Near Surface Disposal Facility

Deep River, Renfrew County, Ontario

ENVIRONMENTAL IMPACT STATEMENT

Volume 2: EIS Report

Canadian Nuclear Laboratories

Laboratoires Nucléaires Canadiens

Prepared by:

GOLDER

Project Number: 1547525
Revision 2; November 27, 2020

Revision History

Title	Environmental Impact Statement for the Near Surface Disposal Facility Project

Revision No.	Revision 0
Date:	March 17, 2017
Prepared by:	Golder Associates Ltd.
Reviewed by:	Marci Mehl and Alyson Beal (Golder Associates Ltd.)
Accepted by:	Canadian Nuclear Laboratories

Revision No.	Revision 1
Date:	November 13, 2019
Prepared by:	Golder Associates Ltd.
Contribution by:	Arcadis Canada Inc. (Input to Section 5.7 and Section 5.8)
Reviewed by:	Callum Squires and Alyson Beal (Golder Associates Ltd.)
Accepted by:	Canadian Nuclear Laboratories

Revision No.	Revision 2
Date:	November 27, 2020
Prepared by:	Golder Associates Ltd.
Contribution by:	Arcadis Canada Inc. (Input to Section 5.7 and Section 5.8)
Reviewed by:	Callum Squires and Alyson Beal (Golder Associates Ltd.)
Accepted by:	Canadian Nuclear Laboratories

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1.0 INTRODUCTION

Canadian Nuclear Laboratories (CNL) is proposing the construction and operation of a Near Surface Disposal Facility (NSDF) for the disposal of solid, low-level radioactive waste (LLW) at Chalk River Laboratories (CRL) (referred to as the NSDF Project). The NSDF Project is based on the mandate of Atomic Energy of Canada Limited (AECL), a federal crown corporation, to substantially reduce the risks associated with the waste and to create conditions for the revitalization of the CRL site. CNL is a private-sector company that is contractually responsible for the management and operation of nuclear sites, facilities and assets owned by AECL.

For more than 70 years, AECL (and now CNL) has been making advances in nuclear science and technology in the interest of Canadians. This includes the production of medical isotopes that have treated over one billion patients worldwide, as well as developments in clean energy which help reduce greenhouse gas emissions. Through investments in the revitalization of the CRL site, that mission and innovative science will continue into the future. However, this proud history has created nuclear liabilities in the form of waste. Furthermore, past waste management practices, which met the standards of the day, are no longer acceptable now. Specifically, the historic waste management areas lack robust containment, which has led to impacts in the surrounding environment.

Presently, wastes at the CNL sites are temporarily and safely contained in waste storage systems in accordance with current licence conditions that protect workers, the public and the environment. However, the practice of continuing to build additional temporary storage systems at the CRL site for LLW is not consistent with modern waste management principles. In accordance with *Canada's Radioactive Waste Policy Framework* (Government of Canada 2015), the waste producers and owners of radioactive waste are responsible for the funding, organization, management and operation of disposal and other facilities required for their wastes. Responsible nuclear waste management includes full life cycle management from generation to disposal.

The purpose of the NSDF Project is to provide the permanent disposal of current and future LLW at the CRL site in a manner that is protective of both the public and the environment. Further, the NSDF Project would enable the remediation of historically contaminated lands and legacy waste management areas, as well as the decommissioning of outdated infrastructure to facilitate the CRL site revitalization.

The NSDF is designed to be a permanent solution which will reduce the risk associated with temporary waste storage at the CRL site because the facility has the appropriate design life to contain and isolate the inventory until it is sufficiently decayed. The facility has been designed so that the wastes will be safely managed long term without a need for retrieval. An overview of the CRL site, including the CRL main campus, existing waste management areas and proposed NSDF Project location is presented on Figure 1.0-1.

The waste to be placed in the NSDF will be LLW, which is a type of radioactive waste suitable for disposal in engineered near surface facilities that provide isolation and containment for periods of up to a few hundred years in alignment with international standards. All LLW to be disposed at the NSDF Project will be required to meet the waste acceptance criteria established to assure that it is acceptable for disposal at the NSDF to meet operational and post-closure safety requirements. This is described in detail in Section 3.3.3.

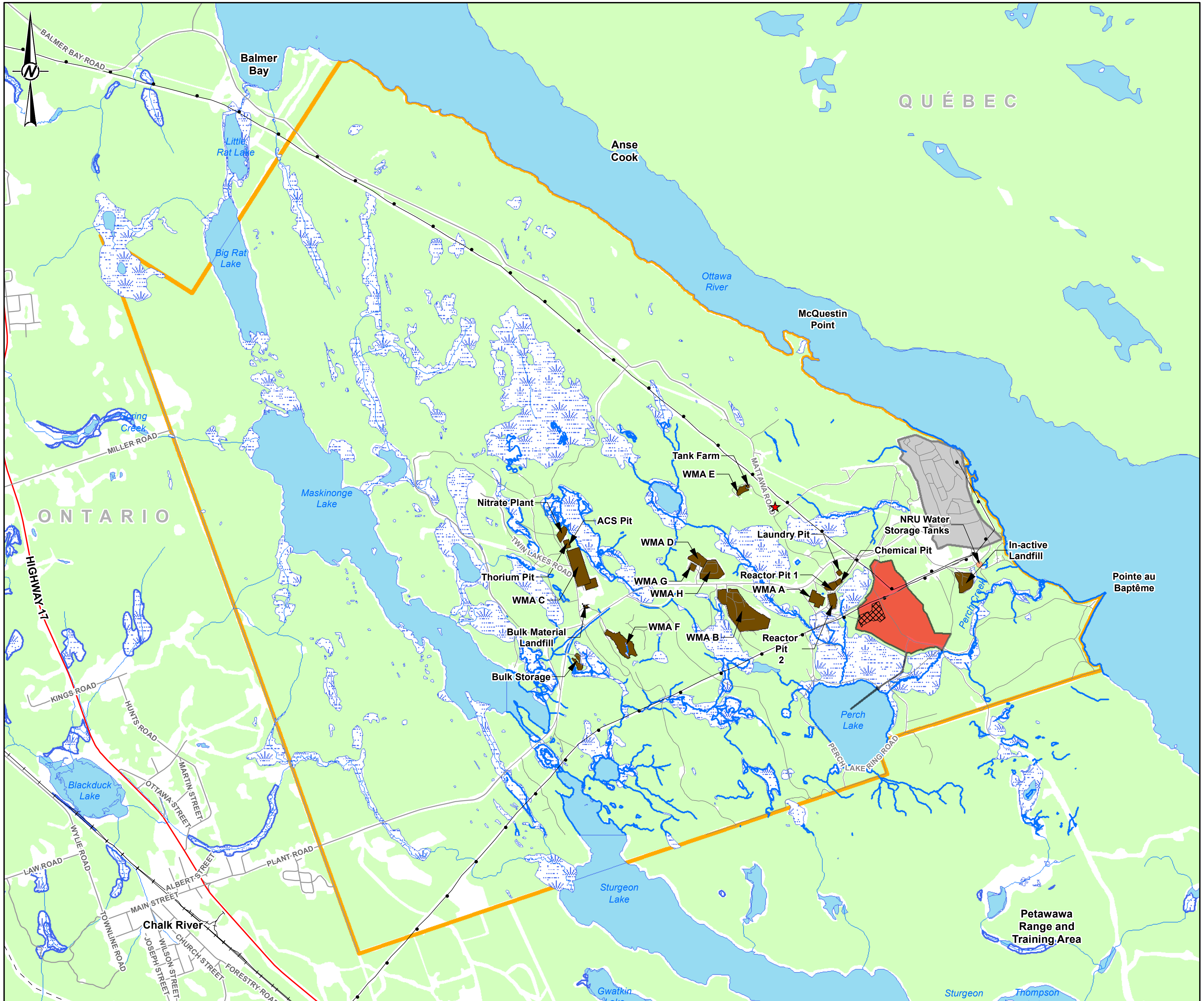
The majority of LLW proposed for the NSDF is currently located on the CRL site, with a small percentage of the waste volume coming from off-site locations (i.e., approximately 10% by volume). The sources of waste proposed for the NSDF by percentage are as follows:

- 90 percent (%) waste from CRL – past, present and future (waste owned by AECL);
- 5% from commercial waste Canadian sources such as universities and hospitals; and
- 5% waste from decommissioning at Whiteshell Laboratories in Manitoba and other AECL nuclear liabilities.

CNL, and previously AECL, has been transporting wastes safely and without incident for over 50 years. Transportation of radioactive wastes has been demonstrated to be safe and will be carried out in order to consolidate all radioactive wastes at the CRL site. CNL implements a *Transportation of Dangerous Goods Program* to ensure that all shipments are carried out in accordance with the applicable Canadian regulatory requirements and best industry practices (CNL 2019a). Continuing this program will ensure that transportation activities do not result in negative consequences to Canadians. CNL also engages with the public and Indigenous peoples on a regular basis to explain the status of work underway to consolidate wastes at the CRL site, and how this work will reduce Canada's nuclear liability and long-term risk.

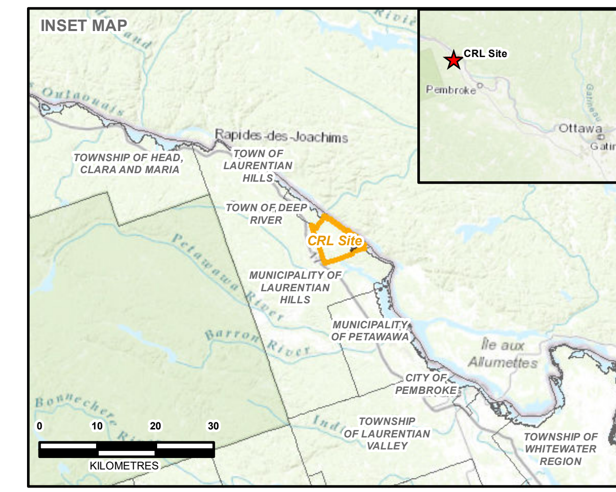
CNL is proposing to carry out the designated NSDF Project on land that is owned by AECL. As such, CNL is the proponent for the development of the NSDF Project and associated infrastructure.

A key element of the regulatory approvals process is the completion of an environmental assessment under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012), the results of which are documented in this Environmental Impact Statement (EIS). This EIS describes the analysis of alternatives, process of public and Indigenous engagement, studies of baseline conditions, and assessment of project activities during the construction, operations, closure and post-closure phases of the NSDF Project.



LEGEND

- HIGHWAY
- ROAD
- RAILWAY
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- TREE RESEARCH PLANTATION
- NSDF PROJECT SITE
- CRL MAIN CAMPUS
- CRL SITE
- WASTE MANAGEMENT AREAS (WMA)[1]



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NOTE(S)

1. LIQUID DISPERSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
LOCATION OF NEAR SURFACE DISPOSAL FACILITY

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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1.1 Project Overview

The NSDF will be a waste disposal facility using an engineered containment mound (ECM) that will hold LLW waste at near-surface level on the CRL site, similar to a municipal landfill, yet with more robust measures to contain and isolate the wastes from the surrounding environment. The facility is expected to be operational for approximately 50 years and will receive up to 1,000,000 cubic metres (m3) of LLW over its operational lifetime. The placement of the wastes in the ECM will be completed in phases as follows:

- Phase 1: with a design capacity of 525,000 m^3 to accommodate wastes currently in storage and wastes to be generated over the next 20 to 25 years, to create the conditions for the revitalization of the CRL site.
- Phase 2: during which the design capacity will be expanded to 1,000,000 m^3 to accommodate wastes expected to be generated following Phase 1.

Phase 2 will allow for the inclusion of waste from future operations, decommissioning and remediation at the CRL site and off-site CNL managed facilities. Following its closure, the ECM will resemble a grassy hillside, but will not be visible from the CRL main campus or the Ottawa River.

The main physical works related to the NSDF Project are the ECM that will contain the waste, the Wastewater Treatment Plant (WWTP), operation support facilities and site infrastructure. These are briefly described below.

The ECM includes the following components.

- Base liner system, which includes a primary and secondary liner to contain the waste and to limit the potential release of contamination to the subsurface and groundwater.
- Interim cover as each disposal cell is filled, including a sacrificial temporary geomembrane to limit water requiring treatment.
- Leachate collection and leak detection system.
- Surface water management system, which will control clean surface water on-site, and prevent contact with contaminated waste.
- Final cover system (i.e., cap for the mound); which will isolate the waste, provide radiation shielding, and prevent water from entering. The waste will be covered as each disposal cell is filled.
- Environmental monitoring systems, which will monitor air, surface water and groundwater consistent with existing CRL licence requirements.

The WWTP is designed to treat leachate (i.e., precipitation water that has percolated through the ECM), contact water (i.e., precipitation surface water that has not infiltrated into the ECM, but is treated as suspect of contamination), and wastewaters arising from NSDF operations. The WWTP will use the best available technology that is economically achievable. Treated effluent will meet effluent discharge targets for the protection of the environment and human health and will be discharged to an approved discharge location or locations.

Operation support facilities include an administration building, operation support centre, vehicle decontamination facility, potable water pump station, and weighing station kiosks. Site infrastructure includes access roads, parking, site security, temporary storage areas, and utilities.

Development of the NSDF Project is planned to occur in several phases. The construction phase, which includes site preparation, is anticipated to start in 2021 or as soon as the relevant regulatory permits and approvals are in place. The operations phase is anticipated to begin in 2024 and will end in approximately 2070 (i.e., approximately 50 years). The operations phase will be completed in two phases as described above. The closure phase primarily includes activities needed to complete the installation of the final cover of the ECM, continued treatment of residual leachate and continued environmental monitoring. Closure activities are expected to start in 2070 and continue through to 2100, after which the NSDF Project will transfer into the post-closure phase. The post-closure phase is defined by two discrete periods: institutional control and post-institutional control. The institutional control period includes implementation of institutional controls throughout 2100 to 2400 (i.e., 300 years). During the institutional control period, groundwater monitoring and groundwater quality management will continue to demonstrate compliance with the environmental assessment predictions. Regulatory approval will be required to cease monitoring activities. The post-institutional control period occurs after year 2400 and continues indefinitely.

1.2 Project Location

The NSDF Project is proposed to be located entirely within the CRL site (Figure 1.0-1). The CRL site is located in Renfrew County, Ontario, adjacent to the Ottawa River. The CRL site contains several licenced nuclear facilities, waste management areas and other nuclear and non-nuclear facilities and laboratories. Two hydro lines cross the CRL site and provide electricity for CRL operations. The CRL site has a total area of approximately 4,000 hectares (ha) and is located approximately 185 kilometres (km) northwest of Ottawa, within the boundaries of the Corporation of the Town of Deep River (Figure 1.2-1). The federal Department of National Defence Garrison Petawawa borders the CRL site to the southeast, and the Village of Chalk River, in the Municipality of Laurentian Hills, is to the southwest. The Ottawa River forms the northeastern boundary of the CRL site. The approximate geographic coordinates of the NSDF Project are 46 02’ 33” N, 77 22’ 13” W.

Nearby population centres include the Village of Chalk River (7 km west of the CRL site) and the Town of Deep River (9 km northwest of the CRL site). Surrounding these communities are the Townships of Rolph, Buchanan, Wylie and McKay, which with Chalk River, form the Municipality of Laurentian Hills. The Town of Deep River has approximately 4,100 residents and the Municipality of Laurentian Hills has approximately 2,800. The Town of Petawawa and the Garrison Petawawa, totalling about 17,200 residents, are located 20 km and 17 km southeast of the CRL site. The other main population centre in the region is the City of Pembroke, with about 15,940 residents, is 34 km southeast of the CRL site. The portion of the Pontiac Regional County Municipality in the Province of Quebec that lies on the opposite side of the Ottawa River (i.e., the north side) is normally uninhabited, except during the summer months when a few cottage dwellers may be present (CNL 2015). The closest permanent residents in the Pontiac Regional County Municipality are located 3 km southeast of the CRL site, in the Harrington Bay area. The closest community on the Quebec side of the Ottawa River is the Municipality of Sheenboro, approximately 16 km downstream.

The closest Indigenous community is the Algonquins of Pikwakanagan, located at Golden Lake, approximately 50 km southeast of the CRL site. The Algonquins of Pikwakanagan First Nation are part of the larger Algonquins of Ontario organization, which has reached an Agreement-In-Principle with the Governments of Ontario and Canada regarding a land claim in the Ottawa Valley, which they consider their traditional homelands. The area that is subject of the Algonquin claim in Ontario includes the National Capital Region, all of Renfrew County and most of Algonquin Park, which is a provincial park (CNL 2016a). In addition, the CRL site falls within the Métis Nation of Ontario’s Ottawa River traditional harvesting territory (MNO 2004).

The Ottawa River is the dominant drainage feature in the area. The CRL site contains several small drainage basins that drain directly to the Ottawa River or to smaller on-site lakes and streams, which in turn drain to the Ottawa River. The CRL site is located in the Allumette Lake and Lac Coulonge reach of the Ottawa River, between La Passe and the Des-Joachims Dam. The distance from the NSDF Project site to the closest point on the Ottawa River is approximately 1.1 km. Perch Lake is located southwest of the NSDF Project site (Figure 1.0-1).

The CRL site supports a diverse mix of upland and wetland habitats. Vegetation includes deciduous and coniferous forest and a wide variety of plant species. In the western region of the NSDF Project site, approximately 2.6 ha of land is occupied by a Petawawa Research Forest Plantation. The plantation was established in 1956 to determine frost and White Pine weevil resistance in Norway spruce. The Petawawa Research Forest has confirmed it no longer has interest in this plantation. The south and west boundaries of the NSDF Project site are adjoining the Perch Lake wetland complex (Figure 1.0-1).

Aside from the operations and activities undertaken by CNL, other land uses of the CRL site are prohibited due to restricted public access (CNL 2018). No hunting or fishing is permitted on the CRL site. The CRL site is not used for traditional purposes by Indigenous peoples (CNL 2018). Land use in the region consists primarily of forestry, recreation and tourism, with limited agriculture, trapping and mining (CNL 2018). The nearest area of considerable agriculture and dairy farming is 15 km southeast on the Quebec side of the Ottawa River and 35 km southeast on the Ontario side (CNL 2018). The Ottawa River is an important recreational resource for swimming, sport fishing and boating; there is little commercial fishing opportunity. There are several sand beaches along both sides of the river that provide popular recreational sites. In addition, two provincial parks, Algonquin and Driftwood, are located to the west of the CRL site and offer opportunities for canoeing, hiking, fishing and hunting. Winter recreational activities in the region include cross-country skiing, snowmobiling and ice-fishing.

