marsh	64.3	13.1	13.1	0.0
BS17 - Black spruce treed bog	1,517.3	433.3	433.3	0.0
BS18 - Labrador tea shrubby bog	1,481.3	270.2	270.2	0.0
BS19 - Graminoid bog	0.2	0.1	0.1	0.0
BS20 - Open bog	0.9	0.3	0.3	0.0
BS21 - Tamarack treed fen	0.3	0.1	0.1	0.0
BS22 - Leatherleaf shrubby poor fen	205.0	30.1	30.1	0.0
BS23 - Willow shrubby rich fen	4.5	0.9	0.9	0.0
BS24 - Graminoid fen	41.8	3.1	3.1	0.0
BS25 - Open fen	<0.1	<0.1	<0.1	0.0
BS26 - Rush sandy shore	15.2	0.3	0.3	0.0
BP18(BU) - Black spruce - tamarack treed swamp (Burned)	49.9	6.2	6.2	0.0
BP19(BU) - Black spruce treed bog (Burned)	2,240.8	580.2	579.8	-0.5

Table 13.5-11: Changes to Traditional Use Plant Species Habitat Availability per ELC Unit in the Application Case

Traditional Use Plant Habitat ELC Unit[(a)]	RSA			
	ELC Unit Area (ha)	Habitat Availability Base Case (ha)	Habitat Availability Application Case (ha)	Change in Area (ha)
BP20(BU) - Labrador tea shrubby bog (Burned)	82.2	15.0	15.0	0.0
BP21(BU) - Graminoid bog (Burned)	0.3	0.1	0.1	0.0
BP23(BU) - Tamarack treed fen (Burned)	25.3	8.1	8.1	0.0
BP24(BU) - Leatherleaf shrubby poor fen (Burned)	11.6	1.7	1.7	0.0
BP25(BU) - Willow shrubby rich fen (Burned)	142.0	29.5	29.5	0.0
BP26(BU) - Graminoid fen (Burned)	401.6	30.3	30.3	0.0
BP28(BU) - Seaside arrow-grass marsh (Burned)	109.9	22.4	22.4	0.0
BS16(BU) - Black spruce/balsam poplar/river alder swamp (Burned)	<0.1	<0.1	<0.1	0.0
BS17(BU) - Black spruce treed bog (Burned)	1,540.3	398.8	398.8	0.0
BS18(BU) - Labrador tea shrubby bog (Burned)	1,052.9	192.1	192.1	0.0
BS19(BU) - Graminoid bog (Burned)	0.1	0.1	0.1	0.0
BS20(BU) - Open bog (Burned)	2.2	0.8	0.8	0.0
BS21(BU) - Tamarack treed fen (Burned)	7.0	2.4	2.4	0.0
BS22(BU) - Leatherleaf shrubby poor fen (Burned)	411.4	60.4	60.4	0.0
BS23(BU) - Willow shrubby rich fen (Burned)	33.1	6.9	6.9	0.0
BS24(BU) - Graminoid fen (Burned)	89.1	6.6	6.6	0.0
BS25(BU) - Open fen (Burned)	0.1	<0.1	<0.1	0.0
BS26(BU) - Rush sandy shore (Burned)	36.6	0.7	0.7	0.0
Recent burn wetland	96.8	1.3	1.3	0.0
Total	**88,211.2**	**29,449.0**	**29,151.0**	**-298.1**

Note: Traditional use plant habitat totals do not include disturbance or water ELC units. Ecosystem services provided by traditional use plant species are assessed in Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use, and Section 17, Other Land and Resource Use.

a) McLaughlan et al. 2010.

RSA = regional study area; ELC = Ecological Land Classification; < = less than.

13.5.4.2 Reasonably Foreseeable Development Case

13.5.4.2.1 Habitat Availability

Availability of traditional use plant habitat in the RFD Case is predicted to be decreased by approximately 744.0 ha from the Base Case availability (i.e., 2.5%; Table 13.5-12; Figure 13.5-12). The largest changes in availability were associated with common boreal forest species (i.e., blueberry [loss of 244.0 ha], jack pine [loss of 209.6 ha], and bog cranberry [loss of 73.5 ha]). Changes in availability were most pronounced within the burned and unburned white birch/lingonberry – Labrador tea dominant ELC units BS14 and BS14(BU), the burned and unburned jack pine/lichen ELC units BP02(BU), BS04, BS03(BU), and BS04(BU) BP02, burned Balsam poplar - trembling aspen/prickly rose ELC unit BP16(BU), and Black spruce/Labrador tea/feathermoss ELC unit BP14 (Table 13.5-13). Small changes in availability were observed within less common ELC units: Leatherleaf shrubby poor fen (BP24), jack pine/feathermoss (BP03), Labrador tea shrubby bog (BP20), and Black spruce treed bog (BP19). Habitat availability is predicted to decrease for five traditional use plant species (i.e., Nagoon berry [*Rubus arcticus* ssp. *acaulis*, dewberry [*Rubus pubescens*], dwarf birch [*Betula glandulosa*], hard-stemmed bulrush [*Schoenoplectus acutus* var. *acutus*], and swamp red currant [*Ribes tristel*]) in the RFD Case that were not disturbed in the Application Case; however, the change in availability for this species is predicted to be less than 0.1 ha. Changes to traditional use plant species availability due the maximum disturbance area and the Fission Patterson Lake South Property have been conservatively overestimated. Effects are likely to occur but are uncertain given that the Fission Patterson Lake South Property has recently entered the formal regulatory application process.

Once traditional use plant species habitat is removed, the loss is considered continuous until functional habitat is reclaimed or offset (i.e., beyond Closure). It is anticipated that many traditional use plant species would re-establish quickly following the removal of disturbance (e.g., raspberry, jack pine). However, where traditional use plant species occupy wetland ELC units (e.g., pitcherplant), loss of habitat due to the Project is assumed to be permanent and irreversible because wetland ecosystems are not anticipated to be reclaimed to the same wetland species composition and ecological function following Closure (Section 13.5.2.1.1).

In the RFD Case, the Project and the Fission Patterson Lake South Property would reduce the availability of traditional use plant species by direct removal of habitat availability; however, traditional use plant habitat is predicted to remain abundant across the RSA. The magnitude of the effects would be dependent on the specific habitat requirements of each species (i.e., sensitivity to environmental changes); however, the cumulative effects as a result of the Project, the Fission Patterson Lake South Property, and previous and existing developments are expected to be well within the adaptive and resilience limits of traditional use plant species.

The duration of effects from changes in traditional use plant species availability from the two projects would be a function of the amount of temporal overlap between the period from the start of Construction to the end of the Active Closure Stage and the time required to establish ELC units that support traditional use plant species. Incremental effects as a result of the Project were predicted to occur the period from Construction through the end of the Active Closure Stage and the time required to establish mature upland ELC units (i.e., 60 to 80 years) (Section 13.5.1.2.1, Ecosystem Availability). The duration of effects from direct habitat loss from the Fission Patterson Lake South Property was therefore assumed to be from construction to the end of decommissioning (i.e., 15 years) plus 60 to 80 years for mature upland ELC units to be established. If assumed upland ecosystem loss from the Fission Patterson Lake South Property completely overlapped the upland ecosystem loss associated with the Project, the duration of cumulative effects for the RFD Case would be a maximum of

95 years, which is the duration used for the assessment of the RFD Case. However, a decrease in temporal overlap of the two projects would result in a shorter duration of cumulative effects.

Climate Change

Climate change models predict a longer, warmer growing season. Climate change may alter the processes that influence the availability of traditional use plant habitat and effects would likely occur beyond the RSA. Changes to forest structure and species composition may occur from drought, temperature changes, increased extreme climatic events, increased intensity of fire, and insects and disease (Sauchyn et al. 2009). Overall, it is uncertain whether climate change would positively and/or negatively affect traditional use plant species. Niches occupied by individual traditional use plant species may benefit from specific changes (i.e., potential increase in habitat availability for fire-adapted species). Species with specific habitat requirements (e.g., pitcherplant) may be less resilient to changes in habitat availability driven by climate change.

Table 13.5-12: Changes to Traditional Use Plant Species Availability in the Reasonably Foreseeable Development Case

Traditional Use Plant Species[a]	Scientific Name[b]	SKCDC Common Name[b]	RSA		
			Base Case (ha)	RFD Case (ha)	Change in Area (ha)
Berries	*Rubus arcticus* ssp. *acaulis*	Nagoon berry	2.2	2.2	-<0.1
	Rubus pubescens	Dewberry	1.4	1.4	-<0.1
Birch	*Betula glandulosa*	Dwarf birch	5.8	5.8	-<0.1
	Betula occidentalis	River birch	0.6	0.5	-<0.1
	Betula papyrifera	Paper birch	764.9	735.0	-29.8
	Betula pumila	Swamp birch	70.8	69.9	-1.0
Blueberry	*Vaccinium myrtilloides*	Blueberry	6,230.4	5,986.4	-244.0
Bulrushes	*Juncus alpinoarticulatus*	Northern green rush	0.6	0.5	-<0.1
	Juncus nodosus var. *nodosus*	Knotted rush	0.8	0.8	0.0
	Schoenoplectus acutus var. *acutus*	Hard-stemmed bulrush	0.5	0.5	-<0.1
Chokecherry	*Prunus virginiana* var. *viriginiana*	Chokecherry	n/o	n/o	n/o
Cloudberry	*Rubus chamaemorus*	Cloudberry	176.7	175.7	-1.0
Cranberry	*Vaccinium oxycoccos*	Small cranberry	230.0	228.5	-1.6
Cranberry, bog	*Vaccinium vitis-idaea*	Bog cranberry	3,148.3	3,074.8	-73.5
Cranberry, low bush-	*Viburnum edule*	Low bush-cranberry	0.4	0.4	0.0
Cranberry, high bush	*Viburnum opulus* var. *americanum*	High bush-cranberry	n/o	n/o	n/o
Dogwood	*Cornus sericea* ssp. *sericea*	Red-osier dogwood	n/o	n/o	n/o
Frog tail	*Sarracenia purpurea* ssp. *gibbosa*	Pitcherplant	n/o	n/o	n/o
Gooseberry	*Ribes americanum*	Wild black currant	0.8	0.8	-<0.1
	Ribes glandulosum	Skunk currant	0.2	0.2	0.0
	Ribes hudsonianum	Northern black currant	2.7	2.7	-<0.1
	Ribes oxyacanthoides var. *oxyacanthoides*	Bristly gooseberry	2.4	2.4	-<0.1
	Ribes triste	Swamp red currant	0.2	0.2	-<0.1
Jack pine	*Pinus banksiana*	Jack pine	8,931.3	8,721.7	-209.6
Kinnikinnick	*Arctostaphylos uva-ursi*	Bearberry	1,225.4	1,186.7	-38.8
Labrador tea	*Rhododendron groenlandicum*	Common Labrador tea	2,036.5	2,005.9	-30.5
	Rhododendron tomentosum	Labrador tea	111.7	110.4	-1.4
Mint	*Mentha canadensis*	Wild mint	13.0	12.3	-0.6
Mosses[c]	n/a	n/a	3,439.5	3,400.8	-38.6

Table 13.5-12: Changes to Traditional Use Plant Species Availability in the Reasonably Foreseeable Development Case

Traditional Use Plant Species[a]	Scientific Name[b]	SKCDC Common Name[b]	RSA		
			Base Case (ha)	RFD Case (ha)	Change in Area (ha)
Mushrooms[c]	n/a	n/a	n/o	n/o	n/o
Poplar	*Populus balsamifera* ssp. *balsamifera*	Balsam poplar	13.3	13.3	0.0
	Populus tremuloides	Trembling aspen	530.5	503.0	-27.5
Raspberry	*Rubus idaeus* ssp. *strigosus*	American red raspberry	1.1	1.1	0.0
Rat root	*Acorus americanus*	Sweet flag	n/o	n/o	n/o
Saskatoon	*Amelanchier alnifolia* var. *alnifolia*	Saskatoon	n/o	n/o	n/o
Spruce	*Picea glauca*	White spruce	981.0	965.2	-15.8
	Picea mariana	Black spruce	1,171.8	1,150.6	-21.3
Strawberry	*Fragaria vesca* ssp. *americana*	American wild strawberry	0.3	0.3	-<0.1
	Fragaria virginiana ssp. *glauca*	Smooth wild strawberry	<0.1	<0.1	-<0.1
Sweetgrass	*Anthoxanthum hirtum* ssp. *arcticum*	Sweet grass	n/o	n/o	n/o
Tamarack	*Larix laricina*	Tamarack	35.5	35.2	-0.2
Willow[d]	*Salix* spp.	Willow species	318.5	309.8	-8.6
Total			**29,449.0**	**28,705.1**	**-744.0**

Note: Ecosystem services provided by traditional use plant species are assessed in Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use, and Section 17, Other Land and Resource Use.

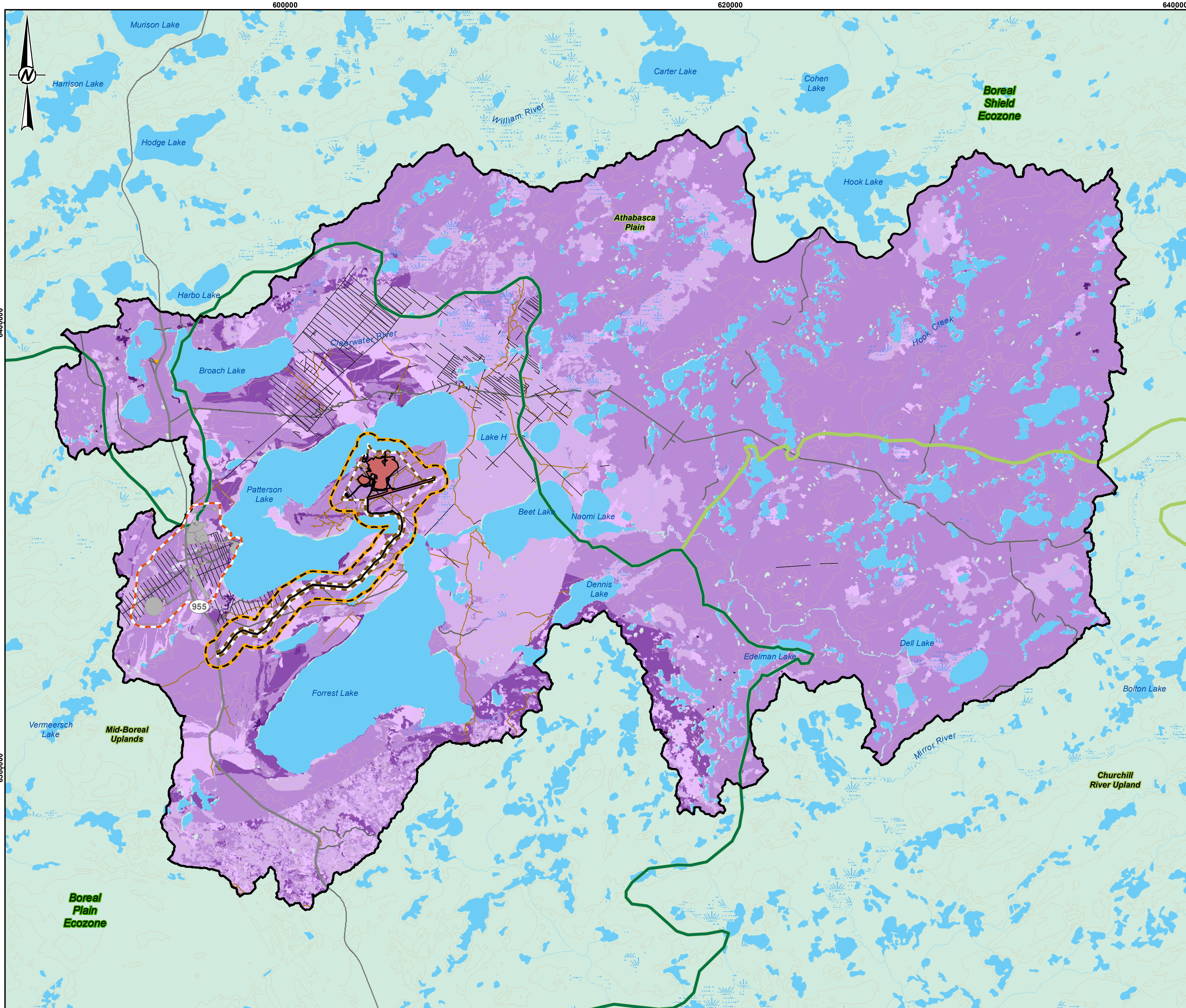
a) TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD VI: YNLR; CRDN 2019a.

b) SKCDC 2021b.

c) Traditional use plant species name reflects broad group of plant or fungi species; therefore, the scientific name and SKCDC common name are not described.

d) Saskatchewan has over 40 willow species (*Salix* sp.; Harms 2017); therefore, the scientific name and SKCDC common name of all potential willow species are not described.

RSA = regional study area; < = less than; n/a = not applicable; n/o = not observed during baseline surveys.



LEGEND

- ELEVATION CONTOUR (20 m INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED
- ECOREGION BOUNDARY
- ECOZONE BOUNDARY
- PROPOSED PROJECT FOOTPRINT
- MAXIMUM DISTURBANCE AREA
- FISSION PATTERSON LAKE SOUTH PROPERTY FOOTPRINT
- PATTERSON LAKE SOUTH PROPERTY HYPOTHETICAL MAXIMUM DISTURBANCE AREA
- LOCAL STUDY
- REGIONAL STUDY

TRADITIONAL USE PLANT SPECIES OCCUPANCY

- 0.00 TO 0.16
- 0.17 TO 0.32
- 0.33 TO 0.48
- 0.49 TO 0.64
- 0.65 TO 0.80
- 0.81 TO 0.96
- 0.97 TO 1.12
- 1.13 TO 1.28

DISTURBANCE CLASS

- ACCESS ROAD
- CUTLINE/SEISMIC
- SECONDARY HIGHWAY
- ROUGH ROAD
- TRAIL
- NON-LINEAR DEVELOPMENT (E.G., CLEARING, EXISTING EXPLORATION)
- OIL AND GAS DEVELOPMENT

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, APRIL 6, 2021. UPDATED JUNE 8, 2021.
2. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. ECOZONES OBTAINED FROM AGRICULTURE AND AGRI-FOOD CANADA (AAFC).
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

TRADITIONAL USE PLANT SPECIES OCCUPANCY IN THE REGIONAL STUDY AREA, REASONABLY FORESEEABLE DEVELOPMENT CASE

CONSULTANT

wsp

PROJECT		20144150	PHASE	3314 - 6
DESIGN	AS	2020-03-13	SCALE AS SHOWN	REV. 0
GIS	NO	2023-02-08		
CHECK	HH	2023-02-08	**FIGURE 13.5-12**	
REVIEW	JV	2023-02-08		

25mm

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

13.5.4.2.2 Habitat Distribution

In the Base Case, traditional use plant habitat is well distributed across the RSA and LSA, and although there has been some change in connectivity because of previous and existing developments, there is sufficient connectivity to support the traditional use plant species in the RSA and LSA. As noted in Section 13.5.4.2.1, Habitat Availability, the RFD Case results in a loss of 744.0 ha of traditional use plant habitat in the RSA, primarily in jack pine forested stands (BP02[BU], BP03, BP02, BP03[BU]) and a balsam poplar forest stand (BP16[BU]). (Table 13.5-13). The actual disturbance would depend on the final design of the Fission Patterson Lake South Property. It is estimated that the hypothetical maximum disturbance area used for the Fission Patterson Lake South Property is six times larger than the footprint presented in the Fission (2019) prefeasibility study.

Changes to traditional plant habitat distribution in the RFD Case would result in a minor reduction of traditional use plant habitat connectivity regionally but are not predicted to affect overall connectivity in the RSA. Minor changes in the fragmentation of traditional use plant habitat would be restricted to the northwest boundary of the RSA, which has an existing aggregation of linear and non-linear disturbances in proximity to Highway 955 (e.g., rough roads, trails, seismic lines / cutlines) (Figure 13.5-3). Therefore, the magnitude of changes on traditional use plant habitat distribution is anticipated to be low (i.e., little to no change in connectivity in most of the RSA).

Planned mitigation of direct disturbance to upland ecosystems from the Fission Patterson Lake South Property includes minimizing land clearing, reclaiming unused areas, and remediating the site at closure (Fission 2019). The duration of effects from direct habitat loss for the Fission Patterson Lake South Property was therefore assumed to be from construction to the end of decommissioning (i.e., 15 years) plus 60 to 80 years for mature upland ELC units to be established (Section 13.5.1.2.1). Therefore, the duration of cumulative effects for the RFD Case would be a maximum of 95 years. The duration of effects on traditional use plant species that occupy wetland ELC units are conservatively assumed to be permanent (Section 13.5.2.1.1), as reclaimed wetland ELC units may not be restored to an equivalent species composition and ecological function similar to the wetland ELC units observed in the Base Case.

Climate Change

Saskatchewan's Boreal Shield Ecozone is known for a naturally short fire-return interval (Neufeld et al. 2020; Parisien et al. 2004), and species tend to be well adapted to this disturbance regime, as self-replacement of forested stands is the most common post-fire trajectory (Hart et al. 2019). Fire-adapted species include several traditional use plants (e.g., jack pine and blueberry), which are anticipated to occupy newly fire-disturbed areas and may have a positive effect on traditional use plant habitat availability and distribution within the RSA. However, not all traditional use plant species are fire adapted, and some may therefore be negatively affected by increased forest fire frequency and intensity.

In the future, due to predicted longer, warmer growing seasons resulting from climate change, forest productivity may increase alter ecological succession (Sauchyn et al. 2009). Increased productivity could result in a shift in species composition. However, changes in species composition related to climate change are uncertain and may result in negative or positive effects on traditional use plant species.