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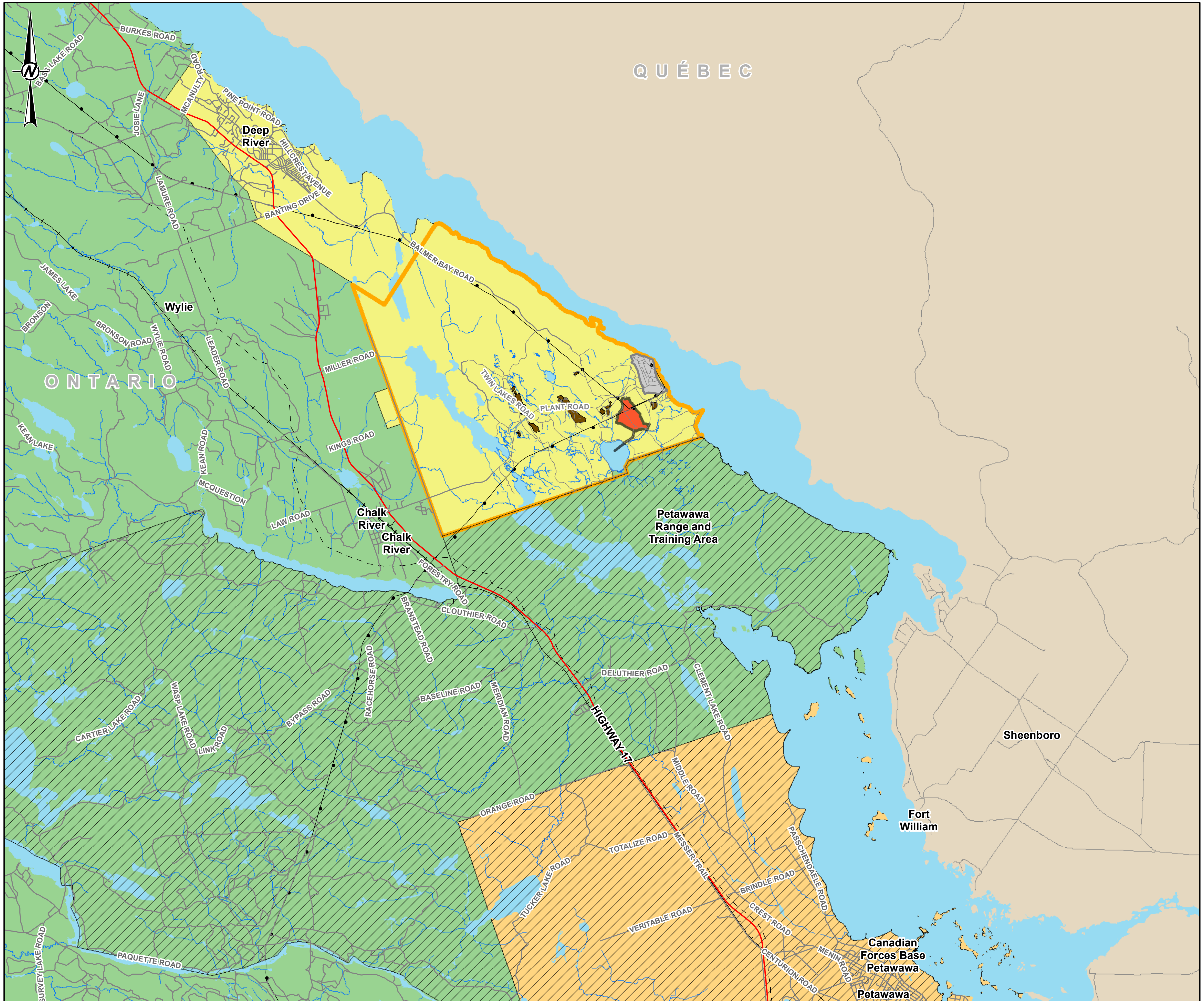
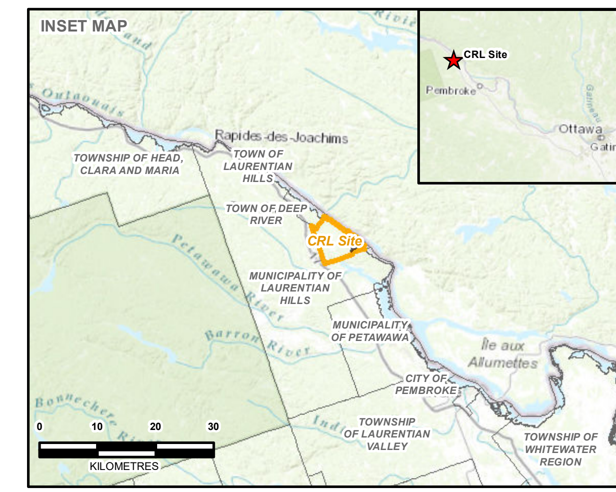


LEGEND

- HIGHWAY
- ROAD
- RAILWAY
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- TOWN OF DEEP RIVER
- MUNICIPALITY OF LAURENTIAN HILLS
- MUNICIPALITY OF PETAWAWA
- PONTIAC REGIONAL COUNTY MUNICIPALITY
- CFB PETAWAWA
- NSDF PROJECT SITE
- CRL MAIN CAMPUS
- CRL SITE
- WASTE MANAGEMENT AREAS (WMA)[1]



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REFERENCE(S)

1. LIQUID DISPERSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

CLIENT	CANADIAN NUCLEAR LABORATORIES LTD.
PROJECT	NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT CHALK RIVER, ONTARIO
TITLE	**GENERAL LOCATION OF THE CHALK RIVER LABORATORIES SITE**

CONSULTANT: GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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1.3 Proponent

CNL is the proponent for the NSDF Project, on land owned by AECL (i.e., located on federal property). AECL is responsible for the long-term management of the lands including the CRL site. AECL is responsible for managing its radioactive waste and decommissioning responsibilities at its sites for which the Government of Canada has accepted responsibility, and AECL has contracted CNL to manage the licenced sites and nuclear activities.

1.3.1 Corporate Purpose

CNL is Canada's leading nuclear science and technology organization and a world leader in developing innovative applications from nuclear technology. Services offered through CNL include research and development, design and engineering of specialized technology, waste management, environmental remediation and decommissioning. CNL is committed to ensuring that Canadians and the world receive energy, health and environmental benefits from nuclear science and technology with confidence that nuclear safety and security are assured. CNL works to deliver safety, execution and innovation in all work activities, and provide the highest performance in meeting the commitments expected of them by regulators, customers, stakeholders and the public.

AECL is a federal Crown corporation, with a mandate to manage the Government of Canada's radioactive waste and decommissioning responsibilities and enable nuclear science and technology. It fulfils this mandate through a long-term contractual arrangement with CNL and its parent companies for the management and operation of AECL's sites, facilities and assets, and the performance of AECL's waste and decommissioning responsibilities under a Government-owned, Contractor-operated ("GoCo") model.

1.3.2 Management Structure

In 2014, as part of an overall government restructuring of AECL, the formation of Canadian Nuclear Laboratories was launched. AECL had maintained and operated the CRL site, as well as other government owned sites (e.g., Whiteshell, Nuclear Power Demonstration, Port Hope Area Initiative) for much of the long history of CRL (60 years). In 2015, Canadian Nuclear Energy Alliance, a consortium of nuclear engineering and management firms, was announced as the preferred bidder to take over management and operation of CNL, including the CRL site. In 2016, the majority of the workforce and management systems that were in place as AECL were transferred to CNL as it took over management and operations of the CRL site, and other government owned sites. As such, CNL is a private-sector entity, while AECL, as a government Crown Corporation, oversees the performance of CNL.

This model is a "Government-Owned Contractor-Operated" (GoCo) model under agreement with AECL, who retains ownership of the CRL site and associated liabilities on behalf of the Government of Canada. The GoCo model is shown on Figure 1.3-1.

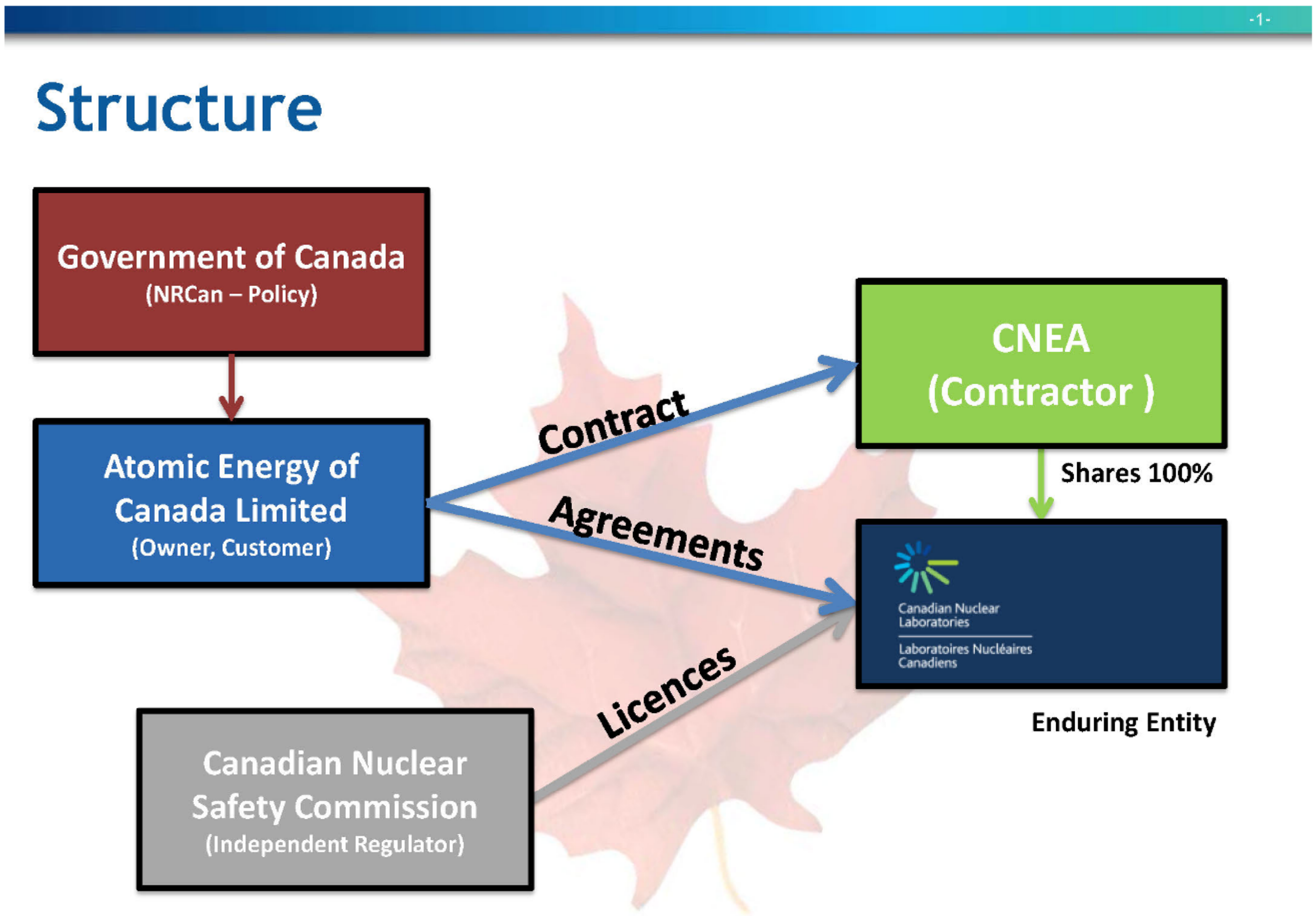
As discussed in Section 1.3, CNL is the licensee and the proponent for this Project.

CNL is led by an Executive Team and a Board of Directors. The President and Chief Executive Officer, along with a Chief Operating Officer and five Vice Presidents, are responsible for different aspects of the business. An organizational chart outlining CNL's internal structure relevant to the NSDF Project is provided on Figure 1.3-2. A full listing of CNL's Board of Directors and Executive Team can be found online at www.cnl.ca. Three Vice Presidents are directly associated with the execution of the NSDF Project.

The Vice President, Environmental Remediation Management, has overall responsibility for the development of the NSDF Project. The Vice President has delegated the responsibility for NSDF Project completion to the NSDF Project Director.

The Vice President, Operations and Chief Nuclear Officer, is also the CRL Site Licence Holder and is responsible for the safe and compliant operation of the facility after it is turned over to operations. The Vice President, Operations and Chief Nuclear Officer, will delegate the responsibility for safe operation of the proposed facility to the NSDF Facility Authority. The Vice President, Operations and Chief Nuclear Officer has also delegated the overall responsibility for compliance programs to the Health, Safety, Security and Environment & Quality Director, such as Radiation Protection, Environmental Protection, Occupational Health and Safety, and Emergency Preparedness. The NSDF Project has been designed and will be operated in accordance with compliance program requirements.

The Vice President, Business Management and Chief Financial Officer has delegated to Corporate Affairs and Corporate Communications the overall responsibility for the facilitation of engagement activities with public and Indigenous peoples to support the NSDF Project development. The Director of Corporate Communications is also responsible for the public relations activities for the CRL site.



REFERENCE(S)

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	PR
PREPARED	PR
REVIEWED	CS
APPROVED	AB

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT CHALK RIVER, ONTARIO

TITLE
CANADIAN NUCLEAR LABORATORIES AND ATOMIC ENERGY OF CANADA LIMITED GOVERNMENT-OWNED CONTRACTOR-OPERATED MODEL

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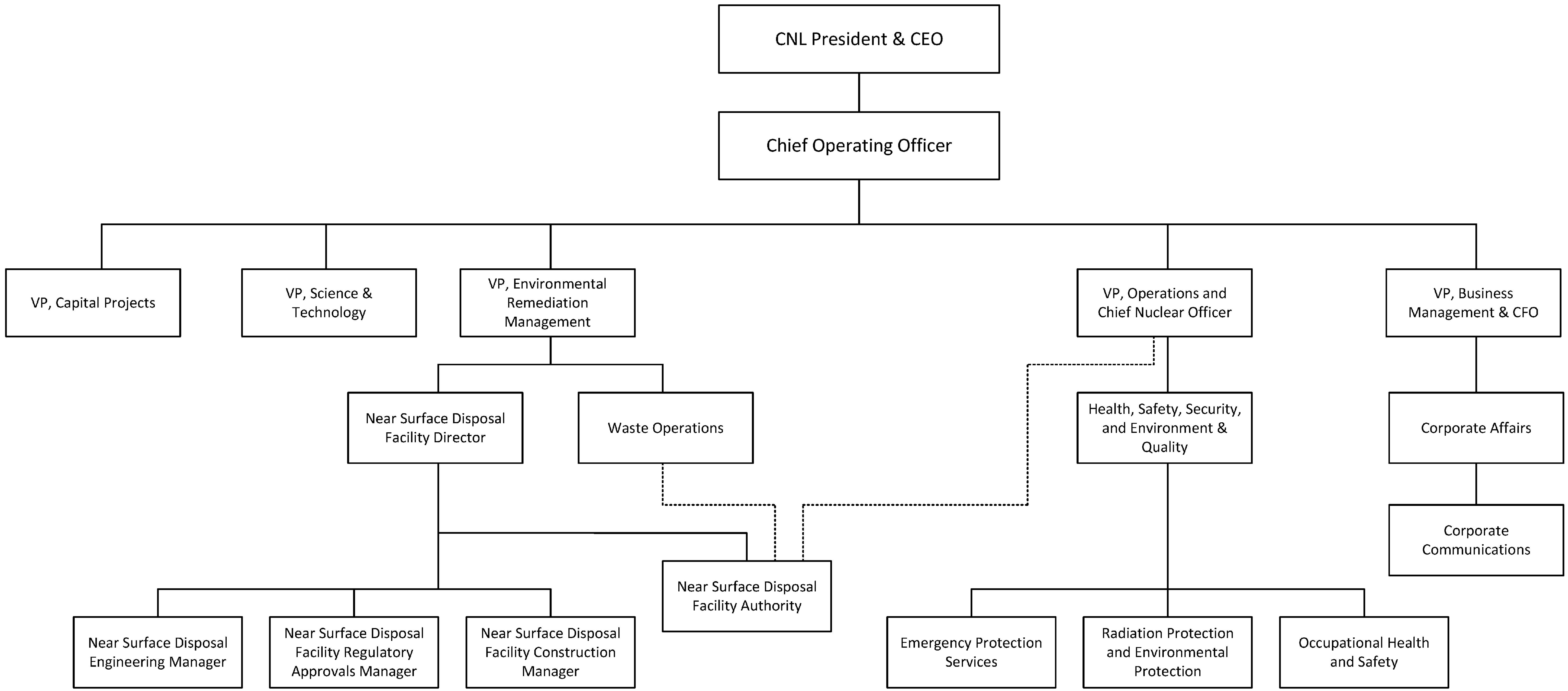

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
ORGANIZATIONAL CHART FOR THE CANADIAN NUCLEAR LABORATORIES AND MANAGEMENT OF THE NEAR SURFACE DISPOSAL FACILITY PROJECT

CONSULTANT: GOLDER

DATE	NOVEMBER 2020
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REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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1.3.3 Key Contact Information

The primary contact for the purposes of this EIS is:

Mr. Pat Quinn
Director, Corporate Communications
Canadian Nuclear Laboratories
Chalk River Laboratories
286 Plant Road, Building 700
Chalk River, Ontario K0J 1J0
Telephone: 613 584 8811 Extension 43417
Email: pat.quinn@cnl.ca

1.4 Regulatory Framework

1.4.1 Federal Review Process

On August 28, 2019, the *Impact Assessment Act* (IAA) came into force, repealing the CEAA 2012. The IAA contains transitional provisions for environmental assessments of designated projects commenced under CEAA 2012 and for which the CNSC is the Responsible Authority. The CNSC has informed CNL that the Environmental Assessment for the NSDF Project will continue under CEAA 2012 (CNSC 2019a). CNSC notes that as per the transition provision described in subsection 182 of the IAA: “Any environmental assessment of a designated project by the Canadian Nuclear Safety Commission or the National Energy Board commenced under the 2012 Act, in respect of which a decision statement has not been issued under section 54 of the 2012 Act before the day on which this Act comes into force, is continued under the 2012 Act as if that Act had not been repealed.” As outlined in subsection 182, given that the NSDF Project was commenced under CEAA 2012 and a decision statement has not yet been issued, it therefore will continue to be completed under its current process.

The federal environmental assessment requirements are detailed in CEAA 2012. In accordance with section 8 of CEAA 2012, a project description document is required to initiate the screening process, which the CNSC uses to determine if a federal environmental assessment is required for each “designated project”. Designated projects are listed in the *Regulations Designating Physical Activities* (Government of Canada 2012) under CEAA 2012. The *Regulations Designating Physical Activitie*s identify the CNSC as the Responsible Authority for projects that are regulated under the *Nuclear Safety and Control Act*. As such, the CNSC is responsible for the conduct of the environmental assessment and ensuring that the requirements of CEAA 2012 are met.

Following submission of the Project Description (CNL 2016a) for the NSDF Project in 2016, the CNSC issued a Notice of Commencement and determined that the NSDF Project requires a federal environmental assessment pursuant to CEAA 2012.

Federal permits, licences and authorizations that may be required for the NSDF Project include the following:

- Environment and Climate Change Canada:
  - A permit from Environment and Climate Change Canada will be required under the *Species at Risk Act* (section 73 of the Act).
  - Petroleum storage tank permit(s) may be required, depending on the size of fuel tanks installed on the site.

- Fisheries and Oceans Canada: a project review will be required for the discharge of treated effluent to Perch Lake.
- Natural Resources Canada: a licence under the *Explosives Act* may be required if explosives are to be stored at the CRL site.

The NSDF Project is located on federal lands and is regulated under the CNSC, therefore, it is anticipated that provincial permits, licences or other authorizations are not required.

1.4.2 Relevant Standards, Codes and Guidelines

It is critical that the environmental assessment be conducted in accordance with relevant standards and codes, while also taking into consideration appropriate guidelines. The environmental assessment and this EIS document were completed in a manner consistent with directions outlined in the following documents.

Canadian Environmental Assessment Act, 2012

- *Canadian Environmental Assessment Act, 2012. S.C. 2012, c. 19, s. 52*
- *Generic Guidelines for the Preparation of an Environmental Impact Statement pursuant to the Canadian Environmental Assessment Act, 2012 (CNSC 2016)*
- *Operational Policy Statement: Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012 (The Agency 2015a)*
- *Operational Policy Statement: Addressing the "Purpose of" and "Alternative Means" under the Canadian Environmental Assessment Act, 2012 (The Agency 2015b)*
- *Operational Policy Statement: Determining Whether a Designated Project is Likely to Cause Significant Adverse Environmental Effects under the Canadian Environmental Assessment Act, 2012 (The Agency 2015c)*
- *Reference Guide Considering Aboriginal Traditional Knowledge in Environmental Assessments Conducted Under the Canadian Environmental Assessment Act, 2012 (The Agency 2015d)*
- *Interim Technical Guidance for Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012 (The Agency 2018a)*
- *Interim Technical Guidance for Determining Whether a Designated Project is Likely to Cause Significant Adverse Effects under the Canadian Environmental Assessment Act, 2012 (The Agency 2018b)*

Canadian Nuclear Safety Acts and Regulations

- *Nuclear Safety and Control Act. S.C. 1997, c. 9.*
- *REGDOC-2.9.1 Environmental Protection: Environmental Principles, Assessments and Protection Measures (CNSC 2017)*
- *REGDOC-3.2.2 Public and Indigenous Engagement: Indigenous Engagement (CNSC 2019b)*
- *REGDOC-2.11.1 Waste Management, Volume III: Assessing the Long-Term Safety of Radioactive Waste Management (CNSC 2018a)*

- *REGDOC-2.4.1 Deterministic Safety Analysis (CNSC 2014)*
- *REGDOC-2.4.3 Nuclear Criticality Safety (CNSC 2018b)*

Canadian Standards Association (CSA)

- *CSA N286-12: Management System Requirements for Nuclear Facilities (CSA Group 2012a); and*
- *CSA N288.6-12: Environmental Risk Assessment at Class 1 nuclear facilities and uranium mines and mills. (CSA Group 2012b).*

Discipline-specific standards, codes and guidelines used in the assessment of effects are identified within each discipline section (Sections 5.2 to 5.10).

A concordance table is provided in Appendix 1.0-1 to help demonstrate compliance with the *Generic Guidelines for the Preparation of an Environmental Impact Statement pursuant to the Canadian Environmental Assessment Act, 2012* (Generic EIS Guidelines) (CNSC 2016) and with *REGDOC-2.9.1 Environmental Protection: Environmental Principles, Assessments and Protection Measures* (CNSC 2017). The concordance table lists the requirements detailed in the Generic EIS Guidelines and in *REGDOC-2.9.1*, and the location of the corresponding information in the EIS.

1.5 Structure of this Document

This document is CNL's EIS for the NSDF Project. It has been prepared following the Generic EIS Guidelines (CNSC 2016). This EIS is organized into the sections described below and shown on Figure 1.5-1.

- **Executive Summary** – This section contains a description of all key components of the NSDF Project and related activities, a summary of all engagement activities, an overview of the results of the environmental assessment, and a summary of the conclusions on the residual environmental effects of the NSDF Project after considering mitigation and the significance of those residual effects.
- **Section 1.0 Introduction** – This section includes an overview of the NSDF Project and location, an introduction to CNL, an overview of the regulatory framework the NSDF Project will follow and an outline of the organization of this EIS document.
- **Section 2.0 Purpose of the Project and Project Alternatives** – This section identifies the objectives of the NSDF Project, the problems and opportunities the NSDF Project is intended to address, and the rationale for proceeding with the development. This section also considers the effects of alternative means of carrying out the NSDF Project, identifies the economically and technically feasible alternatives, and includes environmental and social considerations that were evaluated as means of implementing the NSDF Project.
- **Section 3.0 Project Description** – This section provides a description of all phases of the NSDF Project in detail to allow CNL to predict potential adverse environmental, economic, social and health effects and to address concerns from interested parties; a timeline for all phases of the NSDF Project, and a discussion of components and activities, including infrastructure that will be developed as part of the NSDF Project.
- **Section 4.0 Public and Stakeholder Engagement** – This section summarizes CNL's engagement activities, including documentation of meetings, discussion topics and outcomes, and relevant agreements that were developed.

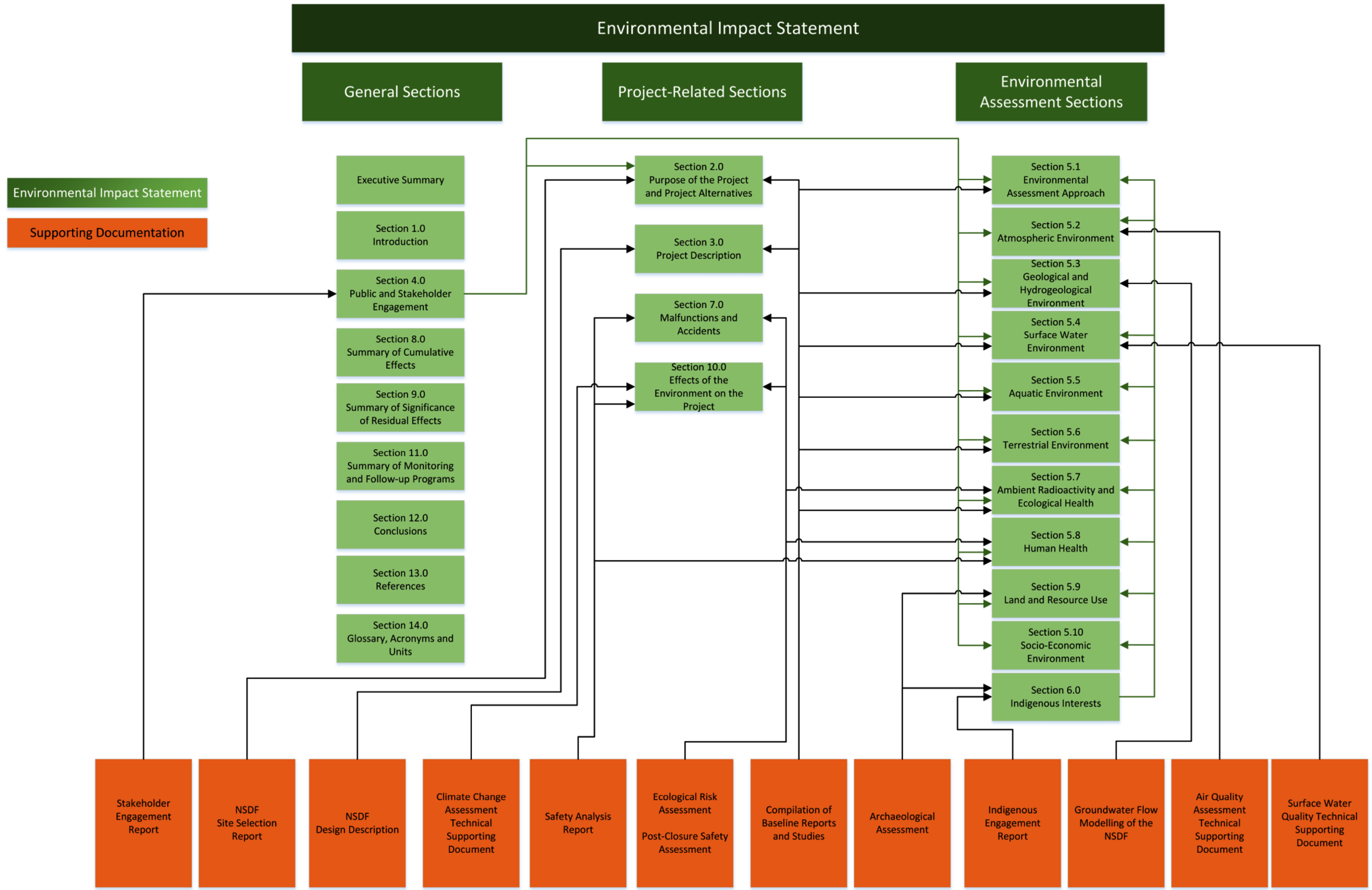
- **Section 5.0 Environmental Effects** – This section presents the environmental assessment approach, selection of valued components, discipline-specific definitions of assessment boundaries, the NSDF Project setting and baseline characterization, results of the environmental assessment, and determination of significance of the residual effects of the NSDF Project on the environmental, economic, social, heritage and health valued components. Section 5.0 Environmental Effects comprises the following subsections:
  - Section 5.1 Environmental Assessment Approach;
  - Section 5.2 Atmospheric Environment;
  - Section 5.3 Geological and Hydrogeological Environment;
  - Section 5.4 Surface Water Environment;
  - Section 5.5 Aquatic Environment;
  - Section 5.6 Terrestrial Environment;
  - Section 5.7 Ambient Radioactivity and Ecological Health;
  - Section 5.8 Human Health;
  - Section 5.9 Land and Resource Use; and
  - Section 5.10 Socio-economic Environment.
- **Section 6.0 Indigenous Interests** – This section presents a summary of relevant issues of expressed interest to Indigenous peoples through engagement completed to date, including traditional land and resource use, socio-economics, and valued components. This section also summarizes CNL's engagement activities with Indigenous peoples, including documentation of meetings, discussion topics and outcomes, and relevant agreements that were developed.
- **Section 7.0 Malfunctions and Accidents** – This section presents a description of potential credible malfunctions and accidents that could be associated with the NSDF Project, the conditions under which they could occur, proposed mitigations and contingency plans.
- **Section 8.0 Summary of Cumulative Effects** – This section contains a summary of the approach to the assessment of cumulative effects, reasonably foreseeable future projects considered in the assessment, and the environmental, economic, social and health effects predicted to occur as a result of the NSDF Project that cannot be avoided or mitigated through the redesign or relocation of the NSDF Project or through commitments made by CNL.
- **Section 9.0 Summary of Significance of Residual Effects** – This section contains a summary of significance of residual environmental, economic, social and health effects predicted to occur as a result of the NSDF Project that cannot be avoided or mitigated through the redesign or relocation of the NSDF Project or through commitments made by CNL. It also presents the high-level conclusion of the evaluation of significance for residual effects as a result of the NSDF Project effects and cumulative effects.

- **Section 10.0 Effects of the Environment on the Project** – This section contains the assessment of effects of the environment on the NSDF Project including the likelihood and severity of the changes or effects and mitigation planned to avoid or limit the changes or effects. The assessment also includes consideration of effects from climate change.
- **Section 11.0 Summary of Monitoring and Follow-up Programs** – This section presents an overview of the follow-up monitoring plans and commitments made for the NSDF Project.
- **Section 12.0 Conclusions** – This section includes a summary of the findings of the effects assessment, the residual effects predicted to occur because of the NSDF Project including cumulative effects, the significance of the residual effects of the NSDF Project, and an overall conclusion for the EIS.
- **Section 13.0 References** – This section includes the references cited throughout the EIS.
- **Section 14.0 Glossary, Acronyms and Units** – This section includes a compilation of key terms and definitions, acronyms and units used in this EIS document.

Figure 1.5-1 shows the EIS sections in green and key technical support documents in orange. Key technical support documents are:

- *NSDF Site Selection Report* (CNL 2016b) for Section 2.0 of the EIS (Purpose of the Project and Project Alternatives).
- *Design Description* (AECOM 2019) for Section 3.0 of the EIS (Project Description).
- *Stakeholder Engagement Report* (CNL 2017a, 2017b, 2019b) for Section 4.0 of the EIS (Public and Stakeholder Engagement).
- *Indigenous Engagement Report* (CNL 2020) for Section 6.0 of the EIS (Indigenous Interests).
- *Air Quality Assessment Technical Supporting Document* (Golder 2019a) for Section 5.2 Atmospheric Environment
- *Groundwater Flow Modelling of the NSDF* (Golder 2019b) for Section 5.3 (Geological and Hydrogeological Environment).
- *Surface Water Quality Technical Supporting Document* (Golder 2019c) for Section 5.4 (Surface Water Environment).
- *NSDF Safety Analysis Report* (CNL 2020) for Section 5.8 (Human Health), Section 7.0 (Malfunctions and Accidents) and Section 10.0 (Effects of the Environment on the Project).
- *Post-Closure Safety Assessment* (Arcadis and Quintessa 2020b) and *Ecological Risk Assessment for the NSDF Project* (Arcadis 2020a) for Section 5.7 (Ambient Radioactivity and Ecological Health), Section 5.8 (Human Health), Section 7.0 (Malfunctions and Accidents), and Section 10.0 (Effects of the Environment on the Project).
- *Stage 4 Archaeological Assessment EMR* Site (Kinickinick Heritage Consulting and Cameron Heritage Consulting Inc. 2018) for Section 5.9 (Land and Resource Use) and Section 6.0 (Indigenous Interests).

- *Climate Change Assessment Technical Supporting Document* (Golder 2019d) for Section 10.0 (Assessment Effects of the Environment on the NSDF Project).
- *Compilation of Baseline Reports and Studies* for Section 2.0 (Purpose of the Project and Project Alternatives), Section 3.0 (Project Description), Section 5.1 (Environmental Assessment Approach), Section 5.3 (Geological and Hydrogeological Environment), Section 5.4 (Surface Water Environment), Section 5.5 (Aquatic Environment), Section 5.6 (Terrestrial Environment), Section 5.7 (Ambient Radioactivity and Ecological Health), Section 5.8 (Human Health).



CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
ENVIRONMENTAL IMPACT STATEMENT DOCUMENT STRUCTURE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0001	FINAL 2	1.5-1

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2.0 PURPOSE OF THE PROJECT AND PROJECT ALTERNATIVES

2.1 Introduction

Canadian Nuclear Laboratories (CNL) is proposing the construction and operation of a Near Surface Disposal Facility (NSDF) for the disposal of up to 1,000,000 m^3 of solid, low-level radioactive waste (LLW) from legacy waste management areas (WMAs), current operations site, future environmental remediation and decommissioning projects at the Chalk River Laboratories (CRL) site and sites owned by AECL (e.g., Whiteshell Laboratories [WL]) and waste from, commercial sources such as hospitals and universities. The NSDF will provide a safe, permanent solution at the CRL site for the disposal of LLW, and will replace the current CNL practice of placing waste in interim storage. The intent of this section is to provide an overview of the existing, planned and anticipated waste disposition routes of CNL-managed radioactive wastes, describe the purpose of the NSDF Project as it relates to this overall waste disposal strategy, and to present alternative means of carrying out the proposed NSDF Project.

2.2 Canadian Nuclear Laboratories Integrated Waste Strategy

In the interest of effectively managing AECL's nuclear liabilities, CNL and AECL are working actively at strategic and operational levels to identify strategies and solutions for waste management of the entire life cycle of all waste classifications including LLW, intermediate level waste (ILW), high level waste (HLW), hazardous waste and clean (non-radiological) waste. Aligned to this, CNL has developed an Integrated Waste Strategy (CNL 2019a) that concisely details a cradle to grave approach for all CNL-managed waste classifications, from generation to disposal. The Integrated Waste Strategy is based on CNL's waste inventory and forecast data and built on the fundamental principles of waste avoidance, minimization and reuse.

This section provides a brief overview of the existing and anticipated storage and disposal routes of CNL wastes, of which the development of the NSDF Project is a key part. Table 2.2.1-1 and Figure 2.2-1 summarize this information.

Table 2.2.1-1: CNL Waste Classification and Disposal Plan

Waste Classification	Description of Waste	Planned Long-Term Waste Strategy
High Level Waste (Used Fuel)	HLW is used nuclear fuel and other wastes (e.g., fuel reprocessing wastes) that have been declared as radioactive waste that generates significant heat via radioactive decay. Used nuclear fuel is associated with penetrating radiation and contains significant quantities of long-lived radionuclides.	▪ National used fuel repository (proponent is Nuclear Waste Management Organization) consistent with the Nuclear Fuel Waste Act.
Intermediate Level Waste	ILW typically exhibits levels of penetrating radiation sufficient to require shielding during handling and interim storage and contains significant quantities of long-lived radionuclides.	▪ Interim storage at CRL until a geological disposal facility is available ▪ WL Whiteshell Reactor (WR-1) and Nuclear Power Demonstration (NPD) – in situ disposal)

Table 2.2.1-1: CNL Waste Classification and Disposal Plan

Waste Classification	Description of Waste	Planned Long-Term Waste Strategy
Low-Level Waste	▪ LLW contains material with radionuclide content above established clearance levels and exemption quantities, but generally has limited amounts of long-lived activity. LLW requires isolation and containment for up to a few hundred years. ▪ LLW does not require significant shielding during handling and transportation.	▪ NSDF ▪ In situ disposal (WL WR-1 and NPD)(a) ▪ Sewage sludge in the CRL Bulk Material Landfill ▪ Port Hope Long-Term Waste Management Facility(b) ▪ Port Granby Long-Term Waste Management Facility(b)
Hazardous Waste	Solid, liquid or gaseous waste material, other than a radioactive material, that may pose a potential hazard to human health or the environment when improperly treated, stored, transported or disposed of, or otherwise managed, and as specified in applicable regulations.	▪ Licensed commercial disposal facility
Clean (Non-radiological) Waste	Non-hazardous material that is declared to be non-radioactive by its history, location and use, or non-hazardous material that has been determined to meet regulatory requirements for unconditional clearance by means of suitable radiological monitoring.	▪ Reuse and recycling ▪ Landfill

(a) The Whiteshell Decommissioning Project is for decommissioning of the WL facility in Pinawa, Manitoba, including the proposed in situ decommissioning of WR-1. The NPD Closure Project is for the proposed in situ decommissioning of the NPD reactor in Rolphton, Ontario.

(b) The Port Hope and Port Granby long-term waste management facilities are facilities for the long-term management of wastes within the Municipality of Port Hope, Ontario, and Municipality of Clarington, Ontario, respectively.

HLW = high level waste; ILW = intermediate level waste; LLW = low-level waste; NPD = Nuclear Power Demonstration; WL = Whiteshell Laboratories.

As shown in Table 2.2.1-1 and on Figure 2.2-1, the NSDF Project provides a disposal solution for LLW that meets the NSDF Waste Acceptance Criteria (see Section 3.3.3). Any waste that does not meet the NSDF Waste Acceptance Criteria will be directed to another appropriate waste management facility. Each of the waste classifications defined in Table 2.2.1-1 are discussed further below.

Overall, LLW comprises the vast majority by volume of the radioactive waste in storage at the CNL-managed sites. In 2015, approximately 95% of the waste in storage at CNL sites by volume was LLW, 4% was ILW and less than 1% was HLW (Figure 2.2-2).

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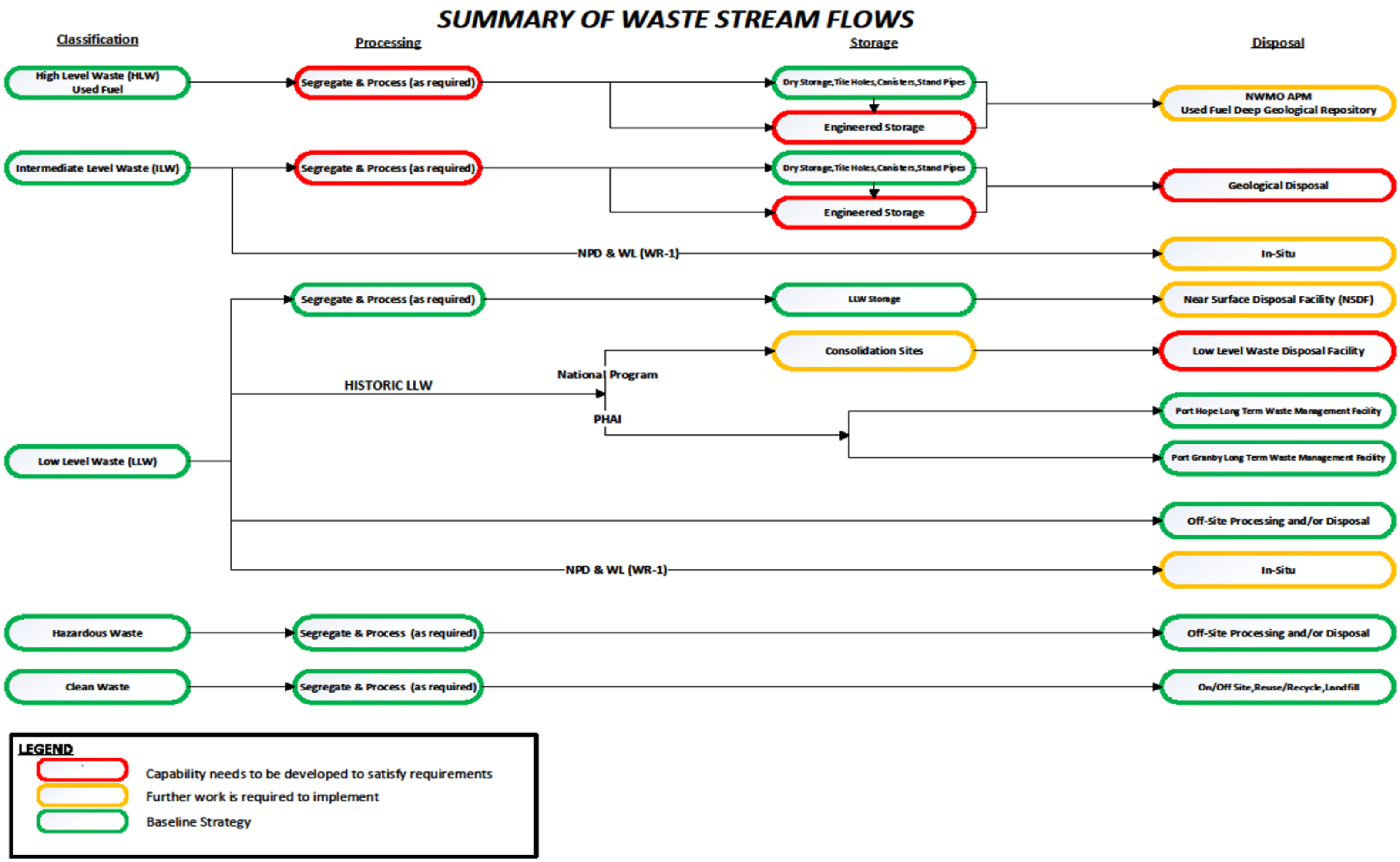