Table 13.5-13: Traditional Use Plant Species Habitat Availability per Ecological Land Classification Unit in the Reasonably Foreseeable Development Case

Traditional Use Plant Habitat ELC Unit[a]	RSA			
	ELC Unit Area (ha)	Habitat Availability Base Case (ha)	Habitat Availability RFD Case (ha)	Change in Area (ha)
BP02 - Jack pine/lichen	2,791.3	337.6	310.4	-27.2
BP03 - Jack pine/feathermoss	3,712.1	2,483.4	2423.7	-59.7
BP04 - Jack pine - trembling aspen/feathermoss	1,000.7	113.0	113.0	0.0
BP06 - Trembling aspen/beaked hazel/sarsaparilla	0.3	0.3	0.3	0.0
BP07 - Trembling aspen - white birch/sarsaparilla	5.1	5.8	5.8	0.0
BP11 - White birch - white spruce - balsam fir	3.2	1.3	1.3	0.0
BP12 - Jack pine - spruce/feathermoss	219.2	90.7	90.7	0.0
BP14 - Black spruce/Labrador tea/feathermoss	129.8	117.7	107.2	-10.4
BP16 - Balsam poplar - trembling aspen/prickly rose	33.3	31.3	31.3	0.0
BS02 - Lichen/felsenmeer - bedrock	<0.1	<0.1	<0.1	0.0
BS03 - Jack pine/blueberry/lichen	4,991.4	1,625.0	1,625.0	0.0
BS04 - Jack pine - black spruce/feathermoss	6,158.9	2,549.1	2,549.1	0.0
BS05 - Jack pine - white birch/feathermoss	1.1	0.8	0.8	0.0
BS06 - Jack pine - trembling aspen/green alder	0.3	0.3	0.3	0.0
BS07 - Black spruce/blueberry/lichen	2.6	1.5	1.5	0.0
BS08 - Black spruce - white birch/lichen	<0.1	<0.1	<0.1	0.0
BS09 - Black spruce - jack pine/feathermoss	23.1	8.2	8.2	0.0
BS10 - Black spruce - white birch/feathermoss	0.1	0.0	0.0	0.0
BS13 - White birch - black spruce - trembling aspen	11.9	12.2	12.2	0.0
BS14 - White birch/lingonberry - Labrador tea	74.0	23.2	15.2	-8.1
BS15 - Trembling aspen - white birch/green alder	<0.1	<0.1	<0.1	0.0
BP02(BU) - Jack pine/lichen (Burned)	8,990.9	2,889.7	2,323.5	-566.2
BP03(BU) - Jack pine/feathermoss (Burned)	4,846.6	2,005.9	2,005.9	0.0
BP04(BU) - Jack pine - trembling aspen/feathermoss (Burned)	1,274.5	409.6	409.6	0.0
BP06(BU) - Trembling aspen/beaked hazel/sarsaparilla (Burned)	0.3	0.4	0.4	0.0
BP07(BU) - Trembling aspen - white birch/sarsaparilla (Burned)	10.4	11.7	11.7	0.0
BP11(BU) - White birch - white spruce - balsam fir (Burned)	0.9	0.4	0.4	0.0
BP12(BU) - Jack pine - spruce/feathermoss (Burned)	4.4	1.8	1.8	0.0
BP14(BU) - Black spruce/Labrador tea/feathermoss (Burned)	25.2	23.2	23.2	0.0
BP16(BU) - Balsam poplar - trembling aspen/prickly rose (Burned)	1,070.4	253.8	223.7	-30.1
BS02(BU) - Lichen/felsenmeer - bedrock (Burned)	0.7	<0.1	<0.1	0.0
BS03(BU) - Jack pine/blueberry/lichen (Burned)	23,172.8	7,447.7	7,423.9	-23.8
BS04(BU) - Jack pine - black spruce/feathermoss (Burned)	9,065.2	3,752.0	3,752.0	0.0
BS05(BU) - Jack pine - white birch/feathermoss (Burned)	5.1	3.7	3.7	0.0
BS06(BU) - Jack pine - trembling aspen/green alder (Burned)	0.9	0.3	0.3	0.0
BS07(BU) - Black spruce/blueberry/lichen (Burned)	5.6	1.8	1.8	0.0
BS08(BU) - Black spruce - white birch/lichen (Burned)	0.1	<0.1	<0.1	0.0
BS09(BU) - Black spruce - jack pine/feathermoss (Burned)	50.1	17.8	17.8	0.0
BS13(BU) - White birch - black spruce - trembling aspen (Burned)	57.7	59.4	59.4	0.0
BS14(BU) - White birch/lingonberry - Labrador tea (Burned)	39.9	9.5	8.5	-0.9
BS15(BU) - Trembling aspen - white birch/green alder (Burned)	0.2	0.2	0.2	0.0
Recent burn upland	7,041.6	1,823.3	1,823.3	0.0
BP18 - Black spruce - tamarack treed swamp	21.9	2.7	2.7	0.0
BP19 - Black spruce treed bog	1,708.0	763.1	754.4	-8.7
BP20 - Labrador tea shrubby bog	1,254.7	329.6	321.9	-7.7

Table 13.5-13: Traditional Use Plant Species Habitat Availability per Ecological Land Classification Unit in the Reasonably Foreseeable Development Case

Traditional Use Plant Habitat ELC Unit[(a)]	RSA			
	ELC Unit Area (ha)	Habitat Availability Base Case (ha)	Habitat Availability RFD Case (ha)	Change in Area (ha)
BP21 - Graminoid bog	25.2	9.0	9.0	0.0
BP22 - Open bog	7.8	2.5	2.5	0.0
BP23 - Tamarack treed fen	40.4	13.0	13.0	0.0
BP24 - Leatherleaf shrubby poor fen	54.5	8.0	7.6	-0.4
BP25 - Willow shrubby rich fen	317.1	65.8	65.8	-0.1
BP26 - Graminoid fen	263.3	19.8	19.7	-0.1
BP27 - Open fen	32.8	6.5	6.5	0.0
BP28 - Seaside arrow-grass marsh	64.3	13.1	13.1	0.0
BS17 - Black spruce treed bog	1,517.3	433.3	433.3	0.0
BS18 - Labrador tea shrubby bog	1,481.3	270.2	270.2	0.0
BS19 - Graminoid bog	0.2	0.1	0.1	0.0
BS20 - Open bog	0.9	0.3	0.3	0.0
BS21 - Tamarack treed fen	0.3	0.1	0.1	0.0
BS22 - Leatherleaf shrubby poor fen	205.0	30.1	30.1	0.0
BS23 - Willow shrubby rich fen	4.5	0.9	0.9	0.0
BS24 - Graminoid fen	41.8	3.1	3.1	0.0
BS25 - Open fen	<0.1	<0.1	<0.1	0.0
BS26 - Rush sandy shore	15.2	0.3	0.3	0.0
BP18(BU) - Black spruce - tamarack treed swamp (Burned)	49.9	6.2	6.2	0.0
BP19(BU) - Black spruce treed bog (Burned)	2,240.8	580.2	579.8	-0.5
BP20(BU) - Labrador tea shrubby bog (Burned)	82.2	15.0	15.0	0.0
BP21(BU) - Graminoid bog (Burned)	0.3	0.1	0.1	0.0
BP23(BU) - Tamarack treed fen (Burned)	25.3	8.1	8.1	0.0
BP24(BU) - Leatherleaf shrubby poor fen (Burned)	11.6	1.7	1.7	0.0
BP25(BU) - Willow shrubby rich fen (Burned)	142.0	29.5	29.5	0.0
BP26(BU) - Graminoid fen (Burned)	401.6	30.3	30.3	0.0
BP28(BU) - Seaside arrow-grass marsh (Burned)	109.9	22.4	22.4	0.0
BS16(BU) - Black spruce/balsam poplar/river alder swamp (Burned)	<0.1	<0.1	<0.1	0.0
BS17(BU) - Black spruce treed bog (Burned)	1,540.3	398.8	398.8	0.0
BS18(BU) - Labrador tea shrubby bog (Burned)	1,052.9	192.1	192.1	0.0
BS19(BU) - Graminoid bog (Burned)	0.1	0.1	0.1	0.0
BS20(BU) - Open bog (Burned)	2.2	0.8	0.8	0.0
BS21(BU) - Tamarack treed fen (Burned)	7.0	2.4	2.4	0.0
BS22(BU) - Leatherleaf shrubby poor fen (Burned)	411.4	60.4	60.4	0.0
BS23(BU) - Willow shrubby rich fen (Burned)	33.1	6.9	6.9	0.0
BS24(BU) - Graminoid fen (Burned)	89.1	6.6	6.6	0.0
BS25(BU) - Open fen (Burned)	0.1	<0.1	<0.1	0.0
BS26(BU) - Rush sandy shore (Burned)	36.6	0.7	0.7	0.0
Recent burn wetland	96.8	1.3	1.3	0.0
Total	**88,211.2**	**29,449.0**	**28705.1**	**-744.0**

Note: Traditional use plant habitat totals do not include disturbance or water ELC units. Ecosystem services provided by traditional use plant species are assessed in Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use, and Section 17, Other Land and Resource Use.
a) McLaughlan et al. 2010.
RFD = reasonably foreseeable development; RSA = regional study area; ELC = Ecological Land Classification; < = less than.

13.5.4.3 Residual Effects Classification and Determination of Significance

The assessment endpoints for traditional use plant species are defined as self-sustaining and ecologically effective plant populations. Ecosystem services (i.e., the benefits people gain from the environment) provided by traditional use plant species are assessed in Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use, and Section 17, Other Land and Resource Use, and are not considered during the residual effects classification and determination of significance in this section.

13.5.4.3.1 Classification Summary

Residual effects were classified for the Application Case and the RFD Case after the implementation of effective mitigation (Table 13.5-14). Residual effects were summarized according to the direction, magnitude, geographic extent, duration, reversibility, frequency, and probability of the effect occurring following the methods described in Section 13.2.9. Effective implementation of mitigation is summarized in Section 13.4 (Table 13.4-1), and progressive reclamation and revegetation is expected to reduce the magnitude and duration of residual effects on traditional use plant species. Following the summary of residual effects, the significance of residual effects for the Application Case and the RFD Case was determined according to the methods described in Section 13.2.9.

Table 13.5-14: Classification of Residual Effects on Traditional Use Plant Species Measurement Indicators for the Application Case and Reasonably Foreseeable Development Case

Measurement Indicator	Criterion	Rating / Effect Size	
		Application Case	RFD Case
Traditional use plant species availability	Direction	▪ Negative	▪ Negative
	Magnitude	▪ Loss of 298.1 ha (1.0% in the RSA) from the Base Case to the Application Case (i.e., low magnitude)	▪ Loss of 744.0 ha (2.5% of RSA) from the Base Case to the RFD Case (i.e., low magnitude)
	Geographic extent	▪ Maximum disturbance area	▪ Regional (Project and the Fission Patterson Lake South Property) ▪ Beyond regional (climate change)
	Duration	▪ Permanent: for wetland ELC units and permanent features (i.e., WRSAs) ▪ Long term (direct loss): 93 to 113 years = 33 years (start of Construction to the end of the Active Closure Stage), or earlier with progressive reclamation, plus 60 years to 80 years to establish mature upland ELC Units	▪ Permanent: wetland ELC units and permanent features ▪ Permanent: climate change effects ▪ Long term: maximum of 95 years for establishment of mature upland ELC units, depending on extent of temporal overlap between the Project and the Fission Patterson Lake South Property
	Reversibility	▪ Reversible (reclaimed ELC units) ▪ Irreversible (wetland ecosystems and permanent features)	▪ Reversible (reclaimed ELC units) ▪ Irreversible (wetland ecosystems and permanent features) ▪ Irreversible (climate change effects)
	Frequency	▪ Continuous	▪ Continuous
	Probability of occurrence	▪ Certain	▪ Probable (Project and the Fission Patterson Lake South Property) ▪ Possible (climate change)

Table 13.5-14: Classification of Residual Effects on Traditional Use Plant Species Measurement Indicators for the Application Case and Reasonably Foreseeable Development Case

Measurement Indicator	Criterion	Rating / Effect Size	
		Application Case	RFD Case
Traditional use plant species distribution	Direction	▪ Negative	▪ Negative
	Magnitude	▪ Minor net change in traditional use plant habitat distribution centred on the LSA. Almost no change in fragmentation at the RSA scale (i.e., low magnitude)	▪ Minor increase in fragmentation of traditional use plant habitat in the RSA near the western boundary in proximity to existing disturbance. Almost no change to connectivity in most of the RSA
	Geographic extent	▪ Local	▪ Regional (Project and the Fission Patterson Lake South Property) ▪ Beyond regional (climate change)
	Duration	▪ Permanent: for wetland ELC units and permanent features (i.e., WRSAs) ▪ Long term (direct loss): 93 to 113 years = 33 years (start of Construction to the end of the Active Closure Stage), or earlier with progressive reclamation, plus 60 years to 80 years to establish mature upland ELC Units	▪ Permanent: wetlands and habitat covered by permanent features ▪ Permanent: climate change effects ▪ Long term: maximum of 95 years for establishment of mature upland ELC units, depending on extent of temporal overlap between the Project and the Fission Patterson Lake South Property
	Reversibility	▪ Reversible (reclaimed ELC units) ▪ Irreversible (wetland ecosystems and permanent features)	▪ Reversible (reclaimed ELC units) ▪ Irreversible (wetland ecosystems and permanent features) ▪ Irreversible (climate change effects)
	Frequency	▪ Continuous	▪ Continuous
	Probability of occurrence	▪ Certain	▪ Probable (Project and the Fission Patterson Lake South Property) ▪ Possible (climate change)

Note: Ecosystem services provided by traditional use plant species are assessed in Section 16, Cultural and Heritage Resources and Indigenous Land and Resource Use, and Section 17, Other Land and Resource Use.
RFD = reasonably foreseeable development; LSA = local study area; RSA = regional study area; ELC = Ecological Land Classification; WRSAs = waste rock storage areas.

13.5.4.3.2 Significance Determination

Application Case

The effects of previous and existing developments and activities in the Base Case have negatively altered habitat availability and habitat distribution, but not to the point where traditional use plant habitat is no longer self-sustaining or ecologically effective. In the Application Case, the Project contributes to adverse changes of low magnitude, local geographic extent and of long-term to permanent duration to traditional use plant habitat availability and distribution in the RSA and LSA. The effects in the Application Case changed little from Base Case conditions, and the traditional use plant habitat is predicted to continue to be self-sustaining and ecologically effective.

RFD Case

For the RFD Case, the combined effects as a result of the Project and planned Fission Patterson Lake South Property development on traditional use plant species in the RSA are expected to be regional. The effects are predicted to be long term, reversible, and continuous for upland habitat and irreversible and permanent for wetland habitat (Table 13.5-14). The weight of evidence from the analysis predicts that changes to the availability and distribution of traditional use plant habitat within the RSA in the RFD Case would be within the resilience and adaptability limits for this VC. Overall, traditional use plant habitat is predicted to be self-sustaining and ecologically effective in the RFD Case.

Climate Change

Climate change is expected to affect the availability and distribution of traditional use plant species continuously at a beyond regional extent (Table 13.5-14). Effects from climate change would likely be permanent, but not certain (i.e., possible) due to the inherent low level of confidence in predicting the magnitude, frequency, and geographic extent of climate-related changes to measurement indicators. However, traditional use plant species are expected to remain abundant and well distributed within and adjacent to the RSA and self-sustaining and ecologically effective.

Overall Significance

Based on several lines of evidence, incremental and cumulative effects from the Project, previous and existing developments, and the Fission Patterson Lake South Property on traditional use plant species are predicted to be not significant. Effects related to climate change are not expected to significantly influence traditional use plants and do not alter the assessment of no significant cumulative effects from the Project and Fission Patterson Lake South Property.

13.5.5 Effects on Biodiversity

Vegetation biodiversity is inclusive of plant life and the ecosystems plants occupy. It includes all levels of organization, from genes to landscapes, and the ecological processes through which these levels are connected. Effects on biodiversity have been assessed based on the effects on ecosystems (Section 13.5.1, Upland Ecosystems; Section 13.5.2, Wetland Ecosystems; Section 13.5.3, Riparian Ecosystems) and the effects on traditional use plant species (Section 13.5.4) and were meant to encapsulate the effects on most of the biodiversity elements of which ecosystems are comprised. For example, plant communities that depend on very old live trees, standing dead trees, coarse woody debris, and forest gap processes found in mature forests would be captured by the ecosystem-level assessment. Similarly, poorly-known species (e.g., lichens) tend to be better captured by assessing the landscape and ecosystems than individual species (Franklin 1993; Poiani et al. 2000). Key biodiversity indicators at the existing conditions include:

- The LSA and RSA consist of predominantly burned and unburned upland ecosystems, 2,172.6 ha (76.7%) and 74,821.7 ha (69.6%), respectively.
- Approximately 369.6 ha (13.1%) of the LSA and 19,158.2 ha (17.8%) of the RSA is composed of undisturbed upland ecosystems.
- Approximately 122.5 ha (4.3%) of the LSA and 7,056.4 ha (6.6%) of the RSA is composed of undisturbed wetland ecosystems.
- Potential riparian ecosystems cover 205.4 ha of the LSA (7.3%) and 9,612.5 ha of the RSA (8.9%).
- Fires have burned approximately 61,996.5 ha (57.7%) of the RSA between 1981 and 2020.
- Anthropogenic disturbances cover 104.7 ha (3.7%) in the of the LSA and 457.8 ha (0.4%) of the RSA.
- Linear feature density is estimated to be 2.9 km/km^2 in the LSA and 0.6 km/km^2 in the RSA.

Vegetation ecosystems in the LSA and RSA in the Base Case are characteristic of those generally found in the Boreal Plain and Boreal Shield ecozones. The RSA is composed of a heterogeneous patchwork of upland and wetland ecosystems interspersed among lakes and rivers. Within this patchwork, some ecosystems and communities have higher potential to support biodiversity (e.g., wetlands); however, these ecosystems and communities do not exist in isolation, and it is the interaction of all ecosystems, along with the absence of anthropogenic disturbance, that is important in the maintenance of an intact landscape. In the Base Case, anthropogenic disturbance is low (i.e., 457.8 ha [0.4% of the RSA]).

Upland ecosystems in the Base Case are dominated by jack pine forests (Jack pine/blueberry/lichen [BS03], Jack pine - black spruce/feathermoss [BS04], and Jack pine/lichen [BP02]), which tend to have lower biodiversity (i.e., species richness) for vascular species but support a higher diversity of non-vascular species. Burned ELC units tend to have low biodiversity potential compared to undisturbed ELC units due to reduced structural complexity and species richness (Annex VII.1).

The relative biodiversity potential of riparian ecosystems is intrinsically high, independent of the ELC units within which they occur. Riparian communities are defined as areas adjacent to rivers and lakes, or ephemeral, intermittent, or perennial streams that differ from the surrounding uplands in plant and animal diversity and productivity (Environment Canada 2013). Riparian areas support important biodiversity functions as they provide a unique transition zone between aquatic and terrestrial ecosystems (Austin et al. 2008). Riparian zones often function as regional wildlife movement corridors linking otherwise unconnected habitats (Haddad et al. 2003; Damschen et al. 2006).

Mature forests are recognized for their contribution to biodiversity values, ecological function not found in younger-aged stands, including important habitat for animals, and providing genetic diversity to nearby tree stands. Mature forests create microhabitats for specialist species high in the tree canopy and on the forest floor in the coarse woody debris (Komonen et al. 2021). Mature forests also provide several additional functions, including carbon sequestration and micro-habitat creation. As forests age, there is an increase in genetic diversity and in the ability of tree species to survive and reproduce (Mosseler et al. 2003). Therefore, old-growth patches act like natural reservoirs of genetic diversity and contribute to the successful dispersal, maintenance, and adaptation of species across a fragmented landscape (Mosseler et al. 2003). Species diversity and structural characteristics of mature forests (e.g., large living and dead trees and large gaps) develop slowly and are difficult to replace once lost. Mature forest patches constitute unique and structurally diverse ecosystems that provide some of the highest quality habitat available for plants and animals (Timoney 2001; Harper et al. 2003).

In the Application Case, the Project is predicted to remove 868.4 ha (1.2%) of upland ELC units. However, over 80% of the maximum disturbance area overlaps areas that have been burned in the last 40 years, which tend to have lower biodiversity potential (i.e., structural diversity and species richness) than unburned ELC units. Change in wetland ecosystems is predicted to be limited to 27.8 ha (i.e., less than 0.1%). The use of previously disturbed areas for Construction and Operations of the Project, including 82.2 ha of associated with the existing exploration camp and access road, would help reduce changes to biodiversity. The existing access road would be upgraded to safely accommodate large vehicles and equipment and would be realigned to avoid the wetland west of the proposed airstrip. Most of the existing trails would be upgraded for site roads and haul roads within the maximum disturbance area. The Project would be in a portion of the RSA that contains an aggregation of existing linear and non-linear features in proximity of Highway 955. The current density of linear features in the RSA (i.e., 0.6 km/km^2) is considered low, and the Project is not expected to change the density of linear features in the LSA and RSA.

In the RFD Case, the Project and the Fission Patterson Lake South Property are predicted to remove 2,390.1 ha (3.1%) of upland ELC units. Similar to the Application Case, these changes are predicted to occur within burned ELC units with low structural diversity and species richness (i.e., approximately 84% of upland ELC units). Loss of wetland ecosystems in the RFD Case is predicted to be 55.6 ha (0.1%), which may disproportionately affect biodiversity even though wetland habitat loss is small compared to the change in upland ecosystems. Disturbance from the projects would be within a portion of the RSA that contains an aggregation of existing linear and non-linear features in the proximity of Highway 955. Use of existing anthropogenic disturbance is predicted to reduce the overall loss of biodiversity but also limit the level of new habitat fragmentation and edge effects.

Reclamation is predicted to reverse effects on disturbed ELC units and provide adequate material for the development of productive soils, which would support the establishment and succession of vegetation communities with a similar function to natural ecosystems not influenced by the Project; however, upland and wetland ecosystems would most likely differ from those present before disturbance in structural complexity and species composition.

Effects of the Project on biodiversity are anticipated to be low in magnitude, with the geographic extent anticipated to be restricted to the maximum disturbance area in the Application Case and regional in the RFD Case. Increased disturbance and the corresponding loss of vegetation ecosystems would be primarily distributed near the western boundary of the RSA in proximity to existing disturbance and habitat fragmentation present in the Base Case. The residual effect is reversible over the long term for some natural ecosystems and plant communities that would regenerate or can be reclaimed but irreversible for others. For example, mature forest would eventually return to the landscape given sufficient time. Organic wetlands with soils disturbance, however, are not predicted to recover within a defined timeframe; therefore, soil disturbance in wetlands is considered irreversible.

Changes in the Application Case and RFD Case are expected to reduce landscape intactness, but biodiversity in the RSA is predicted to recover to equivalent land use and productivity compared to similar undisturbed ecosystems in the RSA.

13.6 Prediction Confidence and Uncertainty

Scientific inference is associated with uncertainty, and prediction confidence (i.e., the level of confidence in assessment results) depends on the level of uncertainty and the way it is addressed. Primary factors affecting confidence in the predictions made in the vegetation assessment include:

- availability and accuracy of baseline data;
- accuracy of ecosystem maps;
- level of understanding of baseline ecosystem conditions, range of natural variation, and ecosystem resilience;
- level of understanding of the strength of primary pathways in terms of the effects they are likely to have on each VC;
- level of certainty associated with the effectiveness of proposed mitigations, where applicable; and
- level of understanding of the cumulative drivers of change in measurement indicators and associated effects on ecosystems, including uncertainty in climate change projections with respect to weather and fire frequency and intensity, and the associated responses of vegetation VCs.

Uncertainty was managed by:

- completing quality assurance and quality control of baseline data;
- reviewing historical data and relevant studies completed in the LSA and RSA;

- using the best available land cover data for mapping upland, wetland, and riparian vegetation ecosystems in the LSA and RSA;
- using data to make inferences about ecological interactions and mechanisms of change;
- assuming that plant species at risk and rare plants would be present in potential habitats where they may occur but were not observed;
- using the maximum disturbance area to enable Project refinements and increase confidence that the effects were not underestimated;
- using the hypothetical maximum disturbance area for the Fission Patterson Lake South Property to increase confidence that the effects were not underestimated;
- comparing assessment results to relevant published scientific literature; and
- addressing climate change in this assessment using a precautionary approach as necessary. Where there was ambiguity in the response of a VC to climate change, the assessment considered a precautionary outcome for each effects criterion (e.g., negative effect of climate change on vegetation VCs). However, where potential effects of climate change were better understood, VC responses were based on available scientific evidence.

Overall, there is a moderate to high degree of confidence in the predictions related to the changes to vegetation VCs, and best management practices during the Project lifespan would be implemented to mitigate effects on upland, wetland, and riparian ecosystem VCs and the traditional use plant species VC. There is some uncertainty regarding the quantity, distribution, and ecological function (i.e., condition) of reclaimed ELC units during and after Closure. Uncertainty was primarily and appropriately addressed by making assumptions that conservatively overestimated rather than underestimated potential effects (i.e., a precautionary assessment), such as expecting that reclaimed vegetation communities would likely not have the same structure as natural ELC units but would be ecologically functional. Further, conservatism was also included into the modelling and analysis completed by intermediate components and VCs such as air quality, hydrogeology, hydrology, surface water quality, and terrain and soils. Monitoring would be used to address residual uncertainty by evaluating the progress of reclamation activities. Different approaches and methods would be implemented, if necessary, to establish a trajectory towards the successful regeneration and succession of vegetation ecosystems that are functionally similar to natural plant communities in the region.

13.7 Monitoring, Follow-Up, and Adaptive Management

Monitoring programs would be used to:

- evaluate the effectiveness of the environmental protection measures (e.g., preventing soil erosion, stockpiling soil for reclamation, preventing the introduction of invasive weeds) and modify or enhance as necessary through monitoring and updating mitigation measures, if needed;
- identify unanticipated negative effects, including possible accidents and malfunctions;
- assess the success of plant community establishment following reclamation; and
- contribute to the overall continual improvement of the Project.

The Environmental Monitoring Plan would be implemented to monitor effects on vegetation. The proposed monitoring programs are outlined in Section 23, Summary of Mitigation, Monitoring, and Follow-Up Programs.

The Preliminary Decommissioning and Reclamation Plan, along with monitoring, would assist in revising or adding mitigation measures to facilitate successful long-term reclamation and establishment of vegetation communities and provision of functional wildlife habitat.

One species of noxious weed (i.e., narrow-leaved hawk's beard) and one species of nuisance weed (i.e., dandelion) designated under *The Weed Control Act* were identified in existing anthropogenically disturbed areas during baseline field surveys (Section 13.3.1.3). Weed species in Saskatchewan are regulated by *The Weed Control Act*. The purpose of this Act is to prevent weeds from being introduced into areas that do not contain these species and prevent the spread of new weeds into and throughout the province. Under *The Weed Control Act*, the following actions are required: eradication of prohibited weeds, eradication of isolated infestations of noxious weeds, and control of established noxious and nuisance weeds. Annual monitoring would be completed to identify and manage new occurrences within the Project footprint.

Eleven provincially tracked vascular plant occurrences were recorded during baseline surveys (Section 13.3.1.3, Ecosystem Condition, and Section 13.3.2.2, Ecosystem Distribution). However, only one occurrence of beautiful sedge was observed within the maximum disturbance area (Section 13.5.1.1.3, Ecosystem Condition). Monitoring and follow-up during Construction would be required to delineate potential activity restriction guideline setbacks (ENV 2017; 30 m setback) to mitigate direct disturbance to this species at this location. Where disturbance to rare plants is unavoidable, the ENV would be consulted to determine the most appropriate course of action.

Cumulative effects in both the Application and RFD cases were predicted to be not significant for traditional use plants. Traditional use plant species are relatively common in parts of the RSA and LSA (Section 13.3.4; Section 13.5.4). Therefore, no specific monitoring actions have been identified for traditional use plant species. However, general monitoring conducted under the Environmental Monitoring Plan would evaluate potential changes or effects to vegetation, including traditional use plant species. Importantly, NexGen is committed to continuing engagement with Indigenous Groups throughout the lifespan of the Project, and providing opportunities for the incorporation of Indigenous and Local Knowledge on the use of traditional plant species as part of reclamation planting prescriptions for the Preliminary Decommissioning and Reclamation Plan.

The Preliminary Decommissioning and Reclamation Plan, along with monitoring, would assist in revising or adding mitigation measures so that there is successful long-term reclamation and establishment of vegetation communities that contribute to overall ecosystem function, wildlife habitat, and biodiversity. Monitoring requirements for reclamation would be outlined in the Preliminary Decommissioning and Reclamation Plan and would include details on reclamation treatments to be used during revegetation, schedules for the frequency of monitoring, and thresholds where adaptive management may be required. The Preliminary Decommissioning and Reclamation Plan would also outline the criteria that would be used to determine reclamation success (i.e., cover and composition of vegetation, and forest health assessment scores). Feedback from reclamation monitoring would be used to develop further actions as required (i.e., planting late seral species not observed to be naturally regenerating, such as white spruce and traditional use plant species; refining vegetation prescriptions; and implementing best management practices to control invasive species).

Wetlands within the maximum disturbance area would be monitored prior to Construction and during Operations to understand the potential Project specific effects to wetland function and to adhere to the *Federal Policy on Wetland Conservation* (Government of Canada 1991) of no net loss of wetland function. Where wetland disturbance cannot be avoided, reclaimed wetlands with similar function would be established following Closure. Post-reclamation wetland surveys would be conducted to understand if reclaimed wetlands are achieving similar functions. Monitoring would provide feedback so that mitigation actions can be modified or added to achieve the expected trajectory for establishing wetlands in designated reclaimed areas. For example, the area of wetland assumed to be reclaimed for the purposes of this assessment may need to be exceeded to achieve no net loss of wetland functions. The assessment conservatively estimated the effects on wetland ecosystems to be permanent and irreversible as restoration of wetland species composition and ecological function equivalent to the wetland ELC units observed in the Base Case is unlikely.

In addition, Environmental Committees (i.e., one per primary Indigenous Group) composed of two NexGen and two Indigenous Group representatives would be established to act in an oversight manner to monitor the environmental performance of the Project and verify the parties are implementing the regulatory and environmental commitments made in respect of the Project.

Indigenous Groups have made recommendations related to mitigating the effects of the Project on the environment, including community-led long-term environmental testing and monitoring during construction and operation of the Project (TSD IV: MN-S; TSD V.2: CRDN; YNLRO 2019). NexGen has committed to provide funding for the lifespan of the Project for a full-time independent Indigenous Monitor chosen by each primary Indigenous Group; this Indigenous Monitor would have access to conduct environmental sampling for the Project, subject to the Indigenous Monitor complying with appropriate health and safety and other reasonable site-specific policies. The Indigenous Monitor would be able to report openly and without restriction to the Environmental Committee and Indigenous Group's community members on the performance of the Project. The Indigenous Monitor would also provide regular reports to the Environmental Committee.

13.8 Key Findings

The objectives of Section 13 were to provide a detailed and comprehensive assessment of all potential Project-specific effects and cumulative effects from the Project and RFDs on vegetation; these objectives were met. A summary of key findings for vegetation is outlined below:

- No unique upland ecosystems would be lost by the development of the Project. Changes to availability and distribution of upland ecosystems are predicted to be localized to the Project. Similar changes are predicted for the RFD Case, with changes limited to the Project and Fission Patterson Lake South Property. Localized fragmentation as a result of the Project and the Fission Patterson Lake South Property is anticipated to occur within common upland ELC units (i.e., BP02[BU]) and it is predicted that upland ecosystems would remain abundant and well distributed across the RSA.
- One provincially tracked vascular plant species (i.e., beautiful sedge) was observed in upland ecosystem within the maximum disturbance area and could be lost or removed by the Project. Four occurrences of the same species were observed outside of the maximum disturbance area where no direct effects are anticipated. Rare plants would be clearly marked and avoided, where feasible. Where disturbance to rare plants is unavoidable, the ENV would be consulted to determine the most appropriate course of action.
- No unique wetland ecosystems would be lost by the development of the Project. Changes to availability and distribution of wetland ecosystems are predicted to be localized to the Project. Similar changes are predicted for the RFD Case, with changes limited to the Project and Fission Patterson Lake South Property. Few to no edge effects are predicted to occur to wetland condition. Localized fragmentation as a result of the Project and the Fission Patterson Lake South Property is anticipated to occur within common wetland ELC units (i.e., BP20[BU]) and it is predicted that wetland ecosystems would remain abundant and well distributed across the RSA.

- Changes to availability, distribution, and condition of riparian ecosystems are predicted to be localized to the Project. Similar changes are predicted for the RFD Case, with changes limited to the Project and Fission Patterson Lake South Property. Changes are predicted to produce few to no edge effects on riparian condition.
- No unique traditional use plant species would be lost by the development of the Project. Changes to the availability and distribution of traditional use plant species are predicted to be localized to the Project. Similar changes are predicted for the RFD Case, with changes limited to the Project and Fission Patterson Lake South Property.
- Key information from the vegetation assessment was carried forward to the wildlife, cultural and heritage resources and Indigenous land and resource use, and other land and resource use discipline sections for consideration in the assessment of valued components.

13.9 References

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Appendix 13A Vegetation Ecosystem Availability in the Base Case, Application Case, and Reasonably Foreseeable Development Case

Table 13A-1: Upland Ecosystem Availability in the Base Case, Application Case, and Reasonably Foreseeable Development Case

Upland ELC Unit[a]	Base Case				Application Case						RFD Case		
	LSA		RSA		LSA			RSA			RSA		
	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Base Case (ha)	Application Case	Change in Area (ha)	Base Case (ha)	Application Case	Change in Area (ha)	Base Case (ha)	RFD Case (ha)	Change in Area (ha)
BP02 - Jack pine/lichen	199.9	7.1	2,791.3	2.6	199.9	147.7	-52.2	2,791.3	2,739.1	-52.2	2,791.3	2,566.3	-225.0
BP03 - Jack pine/feathermoss	133.6	4.7	3,712.1	3.5	133.6	85.2	-48.4	3,712.1	3,663.7	-48.4	3,712.1	3,622.8	-89.2
BP04 - Jack pine - trembling aspen/feathermoss	16.9	0.6	1,000.7	0.9	16.9	16.9	0.0	1,000.7	1,000.7	0.0	1,000.7	1,000.7	0.0
BP06 - Trembling aspen/beaked hazel/sarsaparilla	0.0	0.0	0.3	<0.1	0.0	0.0	0.0	0.3	0.3	0.0	0.3	0.3	0.0
BP07 - Trembling aspen - white birch/sarsaparilla	0.0	0.0	5.1	<0.1	0.0	0.0	0.0	5.1	5.1	0.0	5.1	5.1	0.0
BP11 - White birch - white spruce - balsam fir	0.0	0.0	3.2	<0.1	0.0	0.0	0.0	3.2	3.2	0.0	3.2	3.2	0.0
BP12 - Jack pine - spruce/feathermoss	0.0	0.0	219.2	0.2	0.0	0.0	0.0	219.2	219.2	0.0	219.2	219.2	0.0
BP14 - Black spruce/Labrador tea/feathermoss	19.1	0.7	129.8	0.1	19.1	7.6	-11.5	129.8	118.3	-11.5	129.8	118.3	-11.5
BP16 - Balsam poplar - trembling aspen/prickly rose	0.0	0.0	33.3	<0.1	0.0	0.0	0.0	33.3	33.3	0.0	33.3	33.3	0.0
BS02 - Lichen/felsenmeer – bedrock	0.0	0.0	<0.1	<0.1	0.0	0.0	0.0	<0.1	<0.1	0.0	<0.1	<0.1	0.0
BS03 - Jack pine/blueberry/lichen	0.0	0.0	4,991.4	4.6	0.0	0.0	0.0	4,991.4	4,991.4	0.0	4,991.4	4,991.4	0.0
BS04 - Jack pine - black spruce/feathermoss	0.0	0.0	6,158.9	5.7	0.0	0.0	0.0	6,158.9	6,158.9	0.0	6,158.9	6,158.9	0.0
BS05 - Jack pine - white birch/feathermoss	0.0	0.0	1.1	<0.1	0.0	0.0	0.0	1.1	1.1	0.0	1.1	1.1	0.0
BS06 - Jack pine - trembling aspen/green alder	0.0	0.0	0.3	<0.1	0.0	0.0	0.0	0.3	0.3	0.0	0.3	0.3	0.0
BS07 - Black spruce/blueberry/lichen	0.0	0.0	2.6	<0.1	0.0	0.0	0.0	2.6	2.6	0.0	2.6	2.6	0.0
BS08 - Black spruce - white birch/lichen	0.0	0.0	<0.1	<0.1	0.0	0.0	0.0	<0.1	<0.1	0.0	<0.1	<0.1	0.0
BS09 - Black spruce - jack pine/feathermoss	0.0	0.0	23.1	<0.1	0.0	0.0	0.0	23.1	23.1	0.0	23.1	23.1	0.0
BS10 - Black spruce - white birch/feathermoss	0.0	0.0	0.1	<0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0
BS13 - White birch - black spruce - trembling aspen	0.0	0.0	11.9	<0.1	0.0	0.0	0.0	11.9	11.9	0.0	11.9	11.9	0.0
BS14 - White birch/lingonberry - Labrador tea	0.0	0.0	74.0	0.1	0.0	0.0	0.0	74.0	74.0	0.0	74.0	48.3	-25.7
BS15 - Trembling aspen - white birch/green alder	0.0	0.0	<0.1	<0.1	0.0	0.0	0.0	<0.1	<0.1	0.0	<0.1	<0.1	0.0
Undisturbed upland subtotal	369.6	13.1	19,158.2	17.8	369.6	257.5	-112.1	19,158.2	19,046.1	-112.1	19,158.2	18,806.8	-351.5
BP02(BU/E) - Jack pine/lichen (Burned)	0.0	0.0	176.2	0.2	0.0	0.0	0.0	176.2	176.2	0.0	176.2	176.2	0.0
BP02(BU/L) - Jack pine/lichen (Burned)	1,641.2	58.0	8,814.8	8.2	1,641.2	920.7	-720.4	8,814.8	8,094.3	-720.4	8,814.8	7,053.1	-1,761.7
BP03(BU/E) - Jack pine/feathermoss (Burned)	0.0	0.0	594.9	0.6	0.0	0.0	0.0	594.9	594.9	0.0	594.9	594.9	0.0
BP03(BU/L) - Jack pine/feathermoss (Burned)	0.0	0.0	4,251.7	4.0	0.0	0.0	0.0	4,251.7	4,251.7	0.0	4,251.7	4,251.7	0.0
BP04(BU/E) - Jack pine - trembling aspen/feathermoss (Burned)	0.0	0.0	120.8	0.1	0.0	0.0	0.0	120.8	120.8	0.0	120.8	120.8	0.0
BP04(BU/L) - Jack pine - trembling aspen/feathermoss (Burned)	0.0	0.0	1,153.7	1.1	0.0	0.0	0.0	1,153.7	1,153.7	0.0	1,153.7	1,153.7	0.0
BP06(BU/E) - Trembling aspen/beaked hazel/sarsaparilla (Burned)	0.0	0.0	0.3	<0.1	0.0	0.0	0.0	0.3	0.3	0.0	0.3	0.3	0.0
BP07(BU/E) - Trembling aspen - white birch/sarsaparilla (Burned)	0.0	0.0	<0.1	<0.1	0.0	0.0	0.0	<0.1	<0.1	0.0	<0.1	<0.1	0.0
BP07(BU/L) - Trembling aspen - white birch/sarsaparilla (Burned)	0.0	0.0	10.4	<0.1	0.0	0.0	0.0	10.4	10.4	0.0	10.4	10.4	0.0
BP11(BU/L) - White birch - white spruce - balsam fir (Burned)	0.0	0.0	0.9	<0.1	0.0	0.0	0.0	0.9	0.9	0.0	0.9	0.9	0.0
BP12(BU/L) - Jack pine - spruce/feathermoss (Burned)	0.0	0.0	4.4	<0.1	0.0	0.0	0.0	4.4	4.4	0.0	4.4	4.4	0.0
BP14(BU/E) - Black spruce/Labrador tea/feathermoss (Burned)	0.0	0.0	23.4	<0.1	0.0	0.0	0.0	23.4	23.4	0.0	23.4	23.4	0.0
BP14(BU/L) - Black spruce/Labrador tea/feathermoss (Burned)	0.0	0.0	1.8	<0.1	0.0	0.0	0.0	1.8	1.8	0.0	1.8	1.8	0.0
BP16(BU/L) - Balsam poplar - trembling aspen/prickly rose (Burned)	161.9	5.7	1,070.4	1.0	161.9	126.0	-35.8	1,070.4	1,034.6	-35.8	1,070.4	943.6	-126.8
BS02(BU/L) - Lichen/felsenmeer - bedrock (Burned)	0.0	0.0	0.7	<0.1	0.0	0.0	0.0	0.7	0.7	0.0	0.7	0.7	0.0
BS03(BU/E) - Jack pine/blueberry/lichen (Burned)	0.0	0.0	2,237.8	2.1	0.0	0.0	0.0	2,237.8	2,237.8	0.0	2,237.8	2,237.8	0.0
BS03(BU/L) - Jack pine/blueberry/lichen (Burned)	0.0	0.0	20,935.0	19.5	0.0	0.0	0.0	20,935.0	20,935.0	0.0	20,935.0	20,860.8	-74.2
BS04(BU/E) - Jack pine - black spruce/feathermoss (Burned)	0.0	0.0	1,089.8	1.0	0.0	0.0	0.0	1,089.8	1,089.8	0.0	1,089.8	1,089.8	0.0
BS04(BU/L) - Jack pine - black spruce/feathermoss (Burned)	0.0	0.0	7,975.4	7.4	0.0	0.0	0.0	7,975.4	7,975.4	0.0	7,975.4	7,975.4	0.0
BS05(BU/E) - Jack pine - white birch/feathermoss (Burned)	0.0	0.0	0.1	<0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0
BS05(BU/L) - Jack pine - white birch/feathermoss (Burned)	0.0	0.0	5.0	<0.1	0.0	0.0	0.0	5.0	5.0	0.0	5.0	5.0	0.0

Table 13A-1: Upland Ecosystem Availability in the Base Case, Application Case, and Reasonably Foreseeable Development Case

Upland ELC Unit[a]	Base Case				Application Case						RFD Case		
	LSA		RSA		LSA			RSA			RSA		
	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Base Case (ha)	Application Case	Change in Area (ha)	Base Case (ha)	Application Case	Change in Area (ha)	Base Case (ha)	RFD Case (ha)	Change in Area (ha)
BS06(BU/L) - Jack pine - trembling aspen/green alder (Burned)	0.0	0.0	0.9	<0.1	0.0	0.0	0.0	0.9	0.9	0.0	0.9	0.9	0.0
BS07(BU/E) - Black spruce/blueberry/lichen (Burned)	0.0	0.0	0.2	<0.1	0.0	0.0	0.0	0.2	0.2	0.0	0.2	0.2	0.0
BS07(BU/L) - Black spruce/blueberry/lichen (Burned)	0.0	0.0	5.4	<0.1	0.0	0.0	0.0	5.4	5.4	0.0	5.4	5.4	0.0
BS08(BU/L) - Black spruce - white birch/lichen (Burned)	0.0	0.0	0.1	<0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0
BS09(BU/E) - Black spruce - jack pine/feathermoss (Burned)	0.0	0.0	0.7	<0.1	0.0	0.0	0.0	0.7	0.7	0.0	0.7	0.7	0.0
BS09(BU/L) - Black spruce - jack pine/feathermoss (Burned)	0.0	0.0	49.4	<0.1	0.0	0.0	0.0	49.4	49.4	0.0	49.4	49.4	0.0
BS13(BU/E) - White birch - black spruce - trembling aspen (Burned)	0.0	0.0	5.9	<0.1	0.0	0.0	0.0	5.9	5.9	0.0	5.9	5.9	0.0
BS13(BU/L) - White birch - black spruce - trembling aspen (Burned)	0.0	0.0	51.8	<0.1	0.0	0.0	0.0	51.8	51.8	0.0	51.8	51.8	0.0
BS14(BU/E) - White birch/lingonberry - Labrador tea (Burned)	0.0	0.0	6.3	<0.1	0.0	0.0	0.0	6.3	6.3	0.0	6.3	6.3	0.0
BS14(BU/L) - White birch/lingonberry - Labrador tea (Burned)	0.0	0.0	33.6	<0.1	0.0	0.0	0.0	33.6	33.6	0.0	33.6	29.7	-4.0
BS15(BU/L) - Trembling aspen - white birch/green alder (Burned)	0.0	0.0	0.2	<0.1	0.0	0.0	0.0	0.2	0.2	0.0	0.2	0.2	0.0
Recent burn upland	0.0	0.0	7,041.6	6.6	0.0	0.0	0.0	7,041.6	7,041.6	0.0	7,041.6	7,041.6	0.0
Burned upland subtotal	1,803.0	63.7	55,663.4	51.8	1,803.0	1,046.8	-756.2	55,663.4	54,907.2	-756.2	55,663.4	53,696.7	-1,966.7
Upland total	**2,172.6**	**76.7**	**74,821.7**	**69.6**	**2,172.6**	**1,304.3**	**-868.4**	**74,821.7**	**73,953.3**	**-868.4**	**74,821.7**	**72,503.5**	**-2,318.2**
Wetland total	**553.2**	**19.5**	**32,211.3**	**30.0**	**553.2**	**523.1**	**-30.1**	**32,211.3**	**32,181.2**	**-30.1**	**32,211.3**	**32,139.3**	**-72.0**
Anthropogenic disturbance	**104.7**	**3.7**	**457.8**	**0.4**	**104.7**	**1,003.2**	**898.5**	**457.8**	**1,356.3**	**898.5**	**457.8**	**2,847.9**	**2,390.1**
Grand total	**2,831.6**	**100.0**	**107,490.7**	**100.0**	**2,831.6**	**2,831.6**	**n/a**	**107,490.7**	**107,490.7**	**n/a**	**107,490.7**	**107,490.7**	**n/a**

Note**:** Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
a) McLaughlan MS, Wright RA, Jiricka RD. 2010. Field Guide to the Ecosites of Saskatchewan's Provincial Forests. Prince Albert, SK: Saskatchewan Ministry of Environment, Forest Service. 338 p.
RFD = reasonably foreseeable development; LSA = local study area; RSA = regional study area; ELC = Ecological Land Classification; < = less than; n/a = not applicable.