REFERENCE(S)

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	PR
PREPARED	PR
REVIEWED	CS
APPROVED	AB

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT

TITLE
SUMMARY OF CNL WASTE FLOW

PROJECT NO.	CONTROL	REV.	FIGURE
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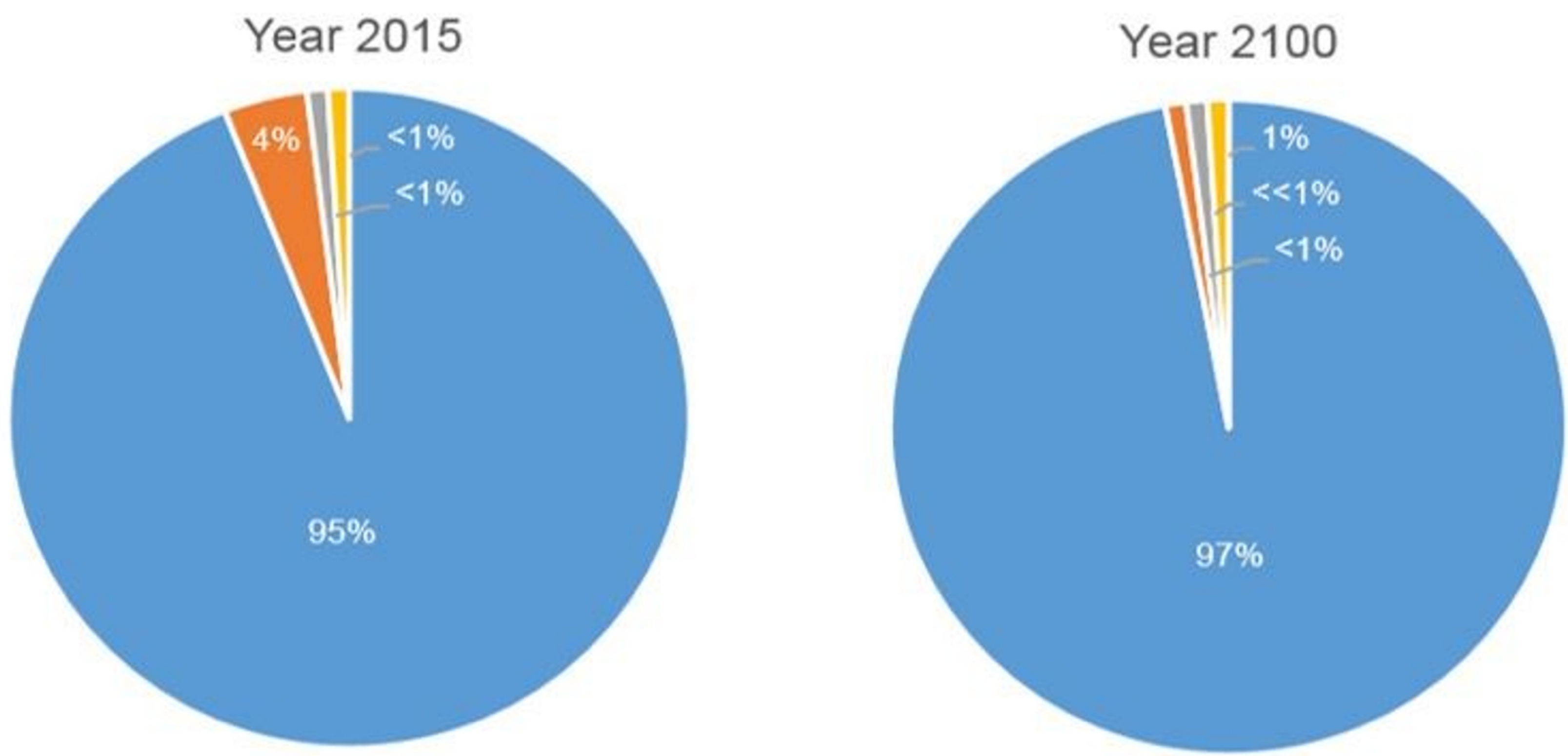

LEGEND

- Low Level Waste
- Intermediate Level Waste
- High Level Waste
- Hazardous Waste

REFERENCE(S)

CLIENT	CANADIAN NUCLEAR LABORATORIES LTD.	PROJECT	NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT CHALK RIVER, ONTARIO
CONSULTANT	GOLDER	TITLE	**CANADIAN NUCLEAR LABORATORIES WASTE CLASSES IN STORAGE BY VOLUME IN 2015 AND PREDICTED IN 2100**
DATE	NOVEMBER 2020	PROJECT NO.	1547525
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2.2.1 Waste Classification

2.2.1.1 High Level Waste (Used Fuel)

CNL's used fuel that has been declared as radioactive waste will be placed in safe, secure and suitable storage facilities until a national deep geological repository designed for used fuel becomes available. The solution is currently being developed by the Nuclear Waste Management Organization as part of its Adaptive Phased Management Plan (NWMO 2019), as per the *Nuclear Fuel Waste Act*.

2.2.1.2 Intermediate Level Waste

Historically, ILW has been stored on CNL managed sites and segregated based on handling and storage requirements. The current strategy is that ILW from all CNL managed sites will be packaged and stored at CRL until a Geological Disposal Repository is available. The exceptions to this are the Nuclear Power Demonstration (NPD) and Whiteshell Reactor 1 (WR-1) facilities which are proposed to be decommissioned in situ.

2.2.1.3 Low-Level Waste

Historically, LLW has been stored on CNL managed sites. At WL, Douglas Point and Gentilly 1 prototype reactor sites, LLW that is not being disposed in-situ will be packaged and shipped to CRL for placement in storage pending availability of the NSDF Project. The exceptions to this are the LLW arising from the NPD and WR-1 facilities, which are proposed to be decommissioned in situ. Historic LLW from the Port Hope Area Initiative (PHAI) are placed in the Long Term Waste Management Facilities as part of the Port Hope and Port Granby projects. LLW being managed through the National Programs initiative are stored at the sites of generation pending long-term solutions.

In the event that historic LLW is identified in the PHAI after the closure of the two long term waste management facilities (engineered containment mounds), it will be packaged to meet the NSDF WAC and sent to CRL for disposal.

2.2.1.4 Hazardous Waste

Small quantities of hazardous waste as defined by provincial and/or federal regulations (e.g., lead, polychlorinated biphenyls [PCBs]) are generated at CNL-managed sites. Hazardous waste will continue to be sent to an off-site licensed waste management service for processing and/or disposal.

2.2.1.5 Clean (Non-radiological) Waste

Clean (non-radiological) waste is disposed as it is generated. Clean waste suitable for reuse or recycling (e.g., paper, cardboard, plastics, metal and compostable waste) is sent to a commercial operator for processing. Concrete at CRL that has been confirmed as clean is processed and reused for on-site roads and backfill. For CRL and WL, the remainder of the waste goes to the on-site non-radiological landfill or off-site municipal landfills. At the prototype reactor sites, suitable clean waste will be sent to a commercial processor for reuse or recycling, with the remaining waste sent to local conventional municipal landfills.

2.2.2 Long-Term Waste Management Facilities for Chalk River Laboratories

The following strategies are in place for the long-term management of ILW and LLW at the CRL site.

2.2.2.1 Intermediate Level Waste

The current strategy for AECL's ILW (managed by CNL) is that it will be disposed in a deep geological repository although the type and location of this is not yet defined. A program of work is planned to assess the options and decide on a path forward. Future work will follow all applicable regulatory processes.

2.2.2.2 Low-Level Waste

The current strategy for AECL's LLW (managed by CNL) is that it will be disposed in the NSDF Project, which will be composed of an engineered containment mound (ECM), Wastewater Treatment Plant (WWTP), supporting facilities for NSDF Project operations, and various site infrastructure. Radioactive waste will be placed in the ECM and, as necessary, treated in advance of shipment to the NSDF Project. The NSDF Project will accept LLW that meets the waste acceptance criteria. The anticipated wastes that will be disposed in the ECM are further described in Section 3.3.

2.3 Purpose of the Project

AECL's nuclear legacy liabilities are the result of nuclear operations supported nuclear science and technology activities, including the production of medical isotopes, which have been underway for over 70 years. The majority of these liabilities are located at the CRL site and consist of shutdown nuclear facilities and radioisotope laboratories, radioactive wastes in interim storage, and contaminated lands.

A nuclear facility for the disposal of LLW is required to manage the volume of LLW arising from:

- past operations of AECL and CNL; waste dating back to the 1940s currently placed in interim storage within the CRL waste management areas which may not meet modern environmental or waste management practices;
- current and future operational activities of CNL's science and technology mission;
- decommissioning and waste management activities, including the near-term campaign to decommission and demolish more than 100 obsolete facilities/buildings and to remediate contaminated lands at the CRL site, as well as the closure of the WL; and
- commercial waste activities (e.g., waste generated by hospitals and universities).

CNL aims to have the NSDF Project operational and ready to accept waste by 2024 and the facility is expected to be operational for approximately 50 years. The ECM will be sized to hold up to up to 1,000,000 m^3 of LLW that is expected to be generated through 2070. Approximately 90% of the LLW will originate at the CRL site, with 5% of the LLW coming from decommissioning at WL in Manitoba and other AECL nuclear liabilities, and 5% from other Canadian sources, such as universities and hospitals.

Presently, wastes at the CNL sites are temporarily and safely contained in waste storage systems in accordance with current licence conditions that protect workers, the public and the environment. However, the practice of continuing to build additional temporary storage systems at the CRL site for LLW is not consistent with modern waste management principles. In accordance with *Canada's Radioactive Waste Policy Framework* (Government of Canada 2015), the waste producers and owners of radioactive waste are responsible for the funding, organization, management and operation of disposal and other facilities required for their wastes. Responsible nuclear waste management includes full life cycle management from generation to disposal.

Since CRL site operations began, wastes produced have been managed with the evolving practices of the time. Early waste management practices included burying LLW in sand trenches with no engineered barriers. To reduce the liability associated with these historical waste management practices, the stored wastes must be retrieved and disposed of using modern engineering technology. Generally, the more significant environmental risks on the CRL site reside in and around the earliest waste management areas that were in operation as early as 1946, where wastes were buried in unlined trenches or liquids were discharged directly into infiltration pits. One of the earliest waste management areas was also used to safely manage the waste produced as a result of the National Research Experimental accident in 1952. Waste management areas are subject to monitoring and remediation is implemented, as required. Although historical contamination is localized to the CRL site, wastes stored in waste management areas are the source of surrounding soil and groundwater contamination that would be better controlled by moving these wastes to a modern engineered facility.

The remediation of contaminated lands is anticipated to generate large volumes of LLW as impacted soils and legacy waste. Currently, large-scale environmental remediation of CRL contaminated lands is deferred until the proposed NSDF is available to mitigate the need for additional storage capability.

AECL has asked CNL to find solutions for the disposal of its LLW as a means to reduce its legacy liabilities and to enable the remediation and revitalization of the CRL site. The baseline strategy for solid LLW at the CRL site, WL site (excluding WR-1), NPD and off-site prototype reactors is to segregate where practical, process as required and place in storage until the proposed NSDF becomes available (CNL 2019a). The NSDF Project will enable the remediation of historically contaminated lands and legacy waste management areas, as well as the decommissioning of outdated infrastructure to facilitate the CRL site revitalization. Remediation will involve progressively reducing the risk and liability through prudent management and cleanup of contaminated and affected sites at the CRL site.

CNL has a wealth of operating experience for LLW facilities (including the Port Hope and Port Granby Long-term Waste Management Facilities), and there is international operating experience for LLW disposal facilities. The NSDF Project has been specifically designed as a permanent solution to reduce environmental risk and achieve isolation and containment of the sources of contamination for a sufficiently long period, according to the requirements set forth in the International Atomic Energy Agency (IAEA) *Disposal of Radioactive Waste Specific Safety Requirements No. SSR-5* (SSR-5; IAEA 2011). The facility has been designed so that the wastes will be safely managed long term without a need for retrieval. Although the intent is not to retrieve the waste, and to prevent inadvertent exposure to the public, consistent with international practices, the design of NSDF does not preclude future generations from retrieving NSDF contents.

2.4 Project Design Principles

The NSDF Project safety requirements have been captured by the NSDF Project design (AECOM 2019) and can be summarized as the following:

- The NSDF Project shall be designed and operated to ensure radiation safety is provided by multiple engineered barriers.
- The NSDF Project shall be designed to ensure safety is provided by passive means during the post-closure phase.

- The NSDF Project shall be designed, constructed, and operated so that projections of incremental doses to members of the public do not exceed 0.3 millisieverts (mSv) in a year from natural processes (i.e., all processes other than human intrusion into the waste).
- The NSDF Project shall comply with CRL site licence conditions and be licenced as a radioactive waste disposal facility.
- The NSDF Project shall comply with all CNL Management System Requirements.
- Safety classified NSDF systems must meet specified safety functions throughout their operation in order to protect radiological safety of public or facility personnel by limiting release of radioactive material and/or hazardous material, or limiting radiation exposure during and following normal, anticipated transient and accident conditions.

Any nuclear facility designed, constructed and operated at the CRL site is required to satisfy the CRL licence requirements and CNL Management Systems thus are not carried into the alternative means assessment. With respect to the first three safety requirements CNL has utilized CNSC and IAEA design principles which ensure the safety of radioactive waste long-term waste management or disposal facilities. These principles are essential elements in the design and development of a disposal facility and were used to inform the definition of evaluation criteria in Section 2.5.1. The alternative selected as the preferred or most favourable means of developing a disposal facility must meet the design principles and requirements discussed in Sections 2.4.1 and 2.4.2.

2.4.1 Canadian Nuclear Safety Commission

A primary driver for the NSDF Project is to safely and responsibly dispose of radioactive low-level as required in CNSC's *REGDOC-2.11.1 Waste Management, Volume I: Management of Radioactive Waste* (CNSC 2019, in development). CNL's current practice of interim storage of waste does not provide a cradle to grave management strategy thus pushes the burden of radioactive waste management forward in time to future generations. The NSDF Project is proposed as a responsible and safe solution for disposal of up to 1,000,000 cubic metres of LLW.

Canadian regulatory guidance for approaches to long-term safety of radioactive waste management is provided in CNSC's *REGDOC-2.11.1 Waste Management, Volume III: Assessing the Long-Term Safety of Radioactive Waste Management* (CNSC 2018). The CNSC identifies the need for long-term management of radioactive waste arising from licensed activities and considers the extent to which the owner of the waste has addressed the following principles:

- The management of radioactive waste is commensurate with its radiological, chemical and biological hazard to the health and safety of persons and the environment, and to national security;
- The assessment of future impacts of radioactive waste on the health and safety of persons and the environment encompasses the period of time when the maximum impact is predicted to occur; and
- The predicted impact on the health and safety of persons and the environment from the management of radioactive waste is no greater than the impact that is permissible in Canada at the time of the regulatory decision.

The design concepts for long-term management are based on the containment and isolation of the waste, which can be achieved through a robust design based on multiple barriers providing defense in depth. Isolation is achieved through proper site selection and institutional controls to limit access and land use.

2.4.2 International Atomic Energy Agency

The safety principles to be applied in all activities for radioactive waste management are set out in the IAEA Safety Fundamentals. The IAEA's *Fundamental Safety Principles* (IAEA 2006) outline and describe 10 safety principles in terms of radiation protection in design:

1) responsibility for safety;
2) role of government;
3) leadership and management for safety;
4) justification of facilities and activities;
5) optimization of protection;
6) limitation of risks to individuals;
7) protection of present and future generations;
8) prevention of accidents;
9) emergency preparedness and response; and
10) protective actions to reduce existing or unregulated radiation risks.

The IAEA has published safety requirements relating to the disposal of radioactive waste of all types in SSR-5 (IAEA 2011). The objective of IAEA's SSR-5 is to set out the safety objectives and criteria for the disposal of all types of radioactive waste and to establish, on the basis of the IAEA's *Fundamental Safety Principles* (IAEA 2006), the requirements that must be satisfied in the disposal of radioactive waste. Design principles and concepts to ensure safety in the disposal of radioactive waste shall include:

- multiple safety functions;
- containment of radioactive waste;
- isolation of radioactive waste; and
- surveillance and control of passive safety features.

Furthermore, the disposal facility and its engineered barriers shall be designed to contain the waste with its associated hazard, to be physically and chemically compatible with the host geological formation and/or surface environment, and to provide safety features after closure that complement those features afforded by the host environment. The facility and its engineered barriers shall be designed to provide safety during the operational period.

2.5 Alternative Means for Carrying Out the Project

The *Canadian Environmental Assessment Act, 2012* (CEAA 2012), requires that federal environmental assessments evaluate alternative means of carrying out a project that are technically and economically feasible and the environmental effects of any such alternative means. The Canadian Environmental Assessment Agency identifies in its operational policy statement *Addressing "Purpose of" and "Alternative Means" under the Canadian Environmental Assessment Act, 2012* the overall approach for considering the "alternative means" of carrying out a project (The Agency 2015). "Alternative means" is defined as the "various technical and economically feasible ways under consideration by the proponent that would allow a designated project to be carried out". In addition, environmental effects of each alternative means are also considered including biophysical, socio-economic, and public and worker health and safety. The CNSC's *REGDOC-2.9.1 Environmental Protection: Environmental Principles, Assessments and Protection Measures* (CNSC 2017) also requires that an assessment under the CEAA 2012 considers the different alternative means for carrying out a project.

The purpose of this section is to present the alternative means of developing a disposal facility for the long-term management of 1,000,000 m^3 of LLW. The consideration of alternatives is presented for each category in three steps:

- identification of technical and economically feasible alternative means;
- identification of effects on Valued Components (VCs); and
- application of criteria and completion of a comparative evaluation to identify the preferred option.

Each alternative is assessed and the most preferable option is selected after a systematic consideration of technical feasibility, economic feasibility and environmental effects. Public engagement is a key aspect of the decision-making process. A summary of the alternative means assessment was made available to the public and Indigenous peoples, and input received was taken into consideration for the final NSDF Project design. Topics addressed included:

- The alternative site locations for the potential NSDF Project were presented. The public requested additional information on the site selection process including "why the CRL site." Additional information has been included in Sections 2.5.4 and 2.5.5 regarding the process used and the sites considered.
- Alternative means for NSDF's effluent management strategy was explored as a one-day session with a focus group. Participants included stakeholders who expressed concern with respect to the NSDF Project's effluent management strategy and specifically included members of the public, local municipalities and non-governmental organizations. The purpose of the session was to elicit stakeholder insights and evaluation of the NSDF Project's proposed effluent management strategy. CNL solicited the participants' evaluation of the effluent discharge options using focus group developed criteria. The discussions from the focus group session have been considered by CNL for potential improvements to the NSDF Project, and have been incorporated into discussions within Section 2.5.6 (leachate management), Section 2.5.7 (effluent discharge options) and Section 2.5.8 (discharge type).

A social acceptability criterion was also included as part of the alternative means analysis to provide weight to any concerns and preferences expressed by the public and Indigenous peoples (Section 2.5.1).

The alternative means considered in the Environmental Impact Statement (EIS) are grouped into seven categories, as presented in Table 2.5-1. These alternatives were evaluated in the context of the NSDF Project design principles (described in Section 2.4) for the development of a permanent solution for the disposal of LLW.