Table 13A-2: Wetland Ecosystem Availability in the Base Case, Application Case, and Reasonably Foreseeable Development Case

Wetland ELC Unit[a]	Base Case				Application Case						RFD Case		
	LSA		RSA		LSA			RSA			RSA		
	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Base Case (ha)	Application Case	Change in Area (ha)	Base Case (ha)	Application Case	Change in Area (ha)	Base Case (ha)	RFD Case (ha)	Change in Area (ha)
BP18 - Black spruce - tamarack treed swamp	0.0	0.0	21.9	<0.1	0.0	0.0	0.0	21.9	21.9	0.0	21.9	21.9	0.0
BP19 - Black spruce treed bog	52.9	1.9	1,708.0	1.6	52.9	43.9	-9.0	1,708.0	1,699.0	-9.0	1,708.0	1,688.6	-19.4
BP20 - Labrador tea shrubby bog	57.6	2.0	1,254.7	1.2	57.6	41.0	-16.6	1,254.7	1,238.1	-16.6	1,254.7	1,225.4	-29.3
BP21 - Graminoid bog	0.0	0.0	25.2	<0.1	0.0	0.0	0.0	25.2	25.2	0.0	25.2	25.1	-0.1
BP22 - Open bog	0.0	0.0	7.8	<0.1	0.0	0.0	0.0	7.8	7.8	0.0	7.8	7.8	0.0
BP23 - Tamarack treed fen	0.8	<0.1	40.4	<0.1	0.8	0.8	0.0	40.4	40.4	0.0	40.4	40.4	0.0
BP24 - Leatherleaf shrubby poor fen	6.2	0.2	54.5	0.1	6.2	6.2	0.0	54.5	54.5	0.0	54.5	51.6	-2.9
BP25 - Willow shrubby rich fen	4.5	0.2	317.1	0.3	4.5	4.1	-0.4	317.1	316.7	-0.4	317.1	316.7	-0.4
BP26 - Graminoid fen	0.2	<0.1	263.3	0.2	0.2	0.2	0.0	263.3	263.3	0.0	263.3	261.6	-1.7
BP27 - Open fen	0.0	0.0	32.8	<0.1	0.0	0.0	0.0	32.8	32.8	0.0	32.8	32.8	0.0
BP28 - Seaside arrow-grass marsh	0.0	0.0	64.3	0.1	0.0	0.0	0.0	64.3	64.3	0.0	64.3	64.3	0.0
BS17 - Black spruce treed bog	0.0	0.0	1,517.3	1.4	0.0	0.0	0.0	1,517.3	1,517.3	0.0	1,517.3	1,517.3	0.0
BS18 - Labrador tea shrubby bog	0.0	0.0	1,481.3	1.4	0.0	0.0	0.0	1,481.3	1,481.3	0.0	1,481.3	1,481.3	0.0
BS19 - Graminoid bog	0.0	0.0	0.2	<0.1	0.0	0.0	0.0	0.2	0.2	0.0	0.2	0.2	0.0
BS20 - Open bog	0.0	0.0	0.9	<0.1	0.0	0.0	0.0	0.9	0.9	0.0	0.9	0.9	0.0
BS21 - Tamarack treed fen	0.0	0.0	0.3	<0.1	0.0	0.0	0.0	0.3	0.3	0.0	0.3	0.3	0.0
BS22 - Leatherleaf shrubby poor fen	0.0	0.0	205.0	0.2	0.0	0.0	0.0	205.0	205.0	0.0	205.0	205.0	0.0
BS23 - Willow shrubby rich fen	0.0	0.0	4.5	<0.1	0.0	0.0	0.0	4.5	4.5	0.0	4.5	4.5	0.0
BS24 - Graminoid fen	0.0	0.0	41.8	<0.1	0.0	0.0	0.0	41.8	41.8	0.0	41.8	41.8	0.0
BS25 - Open fen	0.0	0.0	<0.1	<0.1	0.0	0.0	0.0	<0.1	<0.1	0.0	<0.1	<0.1	0.0
BS26 - Rush sandy shore	0.2	<0.1	15.2	<0.1	0.2	0.2	0.0	15.2	15.2	0.0	15.2	15.1	0.0
Undisturbed wetland subtotal	122.5	4.3	7,056.4	6.6	122.5	96.5	-26.0	7,056.4	7,030.4	-26.0	7,056.4	7,002.6	-53.9
BP18(BU/E) - Black spruce - tamarack treed swamp (Burned)	0.0	0.0	36.6	<0.1	0.0	0.0	0.0	36.6	36.6	0.0	36.6	36.6	0.0
BP18(BU/L) - Black spruce - tamarack treed swamp (Burned)	0.0	0.0	13.3	<0.1	0.0	0.0	0.0	13.3	13.3	0.0	13.3	13.3	0.0
BP19(BU/E) - Black spruce treed bog (Burned)	0.0	0.0	22.0	<0.1	0.0	0.0	0.0	22.0	22.0	0.0	22.0	22.0	0.0
BP19(BU/L) - Black spruce treed bog (Burned)	35.5	1.3	2,218.7	2.1	35.5	33.7	-1.8	2,218.7	2,216.9	-1.8	2,218.7	2,216.9	-1.8
BP20(BU/E) - Labrador tea shrubby bog (Burned)	0.0	0.0	0.5	<0.1	0.0	0.0	0.0	0.5	0.5	0.0	0.5	0.5	0.0
BP20(BU/L) - Labrador tea shrubby bog (Burned)	0.0	0.0	81.7	0.1	0.0	0.0	0.0	81.7	81.7	0.0	81.7	81.7	0.0
BP21(BU/L) - Graminoid bog (Burned)	0.0	0.0	0.3	<0.1	0.0	0.0	0.0	0.3	0.3	0.0	0.3	0.3	0.0
BP23(BU/E) - Tamarack treed fen (Burned)	0.0	0.0	0.1	<0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0
BP23(BU/L) - Tamarack treed fen (Burned)	0.0	0.0	25.2	<0.1	0.0	0.0	0.0	25.2	25.2	0.0	25.2	25.2	0.0
BP24(BU/L) - Leatherleaf shrubby poor fen (Burned)	0.0	0.0	11.6	<0.1	0.0	0.0	0.0	11.6	11.6	0.0	11.6	11.6	0.0
BP25(BU/E) - Willow shrubby rich fen (Burned)	0.0	0.0	3.5	<0.1	0.0	0.0	0.0	3.5	3.5	0.0	3.5	3.5	0.0
BP25(BU/L) - Willow shrubby rich fen (Burned)	0.0	0.0	138.5	0.1	0.0	0.0	0.0	138.5	138.5	0.0	138.5	138.5	0.0
BP26(BU/E) - Graminoid fen (Burned)	0.0	0.0	90.2	0.1	0.0	0.0	0.0	90.2	90.2	0.0	90.2	90.2	0.0
BP26(BU/L) - Graminoid fen (Burned)	0.0	0.0	311.4	0.3	0.0	0.0	0.0	311.4	311.4	0.0	311.4	311.4	0.0
BP28(BU/E) - Seaside arrow-grass marsh (Burned)	0.0	0.0	4.8	<0.1	0.0	0.0	0.0	4.8	4.8	0.0	4.8	4.8	0.0
BP28(BU/L) - Seaside arrow-grass marsh (Burned)	0.0	0.0	105.1	0.1	0.0	0.0	0.0	105.1	105.1	0.0	105.1	105.1	0.0
BS16(BU/L) - Black spruce/balsam poplar/river alder swamp (Burned)	0.0	0.0	<0.1	<0.1	0.0	0.0	0.0	<0.1	<0.1	0.0	<0.1	<0.1	0.0
BS17(BU/E) - Black spruce treed bog (Burned)	0.0	0.0	60.3	0.1	0.0	0.0	0.0	60.3	60.3	0.0	60.3	60.3	0.0
BS17(BU/L) - Black spruce treed bog (Burned)	0.0	0.0	1,480.0	1.4	0.0	0.0	0.0	1,480.0	1,480.0	0.0	1,480.0	1,480.0	0.0
BS18(BU/E) - Labrador tea shrubby bog (Burned)	0.0	0.0	39.1	<0.1	0.0	0.0	0.0	39.1	39.1	0.0	39.1	39.1	0.0
BS18(BU/L) - Labrador tea shrubby bog (Burned)	0.0	0.0	1,013.8	0.9	0.0	0.0	0.0	1,013.8	1,013.8	0.0	1,013.8	1,013.8	0.0

Table 13A-2: Wetland Ecosystem Availability in the Base Case, Application Case, and Reasonably Foreseeable Development Case

Wetland ELC Unit[a]	Base Case				Application Case						RFD Case		
	LSA		RSA		LSA			RSA			RSA		
	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Base Case (ha)	Application Case	Change in Area (ha)	Base Case (ha)	Application Case	Change in Area (ha)	Base Case (ha)	RFD Case (ha)	Change in Area (ha)
BS19(BU/L) - Graminoid bog (Burned)	0.0	0.0	0.1	<0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0
BS20(BU/E) - Open bog (Burned)	0.0	0.0	0.2	<0.1	0.0	0.0	0.0	0.2	0.2	0.0	0.2	0.2	0.0
BS20(BU/L) - Open bog (Burned)	0.0	0.0	2.0	<0.1	0.0	0.0	0.0	2.0	2.0	0.0	2.0	2.0	0.0
BS21(BU/E) - Tamarack treed fen (Burned)	0.0	0.0	<0.1	<0.1	0.0	0.0	0.0	<0.1	<0.1	0.0	<0.1	<0.1	0.0
BS21(BU/L) - Tamarack treed fen (Burned)	0.0	0.0	7.0	<0.1	0.0	0.0	0.0	7.0	7.0	0.0	7.0	7.0	0.0
BS22(BU/E) - Leatherleaf shrubby poor fen (Burned)	0.0	0.0	123.9	0.1	0.0	0.0	0.0	123.9	123.9	0.0	123.9	123.9	0.0
BS22(BU/L) - Leatherleaf shrubby poor fen (Burned)	0.0	0.0	287.4	0.3	0.0	0.0	0.0	287.4	287.4	0.0	287.4	287.4	0.0
BS23(BU/E) - Willow shrubby rich fen (Burned)	0.0	0.0	1.1	<0.1	0.0	0.0	0.0	1.1	1.1	0.0	1.1	1.1	0.0
BS23(BU/L) - Willow shrubby rich fen (Burned)	0.0	0.0	32.0	<0.1	0.0	0.0	0.0	32.0	32.0	0.0	32.0	32.0	0.0
BS24(BU/E) - Graminoid fen (Burned)	0.0	0.0	14.5	<0.1	0.0	0.0	0.0	14.5	14.5	0.0	14.5	14.5	0.0
BS24(BU/L) - Graminoid fen (Burned)	0.0	0.0	74.6	0.1	0.0	0.0	0.0	74.6	74.6	0.0	74.6	74.6	0.0
BS25(BU/L) - Open fen (Burned)	0.0	0.0	0.1	<0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0
BS26(BU/E) - Rush sandy shore (Burned)	0.0	0.0	<0.1	<0.1	0.0	0.0	0.0	<0.1	<0.1	0.0	<0.1	<0.1	0.0
BS26(BU/L) - Rush sandy shore (Burned)	0.0	0.0	36.5	<0.1	0.0	0.0	0.0	36.5	36.5	0.0	36.5	36.5	0.0
Recent burn wetland	0.0	0.0	96.8	0.1	0.0	0.0	0.0	96.8	96.8	0.0	96.8	96.8	0.0
Burned wetland subtotal	35.5	1.3	6,333.1	5.9	35.5	33.7	-1.8	6,333.1	6,331.3	-1.8	6,333.1	6,331.3	-1.8
Water	395.3	14.0	18,821.8	17.5	395.3	392.9	-2.4	18,821.8	18,819.4	-2.4	18,821.8	18,805.5	-16.3
Wetland total	**553.2**	**19.5**	**32,211.3**	**30.0**	**553.2**	**523.1**	**-30.1**	**32,211.3**	**32,181.2**	**-30.1**	**32,211.3**	**32,139.3**	**-72.0**
Upland total	**2,172.6**	**76.7**	**74,821.7**	**69.6**	**2,172.6**	**1,304.3**	**-868.4**	**74,821.7**	**73,953.3**	**-868.4**	**74,821.7**	**72,503.5**	**-2,318.2**
Anthropogenic disturbance	**104.7**	**3.7**	**457.8**	**0.4**	**104.7**	**1,003.2**	**898.5**	**457.8**	**1,356.3**	**898.5**	**457.8**	**2,847.9**	**2,390.1**
Grand total	**2,831.6**	**100.0**	**107,490.7**	**100.0**	**2,831.6**	**2,831.6**	**n/a**	**107,490.7**	**107,490.7**	**n/a**	**107,490.7**	**107,490.7**	**n/a**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
a) McLaughlan MS, Wright RA, Jiricka RD. 2010. Field Guide to the Ecosites of Saskatchewan's Provincial Forests. Prince Albert, SK: Saskatchewan Ministry of Environment, Forest Service. 338 p.
RFD = reasonably foreseeable development; LSA = local study area; RSA = regional study area; ELC = Ecological Land Classification; < = less than; n/a = not applicable.

Table 13A-3: Riparian Ecosystem Availability in the Base Case, Application Case, and Reasonably Foreseeable Development Case

Riparian ELC Unit[a]	Base Case				Application Case						RFD Case		
	LSA		RSA		LSA			RSA			RSA		
	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Base Case (ha)	Application Case	Change in Area (ha)	Base Case (ha)	Application Case	Change in Area (ha)	Base Case (ha)	RFD Case (ha)	Change in Area (ha)
BP07 - Trembling aspen - white birch/sarsaparilla	0.0	0.0	<0.1	<0.1	0.0	0.0	0.0	<0.1	<0.1	0.0	<0.1	<0.1	0.0
BP12 - Jack pine - spruce/feathermoss	0.0	0.0	216.2	0.2	0.0	0.0	0.0	216.2	216.2	0.0	216.2	216.2	0.0
BP14 - Black spruce/Labrador tea/feathermoss	17.3	0.6	96.7	0.1	17.3	7.4	-9.8	96.7	86.8	-9.8	96.7	86.8	-9.8
BP16 - Balsam poplar - trembling aspen/prickly rose	0.0	0.0	32.4	<0.1	0.0	0.0	0.0	32.4	32.4	0.0	32.4	32.4	0.0
BP18 - Black spruce - tamarack treed swamp	0.0	0.0	3.6	<0.1	0.0	0.0	0.0	3.6	3.6	0.0	3.6	3.6	0.0
BP19 - Black spruce treed bog	51.4	1.8	822.2	0.8	51.4	42.4	-9.0	822.2	813.2	-9.0	822.2	804.3	-17.8
BP20 - Labrador tea shrubby bog	35.1	1.2	1,003.6	0.9	35.1	24.7	-10.4	1,003.6	993.2	-10.4	1,003.6	985.0	-18.6
BP21 - Graminoid bog	0.0	0.0	12.3	<0.1	0.0	0.0	0.0	12.3	12.3	0.0	12.3	12.2	-0.1
BP22 - Open bog	0.0	0.0	3.6	<0.1	0.0	0.0	0.0	3.6	3.6	0.0	3.6	3.6	0.0
BP23 - Tamarack treed fen	0.7	<0.1	27.3	<0.1	0.7	0.7	0.0	27.3	27.3	0.0	27.3	27.3	0.0
BP24 - Leatherleaf shrubby poor fen	6.2	0.2	36.8	<0.1	6.2	6.2	0.0	36.8	36.8	0.0	36.8	35.3	-1.5
BP25 - Willow shrubby rich fen	4.5	0.2	216.5	0.2	4.5	4.1	-0.4	216.5	216.1	-0.4	216.5	216.1	-0.4
BP26 - Graminoid fen	1.2	<0.1	97.5	0.1	1.2	1.2	0.0	97.5	97.5	0.0	97.5	97.1	-0.5
BP27 - Open fen	0.0	0.0	15.6	<0.1	0.0	0.0	0.0	15.6	15.6	0.0	15.6	15.6	0.0
BP28 - Seaside arrow-grass marsh	0.0	0.0	46.0	<0.1	0.0	0.0	0.0	46.0	46.0	0.0	46.0	46.0	0.0
BS06 - Jack pine - trembling aspen/green alder	0.0	0.0	0.3	<0.1	0.0	0.0	0.0	0.3	0.3	0.0	0.3	0.3	0.0
BS09 - Black spruce - jack pine/feathermoss	0.0	0.0	23.1	<0.1	0.0	0.0	0.0	23.1	23.1	0.0	23.1	23.1	0.0
BS10 - Black spruce - white birch/feathermoss	0.0	0.0	0.1	<0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0
BS13 - White birch - black spruce - trembling aspen	0.0	0.0	0.5	<0.1	0.0	0.0	0.0	0.5	0.5	0.0	0.5	0.5	0.0
BS15 - Trembling aspen - white birch/green alder	0.0	0.0	<0.1	<0.1	0.0	0.0	0.0	<0.1	<0.1	0.0	<0.1	<0.1	0.0
BS17 - Black spruce treed bog	0.0	0.0	1,281.4	1.2	0.0	0.0	0.0	1,281.4	1,281.4	0.0	1,281.4	1,281.4	0.0
BS18 - Labrador tea shrubby bog	0.0	0.0	1,302.8	1.2	0.0	0.0	0.0	1,302.8	1,302.8	0.0	1,302.8	1,302.8	0.0
BS19 - Graminoid bog	0.0	0.0	0.2	<0.1	0.0	0.0	0.0	0.2	0.2	0.0	0.2	0.2	0.0
BS20 - Open bog	0.0	0.0	0.7	<0.1	0.0	0.0	0.0	0.7	0.7	0.0	0.7	0.7	0.0
BS21 - Tamarack treed fen	0.0	0.0	<0.1	<0.1	0.0	0.0	0.0	<0.1	<0.1	0.0	<0.1	<0.1	0.0
BS22 - Leatherleaf shrubby poor fen	0.0	0.0	171.9	0.2	0.0	0.0	0.0	171.9	171.9	0.0	171.9	171.9	0.0
BS23 - Willow shrubby rich fen	0.0	0.0	2.7	<0.1	0.0	0.0	0.0	2.7	2.7	0.0	2.7	2.7	0.0
BS24 - Graminoid fen	0.0	0.0	30.8	<0.1	0.0	0.0	0.0	30.8	30.8	0.0	30.8	30.8	0.0
BS25 - Open fen	0.0	0.0	<0.1	<0.1	0.0	0.0	0.0	<0.1	<0.1	0.0	<0.1	<0.1	0.0
BS26 - Rush sandy shore	0.2	<0.1	11.9	<0.1	0.2	0.2	0.0	11.9	11.9	0.0	11.9	11.8	-0.1
Undisturbed riparian subtotal	116.6	4.1	5,456.3	5.1	116.6	87.0	-29.6	5,456.3	5,426.7	-29.6	5,456.3	5,407.4	-48.8
BP11(BU/L) - White birch - white spruce - balsam fir (Burned)	0.0	0.0	0.5	<0.1	0.0	0.0	0.0	0.5	0.5	0.0	0.5	0.5	0.0
BP12(BU/L) - Jack pine - spruce/feathermoss (Burned)	0.0	0.0	0.5	<0.1	0.0	0.0	0.0	0.5	0.5	0.0	0.5	0.5	0.0
BP14(BU/L) - Black spruce/Labrador tea/feathermoss (Burned)	0.0	0.0	<0.1	<0.1	0.0	0.0	0.0	<0.1	<0.1	0.0	<0.1	<0.1	0.0
BP16(BU/L) - Balsam poplar - trembling aspen/prickly rose (Burned)	64.4	2.3	729.1	0.7	64.4	54.4	-10.0	729.1	719.1	-10.0	729.1	675.3	-53.8
BP18(BU/L) - Black spruce - tamarack treed swamp (Burned)	0.0	0.0	6.8	<0.1	0.0	0.0	0.0	6.8	6.8	0.0	6.8	6.8	0.0
BP19(BU/E) - Black spruce treed bog (Burned)	0.0	0.0	2.1	<0.1	0.0	0.0	0.0	2.1	2.1	0.0	2.1	2.1	0.0
BP19(BU/L) - Black spruce treed bog (Burned)	24.4	0.9	871.2	0.8	24.4	24.4	0.0	871.2	871.2	0.0	871.2	871.2	0.0
BP20(BU/L) - Labrador tea shrubby bog (Burned)	0.0	0.0	25.2	<0.1	0.0	0.0	0.0	25.2	25.2	0.0	25.2	25.2	0.0
BP23(BU/L) - Tamarack treed fen (Burned)	0.0	0.0	12.2	<0.1	0.0	0.0	0.0	12.2	12.2	0.0	12.2	12.2	0.0
BP25(BU/L) - Willow shrubby rich fen (Burned)	0.0	0.0	20.7	<0.1	0.0	0.0	0.0	20.7	20.7	0.0	20.7	20.7	0.0
BP26(BU/E) - Graminoid fen (Burned)	0.0	0.0	7.6	<0.1	0.0	0.0	0.0	7.6	7.6	0.0	7.6	7.6	0.0
BP26(BU/L) - Graminoid fen (Burned)	0.0	0.0	98.2	0.1	0.0	0.0	0.0	98.2	98.2	0.0	98.2	98.2	0.0

Table 13A-3: Riparian Ecosystem Availability in the Base Case, Application Case, and Reasonably Foreseeable Development Case

Riparian ELC Unit[a]	Base Case				Application Case						RFD Case		
	LSA		RSA		LSA			RSA			RSA		
	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Base Case (ha)	Application Case	Change in Area (ha)	Base Case (ha)	Application Case	Change in Area (ha)	Base Case (ha)	RFD Case (ha)	Change in Area (ha)
BP28(BU/E) - Seaside arrow-grass marsh (Burned)	0.0	0.0	0.7	<0.1	0.0	0.0	0.0	0.7	0.7	0.0	0.7	0.7	0.0
BP28(BU/L) - Seaside arrow-grass marsh (Burned)	0.0	0.0	97.8	0.1	0.0	0.0	0.0	97.8	97.8	0.0	97.8	97.8	0.0
BS06(BU/L) - Jack pine - trembling aspen/green alder (Burned)	0.0	0.0	0.7	<0.1	0.0	0.0	0.0	0.7	0.7	0.0	0.7	0.7	0.0
BS07(BU/L) - Black spruce/blueberry/lichen (Burned)	0.0	0.0	5.3	<0.1	0.0	0.0	0.0	5.3	5.3	0.0	5.3	5.3	0.0
BS09(BU/E) - Black spruce - jack pine/feathermoss (Burned)	0.0	0.0	0.7	<0.1	0.0	0.0	0.0	0.7	0.7	0.0	0.7	0.7	0.0
BS09(BU/L) - Black spruce - jack pine/feathermoss (Burned)	0.0	0.0	47.1	<0.1	0.0	0.0	0.0	47.1	47.1	0.0	47.1	47.1	0.0
BS13(BU/E) - White birch - black spruce - trembling aspen (Burned)	0.0	0.0	<0.1	<0.1	0.0	0.0	0.0	<0.1	<0.1	0.0	<0.1	<0.1	0.0
BS13(BU/L) - White birch - black spruce - trembling aspen (Burned)	0.0	0.0	26.6	<0.1	0.0	0.0	0.0	26.6	26.6	0.0	26.6	26.6	0.0
BS15(BU/L) - Trembling aspen - white birch/green alder (Burned)	0.0	0.0	0.1	<0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0
BS17(BU/E) - Black spruce treed bog (Burned)	0.0	0.0	26.7	<0.1	0.0	0.0	0.0	26.7	26.7	0.0	26.7	26.7	0.0
BS17(BU/L) - Black spruce treed bog (Burned)	0.0	0.0	1,162.6	1.1	0.0	0.0	0.0	1,162.6	1,162.6	0.0	1,162.6	1,162.6	0.0
BS18(BU/E) - Labrador tea shrubby bog (Burned)	0.0	0.0	8.7	<0.1	0.0	0.0	0.0	8.7	8.7	0.0	8.7	8.7	0.0
BS18(BU/L) - Labrador tea shrubby bog (Burned)	0.0	0.0	656.3	0.6	0.0	0.0	0.0	656.3	656.3	0.0	656.3	656.3	0.0
BS19(BU/L) - Graminoid bog (Burned)	0.0	0.0	0.1	<0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0
BS20(BU/E) - Open bog (Burned)	0.0	0.0	0.2	<0.1	0.0	0.0	0.0	0.2	0.2	0.0	0.2	0.2	0.0
BS20(BU/L) - Open bog (Burned)	0.0	0.0	1.2	<0.1	0.0	0.0	0.0	1.2	1.2	0.0	1.2	1.2	0.0
BS21(BU/L) - Tamarack treed fen (Burned)	0.0	0.0	3.3	<0.1	0.0	0.0	0.0	3.3	3.3	0.0	3.3	3.3	0.0
BS22(BU/E) - Leatherleaf shrubby poor fen (Burned)	0.0	0.0	81.4	0.1	0.0	0.0	0.0	81.4	81.4	0.0	81.4	81.4	0.0
BS22(BU/L) - Leatherleaf shrubby poor fen (Burned)	0.0	0.0	184.7	0.2	0.0	0.0	0.0	184.7	184.7	0.0	184.7	184.7	0.0
BS23(BU/E) - Willow shrubby rich fen (Burned)	0.0	0.0	0.6	<0.1	0.0	0.0	0.0	0.6	0.6	0.0	0.6	0.6	0.0
BS23(BU/L) - Willow shrubby rich fen (Burned)	0.0	0.0	15.9	<0.1	0.0	0.0	0.0	15.9	15.9	0.0	15.9	15.9	0.0
BS24(BU/E) - Graminoid fen (Burned)	0.0	0.0	11.8	<0.1	0.0	0.0	0.0	11.8	11.8	0.0	11.8	11.8	0.0
BS24(BU/L) - Graminoid fen (Burned)	0.0	0.0	25.6	<0.1	0.0	0.0	0.0	25.6	25.6	0.0	25.6	25.6	0.0
BS25(BU/L) - Open fen (Burned)	0.0	0.0	0.1	<0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0
Recent burn wetland	0.0	0.0	23.7	<0.1	0.0	0.0	0.0	23.7	23.7	0.0	23.7	23.7	0.0
Burned riparian subtotal	88.8	3.1	4,156.2	3.9	88.8	78.9	-10.0	4,156.2	4,146.3	-10.0	4,156.2	4,102.4	-53.8
Riparian total	**205.4**	**7.3**	**9,612.5**	**8.9**	**205.4**	**165.8**	**-39.6**	**9,612.5**	**9,572.9**	**-39.6**	**9,612.5**	**9,509.9**	**-102.6**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
a) McLaughlan MS, Wright RA, Jiricka RD. 2010. Field Guide to the Ecosites of Saskatchewan's Provincial Forests. Prince Albert, SK: Saskatchewan Ministry of Environment, Forest Service. 338 p.
RFD = reasonably foreseeable development; LSA = local study area; RSA = regional study area; ELC = Ecological Land Classification; < = less than.