Table 2.5-1: Alternative Means Evaluated for the Near Surface Disposal Facility Project

Aspect of the Disposal Facility	Alternatives Considered in the EIS
Facility Type (Near Surface vs. Deep Underground)	▪ NSDF ▪ Geologic waste management facility (GWMF)
Facility Design of Near Surface Options	▪ Engineered containment mound (ECM) ▪ Above-ground concrete vault (AGCV)
Facility Location	▪ On-site (at CRL) ▪ Off-site (WL or NPD site)
Site Selection	▪ 15 potential sites at CRL
Leachate Treatment System	▪ Existing wastewater treatment facility ▪ WWTP (new) ▪ No discharge option – leachate evaporation ponds
Effluent Discharge Options	▪ Discharge to ground ▪ Discharge to surface water (Perch Creek, Perch Lake and Ottawa River) ▪ Co-discharge with the NSDF stormwater system and discharge to ground ▪ Discharge to ground and discharge to surface water ▪ No liquid discharge (i.e., thermal evaporator)
Discharge Type	▪ Discharge by surface spray onto Perch Lake ▪ Piped outfall to Perch Lake (submerged outlet in Perch Lake) ▪ Piped outfall to Perch Lake (above-water discharge) ▪ Submerged diffuser in Perch Lake (alignment along lakebed) ▪ Submerged diffuser in Perch Lake (diffuser suspended in water column)

EIS = Environmental Impact Statement; GWMF = geologic waste management facility; WL = Whiteshell Laboratories; NPD = Nuclear Power Demonstration; WWTP = Wastewater Treatment Plant; EMR = East Mattawa Road

2.5.1 Evaluation Criteria

As defined by the Brundtland Commission in *Our Common Future: Report of the World Commission on Environment and Development* (Brundtland Commission 2013), sustainable development is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” Sustainability is a holistic approach that considers ecological, social and economic dimensions, recognizing that all must be considered together to find lasting success. The sustainability of each alternative mean was evaluated through the use of the various criteria (which were categorized as technical feasibility, economic feasibility, or environmental), both independently and holistically. The evaluation criteria selected considered the Environmental and Social Sustainability Performance Standards developed by the International Finance Corporation (IFC 2012), including:

- management of environmental and social risks and effects;
- pollution prevention;

- community health safety, and security;
- biodiversity conservation and sustainable management of living natural resources;
- Indigenous peoples; and
- cultural heritage.

Although not specifically identified as a separate criterion, sustainability is inherent in each of the criteria for the assessment of alternatives. Sustainability as a value is shared by many individuals and organizations who demonstrate this value in their policies, everyday activities and behaviours. For example, CNL's Environmental Policy has recently been amended to include a clear commitment to sustainability. This change supports CNL's alignment to standards set by the Government of Canada, specifically the 2016 to 2019 Federal Sustainable Development Strategy (Government of Canada 2016).

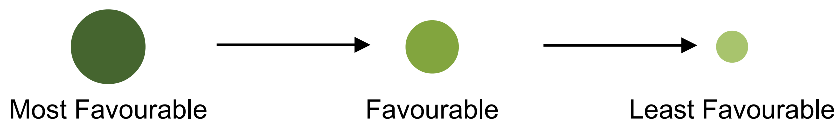
To determine the preferred or most favourable means of developing a disposal facility, each alternative is evaluated first for its technical feasibility. For those alternatives deemed technically feasible, a comparison of economic feasibility (i.e., cost) and the likely environmental effects is completed. Criteria for evaluating each of the alternatives are summarized in Table 2.5.1-1, with further rationale provided in the following sections.

Table 2.5.1-1: Criteria For Evaluating Alternatives

Category		Criteria
Technical Feasibility		▪ Does the alternative meet the project purpose, as defined in Section 2.3? ▪ Does the alternative meet the required storage capacity? ▪ Is the alternative an example of best available technology? ▪ Does the design incorporate compatible construction materials for the radioactive wastes planned for disposal to provide sufficient design robustness to protect the environment? ▪ What is the complexity of monitoring requirements for the alternative?
Economic Feasibility		▪ How does the life cycle cost of each alternative compare in relation to each other?
Environmental Effects	Biophysical	▪ Environmental setting - does the alternative result in new disturbance (i.e., Greenfield site) or is it located within a previously disturbed area (i.e., brownfield site)? ▪ How do the likely effects on biophysical VCs compare (e.g., atmospheric environment, aquatic biodiversity, and terrestrial biodiversity)? ▪ Can it be constructed, operated, and decommissioned in a manner that provides long-term protection of ecological health?
	Social	▪ How do the effects on socio-economic VCs compare (e.g., land and resource use, heritage resources, socio-economic)? ▪ How are the alternatives perceived by the public and Indigenous peoples and is one alternative preferred over another?
	Human Health & Safety	▪ Can the alternative be constructed/operated in a manner that provides protection of public health and safety? ▪ How does the long-term protection of public health and safety compare? ▪ Can the alternative be constructed/operated in a manner that provides protection of worker health and safety?

VC = Valued Component.

The alternatives are described using the above criteria (where applicable) and are summarized in a matrix illustrating the relative preference of each alternative, as shown below. If the alternative has a high chance of successfully addressing a particular criterion, it is rated as most favourable. Similarly, if the alternative has a moderate likelihood of addressing a criterion, it is rated as favourable, while if the alternative is assessed as having a low likelihood of success or having unacceptable risk with a particular criterion, a least favourable rating is used. For the technical criteria, a rating of "least favourable" was also generally considered to be the threshold for an alternative to not be technically feasible.



2.5.1.1 Technical Feasibility

The following criteria were developed for the technical feasibility category:

- **Project Purpose:** The purpose of the NSDF Project is to substantially reduce the risks associated with the CNL legacy wastes, liabilities and the cost of CNL operations to taxpayers and to facilitate CNL's cleanup mission, which allows for the revitalization of the CRL site. The most favourable alternative will satisfy the NSDF Project purpose, while the least favourable alternative will not satisfy the project purpose. Alternatives were considered to be favourable if they partially satisfied the purpose of the NSDF Project.
- **Storage Capacity:** The alternative must accommodate 1,000,000 m^3 of LLW, the majority of which is impacted soils and demolition waste. This volume is based on waste forecasting from future facilities and approaches to waste management. Alternatives that accommodated 1,000,000 m^3 were most favourable, Alternatives that did not accommodate 1,000,000 m^3 of waste were assessed as not technically feasible.
- **An Example of Best Available Technology:** This criterion evaluated the technology to be implemented with the alternative being considered relative to the types of wastes to be disposed. A best available technology was most favourable, while an available technology was considered to be favourable. An alternative was considered to be least favourable if the technology was unavailable, outdated or not appropriate for the type of waste to be disposed.
- **Disposal Facility Design Robustness:** This criterion considers the compatibility of the disposal facility construction materials with the LLW to be disposed as well as the design life of the facility. It is known that certain materials deteriorate over time when subjected to exposure to certain chemicals that may be contained in the leachate that is expected to be generated within the facility. The most favourable alternative will use construction materials compatible with the radiological and chemical characteristics of leachate that is expected to be generated such that the facility will perform effectively for a 500-year or greater post-closure period. A favourable alternative includes use of compatible construction materials that would result in the performance of the facility for less than a 500-year post-closure but more than a 300 year post-closure period. An alternative was assessed as not technically feasible if the construction materials were considered to be incompatible with the leachate and would result in deterioration of the construction materials during the operations phase or near-term post-closure period (i.e., less than 100 years).

- **Complexity of Monitoring:** This criterion considered the monitoring requirements that may be needed in support of each alternative. Standard monitoring requirements were considered most favourable, while a slight increase in monitoring requirements and/or complexity of the program was considered to be favourable. Least favourable alternatives were those that require complex or substantially increased monitoring requirements.

2.5.1.2 Economic Feasibility

The economic feasibility was evaluated by comparing the life cycle cost estimate for each alternative. This estimate includes costs for construction of the facility and supporting infrastructure, operations, and ongoing monitoring and maintenance activities. Additionally, costs incurred during decommissioning and closure, and those associated with long-term monitoring and maintenance activities required during the post-closure period were also considered. Cost information used for other projects and types of facilities can be highly variable depending on where the project is in its lifecycle and certainty in cost estimates (e.g., conceptual design versus construction complete).

2.5.1.3 Environmental Effects

The evaluation of environmental effects is based on a qualitative comparison of biophysical and socio-economic effects on VCs and potential effects on public and worker health and safety. VCs refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community or the public (The Agency 2018). The selection of appropriate VCs allows the assessment to be focused on those aspects of the natural and human environment that are of greatest importance to society.

The list of VCs selected for the NSDF are described in Section 5.1, and considered a number of factors, including:

- presence, abundance and distribution within or relevance to the area associated with the NSDF Project;
- potential for interaction with the NSDF Project and sensitivity to effects;
- species conservation status or concern;
- ecological and socio-economic value to communities, government agencies and the public;
- traditional, cultural and heritage importance to Indigenous peoples; and
- experience with similar projects.

Environmental effects are evaluated for biophysical, social, and human health components. To facilitate comparison of potential environmental effects on VCs between the alternatives, effects are described by discipline; rather than for each individual VC. For example, VCs for the terrestrial biodiversity discipline include species at risk and vegetation communities; however, for the alternatives assessment, environmental effects are evaluated for the terrestrial biodiversity discipline as a whole. The alternatives assessment considers effects on the biophysical (i.e., atmospheric environment, geological and hydrogeological environment, surface water environment, aquatic biodiversity, terrestrial biodiversity, and ecological health), social (socio-economic, land and resource use, and heritage resources), and human health and safety (i.e., public and worker) disciplines.

Environmental setting was included as an additional criterion in the evaluation of effects to the biophysical environment for alternatives (where applicable). The environmental setting criterion considered brownfield versus greenfield site; namely whether construction would occur within existing disturbed or undeveloped area. Development within an existing disturbed area was considered most favourable, while construction within an undeveloped area was favourable. Development within an environmentally sensitive area or that would affect significant cultural resources were considered to be least favourable.

Engagement with the public and Indigenous peoples is a key aspect of the decision-making process. A social acceptability criteria was included to provide weight to any concerns and preferences expressed by the public and Indigenous peoples.

2.5.2 Facility Type

Various types of disposal facilities have been constructed and are in operation around the world. These facility types have different degrees of containment and isolation capability appropriate to the radioactive waste that they will receive and its associated risk. However, regardless of the facility type selected, the specific aims of disposal remain the same according to IAEA's SSR-5:

- to contain the waste;
- to isolate the waste from the accessible biosphere and to reduce substantially the likelihood of, and all possible consequences of, inadvertent human intrusion into the waste;
- to inhibit, reduce and delay the migration of radionuclides at any time from the waste to the accessible biosphere; and
- to confirm that the amounts of radionuclides reaching the accessible biosphere due to any migration from the disposal facility are such that possible radiological consequences are acceptably low at all times.

To meet the requirements of IAEA's SSR-5, CNL has defined the near surface disposal within its Integrated Waste Strategy as the primary disposal path for LLW that meet the Waste Acceptance Criteria.

The alternative facility types to the NSDF considered were:

- a geologic waste management facility (GWMF), which is a deep underground facility for disposal of radioactive waste;
- shallow or intermediate-depth caverns; and
- a separate dedicated very low-level waste (VLLW) repository.

2.5.2.1 Ongoing Waste Storage

2.5.2.1.1 Technical Feasibility

When developing the NSDF Project, CNL also considered maintaining the status quo which would involve the continued use of interim storage. This could involve the use of CRL waste management areas, the use of bunkers and storage buildings and rolling stewardship and monitored retrievable storage. However, as noted in Section 2.3 of the revised EIS, continuing to build additional temporary storage systems at the CRL site for LLW is not consistent with modern waste management principles. In accordance with *Canada's Radioactive Waste Policy Framework* (Government of Canada 2015), the waste producers and owners of radioactive waste are responsible for the funding, organization, management and operation of disposal facilities required for their wastes. As such CNL does not consider the ongoing waste storage as technically feasible as it is not aligned with national policies.

Furthermore, the historic WMAs have minimal to no engineered barriers to contain their inventory. Although the releases and groundwater impact from these WMAs is currently being managed, the risk of future releases and environmental impacts the inventory poses could be substantially reduced through improved containment and isolation of the source term. Leaving the historic WMAs in their current configuration as an alternative to LLW disposal is not technically feasible as it is unlikely to satisfy regulatory and licensing requirements for long-term waste management, specifically those specified within REGDOC-2.11.1 Volume III (CNSC 2018).

2.5.2.2 Near Surface Disposal Facility

2.5.2.2.1 Technical Feasibility

The IAEA definition of a near surface disposal is the placement of solid, or solidified, radioactive waste in a disposal facility located at or near the land surface (IAEA 2014). The preferred option for disposal of LLW is in near surface disposal facilities (IAEA 2001). An NSDF is a suitable and technically feasible means of disposing of LLW and the effectiveness of such facilities for disposal of LLW has been demonstrated as illustrated through the following near surface facilities currently in operation North America. Within Canada, CNL is implementing the Port Hope and Port Granby Projects, on behalf of AECL, in eastern Ontario for the safe, long-term management of historic LLW arising from the operations of the former Crown Corporation Eldorado Nuclear Ltd and its private-sector predecessors. These projects are building facilities for the long-term storage of LLW that are similar in design to the NSDF proposed for CRL.

Selected examples of NSDFs for LLW are provided in Table 2.5.2-1, which provides a summary of the key attributes for these facilities. A number of these are located in wet climates and in close proximity to surface waterbodies similar to the NSDF proposed for CRL.

The NSDF has been designed as a permanent disposal facility, incorporating best available technologies and industry practices, including documented experience from the IAEA and other similar national and international facilities (as described above). In accordance with Requirement 5 of IAEA's SSR-5, the NSDF would also be sited, designed and operated to provide features that are aimed at the isolation of the radioactive waste from people and the environment. Subsurface investigations have concluded that the geology and hydrology on the selected CRL site is acceptable for the construction and operation of the NSDF. Designed and operated in accordance with applicable codes and best practices, the NSDF technology will feature a multilayer, base-liner and cover system to contain the waste, a WWTP with dual process trains to treat the leachate generated, and robust safety monitoring systems such as leak detection, radiation monitoring and environmental monitoring to ensure the safety of workers and the public and the protection of the environment during the operations and post-closure periods.

The safety of the NSDF during post-closure is provided by means of passive features (e.g., berm, final base-liner and cover systems) that will end the need for active management, which is in alignment with Requirement 5 of IAEA's SSR-5. The features of the selected site and the performance of the combined natural and engineered barriers assure safety following the closure of the ECM (IAEA 2014). For example, a primary barrier material, the high-density polyethylene geomembrane, has been specifically tested for compatibility with the leachate quality and concentrations expected during NSDF operations. In addition, institutional controls, including restrictions on land use, and a program for monitoring, will be implemented in the post-closure period to provide long-term safety of the public and the environment.

Adaptive management is a means by which uncertainties in outcomes can be reduced through monitoring. The role of adaptive management is to evaluate the results of monitoring programs in order to develop appropriate responses on an ongoing basis. As such, the potential for applying adaptive management to the NSDF Project has been implicitly incorporated into project design thus facilitating future modifications should monitoring indicate that changes are necessary.

In summary, the NSDF design addresses all of the relevant technical feasibility criteria set out in Table 2.5.1-1.

Table 2.5.2-1: Attributes of Selected Near Surface Facilities in Canada and USA for Long Term Management of Low-Level Waste

Facility	Location	Built	Status	Capacity (m3)	Waste Type	Climate	Annual Precipitation	Terrain	Distance to Nearest Surface Water Body
Proposed CNL Near Surface Disposal Facility	Ontario, Canada	Proposed	Proposed	1,000,000	LLW from past operations, environmental remediation and decommissioning	Wet	87 cm	On a ridge	~0.35 km to Perch Creek, 1.2 km to Ottawa River
Port Granby Long Term Waste Management Facility	Ontario, Canada	2017	In Operation	774, 000	LLW, hazardous and mixed waste from uranium processing and environmental remediation	Wet	83 cm	Flat	0.7 km Lake Ontario
Port Hope Long Term Waste Management Facility	Ontario, Canada	2017	In Operation	1,200,000	LLW, hazardous and mixed waste from uranium processing and environmental remediation	Wet	83 cm	Flat	0.1 km to Brand Creek, 3 km to Lake Ontario
Oakridge National Laboratories, Environmental Management Waste Management Facility	Tennessee, USA	2002	In Operation	1,300,000	LLW, hazardous waste from environmental remediation and decommissioning	Wet	140 cm	On a ridge	0.5 km to Bear Creek & Clinch River
Hanford Environmental Restoration Disposal Facility	Washington, USA	1996	In Operation	16,800,000	LLW, hazardous and mixed waste from environmental remediation and decommissioning	Arid	16 cm	Flat	12 km to Columbia River
Portsmouth On-site Waste Disposal Facility	Ohio, USA	Under Construction	Under Construction	1,000,000	LLW, hazardous and mixed waste from uranium processing	Wet	102 cm	On a ridge	2.4 km to Sciota River
Fernald On-site Disposal Facility	Ohio, USA	1996	Closed	2,250,000	LLW and mixed waste from uranium processing	Wet	105 cm	Flat	~1 km to Great Miami River

2.5.2.2.2 Economic Feasibility

The estimated cost of licensing and constructing the NSDF using an engineered containment mound (i.e., Phase 1 as well as initial development of the Phase 2 footprint) is approximately $365 million (M) (2018 Class 1 estimate). This estimate includes site preparation and construction of the engineered containment mound, WWTP, site development and infrastructure and support facilities. This estimated cost has increased since the NSDF Project draft EIS in 2017 primarily due to an improvement in cost certainty for construction as well as is reflective of project design changes and necessary revisions to environmental studies and modeling to incorporate feedback received on the draft EIS. Installation of capping over Phase 1 as well as completing construction of Phase 2 to operate will cost approximately $110 M.

Operating costs associated with a 50-year operating life that includes both Phases 1 and 2, site closure costs, and surveillance and long-term maintenance costs for a 30-year period following end of operations are estimated at $275 M. This cost is broken down into $240 M for 50 years of operation and maintenance of both Phases 1 and 2 including replacement of operational equipment, $5 M for surveillance and long-term maintenance (30 Years beyond the 50 Years Operation), and $30 M for final closure costs.

This results in a total lifecycle cost of approximately $750 M for the NSDF alternative using an engineered containment mound, which is more than an order of magnitude less than the cost of a GWMF alternative. The total life cycle cost for above ground concrete vaults, another type of near surface disposal facility, is $3,414.8 M which is also less than a GWMF alternative (Section 2.5.3.2.2). The reduced cost of either type of NSDF is more preferable as it further contributes to the reduction of the cost of laboratory operations to the Government of Canada and Canadian taxpayers.

2.5.2.3 Geologic Waste Management Facility

2.5.2.3.1 Technical Feasibility

A GWMF provides an alternative to the NSDF Project as proposed (CNL 2016a). GWMFs are designed for the long-term management of LLW, ILW and HLW. Wastes are processed and packaged for disposal in intermediate to deep underground repositories in stable geological formations.

While there are no GWMFs currently operating in Canada, the US Department of Energy’s Waste Isolation Pilot Plant developed a deep geologic repository (more than 700 m deep) for ILW and HLW, which has been in operation since 1999. There are a number of GWMFs that are either under construction or with licence applications to construct under regulatory review, including:

- Finland’s deep geologic repository for used fuel from Olkiluoto and Loviisa, approximately 400 to 450 m below ground in the Olkiluoto bedrock, as proposed by Posiva.
- Sweden’s Final Repository for Short-Lived Radioactive Waste for operational wastes (up to ILW) is approximately 50 m below the bottom of the Baltic Sea near Forsmark. Sweden is also proposing an underground repository for disposal of spent fuel, approximately 500 m below ground near Forsmark.
- The French National Radioactive Waste Management Agency’s proposed 500 m deep geological repository complex in clay at Bure, France for HLW and long-lived ILW.
- Ontario Power Generation’s (OPG) proposed Deep Geologic Repository (DGR) for LLW and ILW on the Bruce Site in Tiverton, Ontario, approximately 680 m below ground surface.

In addition, China, Germany, India, Japan, Switzerland, the United Kingdom, United States and Canada are also pursuing geologic repositories for the long-term management and disposal for used fuel and other HLW. The use of GWMF as the preferred disposal solution is primarily for HLW and long-lived ILW, where additional barriers for protection are warranted.

CNL conducted assessments of its site geology and confirmed that the geologic characteristics required for a GWMF are present on the CRL site. Significant surface and subsurface investigations including approximately 12,000 m of borehole drilling, core logging, geological mapping, geophysical surveys, hydrogeological surveys, and various geotechnical tests were performed on the CRL site since the 1970s to examine the suitability of the crystalline bedrock to host a GWMF for the permanent disposal of CNL's ILW at a depth between 500 and 1,000 m. Both shallow boreholes (less than 300 m) and deeper boreholes (approximately 1,200 m) were drilled as part of the investigations.

Information derived from characterization activities was used to define bedrock structures on both macroscopic and mesoscopic scales. A descriptive hydrogeological model of the CRL site was developed, outlining the hydrogeological properties and 3D spatial distribution of all important hydrogeological units and features within the bedrock of the CRL site. The rock mass characterization conducted to date provides a reasonable basis for a positive decision to proceed to siting studies for a GWMF at the CRL site. As for the GWMFs discussed above, CNL would need to undertake comprehensive siting assessments and develop a robust design that protects the environment.

Because GWMFs are built subterranean, provided suitable geology is available, there are no practical limitations on the size of the repository. As such, the GWMF can be designed to provide a total waste volume of 1,000,000 m^3.

In GWMFs, isolation is provided primarily by the host geological formation and the depth of disposal. The passive safety features (barriers) of the GWMF design have to be sufficiently robust so as not to require repair or upgrading, in keeping with requirements that disposal facilities for radioactive waste not rely on active institutional control (IAEA 2011). However, institutional controls may contribute to safety by preventing or reducing the likelihood of human actions that could inadvertently interfere with the waste or degrade the safety features of the GWMF. In addition, a program for monitoring would be needed in the post-closure period to demonstrate long-term safety of the public and the environment.

In summary, the GWMF facility type meets most technical feasibility criteria, as set out in Table 2.5.1-1. The GWMF has been demonstrated to provide an adequate level of environmental protection through international experience (as described above). It would satisfy the purpose of the NSDF Project in that it would provide the needed disposal capacity for CNL's LLW. The technology for GWMFs is an example of best available technology and a robust design with monitoring systems that meet international requirements for disposal facilities could be developed at the CRL site based on available geologic data.

2.5.2.3.2 Economic Feasibility

The costs associated with constructing a GWMF are considerably higher than a NSDF. Similarly, the operating costs for a GWMF would also be greater than that of the NSDF due to the need for additional waste packaging and handling of all waste. For example, the total waste volume to be disposed in OPG's DGR Project is 200,000 m^3 of LLW and ILW (OPG 2011a). The estimated capital costs for the DGR Project are estimated at $1,000 M (OPG 2011a). Annual operating costs are estimated at $25 M (Golder 2004). Using these values, the inferred lifetime expenditure for a GWMF with a total waste volume of 1,000,000 m^3 and 50-year operations phase could be greater than $6,250 M.

2.5.2.4 Very Low-Level Waste Disposal Facility

2.5.2.4.1 Technical Feasibility

Very-low-level waste is a considered a subcategory of LLW as per CSA standard for the nuclear industry *N292.0-19 General Principles for the Management of Radioactive Waste and Irradiated Fuel*. CNL previously considered the development of a VLLW disposal facility at the CRL site and implemented a trial to demonstrate the viability of segregation and storage of VLLW (CNL 2016b). The trial demonstrated that the fraction of the total LLW that could be segregated as VLLW was disproportionate to the time, effort and storage requirements that were expended to realize any net benefit from the work. In addition, the LLW with higher activity that is segregated from the VLLW will still require a separate LLW disposal facility. Therefore, the development of a VLLW disposal facility does not meet the Project purpose which recognizes the need for an LLW disposal facility and a VLLW disposal facility is not considered technically feasible.

2.5.2.4.2 Economic Feasibility

The planned cost of developing a VLLW disposal facility is expected to be similar to the cost of developing an LLW disposal facility (i.e., the current NSDF Project); however, a VLLW disposal facility would require additional time and effort to segregate and manage the VLLW from the rest of the LLW (CNL 2016b). The development of an LLW disposal facility (inclusive of VLLW) would eliminate duplication of effort, time, dose and facility construction, operation and closure costs and would enable reduction of Canada’s liabilities earlier than it would have if a small percentage of the total inventory had been segregated and disposed separately. Therefore, the development of a separate VLLW disposal facility is not considered economically feasibility when compared to the cost savings associated with the development of a LLW facility that is inclusive of VLLW.

2.5.2.5 Environmental Effects

The key pathways by which a NSDF or GWMF may interact with the environment is through surface water and groundwater intrusion, migration of contaminated water (leachate), inadvertent intrusion, release of radioactive particulates to the atmosphere, and disturbance to the terrestrial environment from the project footprint. Regardless of whether the facility is a NSDF or GWMF, engineered barriers and mitigation measures would be implemented to prevent or delay the migration of contaminants, protect human and ecological health, and limit effects to the aquatic and terrestrial environments. These barriers and mitigation measures represent an important component of the safety from the operations phase through the post-closure phase.

The majority of effects to air quality would occur during the construction and operations phases for both alternatives. Blasting activities would be required for the construction of both an ECM and a GWMF and fugitive dust emissions would be generated during earth moving activities. During operations and post-closure of the ECM, radioactive gases (e.g., radon and tritium) and radioactive particulates may be released from the wastes within the facility during the operations and post-closure phases. During operations, there would be differences in atmospheric emissions between the two alternatives; the ECM would have heavy equipment placing wastes and cover material at surface, whereas the majority of the equipment during operations of the GWMF will be below ground, and emissions managed through ventilation shafts. Both alternatives would have different types of effects on air quality; they would each implement mitigation that provides for worker and public health and safety and protection of the environment. Greenhouse gas emissions are expected to be of the same order of magnitude for both alternatives.

Potential effects on hydrogeology are related to the alteration of groundwater levels and flows due to the construction of the facility and potential changes to groundwater quality due to migration of leachate following post-closure activities. Subsurface investigations at the CRL site have concluded that the geology on-site is acceptable for the construction and operation of an NSDF. The surface geology of the CRL site is composed of four types of glacial and post-glacial sediments including till, water-deposited sands (fluvial), wind-deposited (Aeolian) sands and organic deposit. To limit potential effects to groundwater, engineered barriers to control for infiltration of surface water, groundwater intrusion, and migration of contaminated water (leachate), would be implemented. Engineered barriers can be used as physical and/or chemical obstructions and can provide either partial containment or complete isolation of the waste or both (IAEA 2001).

In GWMF facilities, the waste is normally placed below the ground water table and will thus have a water saturated environment outside the engineered barriers soon after closure of the repository (Argonne National Laboratory 2011). A study has been performed to gather sufficient facts for the resultant geoscientific interpretations and analyses to determine whether or not suitable bedrock conditions likely exist at CRL for a GWMF. Hydraulic testing was completed which suggests that intrablock regions of the CRL rock base is generally low to very low below the 400 to 500 m depth. In accordance with the groundwater flow models, the deeper bedrock at the CRL site appears to be able to provide moderately strong natural barrier against transport of contaminants from a GWMF. In summary, although both alternatives would be designed to be protective of groundwater; a GWMF is considered to be more favourable as it would provide additional barriers against potential groundwater transport.

Both facility types may affect existing availability of the spatial and temporal distribution of water quantity for aquatic and terrestrial ecosystems. For both the NSDF and GWMF facility types, surface water drainage would be managed within the project footprint. Proposed design features would be based on best available surface water management practices controlling erosion, capturing sediment, and for safely conveying flows associated with a back to back 1:100-year or regional storm event. Because the GWMF design would not be prone to infiltration of precipitation through the waste during placement, only the NSDF alternative would require some form of water treatment to mitigate potential effects to surface water quality associated with the seepage of leachate from the facility (i.e., changes to groundwater quality). The NSDF's water treatment facility would be designed to meet site-specific risk-based effluent quality criteria to be protective of the environment and humans. In conclusion, there are no anticipated differences between the NSDF and GWMF alternatives when considering potential effects to the surface water environment from each facility except the infiltration of water to the waste and related need for treatment to mitigate effects.

Potential effects to terrestrial biodiversity are primarily related to the amount of surface disturbance to vegetation and wildlife habitat. The footprint for a NSDF large enough to accommodate 1,000,000 m^3 of LLW is approximately 37 ha. The surface footprint required for a GWMF is dependent on the size of the underground repository and the volume of waste rock to be managed at surface. As a comparison, the surface footprint required for the DGR Project is approximately 30 ha for management of 200,000 m^3 of waste (OPG 2011a). Therefore, the footprint required for waste rock management at the CRL site for 1,000,000 m^3 could be much larger. This larger footprint would result in greater indirect effects on the terrestrial environment. However, in both cases, mitigation will be implemented to eliminate or reduce potential effects on Species at Risk that may be found or critical habitat.

The objective of the design of a disposal facility is to ensure the facility can be built and the waste received, handled, and disposed without undue risk to human health and the environment, both during facility operation and after facility closure. There are numerous examples of both NSDF and GWMF type facilities that have been successfully constructed and operated. Within Canada, CNL is implementing the Port Hope and Port Granby Projects for the safe, long-term management of historic LLW arising from the operations of the former Eldorado Nuclear Ltd. These projects are building near surface management facilities similar to the design proposed for the

NSDF Project. Public dose estimates were calculated in 2018 for Port Hope and Port Granby. The public dose estimate at Port Hope is 0.0275 millisievert per year (mSv/yr) based on 60 hours at the east fence (CNL 2019b) and the public dose at Port Granby is 0.020.0 mSv/y based on 60 hours at south fence line (CNL 2019c). Both public dose estimates are well below the CNSC dose limit of 1 mSv/yr for members of the public. Radiation doses to members of the public for the long-term maintenance and monitoring phase are predicted to be indistinguishable from the background conditions (Golder 2005).

A detailed safety assessment, performed for OPG's Deep Geologic Repository Preliminary Safety Report (OPG 2011b), concluded that the results of the analysis indicate very low doses to the public, far below the CNSC regulatory limit of 1 mSv/yr. A preliminary post-closure performance and safety assessment for OPG's long-term management of LLW and ILW in a GWMF type facility examined the long-term evolution of the performance post-closure. Results from the simulation showed that estimated dose rates were orders of magnitude below 0.3 millisieverts (mSv), and concluded that there were no results found which would preclude the safe disposal of the six LLW and ILW groups which were used in this study. For a similar GWMF facility (i.e., OPG's Deep Geologic Repository) for the Human Intrusion scenario, a borehole is drilled into the repository and gases and material are released (OPG 2011a). The calculated doses were estimated to be about 1 mSv for the future person farming on the site. However, the likelihood of inadvertent human intrusion into the waste will be low as a consequence of the chosen depth for a GWMF (IAEA 2011).

Regardless of the type of facility, the design would aim to ensure that such releases do not exceed applicable regulatory limits during either the operations or post-closure phases and are protective of humans and the environment. However, given the nature of the GWMF located at a nominal depth, this facility type may be considered more robust against surface activities and therefore is more favourable.

Both a NSDF and GWMF facility type would meet all regulations and be constructed in a manner that protects worker health and safety. Operations at the NSDF will be similar to those applied by CRL at the WMAs for over 70 years. It is expected that the majority of environmental remediation and decommissioning waste will be disposed as bulk material, in unpackaged form. Approximately 13% of LLW will have sufficiently high radionuclide content to require use of packaging in the NSDF. Conversely, increased packaging would be a requirement for a GWMF, and the additional handling and packaging of wastes may result in increased exposure to workers. The design process provides for worker health and safety by maintaining occupations exposures ALARA regardless of which facility type is selected; however, because of the reduced handling and packaging requirements, the NSDF type facility is most favourable.

While both an NSDF and a GWMF can be constructed in a manner that protects public and worker safety, a GWMF includes a natural geologic barrier that provides additional isolation of the wastes. This is expected to be viewed more favourably and considered safer by the public and Indigenous peoples even though this extra layer of protection is not required for the disposal of LLW.

Overall, mitigation through the implementation of the above-described engineered barriers for an NSDF or GWMF facility are anticipated to reduce or limit environmental effects and subsequently risk to human and environmental health. Effects to ecological health are expected to be similar between alternatives (e.g., air and dust emissions and employment and business opportunities generated for both design options are assumed to be similar; both design options would avoid lakes and streams, sensitive and/or critical habitat, and significant cultural resources, and both would require restrictions on future land use).

2.5.2.6 Summary

Both the NSDF and GWMF alternatives meet CNL's overall need and are environmentally feasible options. However, the GWMF does have substantially higher life cycle costs, which are potentially an order of magnitude higher than for an NSDF. Although a GWMF would provide increased barriers for potential releases to the environment in the long-term, the nature of the waste (i.e., LLW), the majority of which is impacted soils and demolition waste, does not warrant the need for these barriers. Low-level waste requires isolation and containment for periods of time up to a few hundred years. A GWMF also requires additional waste handling for waste placement whereas LLW does not require shielding during handing or interim storage. GWMFs are most typically proposed for HLW and ILW, which are not within the scope of the NSDF Project.

Near surface disposal facilities, as proposed for the NSDF project, have been demonstrated globally to be an effective disposal solution for LLW. Therefore, a NSDF is the most feasible and most favourable alternative. Table 2.5.2-2 provides a summary of the evaluation of alternatives.

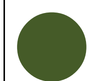
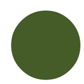
Table 2.5.2-2: Evaluation of Alternatives - Facility Type

Criteria	Alternative 1 – Near Surface Disposal Facility (NSDF)		Alternative 2 – Geologic Waste Management Facility (GWMF)	
Technical Feasibility				
Project Purpose	The NSDF satisfies the project purpose and allows for the planned decommissioning and site restoration activities and reduces liabilities associated with the CNL legacy wastes.		Construction of a GWMF allows for the planned decommissioning and site restoration activities and reduces liabilities associated with the CNL legacy wastes.	
Storage Capacity	The NSDF can be designed to provide a total waste volume of 1,000,000 m^3.		The GWMF can be designed to provide a total waste volume of 1,000,000 m^3.	
An Example of Best Available Technology	The NSDF facilities have been applied for the disposal of LLW globally (e.g., Oak Ridge Tennessee EMWM Facility) and is recognized by the IAEA as a suitable disposal option for LLW (IAEA 2009), especially for non-consolidated waste (e.g., soil and demolition material).		The GWMF facilities have been applied for the disposal of ILW (e.g., Waste Isolation Pilot Plant). The GWMF offers a level of containment that exceeds the requirement for LLW.	
Design Robustness	The NSDF incorporates best available technology, including documented experience from the IAEA and other similar national and international facilities. It is the performance of the combined natural and engineered barriers that provides safety after closure for the NSDF.		Conceptually, a GWMF has been demonstrated to provide an adequate level of environmental protection through international experience, thus is considered to be robust and technically feasible. The natural geologic barrier of a GWMF provides additional isolation of the wastes, as compared to a NSDF.	
Monitoring Complexity	Environmental monitoring is straightforward and could be incorporated into the monitoring program at an existing site (e.g., CRL site).		Environmental monitoring (i.e., groundwater monitoring) is expected to be more complex given the depth of the facility.	

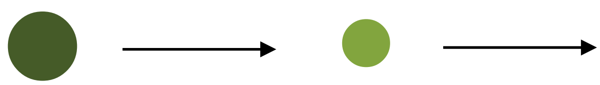
Table 2.5.2-2: Evaluation of Alternatives - Facility Type

Criteria	Alternative 1 – Near Surface Disposal Facility (NSDF)		Alternative 2 – Geologic Waste Management Facility (GWMF)	
Economic Feasibility				
Life Cycle Cost	Approximately $750 million (ECM) to $3,400 million (AGCV)		Up to approximately $6,250 million	
Environmental Effects				
Biophysical				
Atmospheric Environment	No anticipated difference between alternatives.			
Geological and Hydrogeological Environment	Engineered barriers to control infiltration of surface water and prevent release of contaminated water (leachate) from the NSDF, would be implemented.		The natural geologic barrier of a GWMF provides additional isolation of the wastes, as compared to a NSDF.	
Surface Water Environment	There are no anticipated differences between the alternatives.			
Aquatic Biodiversity	There are no anticipated differences between the alternatives.			
Terrestrial Biodiversity	The footprint required for a NSDF is anticipated to be 37 ha; however, mitigation would be implemented to eliminate or reduce potential effects on Species at Risk that may be found or critical habitat.		The footprint required for waste rock management of a GWMF could be much larger. Mitigation would be implemented to eliminate or reduce potential effects on Species at Risk that may be found or critical habitat.	
Ecological Health	No anticipated difference between alternatives.			
Social				
Socio-economics	No anticipated difference between alternatives.			
Land and Resource Use	No anticipated difference between alternatives.			
Social Acceptability	A GWMF is expected to be perceived more favourably compared to an NSDF due to the perception that a GWMF is safer.		A GWMF is expected to be perceived more favourably compared to an NSDF due to the perception that a GWMF is safer.	

Table 2.5.2-2: Evaluation of Alternatives - Facility Type

Criteria	Alternative 1 – Near Surface Disposal Facility (NSDF)		Alternative 2 – Geologic Waste Management Facility (GWMF)	
Human Health and Safety				
Public Health & Safety (construction and operations)	Both alternatives can be developed in a manner that protects public health and safety during construction and operations.			
Public Health & Safety (long-term)	Institutional controls, including restrictions on land use, and a program for monitoring will be implemented in the post-closure period to confirm long-term safety of the public and the environment.		Institutional controls, including restrictions on land use, and a program for monitoring will be implemented in the post-closure phase to confirm long-term safety of the public and the environment. However, given the nature of the GWMF located at a greater depth, human intrusion is less likely.	
Worker Health & Safety	Because of the reduced handling and packaging requirements, the NSDF type facility is most favourable.		All waste will require packaging which increases potential exposure and risk to workers.	

Note:



Most Favourable Favourable Least Favourable

GWMF = Geological Waste Management Facility; LLW = low-level waste; ILW = intermediate level waste; IAEA = International Atomic Energy Agency.

2.5.3 Facility Design

This section evaluates the proposal of disposing waste within two types of NSDF's: an above-ground concrete vault (AGCV) design and an ECM design.

2.5.3.1 Engineered Containment Mound

Disposal facilities constructed on the surface, typically in the form of a mound or hill, primarily use engineered barriers to prevent water from infiltrating the disposed waste, thus maintaining diffusion-controlled transport of radionuclides, which is an extremely slow process (Bergman 2006). To meet the above-mentioned design principles and objectives, the ECM design features composite final cover and base liner systems comprising natural and synthetic materials. The base liner contains both engineered leachate collection and leak detection systems as well as natural drainage elements. The performance of the ECM will be monitored to provide early indications of any need for maintenance or repair. The design of the ECM for the NSDF Project is fundamentally consistent with those for the Port Granby and Port Hope Long-term Waste Management Facilities now in operation.

2.5.3.1.1 Technical Feasibility

An advantage of this mound-type repository design is that the waste is placed above the groundwater table and the waste stays dry as long as the protective barriers are intact, which may be on the order of hundreds of years (Argonne National Laboratory 2011). These mound-type disposal facilities also have relatively moderate technical requirements for the site, so it is usually easy to find places to locate them. For the proposed ECM, soil will be used to fill the space between the waste packages. This type of fill material will help to stabilize the waste in the ECM. This added stability is also important in the long-term as the waste degrades and there is potential for the final cover to settle. These fill materials also allow easy removal of the waste, if such action ever became necessary after disposal.

The vast majority of the waste streams are comprised of impacted soils and demolition debris, which can be readily placed into compacted layers within the ECM. This type of less consolidated waste is typically disposed in ECMs (examples of other ECM facilities are provided in Table 2.5.2-1). When compaction rates are adhered to, the facility throughout its life cycle behaves as a single “entity” and will survive significant seismic events without much damage or implication. Although ECM facilities may require extensive monitoring; these monitoring programs are relatively straight-forward and similar programs are currently in place at CRL site.

The main disadvantage for surface disposal is that the protective cover of the waste is exposed to weathering and erosion that can endanger the integrity of the repository. The cover is designed to divert the precipitation away from the ECM. Available literature on geomembrane service life under the conditions expected for the ECM (i.e., temperature, leachate quality, radiation and stresses) indicates that HDPE geomembrane liner (i.e., primary composite liner and final cover liner) is expected to remain functional over the 500-year post-closure design life of the ECM. The cover liner is also the feature of the facility that is the easiest and cheapest to repair or replace if infiltration does occur (R. Kerry Rowe Inc. 2019).

2.5.3.1.2 Economic Feasibility

The estimated cost to build (i.e., capital expenditures,) the NSDF for the 1,000,000 m^3 of CNL waste is $475 M. This estimate includes site preparation and construction of the engineered containment mound, supporting facilities and buildings, and access roads. Operating costs associated with a 50-year operating life, site closure costs and surveillance and long-term maintenance costs for a 30-year period following end of operations are estimated at $275 M. This results in a total lifecycle cost of $750 M for the NSDF Project.

2.5.3.2 Above-Ground Concrete Vaults

Above-ground concrete vaults (AGCV) are another type of disposal facility employing engineered multi-barrier concrete structures set partially into the ground. With this technology, isolation is provided by a reinforced-concrete building constructed on the surface. Waste containers may be loaded into a vault through an open side or top, which is sealed after the vault has been filled. Concrete containment vaults add structural stability to the disposal unit, help to prevent any infiltrating water from coming in contact with the waste and provides an intrusion barrier around the waste. The waste in the building would be isolated from humans and the environment as long as the integrity of the building is maintained.