Appendix 13B Traditional Use Plant Availability in the Base Case, Application Case, and Reasonably Foreseeable Development Case

Table 13B-1: Traditional Use Plant Species Occupancy Ratios

Traditional Use Plant Species[(a)]	Scientific Name[(b)]	SKCDC Common Name[(b)]	ELC Unit[(c)]																																						
			BP 02	BP 03	BP 04	BP 06	BP 07	BP 11	BP 12	BP 14	BP 16	BS 02	BS 03	BS 04	BS 05	BS 06	BS 07	BS 08	BS 09	BS 10	BS 13	BS 14	BS 15	BP02 (BU)	BP03 (BU)	BP04 (BU)	BP06 (BU)	BP07 (BU)	BP11 (BU)	BP12 (BU)	BP14 (BU)	BP16 (BU)	BS02 (BU)	BS03 (BU)	BS04 (BU)	BS05 (BU)	BS06 (BU)	BS07 (BU)	BS08 (BU)	BS09 (BU)	BS13 (BU)	BS14 (BU)	BS15 (BU)	Recent Burn Upland
Berries	*Rubus arcticus* ssp. *acaulis*	Nagoon berry	0.0	0.0	0.0	0.01	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.01	0.0	0.0	0.0	0.01	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.01	0.0
Berries	*Rubus pubescens*	Dewberry	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0
Birch	*Betula glandulosa*	Dwarf birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Birch	*Betula occidentalis*	River birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Birch	*Betula papyrifera*	Paper birch	<0.01	0.03	<0.01	0.25	0.25	0.16	0.02	0.13	0.0	0.01	<0.01	0.02	0.11	0.05	0.0	0.17	0.01	0.11	0.32	0.16	0.12	<0.01	0.02	<0.01	0.25	0.25	0.16	0.02	0.13	0.11	0.01	<0.01	0.02	0.11	<0.01	<0.01	<0.01	0.01	0.32	0.11	0.12	0.0
Birch	*Betula pumila*	Swamp birch	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	<0.01	0.0	0.0	0.0	0.0	0.01	0.0	0.0	<0.01	0.0	0.0	<0.01	<0.01	<0.01	0.0	0.0	0.0	0.0	<0.01
Blueberry	*Vaccinium myrtilloides*	Blueberry	0.01	0.09	0.01	0.05	0.09	0.02	0.07	0.03	0.0	0.0	0.05	0.07	0.06	0.04	0.07	0.06	<0.01	0.04	0.07	0.02	0.08	0.12	0.07	0.12	0.05	0.09	0.02	0.07	0.03	0.04	0.0	0.12	0.07	0.06	0.12	0.12	0.12	<0.01	0.07	0.04	0.08	<0.01
Bulrushes	*Juncus alpinoarticulatus*	Northern green rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulrushes	*Juncus nodosus* var. *nodosus*	Knotted rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulrushes	*Schoenoplectus acutus* var. *acutus*	Hard-stemmed bulrush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chokecherry	*Prunus virginiana* var. *viriginiana*	Chokecherry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Cloudberry	*Rubus chamaemorus*	Cloudberry	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.01	0.0	0.0	0.01
Cranberry	*Vaccinium oxycoccos*	Small cranberry	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
Cranberry, bog	*Vaccinium vitis-idaea*	Bog cranberry	0.02	0.08	0.01	0.08	0.08	0.01	0.06	0.02	0.0	0.0	0.04	0.06	0.07	0.07	0.02	0.05	0.02	0.07	0.11	0.01	0.08	0.03	0.06	0.03	0.08	0.08	0.01	0.06	0.02	0.01	0.0	0.03	0.06	0.07	0.03	0.03	0.03	0.02	0.11	0.01	0.08	0.02
Cranberry, low bush	*Viburnum edule*	Low bush-cranberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cranberry, high bush	*Viburnum opulus* var. *americanum*	High bush-cranberry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Dogwood	*Cornus sericea* ssp. *sericea*	Red-osier dogwood	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Frog tail	*Sarracenia purpurea* ssp. *gibbosa*	Pitcherplant	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Gooseberry	*Ribes americanum*	Wild black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gooseberry	*Ribes glandulosum*	Skunk currant	0.0	0.0	0.0	0.01	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.01	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0
Gooseberry	*Ribes hudsonianum*	Northern black currant	0.0	0.0	0.0	0.01	0.01	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	<0.01	0.01	0.0	0.0	0.0	0.01	0.01	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.01	0.0
Gooseberry	*Ribes oxyacanthoides* var. *oxyacanthoides*	Bristly gooseberry	0.0	0.0	0.0	0.01	0.01	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.01	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0
Gooseberry	*Ribes triste*	Swamp red currant	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jack pine	*Pinus banksiana*	Jack pine	0.08	0.23	0.03	0.01	0.01	<0.01	0.17	0.13	0.0	0.0	0.21	0.17	0.25	0.27	0.11	0.12	0.01	0.06	0.01	<0.01	0.01	0.09	0.17	0.09	0.01	0.01	<0.01	0.17	0.13	0.03	0.0	0.09	0.17	0.25	0.09	0.09	0.09	0.01	0.01	0.03	0.01	0.02
Kinnikinnick	*Arctostaphylos uva-ursi*	Bearberry	<0.01	0.04	0.0	0.0	0.0	0.01	0.02	0.0	0.0	0.0	0.01	0.02	0.01	0.0	0.0	0.0	0.0	0.01	0.07	0.01	0.0	0.02	0.02	0.02	0.0	0.0	0.01	0.02	0.0	<0.01	0.0	0.02	0.02	0.01	0.02	0.02	0.02	0.0	0.07	<0.01	0.0	0.0
Labrador tea	*Rhododendron groenlandicum*	Common Labrador tea	0.0	<0.01	<0.01	0.01	0.01	0.05	<0.01	0.09	0.0	0.0	<0.01	<0.01	0.07	0.03	0.0	0.07	0.04	0.11	0.11	0.05	0.01	0.01	<0.01	0.01	0.01	0.01	0.05	<0.01	0.09	0.03	0.0	0.01	<0.01	0.07	0.01	0.01	0.01	0.04	0.11	0.03	0.01	0.06
Labrador tea	*Rhododendron tomentosum*	Labrador tea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	<0.01	0.0	0.0	0.0	0.0	0.01	0.0	0.0	<0.01	0.0	0.0	<0.01	<0.01	<0.01	0.0	0.0	0.0	0.0	0.01
Mint	*Mentha canadensis*	Wild mint	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	<0.01	<0.01	<0.01	0.0	0.0	0.0	0.0	0.0
Mosses[(d)]	n/a	Mosses	0.01	0.0	0.06	0.0	0.0	0.01	0.06	0.0	0.04	0.01	<0.01	0.06	0.0	0.06	0.04	0.02	0.17	0.0	0.0	0.01	0.0	0.02	0.06	0.02	0.0	0.0	0.01	0.06	0.0	0.01	0.01	0.02	0.06	0.0	0.02	0.02	0.02	0.17	0.0	0.01	0.0	0.11
Mushroom[(d)]	n/a	Mushrooms	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Poplar	*Populus balsamifera* ssp. *balsamifera*	Balsam poplar	0.0	0.0	0.0	0.01	0.01	0.0	0.0	0.0	0.36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.01	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0
Poplar	*Populus tremuloides*	Trembling aspen	0.0	<0.01	0.0	0.65	0.46	<0.01	0.0	0.01	0.33	0.0	<0.01	0.0	0.0	0.21	0.0	0.0	0.0	0.0	0.10	<0.01	0.47	0.01	0.0	0.01	0.65	0.46	<0.01	0.0	0.01	<0.01	0.0	0.01	0.0	0.0	0.01	0.01	0.01	0.0	0.10	<0.01	0.47	0.0
Raspberry	*Rubus idaeus* ssp. *strigosus*	American red raspberry	0.0	0.0	0.0	0.02	0.02	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.02	0.0	0.0	0.0	0.02	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.02	0.0
Rat root	*Acorus americanus*	Sweet flag	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Saskatoon	*Amelanchier alnifolia* var. *alnifolia*	Saskatoon	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Spruce	*Picea glauca*	White spruce	0.0	0.15	0.0	0.13	0.13	0.09	0.02	<0.01	0.12	0.0	<0.01	0.02	0.16	0.0	0.0	0.0	0.0	0.0	0.20	<0.01	0.13	<0.01	0.02	<0.01	0.13	0.13	0.09	0.02	0.01	<0.01	0.0	<0.01	0.02	0.16	<0.01	<0.01	<0.01	0.0	0.20	<0.01	0.13	0.0
Spruce	*Picea mariana*	Black spruce	<0.01	0.03	0.01	0.0	0.0	0.02	0.01	0.42	0.0	0.01	<0.01	0.01	0.0	0.13	0.36	0.54	0.09	0.0	0.0	0.02	0.0	<0.01	0.01	<0.01	0.0	0.0	0.02	0.01	0.42	<0.01	0.01	<0.01	0.01	0.0	<0.01	<0.01	<0.01	0.09	0.0	<0.01	0.0	0.03
Strawberry	*Fragaria vesca* ssp. *americana*	American wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strawberry	*Fragaria virginiana* ssp. *glauca*	Smooth wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sweetgrass	*Anthoxanthum hirtum* ssp. *arcticum*	Sweet grass	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Tamarack	*Larix laricina*	Tamarack	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01
Willow[(e)]	*Salix* sp.	Willow species	<0.01	0.01	0.0	0.03	0.03	0.02	<0.01	0.03	0.03	0.0	<0.01	<0.01	<0.01	0.01	0.0	0.01	<0.01	0.03	0.01	0.02	0.03	<0.01	<0.01	<0.01	0.03	0.03	0.02	<0.01	0.03	<0.01	0.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.03	0.0
		Total	0.12	0.67	0.11	1.28	1.13	0.40	0.41	0.91	0.94	0.04	0.33	0.41	0.73	0.85	0.60	1.03	0.36	0.43	1.03	0.31	1.00	0.32	0.41	0.32	1.28	1.13	0.40	0.41	0.92	0.24	0.04	0.32	0.41	0.73	0.32	0.32	0.32	0.36	1.03	0.24	1.00	0.26

Table 13B-1: Traditional Use Plant Species Occupancy Ratios

SKCDC Common Name[b]	ELC unit[c]																																									Average
	BP 18	BP 19	BP 20	BP 21	BP 22	BP 23	BP 24	BP 25	BP 26	BP 27	BP 28	BS 17	BS 18	BS 19	BS 20	BS 21	BS 22	BS 23	BS 24	BS 25	BS 26	BP18 (BU)	BP19 (BU)	BP20 (BU)	BP21 (BU)	BP23 (BU)	BP24 (BU)	BP25 (BU)	BP26 (BU)	BP28 (BU)	BS16 (BU)	BS17 (BU)	BS18 (BU)	BS19 (BU)	BS20 (BU)	BS21 (BU)	BS22 (BU)	BS23 (BU)	BS24 (BU)	BS25 (BU)	BS26 (BU)	Recent burn wetland	
Nagoon berry	<0.01	0.0	0.0	0.0	0.0	<0.01	0.0	<0.01	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	<0.01	0.0	<0.01	0.0	0.0	0.0	<0.01	0.0	<0.01	0.0	<0.01	0.0	<0.01	0.0	0.0	<0.01	0.0	<0.01	0.0	0.0	<0.01	0.0	<0.01	0.0	0.0	0.0	0.0	<0.01
Dewberry	<0.01	0.0	0.0	0.0	0.0	<0.01	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	<0.01	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	<0.01	0.0	<0.01	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	<0.01	0.0	<0.01	0.0	0.0	0.0	0.0	<0.01
Dwarf birch	<0.01	0.0	0.0	0.0	0.0	<0.01	<0.01	<0.01	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	<0.01	<0.01	<0.01	0.0	0.0	<0.01	0.0	0.0	0.0	<0.01	<0.01	<0.01	<0.01	0.0	<0.01	0.0	0.0	0.0	0.0	<0.01	<0.01	<0.01	<0.01	0.0	0.0	0.0	<0.01
River birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01
Paper birch	0.04	<0.01	0.01	0.0	0.0	<0.01	0.0	0.01	<0.01	0.0	0.0	<0.01	<0.01	0.0	0.0	<0.01	0.0	0.01	<0.01	0.0	0.02	0.04	0.0	<0.01	0.0	<0.01	0.0	0.01	<0.01	0.0	0.04	0.0	<0.01	0.0	0.0	<0.01	0.0	0.01	<0.01	0.0	0.02	0.0	0.05
Swamp birch	<0.01	0.01	0.0	0.01	0.0	0.01	0.0	0.05	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.05	<0.01	0.0	0.0	<0.01	<0.01	0.0	0.01	0.01	0.0	0.05	<0.01	0.0	<0.01	<0.01	0.0	0.0	0.0	0.01	0.0	0.05	<0.01	0.0	0.0	0.0	<0.01
Blueberry	0.01	0.01	0.01	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	<0.01	0.01	<0.01	<0.01	0.0	0.0	0.0	<0.01	0.0	0.0	0.01	<0.01	<0.01	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	<0.01	0.01	0.03
Northern green rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01
Knotted rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.0	0.0	<0.01
Hard-stemmed bulrush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	<0.01
Chokecherry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Cloudberry	0.01	0.03	<0.01	<0.01	0.0	0.01	0.0	<0.01	<0.01	0.0	0.0	0.03	<0.01	0.0	0.02	0.01	0.0	<0.01	<0.01	0.0	0.0	0.01	0.01	<0.01	<0.01	0.01	0.0	<0.01	<0.01	0.0	0.01	0.01	<0.01	0.0	0.02	0.01	0.0	<0.01	<0.01	0.0	0.0	0.0	<0.01
Small cranberry	0.01	0.01	0.03	0.03	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.0	0.01	0.02	0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.0	0.01	0.01	0.02	0.03	0.02	<0.01	<0.01	<0.01	0.0	0.01	0.01	0.02	0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.0	0.0	<0.01
Bog cranberry	<0.01	0.02	0.01	<0.01	0.0	0.01	0.0	<0.01	<0.01	0.0	0.0	0.02	0.01	0.0	<0.01	0.01	0.0	<0.01	<0.01	0.0	0.0	<0.01	0.02	0.01	<0.01	0.01	0.0	<0.01	<0.01	0.0	<0.01	0.02	0.01	0.0	<0.01	0.01	0.0	<0.01	<0.01	0.0	0.0	0.0	0.02
Low bush-cranberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01
High bush-cranberry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Red-osier dogwood	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Pitcherplant	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Wild black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	<0.01
Skunk currant	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01
Northern black currant	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	<0.01
Bristly gooseberry	0.01	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	<0.01
Swamp red currant	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01
Jack pine	0.01	0.01	0.01	<0.01	0.0	<0.01	0.0	<0.01	0.0	0.0	0.0	<0.01	<0.01	0.0	0.0	<0.01	0.0	<0.01	0.0	0.0	0.0	0.01	0.02	<0.01	<0.01	<0.01	0.0	<0.01	0.0	0.0	0.01	0.02	<0.01	0.0	0.0	<0.01	0.0	<0.01	0.0	0.0	0.0	<0.01	0.04
Bearberry	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.01
Common Labrador tea	<0.01	0.20	0.10	0.02	0.09	0.03	<0.01	<0.01	<0.01	0.0	0.0	0.16	0.09	0.0	0.03	<0.01	<0.01	<0.01	<0.01	0.0	0.0	<0.01	0.06	0.09	0.02	0.03	<0.01	<0.01	<0.01	0.0	<0.01	0.06	0.09	0.0	0.03	<0.01	<0.01	<0.01	<0.01	0.0	0.0	0.0	0.03
Labrador tea	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	<0.01	0.01	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	<0.01	0.01	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01
Wild mint	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01
Mosses	0.01	0.0	0.0	0.28	0.20	0.05	0.13	0.02	0.05	0.16	0.19	0.05	0.04	0.54	0.21	0.05	0.13	0.02	0.05	0.16	0.0	0.01	0.11	0.04	0.28	0.05	0.13	0.02	0.05	0.19	0.01	0.11	0.04	0.54	0.21	0.05	0.13	0.02	0.05	0.16	0.0	<0.01	0.07
Mushrooms	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Balsam poplar	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
Trembling aspen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.05
American red raspberry	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01
Sweet flag	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Saskatoon	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
White spruce	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.02
Black spruce	<0.01	0.11	0.06	0.02	0.02	0.01	<0.01	<0.01	0.0	0.01	0.0	0.02	0.01	<0.01	0.09	0.01	<0.01	<0.01	0.0	0.01	0.0	<0.01	0.03	0.01	0.02	0.01	<0.01	<0.01	0.0	0.0	<0.01	0.03	0.01	<0.01	0.09	0.01	<0.01	<0.01	0.0	0.01	0.0	0.0	0.03
American wild strawberry	<0.01	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01
Smooth wild strawberry	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.01
Sweet grass	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Tamarack	<0.01	0.0	<0.01	0.0	0.0	0.12	<0.01	<0.01	<0.01	0.0	0.0	<0.01	<0.01	0.0	0.0	0.12	<0.01	<0.01	<0.01	0.0	0.0	<0.01	<0.01	<0.01	0.0	0.12	<0.01	<0.01	<0.01	0.0	<0.01	<0.01	<0.01	0.0	0.0	0.12	<0.01	<0.01	<0.01	0.0	0.0	0.0	0.01
Willow species	0.02	0.05	0.01	0.0	0.0	0.07	0.0	0.10	0.01	0.0	0.0	0.0	<0.01	<0.01	0.0	0.13	0.0	0.10	0.01	0.0	<0.01	0.02	0.0	<0.01	0.0	0.07	0.0	0.10	0.01	0.0	0.02	0.0	<0.01	<0.01	0.0	0.13	0.0	0.10	0.01	0.0	<0.01	<0.01	0.02
Total	0.12	0.45	0.26	0.36	0.32	0.32	0.15	0.21	0.08	0.20	0.20	0.29	0.18	0.56	0.38	0.34	0.15	0.21	0.07	0.20	0.02	0.12	0.26	0.18	0.36	0.32	0.15	0.21	0.08	0.20	0.12	0.26	0.18	0.56	0.38	0.34	0.15	0.21	0.07	0.20	0.02	0.01	0.40

a) TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YLNR; CRDN (Clearwater River Dene Nation). 2019. Clearwater River Dene Nation Comments on Project Description NexGen Energy Ltd.'s Rook I Project. May 31, 2019.
b) SKCDC. 2021b. HABISask Project Review website. Accessed April 2021. Available at https://gisappl.saskatchewan.ca/Html5Ext/?viewer=habisask#.
c) McLaughlan MS, Wright RA, Jiricka RD. 2010. Field Guide to the Ecosites of Saskatchewan's Provincial Forests. Prince Albert, SK: Saskatchewan Ministry of Environment, Forest Service. 338 p.
d) Traditional use plant species name reflects broad group of plant or fungi species; therefore, the scientific name and SKCDC common name are not described.
e) Saskatchewan has over 40 willow species (Salix sp.; Harms VL. 2017. 2017 Annotated catalogue of Saskatchewan vascular plants. Saskatoon, SK. 240 p); therefore, the scientific name and SKCDC common name of all potential willow species are not described.
< = less than; n/o = not observed during baseline surveys; ELC = Ecological Land Classification; SKCDC = Saskatchewan Conservation Data Centre; n/a = not applicable.; TSD = technical support document; BNDN = Birch Narrows Dene Nation; BRDN = Buffalo River Dene Nation; MN-S = Métis Nation-Saskatchewan; YLNR = Ya'thi Néné Lands and Resources.

Table 13B-2: Traditional Use Plant Species Occupancy in the Local Study Area in the Base Case

Traditional Use Plant Species[a]	Scientific Name[b]	SKCDC Common Name[b]	ELC Unit[c]																																									
			BP 02	BP 03	BP 04	BP 06	BP 07	BP 11	BP 12	BP 14	BP 16	BS 02	BS 03	BS 04	BS 05	BS 06	BS 07	BS 08	BS 09	BS 10	BS 13	BS 14	BS 15	BP 02 (BU)	BP 03 (BU)	BP 04 (BU)	BP 06 (BU)	BP 07 (BU)	BP 11 (BU)	BP 12 (BU)	BP 14 (BU)	BP 16 (BU)	BS 02 (BU)	BS 03 (BU)	BS 04 (BU)	BS 05 (BU)	BS 06 (BU)	BS 07 (BU)	BS 08 (BU)	BS 09 (BU)	BS 13 (BU)	BS 14 (BU)	BS 15 (BU)	Recent Burn Upland
Berries	*Rubus arcticus* ssp. *acaulis*	Nagoon berry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Berries	*Rubus pubescens*	Dewberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Birch	*Betula glandulosa*	Dwarf birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Birch	*Betula occidentalis*	River birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Birch	*Betula papyrifera*	Paper birch	0.1	3.3	0.1	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Birch	*Betula pumila*	Swamp birch	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Blueberry	*Vaccinium myrtilloides*	Blueberry	2.3	12.4	0.1	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	203.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulrushes	*Juncus alpinoarticulatus*	Northern green rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulrushes	*Juncus nodosus* var. *nodosus*	Knotted rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulrushes	*Schoenoplectus acutus* var. *acutus*	Hard-stemmed bulrush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chokecherry	*Prunus virginiana* var. *viriginiana*	Chokecherry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Cloudberry	*Rubus chamaemorus*	Cloudberry	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cranberry	*Vaccinium oxycoccos*	Small cranberry	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cranberry, bog	*Vaccinium vitis-idaea*	Bog cranberry	3.0	10.5	0.1	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cranberry, low bush	*Viburnum edule*	Low bush-cranberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cranberry, high bush	*Viburnum opulus* var. *americanum*	High bush-cranberry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Dogwood	*Cornus sericea* ssp. *sericea*	Red-osier dogwood	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Frog tail	*Sarracenia purpurea* ssp. *gibbosa*	Pitcherplant	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Gooseberry	*Ribes americanum*	Wild black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gooseberry	*Ribes glandulosum*	Skunk currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gooseberry	*Ribes hudsonianum*	Northern black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gooseberry	*Ribes oxyacanthoides* var. *oxyacanthoides*	Bristly gooseberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gooseberry	*Ribes triste*	Swamp red currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jack pine	*Pinus banksiana*	Jack pine	15.7	30.1	0.5	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	148.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kinnikinnick	*Arctostaphylos uva-ursi*	Bearberry	0.7	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Labrador tea	*Rhododendron groenlandicum*	Common Labrador tea	0.0	0.3	<0.1	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Labrador tea	*Rhododendron tomentosum*	Labrador tea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mint	*Mentha canadensis*	Wild mint	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mosses[d]	n/a	Mosses	1.7	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mushroom[d]	n/a	Mushrooms	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Poplar	*Populus balsamifera* ssp. *balsamifera*	Balsam poplar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Poplar	*Populus tremuloides*	Trembling aspen	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Raspberry	*Rubus idaeus* ssp. *strigosus*	American red raspberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rat root	*Acorus americanus*	Sweet flag	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Saskatoon	*Amelanchier alnifolia* var. *alnifolia*	Saskatoon	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Spruce	*Picea glauca*	White spruce	0.0	20.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spruce	*Picea mariana*	Black spruce	0.5	4.3	0.1	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strawberry	*Fragaria vesca* ssp. *americana*	American wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strawberry	*Fragaria virginiana* ssp. *glauca*	Smooth wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sweetgrass	*Anthoxanthum hirtum* ssp. *arcticum*	Sweet grass	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Tamarack	*Larix laricina*	Tamarack	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Willow[e]	*Salix* sp.	Willow species	0.1	1.2	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Total	47.0	45.7	5.8	24.2	89.4	1.9	0.0	0.0	0.0	0.0	17.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	527.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 13B-2: Traditional Use Plant Species Occupancy in the Local Study Area in the Base Case

SKCDC Common Name[b]	ELC Unit[c]																																										Total
	BP 18	BP 19	BP 20	BP 21	BP 22	BP 23	BP 24	BP 25	BP 26	BP 27	BP 28	BS 17	BS 18	BS 19	BS 20	BS 21	BS 22	BS 23	BS 24	BS 25	BS 26	BP18 (BU)	BP19 (BU)	BP20 (BU)	BP21 (BU)	BP23 (BU)	BP24 (BU)	BP25 (BU)	BP26 (BU)	BP28 (BU)	BS16 (BU)	BS17 (BU)	BS18 (BU)	BS19 (BU)	BS20 (BU)	BS21 (BU)	BS22 (BU)	BS23 (BU)	BS24 (BU)	BS25 (BU)	BS26 (BU)	Recent Burn Wetland	
Nagoon berry	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Dewberry	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Dwarf birch	0.0	0.0	0.0	0.0	0.0	<0.1	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
River birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Paper birch	0.0	0.1	0.6	0.0	0.0	<0.1	0.0	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.8
Swamp birch	0.0	0.5	0.0	0.0	0.0	<0.1	0.0	0.2	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7
Blueberry	0.0	0.3	0.6	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	225.3
Northern green rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Knotted rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hard-stemmed bulrush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Chokecherry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Cloudberry	0.0	1.8	0.1	0.0	0.0	<0.1	0.0	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6
Small cranberry	0.0	0.7	1.6	0.0	0.0	<0.1	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3
Bog cranberry	0.0	1.1	0.7	0.0	0.0	<0.1	0.0	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.2
Low bush-cranberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
High bush-cranberry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Red-osier dogwood	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Pitcherplant	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Wild black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Skunk currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Northern black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Bristly gooseberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Swamp red currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jack pine	0.0	0.3	0.6	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	203.4
Bearberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.7
Common Labrador tea	0.0	10.6	5.6	0.0	0.0	<0.1	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.8
Labrador tea	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2
Wild mint	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Mosses	0.0	0.0	0.0	0.0	0.0	<0.1	0.8	0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.1
Mushrooms	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Balsam poplar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trembling aspen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.8
American red raspberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sweet flag	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Saskatoon	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
White spruce	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.3
Black spruce	0.0	5.7	3.3	0.0	0.0	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.0
American wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smooth wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sweet grass	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Tamarack	0.0	0.0	0.2	0.0	0.0	0.1	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Willow species	0.0	2.6	0.6	0.0	0.0	0.1	0.0	0.4	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.6
Total	0.0	23.6	15.1	0.0	0.0	0.3	0.9	0.9	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	748.8

a) TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YLNR; CRDN (Clearwater River Dene Nation). 2019. Clearwater River Dene Nation Comments on Project Description NexGen Energy Ltd.'s Rook I Project. May 31, 2019.

b) SKCDC (Saskatchewan Conservation Data Centre). 2021. HABISask Project Review website. Accessed April 2021. Available at https://gisappl.saskatchewan.ca/Html5Ext/?viewer=habisask#.

c) McLaughlan MS, Wright RA, Jiricka RD. 2010. Field Guide to the Ecosites of Saskatchewan's Provincial Forests. Prince Albert, SK: Saskatchewan Ministry of Environment, Forest Service. 338 p.

d) Traditional use plant species name reflects broad group of plant or fungi species; therefore, the scientific name and SKCDC common name are not described.

e) Saskatchewan has over 40 willow species (Salix sp.; Harms VL. 2017. 2017 Annotated catalogue of Saskatchewan vascular plants. Saskatoon, SK. 240 p); therefore, the scientific name and SKCDC common name of all potential willow species are not described.

< = less than; n/o = not observed during baseline surveys; ELC = Ecological Land Classification; SKCDC = Saskatchewan Conservation Data Centre; n/a = not applicable.; TSD = technical support document; BNDN = Birch Narrows Dene Nation; BRDN = Buffalo River Dene Nation; MN-S = Métis Nation-Saskatchewan; YLNR = Ya'thi Néné Lands and Resources.

Table 13B-3: Traditional Use Plant Species Occupancy in the Regional Study Area in the Base Case

Traditional Use Plant Species[a]	Scientific Name[b]	SKCDC Common Name[b]	ELC Unit[c]																																								
			BP 02	BP 03	BP 04	BP 06	BP 07	BP 11	BP 12	BP 14	BP 16	BS 02	BS 03	BS 04	BS 05	BS 06	BS 07	BS 08	BS 09	BS 10	BS 13	BS 14	BS 15	BP02 (BU)	BP03 (BU)	BP04 (BU)	BP06 (BU)	BP07 (BU)	BP11 (BU)	BP12 (BU)	BP14 (BU)	BP16 (BU)	BS02 (BU)	BS03 (BU)	BS04 (BU)	BS05 (BU)	BS06 (BU)	BS07 (BU)	BS08 (BU)	BS09 (BU)	BS13 (BU)	BS14 (BU)	BS15 (BU)	Recent Burn Upland
Berries	*Rubus arcticus* ssp. *acaulis*	Nagoon berry	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	<0.1	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	<0.1	0.0
Berries	*Rubus pubescens*	Dewberry	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Birch	*Betula glandulosa*	Dwarf birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Birch	*Betula occidentalis*	River birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Birch	*Betula papyrifera*	Paper birch	1.4	92.8	4.5	0.1	1.3	0.5	3.5	16.9	0.0	<0.1	1.9	98.0	0.1	<0.1	0.0	<0.1	0.2	<0.1	3.8	12.2	<0.1	34.5	77.1	4.9	0.1	2.6	0.1	0.1	3.3	117.6	<0.1	88.8	144.2	0.6	<0.1	<0.1	<0.1	0.5	18.5	4.4	<0.1	0.0
Birch	*Betula pumila*	Swamp birch	0.0	14.8	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	3.9	0.0	0.0	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	4.4
Blueberry	*Vaccinium myrtilloides*	Blueberry	31.5	343.4	8.4	<0.1	0.5	0.1	14.7	3.9	0.0	0.0	255.6	414.3	0.1	<0.1	0.2	<0.1	0.1	<0.1	0.8	1.3	<0.1	1,112.6	326.0	157.7	<0.1	0.9	<0.1	0.3	0.8	39.5	0.0	2,867.6	609.8	0.3	0.1	0.7	<0.1	0.2	4.0	1.5	<0.1	3.1
Bulrushes	*Juncus alpinoarticulatus*	Northern green rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulrushes	*Juncus nodosus* var. *nodosus*	Knotted rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulrushes	*Schoenoplectus acutus* var. *acutus*	Hard-stemmed bulrush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chokecherry	*Prunus virginiana* var. *viriginiana*	Chokecherry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Cloudberry	*Rubus chamaemorus*	Cloudberry	0.0	7.4	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.3	0.0	0.0	38.3
Cranberry	*Vaccinium oxycoccos*	Small cranberry	0.0	14.8	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.6
Cranberry, bog	*Vaccinium vitis-idaea*	Bog cranberry	42.1	291.4	7.1	<0.1	0.4	<0.1	12.5	2.6	0.0	0.0	223.8	351.6	0.1	<0.1	<0.1	<0.1	0.5	<0.1	1.3	0.6	<0.1	297.6	276.7	42.2	<0.1	0.8	<0.1	0.3	0.5	9.5	0.0	767.0	517.5	0.4	<0.1	0.2	<0.1	1.0	6.3	0.4	<0.1	128.5
Cranberry, low bush	*Viburnum edule*	Low bush-cranberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cranberry, high bush	*Viburnum opulus* var. *americanum*	High bush-cranberry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Dogwood	*Cornus sericea* ssp. *sericea*	Red-osier dogwood	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Frog tail	*Sarracenia purpurea* ssp. *gibbosa*	Pitcherplant	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Gooseberry	*Ribes americanum*	Wild black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gooseberry	*Ribes glandulosum*	Skunk currant	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0
Gooseberry	*Ribes hudsonianum*	Northern black currant	0.0	0.0	0.0	<0.1	0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	<0.1	<0.1	0.0	0.0	0.0	<0.1	0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	<0.1	0.0
Gooseberry	*Ribes oxyacanthoides* var. *oxyacanthoides*	Bristly gooseberry	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0
Gooseberry	*Ribes triste*	Swamp red currant	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jack pine	*Pinus banksiana*	Jack pine	219.1	835.2	27.5	<0.1	0.1	<0.1	37.4	16.9	0.0	0.0	1,043.9	1,051.2	0.3	0.1	0.3	<0.1	0.2	<0.1	0.1	0.2	<0.1	815.3	827.2	115.6	<0.1	0.1	<0.1	0.8	3.3	28.0	0.0	2,101.2	1,547.3	1.3	0.1	0.5	<0.1	0.5	0.6	1.0	<0.1	147.0
Kinnikinnick	*Arctostaphylos uva-ursi*	Bearberry	10.0	148.5	0.0	0.0	0.0	<0.1	4.0	0.0	0.0	0.0	70.2	112.0	<0.1	0.0	0.0	0.0	0.0	<0.1	0.8	0.5	0.0	167.1	88.1	23.7	0.0	0.0	<0.1	0.1	0.0	0.6	0.0	430.6	164.8	<0.1	<0.1	0.1	<0.1	0.0	4.0	<0.1	0.0	0.0
Labrador tea	*Rhododendron groenlandicum*	Common Labrador tea	0.0	9.3	0.2	<0.1	0.1	0.2	0.3	11.7	0.0	0.0	10.9	9.8	0.1	<0.1	0.0	<0.1	1.0	<0.1	1.3	4.0	<0.1	82.6	7.7	11.7	<0.1	0.1	<0.1	<0.1	2.3	34.3	0.0	212.8	14.4	0.4	<0.1	0.1	<0.1	2.2	6.3	1.3	<0.1	437.5
Labrador tea	*Rhododendron tomentosum*	Labrador tea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.4	0.0	0.0	0.0	0.0	0.1	0.0	0.0	7.7	0.0	0.0	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	43.1
Mint	*Mentha canadensis*	Wild mint	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0
Mosses[d]	n/a	Mosses	24.4	0.0	57.6	0.0	0.0	<0.1	12.6	0.0	1.4	<0.1	6.8	354.3	0.0	<0.1	0.1	<0.1	3.9	0.0	0.0	0.8	0.0	165.4	278.8	23.4	0.0	0.0	<0.1	0.3	0.0	15.8	<0.1	426.2	521.5	0.0	<0.1	0.1	<0.1	8.6	0.0	0.6	0.0	753.4
Mushroom[d]	n/a	Mushrooms	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Poplar	*Populus balsamifera* ssp. *balsamifera*	Balsam poplar	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0
Poplar	*Populus tremuloides*	Trembling aspen	0.0	7.4	0.0	0.2	2.4	<0.1	0.0	0.9	10.9	0.0	1.6	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.2	0.1	<0.1	132.6	0.0	18.8	0.2	4.8	<0.1	0.0	0.3	1.5	0.0	341.8	0.0	0.0	<0.1	0.1	<0.1	0.0	5.8	0.1	0.1	0.0
Raspberry	*Rubus idaeus* ssp. *strigosus*	American red raspberry	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	<0.1	0.0	0.0	0.0	<0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	<0.1	0.0
Rat root	*Acorus americanus*	Sweet flag	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Saskatoon	*Amelanchier alnifolia* var. *alnifolia*	Saskatoon	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Spruce	*Picea glauca*	White spruce	0.0	564.2	0.0	<0.1	0.7	0.3	3.8	0.4	4.0	0.0	6.2	106.4	0.2	0.0	0.0	0.0	0.0	0.0	2.4	0.3	<0.1	9.0	83.7	1.3	<0.1	1.3	0.1	0.1	0.1	1.9	0.0	23.2	156.6	0.8	<0.1	<0.1	<0.1	0.0	11.5	0.1	<0.1	0.0
Spruce	*Picea mariana*	Black spruce	7.5	120.6	7.6	0.0	0.0	0.1	1.7	54.5	0.0	<0.1	2.1	46.5	0.0	<0.1	0.9	<0.1	2.1	0.0	0.0	1.5	0.0	40.6	36.6	5.8	0.0	0.0	<0.1	<0.1	10.6	2.6	<0.1	104.7	68.4	0.0	<0.1	<0.1	<0.1	4.7	0.0	0.1	0.0	220.0
Strawberry	*Fragaria vesca* ssp. *americana*	American wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strawberry	*Fragaria virginiana* ssp. *glauca*	Smooth wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sweetgrass	*Anthoxanthum hirtum* ssp. *arcticum*	Sweet grass	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Tamarack	*Larix laricina*	Tamarack	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4
Willow[e]	*Salix* sp.	Willow species	1.4	33.4	0.0	<0.1	0.2	0.1	0.2	3.9	1.1	0.0	1.9	5.0	<0.1	<0.1	0.0	<0.1	0.1	<0.1	0.1	1.8	<0.1	25.0	4.0	3.5	<0.1	0.3	<0.1	<0.1	0.8	2.5	0.0	64.5	7.4	<0.1	<0.1	<0.1	<0.1	0.2	0.6	0.1	<0.1	0.0
		Total	655.6	1,269.8	342.3	337.6	2,483.4	113.0	0.3	5.8	1.3	90.7	117.7	31.3	<0.1	1,625.0	2,549.1	0.8	0.3	1.5	<0.1	8.2	<0.1	12.2	23.2	<0.1	2,889.7	2,005.9	409.6	0.4	11.7	0.4	1.8	23.2	253.8	<0.1	7,447.7	3,752.0	3.7	0.3	1.8	<0.1	17.8	59.4

Table 13B-3: Traditional Use Plant Species Occupancy in the Regional Study Area in the Base Case

SKCDC Common Name[b]	ELC Unit[c]																																									Total
	BP 18	BP 19	BP 20	BP 21	BP 22	BP 23	BP 24	BP 25	BP 26	BP 27	BP 28	BS 17	BS 18	BS 19	BS 20	BS 21	BS 22	BS 23	BS 24	BS 25	BS 26	BP18 (BU)	BP19 (BU)	BP20 (BU)	BP21 (BU)	BP23 (BU)	BP24 (BU)	BP25 (BU)	BP26 (BU)	BP28 (BU)	BS16 (BU)	BS17 (BU)	BS18 (BU)	BS19 (BU)	BS20 (BU)	BS21 (BU)	BS22 (BU)	BS23 (BU)	BS24 (BU)	BS25 (BU)	BS26 (BU)	Recent Burn Wetland	
Nagoon berry	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.6	0.0	0.0	0.0	0.0	0.3	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	0.0	0.1	0.0	<0.1	0.0	0.1	0.0	0.3	0.0	0.0	<0.1	0.0	0.2	0.0	0.0	<0.1	0.0	0.1	0.0	0.0	0.0	0.0	2.2
Dewberry	<0.1	0.0	0.0	0.0	0.0	<0.1	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	<0.1	0.0	0.1	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	0.0	0.0	1.4
Dwarf birch	<0.1	0.0	0.0	0.0	0.0	<0.1	0.2	0.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.7	<0.1	0.2	0.0	0.0	0.1	0.0	0.0	0.0	<0.1	<0.1	<0.1	1.7	0.0	<0.1	0.0	0.0	0.0	0.0	<0.1	1.4	<0.1	0.4	0.0	0.0	0.0	5.8
River birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Paper birch	0.9	4.3	12.5	0.0	0.0	0.2	0.0	1.8	0.7	0.0	0.0	0.5	2.5	0.0	0.0	<0.1	0.0	<0.1	0.1	0.0	0.2	2.0	0.0	0.1	0.0	0.1	0.0	0.8	1.0	0.0	<0.1	0.0	1.8	0.0	0.0	<0.1	0.0	0.2	0.2	0.0	0.5	0.0	764.9
Swamp birch	<0.1	17.1	0.0	0.3	0.0	0.3	0.0	14.9	0.4	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.2	0.1	0.0	0.0	<0.1	1.4	0.0	<0.1	0.2	0.0	6.7	0.7	0.0	<0.1	1.0	0.0	0.0	0.0	<0.1	0.0	1.6	0.1	0.0	0.0	0.0	70.8
Blueberry	0.1	8.5	12.5	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	<0.1	0.2	1.0	0.1	0.0	0.0	0.0	0.5	0.0	0.0	<0.1	0.7	1.8	0.0	0.0	0.0	0.0	0.1	0.0	0.0	<0.1	1.1	6,230.4
Northern green rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Knotted rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.8
Hard-stemmed bulrush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.5
Chokecherry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Cloudberry	0.1	58.5	1.7	<0.1	0.0	0.2	0.0	0.5	0.7	0.0	0.0	41.6	1.8	0.0	<0.1	<0.1	0.0	<0.1	0.1	0.0	0.0	0.2	12.2	0.1	<0.1	0.1	0.0	0.2	1.0	0.0	<0.1	8.4	1.2	0.0	<0.1	<0.1	0.0	0.1	0.2	0.0	0.0	0.0	176.7
Small cranberry	0.1	22.2	35.1	0.8	<0.1	0.8	0.3	0.5	0.7	<0.1	0.0	15.8	36.9	<0.1	<0.1	<0.1	1.0	<0.1	0.1	<0.1	0.0	0.2	13.9	2.0	<0.1	0.5	0.1	0.2	1.0	0.0	<0.1	9.5	26.2	<0.1	<0.1	<0.1	1.9	0.1	0.1	<0.1	0.0	0.0	230.0
Bog cranberry	<0.1	34.2	14.6	<0.1	0.0	0.5	0.0	1.1	0.7	0.0	0.0	24.3	10.6	0.0	<0.1	<0.1	0.0	<0.1	0.1	0.0	0.0	<0.1	40.9	0.6	<0.1	0.3	0.0	0.5	1.0	0.0	<0.1	28.1	7.5	0.0	<0.1	0.1	0.0	0.1	0.2	0.0	0.0	0.0	3,148.3
Low bush-cranberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
High bush-cranberry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Red-osier dogwood	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Pitcherplant	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Wild black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.8
Skunk currant	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Northern black currant	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	2.7
Bristly gooseberry	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	2.4
Swamp red currant	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Jack pine	0.1	8.5	12.5	0.1	0.0	0.1	0.0	1.1	0.0	0.0	0.0	2.0	2.7	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	0.0	0.2	46.8	0.2	<0.1	0.1	0.0	0.5	0.0	0.0	<0.1	32.2	1.9	0.0	0.0	<0.1	0.0	0.1	0.0	0.0	0.0	0.1	8,931.3
Bearberry	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	1,225.4
Common Labrador tea	0.1	340.8	123.0	0.4	0.7	1.0	<0.1	<0.1	0.7	0.0	0.0	242.2	129.0	0.0	<0.1	<0.1	<0.1	<0.1	0.1	0.0	0.0	0.2	139.2	7.2	<0.1	0.7	<0.1	<0.1	1.0	0.0	<0.1	95.7	91.7	0.0	0.1	<0.1	0.1	<0.1	0.2	0.0	0.0	0.0	2,036.5
Labrador tea	0.0	0.0	29.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.9	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	1.4	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	111.7
Wild mint	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0
Mosses	0.1	0.0	0.0	7.1	1.6	1.8	7.2	7.2	12.6	5.3	12.5	71.2	65.8	0.1	0.2	<0.1	27.0	0.1	2.0	<0.1	0.0	0.3	239.8	3.7	0.1	1.1	1.5	3.2	19.2	21.3	<0.1	164.8	46.8	0.1	0.5	0.3	54.1	0.7	4.3	<0.1	0.0	<0.1	3,439.5
Mushrooms	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Balsam poplar	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.3
Trembling aspen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	530.5
American red raspberry	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
Sweet flag	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Saskatoon	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
White spruce	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	981.0
Black spruce	<0.1	183.6	71.1	0.4	0.2	0.4	0.3	0.4	0.0	0.4	0.0	31.3	12.8	<0.1	0.1	<0.1	1.0	<0.1	0.0	<0.1	0.0	0.1	70.0	0.7	<0.1	0.3	0.1	0.2	0.0	0.0	<0.1	48.1	9.1	<0.1	0.2	0.1	2.0	<0.1	0.0	<0.1	0.0	0.0	1,171.8
American wild strawberry	<0.1	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Smooth wild strawberry	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Sweet grass	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Tamarack	<0.1	0.0	4.2	0.0	0.0	4.8	0.1	1.1	0.9	0.0	0.0	4.0	2.5	0.0	0.0	<0.1	0.5	<0.1	0.1	0.0	0.0	<0.1	1.4	0.1	0.0	3.0	<0.1	0.5	1.3	0.0	<0.1	1.0	1.8	0.0	0.0	0.8	0.9	0.1	0.3	0.0	0.0	0.0	35.5
Willow species	0.4	85.4	12.5	0.0	0.0	2.9	0.0	31.6	1.4	0.0	0.0	0.0	0.8	<0.1	0.0	<0.1	0.0	0.4	0.2	0.0	0.1	1.0	0.0	<0.1	0.0	1.8	0.0	14.1	2.1	0.0	<0.1	0.0	0.6	<0.1	0.0	0.9	0.0	3.3	0.5	0.0	0.1	<0.1	318.5
Total	2.7	763.1	329.6	9.0	2.5	13.0	8.0	65.8	19.8	6.5	13.1	433.3	270.2	0.1	0.3	0.1	30.1	0.9	3.1	<0.1	0.3	6.2	580.2	15.0	0.1	8.1	1.7	29.5	30.3	22.4	<0.1	398.8	192.1	0.1	0.8	2.4	60.4	6.9	6.6	<0.1	0.7	1.3	29,449.0

a) TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YLNR; CRDN (Clearwater River Dene Nation). 2019. Clearwater River Dene Nation Comments on Project Description NexGen Energy Ltd.'s Rook I Project. May 31, 2019.
b) SKCDC (Saskatchewan Conservation Data Centre). 2021. HABISask Project Review website. Accessed April 2021. Available at https://gisappl.saskatchewan.ca/Html5Ext/?viewer=habisask#.
c) McLaughlan MS, Wright RA, Jiricka RD. 2010. Field Guide to the Ecosites of Saskatchewan's Provincial Forests. Prince Albert, SK: Saskatchewan Ministry of Environment, Forest Service. 338 p.
d) Traditional use plant species name reflects broad group of plant or fungi species; therefore, the scientific name and SKCDC common name are not described.
e) Saskatchewan has over 40 willow species (Salix sp.; Harms VL. 2017. 2017 Annotated catalogue of Saskatchewan vascular plants. Saskatoon, SK. 240 p); therefore, the scientific name and SKCDC common name of all potential willow species are not described.
< = less than; n/o = not observed during baseline surveys; ELC = Ecological Land Classification; SKCDC = Saskatchewan Conservation Data Centre; n/a = not applicable.; TSD = technical support document; BNDN = Birch Narrows Dene Nation; BRDN = Buffalo River Dene Nation; MN-S = Métis Nation-Saskatchewan; YLNR = Ya'thi Néné Lands and Resources.