2.5.3.2.1 Technical Feasibility

Although AGCV facilities may require extensive monitoring; these monitoring programs are relatively straightforward and similar programs are currently in place at the CRL site.

Disposal facilities using AGCV provide concrete barriers to the waste and are therefore not as heavily impacted by weathering and erosion, when compared to the ECM-type; however, there are disadvantages (Argonne National Laboratory 2011). Above-ground facilities are subject to deterioration through exposures to wind, rain, and freeze-thaw cycles and are vulnerable to cracking as a result of uneven settlement and seismic events. While some of these trigger events could be mitigated by earth covers surrounding the AGCV, not all can be reduced. Design features such as reinforcement, expansion joints, sealants and drainage collection would serve to mitigate the impacts of these forces. Further, concrete has been extensively studied and can be made durable enough to last for a few hundred years and perhaps longer (US Congress, Office of Technology Assessment 1989). Some predictive models even indicate that concrete will last longer than 1,000 years; however, beyond about 500 years, the uncertainty of such predictions increases (US Congress, Office of Technology Assessment 1989).

There are several international examples of the use of AGCV, including facilities in France and Spain. The facility located at Centre de l’Aube in France, which began operations in 1992, has been designed to be Europe’s largest repository for LLW and ILW. Waste are placed in concrete vaults constructed on the surface under a movable shelter that protects the wastes from weather during placement. Once a vault is full, a concrete cover is poured in place to completely isolate the waste from the environment. This facility is designed for 1,000,000 m^3 of LLW and ILW, with a future forecast of 1,900,000 m^3, so a future facility will be required at some point. The Centre l’Aube facility receives waste from power plants, research activities and fuel manufacturing and reprocessing plants. This type of waste is suitable for an AGCV given the packaged nature of the waste. The majority of the waste proposed for the NSDF Project is impacted soils and demolition waste which is less consolidated and would be easier to manage in a facility like the ECM (i.e., unconsolidated waste can be moved around more easily).

2.5.3.2.2 Economic Feasibility

The construction cost estimate for AGCV option was developed from the 1999 Organization for Economic Co-operation and Development report titled *Low Level Waste Repositories: An Analysis of Cost* (OECD-NEA 1999) using information from El Cabril facility for LLW in Spain. The construction cost, including research and development, site screening, facility design, 28 disposal vaults, supporting buildings and facilities, for a 100,000 m^3 facility was approximately $229 M (Canadian dollars), plus $762 for every additional cubic metre of waste. For the CNL waste volume of 1,000,000 m^3, the cost to construct an AGCV design would be approximately $914.8 M, which is considerably higher than the ECM design. Annual operating costs are estimated at $2,500/$m^3$ of waste placed (present day value) (OECD-NEA 1999). Using these values, the inferred lifetime expenditure for the AGCVs with a waste volume of 1,000,000 m^3 and 50-year operations phase is estimated. This results in a total life cycle cost of $3,414.8 M ($914.8 M for construction and $2,500 M operations); approximately five times the cost of the ECM alternative.

2.5.3.3 Shallow Cavern

2.5.3.3.1 Technical Feasibility

Another type of NSDF includes the disposal of LLW in shallow caverns. However IAEA guidance (IAEA 2014) recognizes that in the siting process of a near surface disposal facility, the facility design ought to consider the hydrogeological characteristics of the siting location. The groundwater table at the host site should be deep, well below the base of the cavern, to ensure that the cavern does not flood and release radionuclides to the environment. As such shallow caverns were eliminated from consideration for CNL's LLW facility design primary due to the CRL site characteristics.

In the Site Study Area, average groundwater depths range from 0.06 meters below ground surface (mbgs) to 15.95 mbgs, with an average of 4.81 mbgs under normal conditions, and 3.61 mbgs during seasonal high conditions (Section 5.3.2.1.2.1). Near-surface caverns constructed in, or near the water table, are at a very high risk of immediate flooding, and are therefore not appropriate or technically feasible for the disposal of radioactive waste. Furthermore, no single cavern could be excavated to meet the volume of 1,000,000 m^3, resulting in multiple caverns and multiple designs to suit the localized hydrogeology.

Wastes placed into shallow caverns on the CRL site are more likely to come into contact with groundwater very quickly, providing a very short flowpath for the migration of radionuclides into the environment. Thus, the shallow cavern facility design at the CRL site does not align with IAEA guidance (IAEA 2014), and is therefore not suitable or technically feasible.

2.5.3.4 Environmental Effects

The pathways by which contaminants from a NSDF may migrate or be brought into contact with humans and biota is through infiltration of surface water, groundwater intrusion, migration of contaminated water (leachate), inadvertent intrusion and escape of radioactive gas (IAEA 2001). Regardless whether the facility incorporates an ECM or AGCV, engineered barriers will be implemented to prevent or delay the migration of contaminants via these pathways. These barriers represent an important component of the NSDF safety from the operations phase through the post-closure phase. The design of the NSDF will provide that all safety and regulatory requirements are met such that the ECM or AGCV would be constructed and operated in a manner that is safe to the public and workers.

Engineered barriers to control for infiltration of surface water, groundwater intrusion, migration of contaminated water (leachate), inadvertent intrusion and escape of radioactive gas for the ECM include installation of a primary and secondary liner, and a final cover at closure. For the ECM, most of the waste placed in the facility will be unpackaged (i.e., loose/bulk); although some wastes may be packaged (e.g., in high integrity containers) to provide additional short-term containment. Most of the waste to be disposed will arise from the decommissioning of buildings and is lightly contaminated and safe to be disposed in bulk form (i.e., without double-handling and packaging), reducing unnecessary processing and packaging decreases potential exposure and risk to workers.

Greenhouse gas emissions for the AGCV facility are expected to be above that of the ECM because of concrete production. The AGCV facility is constructed of reinforced concrete that offers structural stability and provides an intrusion barrier around the waste. The AGCV also deters infiltration of water to the wastes, and therefore does not generate leachate which requires treatment. The footprint required for the AGCV is 1.5 to 2 times that required for an ECM due to the need to package all waste for an AGCV and constraints on the stacking of waste packages. Based on constructible areas available at the CRL site, it would be necessary to develop at least two sites/locations to establish disposal capacity for 1,000,000 m^3 of waste in an AGCV type facility. Developing multiple sites would have a greater biophysical effect.

Overall, mitigation through the implementation of the above described engineered barriers for an ECM or AGCV facility are anticipated to reduce or limit environmental effects and subsequently risk to human and environmental health. Effects to all other VCs are expected to be similar between alternatives (e.g., air and dust emissions and employment and business opportunities generated for both design options are assumed to be similar; both design options would avoid lakes and streams, sensitive and/or critical habitat, and significant cultural resources, and both would require restrictions on future land use). Because the pathways through by which contaminants may migrate or be brought into contact with humans and biota are similar for both alternatives, similar monitoring programs would also be required during operations and through the post-closure phase to demonstrate long-term safety of the public and the environment. In terms of worker safety, an ECM reduces unnecessary processing and packaging which would be required for an AGCV, thereby decreasing potential exposure and risk to workers.

2.5.3.5 Summary

As summarized in Table 2.5.3-1, both alternatives are technically and environmentally feasible. Both alternatives can be constructed such that they meet the purpose of the NSDF Project and both alternatives can be constructed to accommodate up to 1,000,000 m^3 of radioactive waste. The AGCV and ECM facility designs are best available technology and there are several international examples of each. Both have relatively moderate technical requirements and can be sited on the CRL site. The AGCV is expected to be more vulnerable to seismic events compared to an ECM which behaves as a single “entity” and is more resilient to seismic events. The monitoring requirements for these surface-located options are similar and employ conventional environmental technologies. The life cycle costs associated with an AGCV design are approximately five times the cost of the ECM alternative. In addition, the additional packaging and containment is not required for most of the LLW intended to be disposed on the CRL site. Therefore, the most favourable alternative facility design for the NSDF is an ECM.

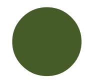
Table 2.5.3-1: Evaluation of Alternatives - Facility Design

Criteria	Alternative 1 – Engineered Containment Mound (ECM)		Alternative 2 – Above-ground Concrete Vaults (AGCV)	
Technical Feasibility				
Project Purpose	Both alternatives meet the technical requirements.			
Storage Capacity	The ECM would require approximately 17 ha to contain 1,000,000 m^3 of radioactive waste within the engineered mound, and approximately 20 additional ha for the WWTP, support facilities and site infrastructure. All NSDF Project elements can fit on a single site on the CRL site.		The AGCV would require 1.5 to 2 times the spatial area of an ECM for the disposal of the same quantity of waste. The concrete vault has limitations on stacking of waste containers resulting in a larger footprint needed to contain CNL's 1,000,000 m^3 volume. Due to the large number of surface waterbodies and wetlands, CRL does not have a single site large enough for an AGCV sized to hold 1,000,000 m^3 of waste and would need to develop (at least) two sites.	
An Example of Best Available Technology	ECM is an example of a best available disposal technology and widely used internationally for disposal of LLW which is mainly composed of impacted soils and demolition waste.		AGCVs are an example of best available disposal technology and have been used for packaged LLW and ILW. The AGCV offers a level of containment that exceeds the requirement for LLW.	
Design Robustness	The ECM offers multiple engineered barriers including a double composite base liner system with redundant leachate systems, and a composite cover system. Natural and manmade materials are employed for system robustness.		The AGCV offers multiple engineered barriers that provide design robustness. These include high strength concrete structural elements and engineered packages for all wastes.	
Monitoring Complexity	Both alternatives may require extensive monitoring; however, these monitoring programs are relatively straight-forward and are currently in place at the CRL site.			
Economic Feasibility				
Life Cycle Cost	Approximately $750 million		Approximately $3,400 million	

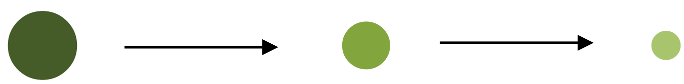
Table 2.5.3-1: Evaluation of Alternatives - Facility Design

Criteria	Alternative 1 – Engineered Containment Mound (ECM)		Alternative 2 – Above-ground Concrete Vaults (AGCV)	
Environmental Effects				
Biophysical				
Atmospheric Environment	No anticipated difference between alternatives.			
Geological and Hydrogeological Environment	Leachate will be generated by the ECM during operations which will require treatment and management to ensure effects are mitigated.	●	Minimal leachate will be generated by an AGCV during operations.	●
Surface Water Environment	No anticipated difference between alternatives.			
Aquatic Biodiversity	No anticipated difference between alternatives.			
Terrestrial Biodiversity	The disturbance footprint would be designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible.	●	The disturbance footprint would be designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible, however AGCVs are likely to have a larger footprint as a result of additional packaging requirements.	●
Ecological Health	No anticipated difference between alternatives.			
Social				
Socio-economic	No anticipated difference between alternatives.			
Land and Resource Use	No anticipated difference between alternatives.			
Social Acceptability	An AGCV is expected to be perceived more favourably compared to an ECM due to the perception that it is safer	●	An AGCV is expected to be perceived more favourably compared to an ECM due to the perception that it is safer. Further, operation of an AGCV generates minimal leachate requiring treatment, and may therefore also be perceived to be preferable.	●
Public Health & Safety (construction and operations)	Both alternatives can be developed in a manner that protects public health and safety in during construction and operations.			
Public Health & Safety (long-term)	Both alternatives can be developed in a manner that protects public health and safety in the long-term.			

Table 2.5.3-1: Evaluation of Alternatives - Facility Design

Criteria	Alternative 1 – Engineered Containment Mound (ECM)		Alternative 2 – Above-ground Concrete Vaults (AGCV)	
Human Health and Safety				
Worker Health & Safety	Reduces unnecessary processing and packaging which decreases potential exposure and risk to workers.		All waste will require packaging which increases potential exposure and risk to workers.	

Note:



Most Favourable Favourable Least Favourable

ECM = engineered containment mound; AGCV = above-ground concrete vaults; LLW = low-level waste; ILW = intermediate level waste; WWTP = Wastewater Treatment Plant.

2.5.4 Facility Location

A few of the factors affecting siting decisions for radioactive disposal include national policies, scale of geography, volumes of waste to be disposed. The Canadian federal government has chosen not to mandate a national repository for disposal of LLW and ILW radioactive wastes, and this policy has implications for disposal choices for various waste owners. Nonetheless the different approaches in siting or design of the disposal facility will always consider of the level of risk the respective waste inventory poses for current and future generations. For example, long-lived radioactive inventories require substantially more collaboration with the public due to the associated hazard and uncertainties of future land use planning. Whereas siting decisions for short-lived radioactive inventories, which decay within approximately 100 years to ranges representative of naturally occurring materials, necessitate less public involvement if reasonable land-use planning by the owner can be demonstrated within the timeframe of decay.

AECL and CNL's preference for an LLW disposal was a technically feasible site on lands currently under AECL ownership and CNL control, ideally close to the location of generation and/or storage of the waste and in an area that is already covered by a nuclear licence.

Previous endeavours by AECL in planning and siting for radioactive waste disposal had already deemed the CRL site technically sufficient. The CRL site is the most suitable host site for AECL/CNL's LLW disposal due to its complex history (e.g., past waste management practices) and the vast majority of waste is already at or will be generated at the CRL site thereby significantly reducing the need for transportation. Low-level waste is by far the largest volume among radioactive waste categories (i.e., in the millions of cubic meters), thus facility siting must underpin the impact of transportation. Similar to national research sites in the US, the CRL site is fairly complex with higher levels of environmental contamination and large volumes of waste thus amalgamation of the associated liabilities at this location is practical. As the owner of the CRL site and associated liabilities, AECL (a federal Crown corporation) will continue to put in place measures to ensure that the site is managed and controlled (e.g., restricting the land use of the NSDF Project footprint) for as long as necessary.

CNL also considered locating the facility at alternative sites owned by AECL for the Government of Canada and operated by CNL, specifically WL in Pinawa, Manitoba, and the NPD prototype reactor site in Rolphton, Ontario. The land at these sites is controlled by CNL and are likely to have suitable technical characteristics to safely manage the waste. The non-CRL options are more likely to raise public concerns related to transportation safety of larger volumes of LLW radioactive wastes. Also, both WL and NPD are scheduled to be closed within the next decade, and therefore, will not have the services and management infrastructure required to safely and securely operate the NSDF.

This section evaluates the proposal of disposing waste at sites owned by AECL either on-site at CRL or off-site at WL or NPD. When evaluating the technical feasibility of the facility location, many of the criterion can be satisfied by both alternatives.

2.5.4.1 On-site Location at Chalk River Laboratories

The CRL site (approximately 4,000 ha) extends approximately 6.5 km inland from the Ottawa River. The controlled WMAs are located within the CRL site. The CRL main campus contains the majority of buildings, laboratories, and nuclear facilities on-site and is located adjacent to the Ottawa River.

2.5.4.1.1 Technical Feasibility

More than 90% of the CNL waste to be managed in the ECM is already on the CRL site thereby reducing the distance the waste needs to be transported.

Subsurface investigations on the CRL site have concluded that the geology on-site is acceptable for the construction and operation of an ECM. The surface geology of the CRL site is composed of four basic types of glacial and post-glacial sediments including till, water-deposited sands (fluvial), wind-deposited (aeolian) sands and organic deposit.

Access within the CRL site is well established and upgrades required for heavy equipment and truck traffic would be minimal. Mandatory services (i.e., Class IV power, water for sanitary and process requirements, gas or other heating sources) are also readily accessible. A robust environmental monitoring program is already in place at the CRL site and the monitoring requirements specific to the NSDF Project could be incorporated into this program.

2.5.4.1.2 Economic Feasibility

As described in Section 2.5.3.1.2, the total life cycle cost of an NSDF facility on the CRL site is approximately $750 M.

2.5.4.2 Off-site Location (CNL Sites excluding Chalk River Laboratories)

The non-CRL off-site locations selected for the alternative means evaluation are those operated by CNL: WL in Pinawa, Manitoba, and the Prototype Reactor Site NPD in Rolphton, Ontario.

2.5.4.2.1 Technical Feasibility

Both WL and NPD sites have sufficient area available on-site to accommodate the construction and operation of a NSDF facility with a storage capacity of 1,000,000 m^3. In addition, both locations may be geologically suitable sites for a NSDF.

Both NPD and WL sites are scheduled to be decommissioned within the next decade. As a result, these sites would need to continue to provide the physical services (i.e., Class IV power, water for sanitary and process requirements, gas or other heating sources, or other nuclear operating infrastructure) and management infrastructure required to support the operation of the NSDF for the 50-year operating period. Both sites have robust environmental monitoring programs in place, but would need to be expanded to address the additional requirements of a NSDF. Shipping of the waste to NPD or WL by transport truck and/or rail is a feasible option.

2.5.4.2.2 Economic Feasibility

Both alternatives are assumed to have similar capital costs for site characterization needed to confirm the suitability for a NSDF. Operational costs would be higher for an off-site facility as the majority of the wastes are located at CRL and would require packaging and transportation. Approximately 90% of the proposed waste for the NSDF Project originate from the CRL site and would require off-site transport. In addition, management and maintenance of services would be higher for sites that would be otherwise decommissioned. Overall, the costs associated with transporting radioactive waste to an off-site facility makes this alternative less favourable. Eventual closure of the NSDF facility and post-closure monitoring and maintenance costs are assumed to be similar for both alternatives.

2.5.4.3 Environmental Effects

The CRL site is located in the Central Gneiss belt of the Grenville Structural Province of the Canadian Shield. The bedrock consists of highly altered gneissic rock and felsic igneous rock of late Precambrian-early Paleozoic age. The overburden of the CRL site consists of boulder, silty sand till deposited during the most recent glaciation, overlain with fine to medium sands. The till contains a wide range of size fractions, from large blocks of rock to fine silts and clay. The general geology of the region is the Precambrian shield with old folding and faulting of the metamorphic rocks (gneiss).

The surface of the NPD site is covered by a boulder pavement (i.e., large boulders), which in most areas has been left as a result of water scouring the area and removing the finer fraction of the river-lain sediments. The base rock is quartz and granite gneiss with some overburden of alluvial sand and gravel. The small amount of overburden and relatively steep incline of the base rocks makes ground and subsurface water run off very quickly to the river.

At the WL site, the regional surficial geology comprises widespread deposits of till and glacio-fluvial and glaciolacustrine materials. The stratigraphic units in sequence from bedrock upwards are silty sand till, clayey silt till, silty clay and an upper soil complex comprised of laminated clayey silt with minor interbeds of massive silty clay and finally surface organics.

Subsurface investigations on the CRL site have concluded that the geology on-site is acceptable for the construction and operation of an ECM. Both WL and NPD locations may be geologically suitable sites for a NSDF. It is expected that a facility could be constructed safety at either of the locations based on similar geology at the sites.

All three sites support a diverse mix of upland and wetland habitats. Vegetation on the CRL site includes deciduous and coniferous forest and a wide variety of plant species, including eight provincial species at risk plant species. The NPD site is mainly wooded with the exception of open wetland areas. Wooded uplands generally range from 40 to 80 years old and wetlands are mainly found on the western half of the NPD site.

The WL site is primarily under treed cover, consisting of a mixture of wetlands and forests of broadleaf, mixed and coniferous stand types. A large area contains a complex of bog, fen and swamp wetlands spanning the center and east portions of the WL site. The disturbance footprint of the NSDF would be similar for all sites, and similar mitigation would be implemented to reduce or limit effects to the terrestrial biodiversity. For example, the disturbance footprint would be designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible.

Wildlife species found on the CRL and NPD sites are generally typical for a boreal region in Ontario. At the CRL site, a total of 23 federal and/or provincial species at risk have been confirmed including four species of turtles, three species of bats, several forest songbirds, eastern milksnake (*Lampropeltis triangulum*), western chorus frog (*Pseudacris triseriata*), and monarch butterfly (*Danaus plexippus*) (*Species at Risk Act* Schedule 1: List of Wildlife Species at Risk; *O. Reg. 230/08 Species At Risk In Ontario List*). A full list of species at risk at CRL is presented in Appendix 5.6-1.