Table 13B-4: Traditional Use Plant Species Occupancy in the Local Study Area in the Application Case

Traditional Use Plant Species[a]	Scientific Name[b]	SKCDC Common Name[b]	ELC Unit[c]																																						
			BP 02	BP 03	BP 04	BP 06	BP 07	BP 11	BP 12	BP 14	BP 16	BS 02	BS 03	BS 04	BS 05	BS 06	BS 07	BS 08	BS 09	BS 10	BS 13	BS 14	BS 15	BP02 (BU)	BP03 (BU)	BP04 (BU)	BP06 (BU)	BP07 (BU)	BP11 (BU)	BP12 (BU)	BP14 (BU)	BP16 (BU)	BS02 (BU)	BS03 (BU)	BS04 (BU)	BS05 (BU)	BS06 (BU)	BS07 (BU)	BS08 (BU)	BS09 (BU)	BS13 (BU)	BS14 (BU)	BS15 (BU)	Recent Burn Upland
Berries	*Rubus arcticus* ssp. *acaulis*	Nagoon berry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Berries	*Rubus pubescens*	Dewberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Birch	*Betula glandulosa*	Dwarf birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Birch	*Betula occidentalis*	River birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Birch	*Betula papyrifera*	Paper birch	0.1	2.1	0.1	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Birch	*Betula pumila*	Swamp birch	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Blueberry	*Vaccinium myrtilloides*	Blueberry	1.7	7.9	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	113.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulrushes	*Juncus alpinoarticulatus*	Northern green rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulrushes	*Juncus nodosus* var. *nodosus*	Knotted rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulrushes	*Schoenoplectus acutus* var. *acutus*	Hard-stemmed bulrush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chokecherry	*Prunus virginiana* var. *viriginiana*	Chokecherry	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cloudberry	*Rubus chamaemorus*	Cloudberry	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cranberry	*Vaccinium oxycoccos*	Small cranberry	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cranberry, bog	*Vaccinium vitis-idaea*	Bog cranberry	2.2	6.7	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cranberry, low bush	*Viburnum edule*	Low bush-cranberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cranberry, high bush	*Viburnum opulus* var. *americanum*	High bush-cranberry	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Dogwood	*Cornus sericea* ssp. *sericea*	Red-osier dogwood	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Frog tail	*Sarracenia purpurea* ssp. *gibbosa*	Pitcherplant	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Gooseberry	*Ribes americanum*	Wild black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gooseberry	*Ribes glandulosum*	Skunk currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gooseberry	*Ribes hudsonianum*	Northern black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gooseberry	*Ribes oxyacanthoides* var. *oxyacanthoides*	Bristly gooseberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gooseberry	*Ribes triste*	Swamp red currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jack pine	*Pinus banksiana*	Jack pine	11.6	19.2	0.5	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kinnikinnick	*Arctostaphylos uva-ursi*	Bearberry	0.5	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Labrador tea	*Rhododendron groenlandicum*	Common Labrador tea	0.0	0.2	<0.1	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Labrador tea	*Rhododendron tomentosum*	Labrador tea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mint	*Mentha canadensis*	Wild mint	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mosses[d]	n/a	Mosses	1.3	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mushroom[d]	n/a	Mushrooms	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Poplar	*Populus balsamifera* ssp. *balsamifera*	Balsam poplar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Poplar	*Populus tremuloides*	Trembling aspen	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Raspberry	*Rubus idaeus* ssp. *strigosus*	American red raspberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rat root	*Acorus americanus*	Sweet flag	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Saskatoon	*Amelanchier alnifolia* var. *alnifolia*	Saskatoon	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Spruce	*Picea glauca*	White spruce	0.0	13.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spruce	*Picea mariana*	Black spruce	0.4	2.8	0.1	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strawberry	*Fragaria vesca* ssp. *americana*	American wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strawberry	*Fragaria virginiana* ssp. *glauca*	Smooth wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sweetgrass	*Anthoxanthum hirtum* ssp. *arcticum*	Sweet grass	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Tamarack	*Larix laricina*	Tamarack	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Willow[e]	*Salix* sp.	Willow species	0.1	0.8	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Total	34.7	29.2	5.8	17.9	57.0	1.9	0.0	0.0	0.0	0.0	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	295.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 13B-4: Traditional Use Plant Species Occupancy in the Local Study Area in the Application Case

SKCDC Common Name[b]	ELC Unit[c]																																										Total
	BP 18	BP 19	BP 20	BP 21	BP 22	BP 23	BP 24	BP 25	BP 26	BP 27	BP 28	BS 17	BS 18	BS 19	BS 20	BS 21	BS 22	BS 23	BS 24	BS 25	BS 26	BP18 (BU)	BP19 (BU)	BP20 (BU)	BP21 (BU)	BP23 (BU)	BP24 (BU)	BP25 (BU)	BP26 (BU)	BP28 (BU)	BS16 (BU)	BS17 (BU)	BS18 (BU)	BS19 (BU)	BS20 (BU)	BS21 (BU)	BS22 (BU)	BS23 (BU)	BS24 (BU)	BS25 (BU)	BS26 (BU)	Recent Burn Wetland	
Nagoon berry	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Dewberry	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Dwarf birch	0.0	0.0	0.0	0.0	0.0	<0.1	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
River birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Paper birch	0.0	0.1	0.4	0.0	0.0	<0.1	0.0	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.2
Swamp birch	0.0	0.4	0.0	0.0	0.0	<0.1	0.0	0.2	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Blueberry	0.0	0.2	0.4	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	129.2
Northern green rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Knotted rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hard-stemmed bulrush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Chokecherry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Cloudberry	0.0	1.5	0.1	0.0	0.0	<0.1	0.0	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
Small cranberry	0.0	0.6	1.1	0.0	0.0	<0.1	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4
Bog cranberry	0.0	0.9	0.5	0.0	0.0	<0.1	0.0	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.8
Low bush-cranberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
High bush-cranberry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Red-osier dogwood	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Pitcherplant	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Wild black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Skunk currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Northern black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Bristly gooseberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Swamp red currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jack pine	0.0	0.2	0.4	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	120.4
Bearberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.1
Common Labrador tea	0.0	8.8	4.0	0.0	0.0	<0.1	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.3
Labrador tea	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
Wild mint	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Mosses	0.0	0.0	0.0	0.0	0.0	<0.1	0.8	0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.6
Mushrooms	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Balsam poplar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trembling aspen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0
American red raspberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sweet flag	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Saskatoon	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
White spruce	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.1
Black spruce	0.0	4.7	2.3	0.0	0.0	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.1
American wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smooth wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sweet grass	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Tamarack	0.0	0.0	0.1	0.0	0.0	0.1	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Willow species	0.0	2.2	0.4	0.0	0.0	0.1	0.0	0.4	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0
Total	0.0	19.6	10.8	0.0	0.0	0.3	0.9	0.9	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	8.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	450.7

a) TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YLNR; CRDN (Clearwater River Dene Nation). 2019. Clearwater River Dene Nation Comments on Project Description NexGen Energy Ltd.'s Rook I Project. May 31, 2019.
b) SKCDC (Saskatchewan Conservation Data Centre). 2021. HABISask Project Review website. Accessed April 2021. Available at https://gisappl.saskatchewan.ca/Html5Ext/?viewer=habisask#.
c) McLaughlan MS, Wright RA, Jiricka RD. 2010. Field Guide to the Ecosites of Saskatchewan's Provincial Forests. Prince Albert, SK: Saskatchewan Ministry of Environment, Forest Service. 338 p.
d) Traditional use plant species name reflects broad group of plant or fungi species; therefore, the scientific name and SKCDC common name are not described.
e) Saskatchewan has over 40 willow species (Salix sp.; Harms VL. 2017. 2017 Annotated catalogue of Saskatchewan vascular plants. Saskatoon, SK. 240 p); therefore, the scientific name and SKCDC common name of all potential willow species are not described.
< = less than; n/o = not observed during baseline surveys; ELC = Ecological Land Classification; SKCDC = Saskatchewan Conservation Data Centre; n/a = not applicable.; TSD = technical support document; BNDN = Birch Narrows Dene Nation; BRDN = Buffalo River Dene Nation; MN-S = Métis Nation-Saskatchewan; YLNR = Ya'thi Néné Lands and Resources.

Table 13B-5: Traditional Use Plant Species Occupancy in the Regional Study Area in the Application Case

Traditional Use Plant Species[a]	Scientific Name[b]	SKCDC Common Name[b]	ELC Unit[c]																																								
			BP 02	BP 03	BP 04	BP 06	BP 07	BP 11	BP 12	BP 14	BP 16	BS 02	BS 03	BS 04	BS 05	BS 06	BS 07	BS 08	BS 09	BS 10	BS 13	BS 14	BS 15	BP02 (BU)	BP03 (BU)	BP04 (BU)	BP06 (BU)	BP07 (BU)	BP11 (BU)	BP12 (BU)	BP14 (BU)	BP16 (BU)	BS02 (BU)	BS03 (BU)	BS04 (BU)	BS05 (BU)	BS06 (BU)	BS07 (BU)	BS08 (BU)	BS09 (BU)	BS13 (BU)	BS14 (BU)	BS15 (BU)	Recent Burn Upland
Berries	*Rubus arcticus* ssp. *acaulis*	Nagoon berry	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	<0.1	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	<0.1	0.0
Berries	*Rubus pubescens*	Dewberry	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Birch	*Betula glandulosa*	Dwarf birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Birch	*Betula occidentalis*	River birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Birch	*Betula papyrifera*	Paper birch	1.4	91.6	4.5	0.1	1.3	0.5	3.5	15.4	0.0	<0.1	1.9	98.0	0.1	<0.1	0.0	<0.1	0.2	<0.1	3.8	12.2	<0.1	31.7	77.1	4.9	0.1	2.6	0.1	0.1	3.3	113.6	<0.1	88.8	144.2	0.6	<0.1	<0.1	<0.1	0.5	18.5	4.4	<0.1	0.0
Birch	*Betula pumila*	Swamp birch	0.0	14.7	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	3.9	0.0	0.0	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	4.4
Blueberry	*Vaccinium myrtilloides*	Blueberry	31.0	338.9	8.4	<0.1	0.5	0.1	14.7	3.5	0.0	0.0	255.6	414.3	0.1	<0.1	0.2	<0.1	0.1	<0.1	0.8	1.3	<0.1	1,023.5	326.0	157.7	<0.1	0.9	<0.1	0.3	0.8	38.2	0.0	2,867.6	609.8	0.3	0.1	0.7	<0.1	0.2	4.0	1.5	<0.1	3.1
Bulrushes	*Juncus alpinoarticulatus*	Northern green rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulrushes	*Juncus nodosus* var. *nodosus*	Knotted rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulrushes	*Schoenoplectus acutus* var. *acutus*	Hard-stemmed bulrush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chokecherry	*Prunus virginiana* var. *viriginiana*	Chokecherry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Cloudberry	*Rubus chamaemorus*	Cloudberry	0.0	7.3	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.3	0.0	0.0	38.3
Cranberry	*Vaccinium oxycoccos*	Small cranberry	0.0	14.7	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.6
Cranberry, bog	*Vaccinium vitis-idaea*	Bog cranberry	41.4	287.6	7.1	<0.1	0.4	<0.1	12.5	2.4	0.0	0.0	223.8	351.6	0.1	<0.1	<0.1	<0.1	0.5	<0.1	1.3	0.6	<0.1	273.8	276.7	42.2	<0.1	0.8	<0.1	0.3	0.5	9.2	0.0	767.0	517.5	0.4	<0.1	0.2	<0.1	1.0	6.3	0.4	<0.1	128.5
Cranberry, low bush	*Viburnum edule*	Low bush-cranberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cranberry, high bush	*Viburnum opulus* var. *americanum*	High bush-cranberry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Dogwood	*Cornus sericea* ssp. *sericea*	Red-osier dogwood	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Frog tail	*Sarracenia purpurea* ssp. *gibbosa*	Pitcherplant	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Gooseberry	*Ribes americanum*	Wild black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gooseberry	*Ribes glandulosum*	Skunk currant	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0
Gooseberry	*Ribes hudsonianum*	Northern black currant	0.0	0.0	0.0	<0.1	0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	<0.1	<0.1	0.0	0.0	0.0	<0.1	0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	<0.1	0.0
Gooseberry	*Ribes oxyacanthoides* var. *oxyacanthoides*	Bristly gooseberry	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0
Gooseberry	*Ribes triste*	Swamp red currant	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jack pine	*Pinus banksiana*	Jack pine	215.0	824.3	27.5	<0.1	0.1	<0.1	37.4	15.4	0.0	0.0	1,043.9	1,051.2	0.3	0.1	0.3	<0.1	0.2	<0.1	0.1	0.2	<0.1	749.9	827.2	115.6	<0.1	0.1	<0.1	0.8	3.3	27.0	0.0	2,101.2	1,547.3	1.3	0.1	0.5	<0.1	0.5	0.6	1.0	<0.1	147.0
Kinnikinnick	*Arctostaphylos uva-ursi*	Bearberry	9.9	146.5	0.0	0.0	0.0	<0.1	4.0	0.0	0.0	0.0	70.2	112.0	<0.1	0.0	0.0	0.0	0.0	<0.1	0.8	0.5	0.0	153.7	88.1	23.7	0.0	0.0	<0.1	0.1	0.0	0.6	0.0	430.6	164.8	<0.1	<0.1	0.1	<0.1	0.0	4.0	<0.1	0.0	0.0
Labrador tea	*Rhododendron groenlandicum*	Common Labrador tea	0.0	9.2	0.2	<0.1	0.1	0.2	0.3	10.6	0.0	0.0	10.9	9.8	0.1	<0.1	0.0	<0.1	1.0	<0.1	1.3	4.0	<0.1	76.0	7.7	11.7	<0.1	0.1	<0.1	<0.1	2.3	33.2	0.0	212.8	14.4	0.4	<0.1	0.1	<0.1	2.2	6.3	1.3	<0.1	437.5
Labrador tea	*Rhododendron tomentosum*	Labrador tea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.4	0.0	0.0	0.0	0.0	0.1	0.0	0.0	7.7	0.0	0.0	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	43.1
Mint	*Mentha canadensis*	Wild mint	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0
Mosses[d]	n/a	Mosses	24.0	0.0	57.6	0.0	0.0	<0.1	12.6	0.0	1.4	<0.1	6.8	354.3	0.0	<0.1	0.1	<0.1	3.9	0.0	0.0	0.8	0.0	152.1	278.8	23.4	0.0	0.0	<0.1	0.3	0.0	15.2	<0.1	426.2	521.5	0.0	<0.1	0.1	<0.1	8.6	0.0	0.6	0.0	753.4
Mushroom[d]	n/a	Mushrooms	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Poplar	*Populus balsamifera* ssp. *balsamifera*	Balsam poplar	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0
Poplar	*Populus tremuloides*	Trembling aspen	0.0	7.3	0.0	0.2	2.4	<0.1	0.0	0.8	10.9	0.0	1.6	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.2	0.1	<0.1	122.0	0.0	18.8	0.2	4.8	<0.1	0.0	0.3	1.5	0.0	341.8	0.0	0.0	<0.1	0.1	<0.1	0.0	5.8	0.1	0.1	0.0
Raspberry	*Rubus idaeus* ssp. *strigosus*	American red raspberry	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	<0.1	0.0	0.0	0.0	<0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	<0.1	0.0
Rat root	*Acorus americanus*	Sweet flag	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Saskatoon	*Amelanchier alnifolia* var. *alnifolia*	Saskatoon	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Spruce	*Picea glauca*	White spruce	0.0	556.9	0.0	<0.1	0.7	0.3	3.8	0.4	4.0	0.0	6.2	106.4	0.2	0.0	0.0	0.0	0.0	0.0	2.4	0.3	<0.1	8.3	83.7	1.3	<0.1	1.3	0.1	0.1	0.1	1.8	0.0	23.2	156.6	0.8	<0.1	<0.1	<0.1	0.0	11.5	0.1	<0.1	0.0
Spruce	*Picea mariana*	Black spruce	7.4	119.1	7.6	0.0	0.0	0.1	1.7	49.7	0.0	<0.1	2.1	46.5	0.0	<0.1	0.9	<0.1	2.1	0.0	0.0	1.5	0.0	37.4	36.6	5.8	0.0	0.0	<0.1	<0.1	10.6	2.5	<0.1	104.7	68.4	0.0	<0.1	<0.1	<0.1	4.7	0.0	0.1	0.0	220.0
Strawberry	*Fragaria vesca* ssp. *americana*	American wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strawberry	*Fragaria virginiana* ssp. *glauca*	Smooth wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sweetgrass	*Anthoxanthum hirtum* ssp. *arcticum*	Sweet grass	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Tamarack	*Larix laricina*	Tamarack	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4
Willow[e]	*Salix* sp.	Willow species	1.4	33.0	0.0	<0.1	0.2	0.1	0.2	3.5	1.1	0.0	1.9	5.0	<0.1	<0.1	0.0	<0.1	0.1	<0.1	0.1	1.8	<0.1	23.0	4.0	3.5	<0.1	0.3	<0.1	<0.1	0.8	2.5	0.0	64.5	7.4	<0.1	<0.1	<0.1	<0.1	0.2	0.6	0.1	<0.1	0.0
		Total	643.4	1,253.2	342.3	331.3	2,451.0	113.0	0.3	5.8	1.3	90.7	107.2	31.3	<0.1	1,625.0	2,549.1	0.8	0.3	1.5	<0.1	8.2	<0.1	12.2	23.2	<0.1	2,658.1	2,005.9	409.6	0.4	11.7	0.4	1.8	23.2	245.3	<0.1	7,447.7	3,752.0	3.7	0.3	1.8	<0.1	17.8	59.4

Table 13B-5: Traditional Use Plant Species Occupancy in the Regional Study Area in the Application Case

SKCDC Common Name[b]	ELC Unit[c]																																											Total
	BP 18	BP 19	BP 20	BP 21	BP 22	BP 23	BP 24	BP 25	BP 26	BP 27	BP 28	BS 17	BS 18	BS 19	BS 20	BS 21	BS 22	BS 23	BS 24	BS 25	BS 26	BP18 (BU)	BP19 (BU)	BP20 (BU)	BP21 (BU)	BP23 (BU)	BP24 (BU)	BP25 (BU)	BP26 (BU)	BP28 (BU)	BS16 (BU)	BS17 (BU)	BS18 (BU)	BS19 (BU)	BS20 (BU)	BS21 (BU)	BS22 (BU)	BS23 (BU)	BS24 (BU)	BS25 (BU)	BS26 (BU)	Recent Burn Wetland	
Nagoon berry	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.6	0.0	0.0	0.0	0.0	0.3	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	0.0	0.1	0.0	<0.1	0.0	0.1	0.0	0.3	0.0	0.0	<0.1	0.0	0.2	0.0	0.0	<0.1	0.0	0.1	0.0	0.0	0.0	0.0	2.2
Dewberry	<0.1	0.0	0.0	0.0	0.0	<0.1	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	<0.1	0.0	0.1	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	0.0	0.0	1.4
Dwarf birch	<0.1	0.0	0.0	0.0	0.0	<0.1	0.2	0.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.7	<0.1	0.2	0.0	0.0	0.1	0.0	0.0	0.0	<0.1	<0.1	<0.1	1.7	0.0	<0.1	0.0	0.0	0.0	0.0	<0.1	1.4	<0.1	0.4	0.0	0.0	0.0	5.8
River birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Paper birch	0.9	4.2	12.4	0.0	0.0	0.2	0.0	1.8	0.7	0.0	0.0	0.5	2.5	0.0	0.0	<0.1	0.0	<0.1	0.1	0.0	0.2	2.0	0.0	0.1	0.0	0.1	0.0	0.8	1.0	0.0	<0.1	0.0	1.8	0.0	0.0	<0.1	0.0	0.2	0.2	0.0	0.5	0.0	755.3
Swamp birch	<0.1	17.0	0.0	0.3	0.0	0.3	0.0	14.9	0.4	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.2	0.1	0.0	0.0	<0.1	1.4	0.0	<0.1	0.2	0.0	6.7	0.7	0.0	<0.1	1.0	0.0	0.0	0.0	<0.1	0.0	1.6	0.1	0.0	0.0	0.0	70.3
Blueberry	0.1	8.5	12.4	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	<0.1	0.2	1.0	0.1	0.0	0.0	0.0	0.5	0.0	0.0	<0.1	0.7	1.8	0.0	0.0	0.0	0.0	0.1	0.0	0.0	<0.1	1.1	6,134.3
Northern green rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Knotted rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.8
Hard-stemmed bulrush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.5
Chokecherry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Cloudberry	0.1	58.2	1.7	<0.1	0.0	0.2	0.0	0.5	0.7	0.0	0.0	41.6	1.8	0.0	<0.1	<0.1	0.0	<0.1	0.1	0.0	0.0	0.2	12.2	0.1	<0.1	0.1	0.0	0.2	1.0	0.0	<0.1	8.4	1.2	0.0	<0.1	<0.1	0.0	0.1	0.2	0.0	0.0	0.0	176.1
Small cranberry	0.1	22.1	34.7	0.8	<0.1	0.8	0.3	0.5	0.7	<0.1	0.0	15.8	36.9	<0.1	<0.1	<0.1	1.0	<0.1	0.1	<0.1	0.0	0.2	13.9	2.0	<0.1	0.5	0.1	0.2	1.0	0.0	<0.1	9.5	26.2	<0.1	<0.1	<0.1	1.9	0.1	0.1	<0.1	0.0	0.0	229.1
Bog cranberry	<0.1	34.0	14.4	<0.1	0.0	0.5	0.0	1.1	0.7	0.0	0.0	24.3	10.6	0.0	<0.1	<0.1	0.0	<0.1	0.1	0.0	0.0	<0.1	40.9	0.6	<0.1	0.3	0.0	0.5	1.0	0.0	<0.1	28.1	7.5	0.0	<0.1	0.1	0.0	0.1	0.2	0.0	0.0	0.0	3,119.0
Low bush-cranberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
High bush-cranberry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Red-osier dogwood	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Pitcherplant	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Wild black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.8
Skunk currant	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Northern black currant	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	2.7
Bristly gooseberry	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	2.4
Swamp red currant	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Jack pine	0.1	8.5	12.4	0.1	0.0	0.1	0.0	1.1	0.0	0.0	0.0	2.0	2.7	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	0.0	0.2	46.7	0.2	<0.1	0.1	0.0	0.5	0.0	0.0	<0.1	32.2	1.9	0.0	0.0	<0.1	0.0	0.1	0.0	0.0	0.0	0.1	8,848.3
Bearberry	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	1,209.9
Common Labrador tea	0.1	339.0	121.3	0.4	0.7	1.0	<0.1	<0.1	0.7	0.0	0.0	242.2	129.0	0.0	<0.1	<0.1	<0.1	<0.1	0.1	0.0	0.0	0.2	139.1	7.2	<0.1	0.7	<0.1	<0.1	1.0	0.0	<0.1	95.7	91.7	0.0	0.1	<0.1	0.1	<0.1	0.2	0.0	0.0	0.0	2,024.0
Labrador tea	0.0	0.0	29.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.9	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	1.4	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	111.0
Wild mint	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.7
Mosses	0.1	0.0	0.0	7.1	1.6	1.8	7.2	7.2	12.6	5.3	12.5	71.2	65.8	0.1	0.2	<0.1	27.0	0.1	2.0	<0.1	0.0	0.3	239.6	3.7	0.1	1.1	1.5	3.2	19.2	21.3	<0.1	164.8	46.8	0.1	0.5	0.3	54.1	0.7	4.3	<0.1	0.0	<0.1	3,425.0
Mushrooms	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Balsam poplar	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.3
Trembling aspen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	519.7
American red raspberry	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
Sweet flag	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Saskatoon	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
White spruce	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	972.8
Black spruce	<0.1	182.6	70.2	0.4	0.2	0.4	0.3	0.4	0.0	0.4	0.0	31.3	12.8	<0.1	0.1	<0.1	1.0	<0.1	0.0	<0.1	0.0	0.1	70.0	0.7	<0.1	0.3	0.1	0.2	0.0	0.0	<0.1	48.1	9.1	<0.1	0.2	0.1	2.0	<0.1	0.0	<0.1	0.0	0.0	1,160.0

Table 13B-5: Traditional Use Plant Species Occupancy in the Regional Study Area in the Application Case

SKCDC Common Name[b]	ELC Unit[c]																																									Total
	BP 18	BP 19	BP 20	BP 21	BP 22	BP 23	BP 24	BP 25	BP 26	BP 27	BP 28	BS 17	BS 18	BS 19	BS 20	BS 21	BS 22	BS 23	BS 24	BS 25	BS 26	BP18 (BU)	BP19 (BU)	BP20 (BU)	BP21 (BU)	BP23 (BU)	BP24 (BU)	BP25 (BU)	BP26 (BU)	BP28 (BU)	BS16 (BU)	BS17 (BU)	BS18 (BU)	BS19 (BU)	BS20 (BU)	BS21 (BU)	BS22 (BU)	BS23 (BU)	BS24 (BU)	BS25 (BU)	BS26 (BU)	Recent Burn Wetland	
American wild strawberry	<0.1	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Smooth wild strawberry	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1
Sweet grass	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Tamarack	<0.1	0.0	4.1	0.0	0.0	4.8	0.1	1.1	0.9	0.0	0.0	4.0	2.5	0.0	0.0	<0.1	0.5	<0.1	0.1	0.0	0.0	<0.1	1.4	0.1	0.0	3.0	<0.1	0.5	1.3	0.0	<0.1	1.0	1.8	0.0	0.0	0.8	0.9	0.1	0.3	0.0	0.0	0.0	35.3
Willow species	0.4	85.0	12.4	0.0	0.0	2.9	0.0	31.5	1.4	0.0	0.0	0.0	0.8	<0.1	0.0	<0.1	0.0	0.4	0.2	0.0	0.1	1.0	0.0	<0.1	0.0	1.8	0.0	14.1	2.1	0.0	<0.1	0.0	0.6	<0.1	0.0	0.9	0.0	3.3	0.5	0.0	0.1	<0.1	314.9
Total	2.7	759.0	325.2	9.0	2.5	13.0	8.0	65.8	19.8	6.5	13.1	433.3	270.2	0.1	0.3	0.1	30.1	0.9	3.1	<0.1	0.3	6.2	579.8	15.0	0.1	8.1	1.7	29.5	30.3	22.4	<0.1	398.8	192.1	0.1	0.8	2.4	60.4	6.9	6.6	<0.1	0.7	1.3	29,151.0

a) TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YLNR; CRDN (Clearwater River Dene Nation). 2019. Clearwater River Dene Nation Comments on Project Description NexGen Energy Ltd.'s Rook I Project. May 31, 2019.
b) SKCDC (Saskatchewan Conservation Data Centre). 2021. HABISask Project Review website. Accessed April 2021. Available at https://gisappl.saskatchewan.ca/Html5Ext/?viewer=habisask#.
c) McLaughlan MS, Wright RA, Jiricka RD. 2010. Field Guide to the Ecosites of Saskatchewan's Provincial Forests. Prince Albert, SK: Saskatchewan Ministry of Environment, Forest Service. 338 p.
d) Traditional use plant species name reflects broad group of plant or fungi species; therefore, the scientific name and SKCDC common name are not described.
e) Saskatchewan has over 40 willow species (Salix sp.; Harms VL. 2017. 2017 Annotated catalogue of Saskatchewan vascular plants. Saskatoon, SK. 240 p); therefore, the scientific name and SKCDC common name of all potential willow species are not described.
< = less than; n/o = not observed during baseline surveys; ELC = Ecological Land Classification; SKCDC = Saskatchewan Conservation Data Centre; n/a = not applicable.; TSD = technical support document; BNDN = Birch Narrows Dene Nation; BRDN = Buffalo River Dene Nation; MN-S = Métis Nation-Saskatchewan; YLNR = Ya'thi Néné Lands and Resources.

Table 13B-6: Traditional Use Plant Species Occupancy in the Regional Study Area in the Reasonably Foreseeable Development Case

Traditional Use Plant Species[a]	Scientific Name[b]	SKCDC Common Name[b]	ELC Unit[c]																																								
			BP 02	BP 03	BP 04	BP 06	BP 07	BP 11	BP 12	BP 14	BP 16	BS 02	BS 03	BS 04	BS 05	BS 06	BS 07	BS 08	BS 09	BS 10	BS 13	BS 14	BS 15	BP02 (BU)	BP03 (BU)	BP04 (BU)	BP06 (BU)	BP07 (BU)	BP11 (BU)	BP12 (BU)	BP14 (BU)	BP16 (BU)	BS02 (BU)	BS03 (BU)	BS04 (BU)	BS05 (BU)	BS06 (BU)	BS07 (BU)	BS08 (BU)	BS09 (BU)	BS13 (BU)	BS14 (BU)	BS15 (BU)	Recent Burn Upland
Berries	*Rubus arcticus* ssp. *acaulis*	Nagoon berry	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	<0.1	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	<0.1	0.0
Berries	*Rubus pubescens*	Dewberry	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Birch	*Betula glandulosa*	Dwarf birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Birch	*Betula occidentalis*	River birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Birch	*Betula papyrifera*	Paper birch	1.3	90.6	4.5	0.1	1.3	0.5	3.5	15.4	0.0	<0.1	1.9	98.0	0.1	<0.1	0.0	<0.1	0.2	<0.1	3.8	8.0	<0.1	27.7	77.1	4.9	0.1	2.6	0.1	0.1	3.3	103.6	<0.1	88.5	144.2	0.6	<0.1	<0.1	<0.1	0.5	18.5	3.9	<0.1	0.0
Birch	*Betula pumila*	Swamp birch	0.0	14.5	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	3.8	0.0	0.0	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	4.4
Blueberry	*Vaccinium myrtilloides*	Blueberry	29.0	335.1	8.4	<0.1	0.5	0.1	14.7	3.5	0.0	0.0	255.6	414.3	0.1	<0.1	0.2	<0.1	0.1	<0.1	0.8	0.8	<0.1	894.6	326.0	157.7	<0.1	0.9	<0.1	0.3	0.8	34.8	0.0	2,858.5	609.8	0.3	0.1	0.7	<0.1	0.2	4.0	1.3	<0.1	3.1
Bulrushes	*Juncus alpinoarticulatus*	Northern green rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulrushes	*Juncus nodosus* var. *nodosus*	Knotted rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulrushes	*Schoenoplectus acutus* var. *acutus*	Hard-stemmed bulrush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chokecherry	*Prunus virginiana* var. *viriginiana*	Chokecherry	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cloudberry	*Rubus chamaemorus*	Cloudberry	0.0	7.2	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.3	0.0	0.0	38.3
Cranberry	*Vaccinium oxycoccos*	Small cranberry	0.0	14.5	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.6
Cranberry, bog	*Vaccinium vitis-idaea*	Bog cranberry	38.8	284.4	7.1	<0.1	0.4	<0.1	12.5	2.4	0.0	0.0	223.8	351.6	0.1	<0.1	<0.1	<0.1	0.5	<0.1	1.3	0.4	<0.1	239.3	276.7	42.2	<0.1	0.8	<0.1	0.3	0.5	8.4	0.0	764.6	517.5	0.4	<0.1	0.2	<0.1	1.0	6.3	0.3	<0.1	128.5
Cranberry, low bush	*Viburnum edule*	Low bush-cranberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cranberry, high bush	*Viburnum opulus* var. *americanum*	High bush-cranberry	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Dogwood	*Cornus sericea* ssp. *sericea*	Red-osier dogwood	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Frog tail	*Sarracenia purpurea* ssp. *gibbosa*	Pitcherplant	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Gooseberry	*Ribes americanum*	Wild black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gooseberry	*Ribes glandulosum*	Skunk currant	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0
Gooseberry	*Ribes hudsonianum*	Northern black currant	0.0	0.0	0.0	<0.1	0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	<0.1	<0.1	0.0	0.0	0.0	<0.1	0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	<0.1	0.0
Gooseberry	*Ribes oxyacanthoides* var. *oxyacanthoides*	Bristly gooseberry	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0
Gooseberry	*Ribes triste*	Swamp red currant	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jack pine	*Pinus banksiana*	Jack pine	201.5	815.1	27.5	<0.1	0.1	<0.1	37.4	15.4	0.0	0.0	1,043.9	1,051.2	0.3	0.1	0.3	<0.1	0.2	<0.1	0.1	0.1	<0.1	655.5	827.2	115.6	<0.1	0.1	<0.1	0.8	3.3	24.6	0.0	2,094.5	1,547.3	1.3	0.1	0.5	<0.1	0.5	0.6	0.9	<0.1	147.0
Kinnikinnick	*Arctostaphylos uva-ursi*	Bearberry	9.2	144.9	0.0	0.0	0.0	<0.1	4.0	0.0	0.0	0.0	70.2	112.0	<0.1	0.0	0.0	0.0	0.0	<0.1	0.8	0.3	0.0	134.3	88.1	23.7	0.0	0.0	<0.1	0.1	0.0	0.5	0.0	429.2	164.8	<0.1	<0.1	0.1	<0.1	0.0	4.0	<0.1	0.0	0.0
Labrador tea	*Rhododendron groenlandicum*	Common Labrador tea	0.0	9.1	0.2	<0.1	0.1	0.2	0.3	10.6	0.0	0.0	10.9	9.8	0.1	<0.1	0.0	<0.1	1.0	<0.1	1.3	2.6	<0.1	66.4	7.7	11.7	<0.1	0.1	<0.1	<0.1	2.3	30.3	0.0	212.1	14.4	0.4	<0.1	0.1	<0.1	2.2	6.3	1.2	<0.1	437.5
Labrador tea	*Rhododendron tomentosum*	Labrador tea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.4	0.0	0.0	0.0	0.0	0.1	0.0	0.0	7.7	0.0	0.0	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	43.1
Mint	*Mentha canadensis*	Wild mint	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0
Mosses[d]	n/a	Mosses	22.5	0.0	57.6	0.0	0.0	<0.1	12.6	0.0	1.4	<0.1	6.8	354.3	0.0	<0.1	0.1	<0.1	3.9	0.0	0.0	0.5	0.0	133.0	278.8	23.4	0.0	0.0	<0.1	0.3	0.0	13.9	<0.1	424.8	521.5	0.0	<0.1	0.1	<0.1	8.6	0.0	0.5	0.0	753.4
Mushroom[d]	n/a	Mushrooms	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Poplar	*Populus balsamifera* ssp. *balsamifera*	Balsam poplar	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0
Poplar	*Populus tremuloides*	Trembling aspen	0.0	7.2	0.0	0.2	2.4	<0.1	0.0	0.8	10.9	0.0	1.6	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.2	<0.1	<0.1	106.6	0.0	18.8	0.2	4.8	<0.1	0.0	0.3	1.3	0.0	340.7	0.0	0.0	<0.1	0.1	<0.1	0.0	5.8	0.1	0.1	0.0
Raspberry	*Rubus idaeus* ssp. *strigosus*	American red raspberry	0.0	0.0	0.0	<0.1	0.1	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	<0.1	0.0	0.0	0.0	<0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	<0.1	0.0
Rat root	*Acorus americanus*	Sweet flag	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Saskatoon	*Amelanchier alnifolia* var. *alnifolia*	Saskatoon	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Spruce	*Picea glauca*	White spruce	0.0	550.7	0.0	<0.1	0.7	0.3	3.8	0.4	4.0	0.0	6.2	106.4	0.2	0.0	0.0	0.0	0.0	0.0	2.4	0.2	<0.1	7.2	83.7	1.3	<0.1	1.3	0.1	0.1	0.1	1.7	0.0	23.1	156.6	0.8	<0.1	<0.1	<0.1	0.0	11.5	0.1	<0.1	0.0
Spruce	*Picea mariana*	Black spruce	6.9	117.7	7.6	0.0	0.0	0.1	1.7	49.7	0.0	<0.1	2.1	46.5	0.0	<0.1	0.9	<0.1	2.1	0.0	0.0	1.0	0.0	32.7	36.6	5.8	0.0	0.0	<0.1	<0.1	10.6	2.3	<0.1	104.3	68.4	0.0	<0.1	<0.1	<0.1	4.7	0.0	0.1	0.0	220.0
Strawberry	*Fragaria vesca* ssp. *americana*	American wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strawberry	*Fragaria virginiana* ssp. *glauca*	Smooth wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sweetgrass	*Anthoxanthum hirtum* ssp. *arcticum*	Sweet grass	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Tamarack	*Larix laricina*	Tamarack	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4
Willow[e]	*Salix* sp.	Willow species	1.3	32.6	0.0	<0.1	0.2	0.1	0.2	3.5	1.1	0.0	1.9	5.0	<0.1	<0.1	0.0	<0.1	0.1	<0.1	0.1	1.2	<0.1	20.1	4.0	3.5	<0.1	0.3	<0.1	<0.1	0.8	2.2	0.0	64.3	7.4	<0.1	<0.1	<0.1	<0.1	0.2	0.6	0.1	<0.1	0.0
		Total	602.8	1,239.2	342.3	310.4	2,423.7	113.0	0.3	5.8	1.3	90.7	107.2	31.3	<0.1	1,625.0	2,549.1	0.8	0.3	1.5	<0.1	8.2	<0.1	12.2	15.2	<0.1	2,323.5	2,005.9	409.6	0.4	11.7	0.4	1.8	23.2	223.7	<0.1	7,423.9	3,752.0	3.7	0.3	1.8	<0.1	17.8	59.4

Table 13B-6: Traditional Use Plant Species Occupancy in the Regional Study Area in the Reasonably Foreseeable Development Case

SKCDC Common Name[b]	ELC Unit[c]																																									Total
	BP 18	BP 19	BP 20	BP 21	BP 22	BP 23	BP 24	BP 25	BP 26	BP 27	BP 28	BS 17	BS 18	BS 19	BS 20	BS 21	BS 22	BS 23	BS 24	BS 25	BS 26	BP18 (BU)	BP19 (BU)	BP20 (BU)	BP21 (BU)	BP23 (BU)	BP24 (BU)	BP25 (BU)	BP26 (BU)	BP28 (BU)	BS16 (BU)	BS17 (BU)	BS18 (BU)	BS19 (BU)	BS20 (BU)	BS21 (BU)	BS22 (BU)	BS23 (BU)	BS24 (BU)	BS25 (BU)	BS26 (BU)	Recent Burn Wetland	
Nagoon berry	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.6	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.3	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	2.2
Dewberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4
Dwarf birch	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.4	0.0	0.0	0.0	5.8
River birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Paper birch	0.9	4.2	12.3	0.0	0.0	0.2	0.0	1.8	0.7	0.0	0.0	0.5	2.5	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	2.0	0.0	0.1	0.0	0.1	0.0	0.8	1.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.5	0.0	735.0
Swamp birch	0.0	16.9	0.0	0.3	0.0	0.3	0.0	14.9	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	1.4	0.0	0.0	0.2	0.0	6.7	0.7	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.6	0.1	0.0	0.0	0.0	69.9
Blueberry	0.1	8.4	12.3	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.0	0.1	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.7	1.8	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.1	5,986.4
Northern green rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Knotted rush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
Hard stemmed bulrush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.5
Chokecherry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Cloudberry	0.1	57.8	1.6	0.0	0.0	0.2	0.0	0.5	0.7	0.0	0.0	41.6	1.8	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	12.2	0.1	0.0	0.1	0.0	0.2	1.0	0.0	0.0	8.4	1.2	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	175.7
Small cranberry	0.1	22.0	34.3	0.8	0.0	0.8	0.2	0.5	0.7	0.0	0.0	15.8	36.9	0.0	0.0	0.0	1.0	0.0	0.1	0.0	0.0	0.2	13.9	2.0	0.0	0.5	0.1	0.2	1.0	0.0	0.0	9.5	26.2	0.0	0.0	0.0	1.9	0.1	0.1	0.0	0.0	0.0	228.5
Bog cranberry	0.0	33.8	14.3	0.0	0.0	0.5	0.0	1.1	0.7	0.0	0.0	24.3	10.6	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	40.9	0.6	0.0	0.3	0.0	0.5	1.0	0.0	0.0	28.1	7.5	0.0	0.0	0.1	0.0	0.1	0.2	0.0	0.0	0.0	3,074.8
Low bush-cranberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
High bush-cranberry	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Red osier dogwood	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Pitcherplant	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Wild black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.8
Skunk currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Northern black currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	2.7
Bristly gooseberry	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	2.4
Swamp red currant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Jack pine	0.1	8.4	12.3	0.1	0.0	0.1	0.0	1.1	0.0	0.0	0.0	2.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	46.7	0.2	0.0	0.1	0.0	0.5	0.0	0.0	0.0	32.2	1.9	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	8,721.7
Bearberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,186.7
Common Labrador tea	0.1	336.9	120.1	0.4	0.7	1.0	0.0	0.0	0.7	0.0	0.0	242.2	129.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	139.1	7.2	0.0	0.7	0.0	0.0	1.0	0.0	0.0	95.7	91.7	0.0	0.1	0.0	0.1	0.0	0.2	0.0	0.0	0.0	2,005.9
Labrador tea	0.0	0.0	29.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	110.4
Wild mint	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.3
Mosses	0.1	0.0	0.0	7.1	1.6	1.8	6.8	7.2	12.5	5.3	12.5	71.2	65.8	0.1	0.2	0.0	27.0	0.1	2.0	0.0	0.0	0.3	239.6	3.7	0.1	1.1	1.5	3.2	19.2	21.3	0.0	164.8	46.8	0.1	0.5	0.3	54.1	0.7	4.3	0.0	0.0	0.0	3,400.8
Mushrooms	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Balsam poplar	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.3
Trembling aspen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	503.0
American red raspberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
Sweet flag	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Saskatoon	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
White spruce	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	965.2
Black spruce	0.0	181.5	69.4	0.4	0.2	0.4	0.2	0.4	0.0	0.4	0.0	31.3	12.8	0.0	0.1	0.0	1.0	0.0	0.0	0.0	0.0	0.1	70.0	0.7	0.0	0.3	0.1	0.2	0.0	0.0	0.0	48.1	9.1	0.0	0.2	0.1	2.0	0.0	0.0	0.0	0.0	0.0	1,150.6
American wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Smooth wild strawberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sweet grass	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Tamarack	0.0	0.0	4.1	0.0	0.0	4.8	0.1	1.1	0.9	0.0	0.0	4.0	2.5	0.0	0.0	0.0	0.5	0.0	0.1	0.0	0.0	0.0	1.4	0.1	0.0	3.0	0.0	0.5	1.3	0.0	0.0	1.0	1.8	0.0	0.0	0.8	0.9	0.1	0.3	0.0	0.0	0.0	35.2
Willow species	0.4	84.4	12.3	0.0	0.0	2.9	0.0	31.5	1.4	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.4	0.2	0.0	0.1	1.0	0.0	0.0	0.0	1.8	0.0	14.1	2.1	0.0	0.0	0.0	0.6	0.0	0.0	0.9	0.0	3.3	0.5	0.0	0.1	0.0	309.8
Total	2.7	754.4	321.9	9.0	2.5	13.0	7.6	65.8	19.7	6.5	13.1	433.3	270.2	0.1	0.3	0.1	30.1	0.9	3.1	0.0	0.3	6.2	579.8	15.0	0.1	8.1	1.7	29.5	30.3	22.4	0.0	398.8	192.1	0.1	0.8	2.4	60.4	6.9	6.6	0.0	0.7	1.3	28,705.1

a) TSD II: BNDN; TSD III: BRDN; TSD IV: MN-S; TSD V.1: CRDN; TSD V.2: CRDN; TSD VI: YLNR; CRDN (Clearwater River Dene Nation). 2019. Clearwater River Dene Nation Comments on Project Description NexGen Energy Ltd.'s Rook I Project. May 31, 2019.
b) SKCDC (Saskatchewan Conservation Data Centre). 2021. HABISask Project Review website. Accessed April 2021. Available at https://gisappl.saskatchewan.ca/Html5Ext/?viewer=habisask#.
c) McLaughlan MS, Wright RA, Jiricka RD. 2010. Field Guide to the Ecosites of Saskatchewan's Provincial Forests. Prince Albert, SK: Saskatchewan Ministry of Environment, Forest Service. 338 p.
d) Traditional use plant species name reflects broad group of plant or fungi species; therefore, the scientific name and SKCDC common name are not described.
e) Saskatchewan has over 40 willow species (Salix sp.; Harms VL. 2017. 2017 Annotated catalogue of Saskatchewan vascular plants. Saskatoon, SK. 240 p); therefore, the scientific name and SKCDC common name of all potential willow species are not described.
< = less than; n/o = not observed during baseline surveys; ELC = Ecological Land Classification; SKCDC = Saskatchewan Conservation Data Centre; n/a = not applicable.; TSD = technical support document; BNDN = Birch Narrows Dene Nation; BRDN = Buffalo River Dene Nation; MN-S = Métis Nation-Saskatchewan; YLNR = Ya'thi Néné Lands and Resources.