Seven federal species at risk (*Species at Risk Act*, Schedule 1: List of Wildlife Species at Risk) have been confirmed on the overall NPD site: little brown myotis (*Myotis lucifugus*), northern myotis (*Myotis septentrionalis)*, eastern milksnake, monarch butterfly, and three bird species, eastern wood-pewee (*Contopus virens*), common nighthawk, (*Chordeiles minor*) and, most notably, chimney swift (*Chaetura pelagica*).

Over 50 species of mammals can be expected to be found around the WL site; many of the mammals are common and widespread. The Winnipeg River is an important migratory corridor for many bird species and there are important bird migration staging areas on, or near the WL site, centering on the Winnipeg River. Five federal species at risk have been confirmed on the overall WL site, including little brown myotis, northern myotis, snapping turtle (*Chelydra serpentine*), Canada warbler (*Wilsonia canadensis)* and barn swallow (*Hirundo rustica*).

Although the footprint for each alternative would be similar, the wildlife habitat potentially affected is different. A portion of the CRL site has identified critical habitat for Blanding's turtle (*Emydoidea blandingii*), whereas there is no critical habitat identified by Environment and Climate Change Canada at the WL or NPD sites with the exception of a stack at the NPD site which is proposed critical habitat for chimney swift. However, as mentioned above, the disturbance footprint would be designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. Other potential effects are similar between the alternatives and include short-term sensory effects of noise on bats and songbirds, and increased injury and mortality to wildlife from traffic, particularly turtles. Mitigation to be implemented is standard at all CNL sites and includes, for example, implementation of a Blasting Plan and enforcement of reduced speed limits on-site, respectively.

The Ottawa River is the dominant drainage feature in the area for both the CRL and NPD sites, and all surface drainage on these sites ultimately drains to the river. The CRL and NPD sites are located in the Allumette Lake and Lac Coulonge reach of the Ottawa River, which extends approximately 90 km between La Passe and the Des-Joachims hydroelectric dam. The Ottawa River supports diverse warm-water and cool-water fish communities consisting of at least 85 documented species. Typical catches from the Ottawa River include Walleye (*Sander vitreus*), Northern Pike (*Esox lucius*), Channel Catfish (*Ictalurus punctatus*), Smallmouth Bass (*Micropterus dolomieu*) and Lake Sturgeon (*Acipenser fulvescens*), Channel Catfish being the most abundant. The provincial and federal fish Species At Risk in the Ottawa River are American Eel (*Anguilla rostrata*), Lake Sturgeon, Northern Brook Lamprey (*Ichthyomyzon fossor*), and River Redhorse (*Moxostoma carinatum*). Fish in inland lakes on the CRL site include Pumpkinseed (*Lepomis gibbosus*), Northern Pike, bass species, and Yellow Perch (*Perca flavescens*). Minnow species such as shiner, dace, and chub are abundant in streams and lakes on the CRL site.

The Winnipeg River is the dominant drainage feature in the area of the WL site, where all surface water runoff drains into the Winnipeg River. The Winnipeg River supports a variety of forage fish species such as carp and minnow species. Predator fish in the area include Walleye, Northern Pike, Smallmouth Bass, mooneye species, and Lake Trout (*Salvelinus namaycush*). The Carmine Shiner (*Notropis percobromus*), listed as Threatened under the *Species at Risk Act*, is likely to occur in the vicinity of WL site. No differences are anticipated between the alternatives as mitigation would be implemented to reduce or eliminate effects to aquatic diversity. For example, regardless of whether or not the facility is constructed and operated on-site or off-site, leachate from the ECM would be collected and treated via a WWTP prior to discharge to the receiving environment.

Shipping nearly 1,000,000 m^3 of waste from CRL to WL or the NPD site, at an average of 20 m^3 of waste per truck, would result in 50,000 shipments. The potential environmental effects of transporting such large volumes by truck will be greater than disposal in an on-site facility at CRL. The off-site transport of large amounts of radioactive waste on public roads (i.e., 50,000 shipments travelling roughly 1,900 km from CRL to WL or 35 km from CRL to NPD) may raise perceived safety concerns amongst the public.

2.5.4.4 Summary

The comparative evaluation between facility location alternatives is provided in Table 2.5.4-1. All three sites are anticipated to have the suitable geology and area needed for the safe construction and operation of a NSDF. Building a disposal facility on the CRL site has the advantages of being closest to future decommissioning waste and legacy waste stored at CRL WMAs. The associated cost of transporting waste to a facility at CRL is considerably less than transporting the waste to a WL or NPD location. Moreover, the non-CRL options are more likely to raise public concerns related to transportation safety of large volumes of LLW radioactive wastes. Both WL and NPD are scheduled to be closed within the next decade, and therefore, will not have the services and management infrastructure required to safely and securely operate the NSDF. As such, WL and NPD off-site locations are less favourable.

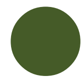
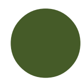
Table 2.5.4-1: Evaluation of Alternatives – Facility Location

Criteria	Alternative 1 – On-site at CRL		Alternative 2 – Off-site at Non-CRL sites	
Technical Feasibility				
Project Purpose	The CRL site satisfies the project purpose and allows for the planned decommissioning and site restoration activities and reduces liabilities and the cost of CNL operations to taxpayers.	●	As closure is planned at WL and NPD and will be completed within the next decade, these sites are not considered technically feasible without continuation of the support services required.	●
Storage Capacity	Both alternatives have sufficient area available to develop a facility with a storage capacity of 1,000,000 m^3.			
An Example of Best Available Technology	Both alternatives would be using the same best available technology for the NSDF design.			
Design Robustness	Design requirements would be the same for a NSDF facility at CRL or off-site.			
Monitoring Complexity	Robust monitoring is currently in place at the CRL site which can be expanded to accommodate any additional monitoring requirements for the NSDF.	●	Both sites have monitoring programs in place. Additional resources may be required to implement monitoring for a NSDF during the 50-year operating period at these sites.	●
Economic Feasibility				
Life Cycle Costs	Total life cycle costs are estimated to be approximately $750 million for a facility on the CRL site.	●	Operations costs would be much higher at a non-CRL site as a result of the additional packaging and transportation of waste off-site that would be required.	● (WL site) ● (NPD site)

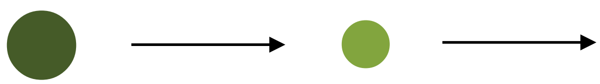
Table 2.5.4-1: Evaluation of Alternatives – Facility Location

Criteria	Alternative 1 – On-site at CRL		Alternative 2 – Off-site at Non-CRL sites	
Environmental Effects				
Biophysical				
Atmospheric Environment	Decreased air emissions and greenhouse gases as most of the waste to be disposed in the NSDF is from the CRL site.		Additional transportation of waste would result in increased air emissions and greenhouse gases.	
Geological and Hydrogeological Environment	Subsurface investigations on CRL site have concluded that the geology on-site is acceptable for the construction and operation of an ECM.		Geotechnical investigations to support in-situ disposal have been conducted at both WL and NPD and confirm that these sites are suitable for an NSDF type facility.	
Surface Water Environment	No differences are anticipated between the alternatives; all three sites are located within close proximity to a major water feature (i.e., Winnipeg River or Ottawa River).			
Aquatic Biodiversity	No differences are anticipated between the alternatives.			
Terrestrial Biodiversity	Critical habitat for species at risk have been identified at CRL, whereas it is not at WL or NPD. However, the disturbance footprint would be designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible.		No critical habitat for species at risk is present on the NPD or WL site with the exception of a stack at the NPD site which is proposed critical habitat for chimney swift.	
Ecological Health	No differences are anticipated between the alternatives.			
Social				
Socio-economics	New employment and business opportunities associated with the NSDF Project.		New employment and business opportunities associated with the NSDF Project.	
Land and Resource Use	No off-site transport of waste required therefore minimizing energy use.		Transport of waste is an energy intensive activity.	
Social Acceptability	Most waste to be disposed is already located at the CRL site which limits the transportation of waste off-site and is expected to be more acceptable to the public and Indigenous peoples compared to Alternative 2.		The off-site transport of large amounts of radioactive waste on public roads may raise perceived safety concerns amongst the public and Indigenous peoples.	

Table 2.5.4-1: Evaluation of Alternatives – Facility Location

Criteria	Alternative 1 – On-site at CRL		Alternative 2 – Off-site at Non-CRL sites	
Human Health and Safety				
Public Health & Safety (construction and operations)	Most waste to be disposed is already located at the CRL site which limits the transportation of waste off-site.		The off-site transport of large amounts of radioactive waste on public roads may raise perceived safety concerns amongst the public.	
Public Health & Safety (long-term)	Transport of waste on public roads is minimized reducing the risk of traffic accidents		Higher risk of traffic accidents from transport of waste on public roads (50,000 trips)	
Worker Health & Safety	Both alternatives can be developed in a manner that protects worker health and safety.			

Note:



Most Favourable Favourable Least Favourable

WL = Whiteshell Laboratories; NPD = Nuclear Power Demonstration; ECM = engineered containment mound.

2.5.5 Site Selection

The selection process for the siting of the NSDF at CRL included the identification of 15 potential sites within the CRL site for initial screening. This screening process included the development of mandatory criteria that must be satisfied by candidate locations; mandatory criteria included:

- minimum area of 14 ha;
- site must be at least 200 m wide;
- access to Class IV electricity for power;
- access to water for sanitary and process requirements; and
- access to gas or other heating source.

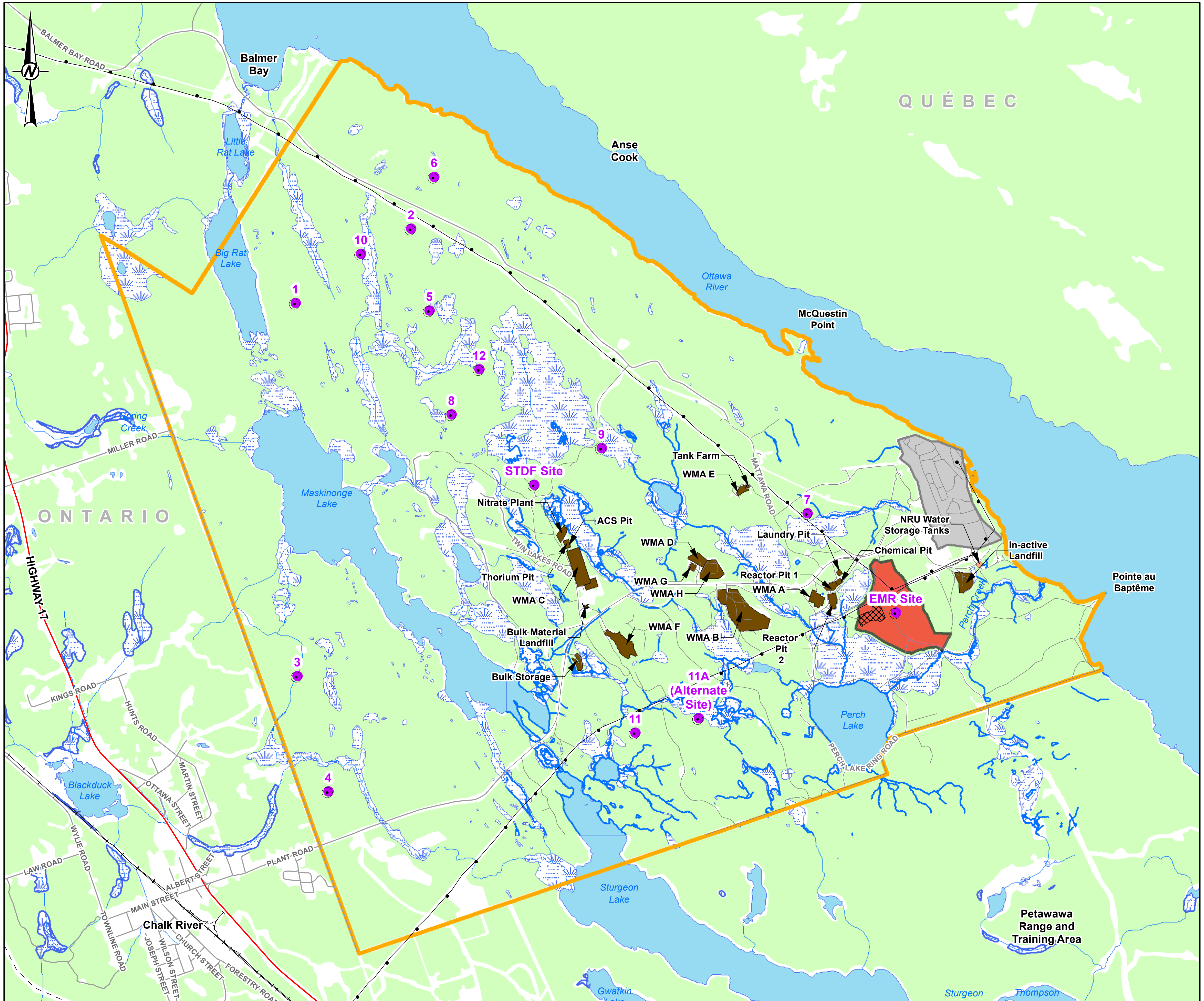
Exclusion criteria were then applied to remove any locations that were constrained by NSDF Project requirements or by pre-defined factors; exclusion criteria were physical, cultural, and biological features that would eliminate a location from the list of potential sites because development is either not permitted or poses a risk for the intended use/project (CNL 2016c). Exclusion criteria included:

- Ottawa River Floodplain:
  - Areas which are below the 1 in 100 year Ottawa River flood elevation of 115 metres above sea level (masl).
  - Areas that are below the flood elevation of 130 masl which would result from a hypothetical failure of the Des-Joachims hydroelectric dam and McConnell Lake Control Dam.

- Areas with a slope in excess of 25%; areas with a slope of less than 10% are desirable.
- Areas within 50 m of Plant Road. The three key reasons for this setback are:
  - Protection of CRL workers in transit on Plant Road during waste placement.
  - Limiting visibility of structures from Plant Road.
- Geotechnical Characteristics:
  - Areas with outcrops and organics less than 20% of the proposed siting area.
  - Areas with liquefaction potential and active fault lines.
- Species at Risk:
  - Areas of nationally or provincially significant plant or tree species, in small groups or stands, in accordance with the Federal *Species at Risk Act* and habitat of those threatened or endangered species as per the *Committee on the Status of Endangered Wildlife in Canada* (COSEWIC) listing. Research plantations at CRL may contain these species.
  - Known or likely habitats of national or provincially significant wildlife species in accordance with the Federal *Species at Risk Act* or COSEWIC listing as per guidance by CNL Environmental Protection.
- Wetlands:
  - Areas that are seasonally or permanently inundated with water.
  - Areas within 30 m from watercourses or wetlands.
- Located adjacent to provincially registered archaeological sites.
- Areas within 100 m from existing CRL site boundaries.
- Sites of existing or previously sited facilities.

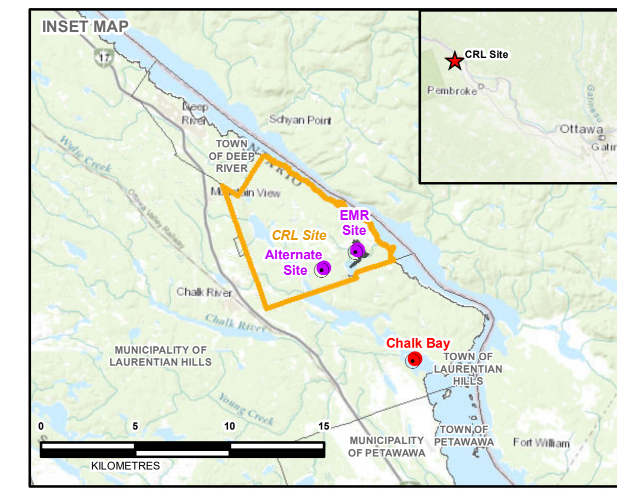
Table 2.5.5-1 summarizes the candidate sites and provides rationale for the exclusion of select sites, and identifies those sites carried forward for further evaluation based on the mandatory and exclusion criteria listed above.

Two candidate locations were identified for further evaluation after the application of the mandatory attribute criteria and the exclusion criteria; 1) the East Mattawa Road (EMR) site; and 2) the Alternate site (11A). The locations of the two sites are shown on Figure 2.5.5-2 and described below. When evaluating the technical feasibility of the facility location, many of the criterion can be satisfied by both alternatives. For example, both alternatives can be constructed such that they meet the purpose of the NSDF Project and both alternatives can be constructed to accommodate 1,000,000 m^3 of LLW. Key differences in the alternatives are primarily related to monitoring complexity, life cycle costs and potential environmental effects; as such, the evaluation focuses on these criterion.



LEGEND

- Potential Sites
- HIGHWAY
- ROAD
- RAILWAY
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- TREE RESEARCH PLANTATION
- NSDF PROJECT
- CRL MAIN CAMPUS
- CRL SITE
- WASTE MANAGEMENT AREAS (WMA)[1]



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1:35,000 KILOMETRES

NOTE(S)

1. LIQUID DISPERSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

POTENTIAL SITES FOR THE PROJECT CONSIDERED BY CNL

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO/PR
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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Table 2.5.5-1: Potential Sites for the Project Considered by CNL

Site Number	Description	Rationale for Exclusion or Inclusion
1	▪ 42 ha in size; ▪ Located at the north end of the CRL site; and ▪ Located in the Balmer Bay drainage basin.	Excluded: ▪ Less than 100 m from the CRL site boundary
2	▪ 31 ha in size; ▪ Located at the north end of the CRL site; ▪ Several areas of exclusion (i.e., small ponds and archaeological sites) interspersed through the area; ▪ Hydro is available 0.4 km from the site; ▪ The site is located a long distance from Plant Road (5 km on Mattawa Road); and ▪ Located in the Maskinonge Lake / Balmer Bay drainage basins	Excluded: ▪ Located adjacent to recorded archaeological sites
3	▪ 24 ha in size; ▪ Located at the south west boundary of the CRL site; and ▪ Located in the Chalk Lake West drainage basin.	Excluded: ▪ Less than 100 m from the CRL site boundary.
4	▪ 17 ha in size; ▪ Located at the south west boundary; and ▪ Located in the Chalk Lake West drainage basin.	Excluded: ▪ Less than 100 m from the CRL site boundary.
5	▪ 12 ha in size; ▪ Area is interrupted by a small stream; ▪ No access road from within the 300 m distance; ▪ Approximately 4.3 km from Plant Road; ▪ The area is generally flat or gently sloping; ▪ Number of woodland pools throughout; and ▪ Located in the Maskinonge Lake / Balmer Bay drainage basin.	Excluded: ▪ Area is less than 14 ha and not considered large enough to accommodate the NSDF Project.
6	▪ 12 ha in size; ▪ Located at the north end of the CRL site; and ▪ Located in the Ottawa River watershed.	Excluded: ▪ Area is less than 14 ha and not considered large enough to accommodate the NSDF Project.
7	▪ 11 ha in size; ▪ Located adjacent to the Mattawa Road and close to Plant Road; ▪ Large areas of exclusion (wetland areas) along the north-east edge; ▪ Hydro is available at the site; and ▪ Located in the Perch Creek and Perch Lake Watershed.	Excluded: ▪ Area is less than 14 ha and not considered large enough to accommodate the NSDF Project.

Table 2.5.5-1: Potential Sites for the Project Considered by CNL

Site Number	Description	Rationale for Exclusion or Inclusion
8	▪ 10 ha in size; ▪ Access to the site is poor (an old logging road which is not maintained is the only existing access); ▪ The closest road is approximately 500 m (Bass Lakes Road); ▪ The site is surrounded by wetlands and surface ponds, which interrupt the usable areas; and ▪ Located in the Maskinonge Lake drainage basin.	Excluded: ▪ Area is less than 14 ha and not considered large enough to accommodate the NSDF Project.
9	▪ 10 ha in size; ▪ Site is interrupted by areas of wetlands and much of the site is covered by wetlands; ▪ Adjacent areas are not considerably above the wetland elevation; therefore, the site is prone to flooding; ▪ Hydro is available within 1 km of the site; and ▪ Located in the Perch Lake / Maskinonge Lake drainage basins.	Excluded: ▪ Area is less than 14 ha and not considered large enough to accommodate the NSDF Project.
10	▪ The site is 10 ha in size; ▪ Located at the north end of the CRL site; and ▪ Located in the Balmer Bay drainage basin.	Excluded: ▪ Area is less than 14 ha and not considered large enough to accommodate the NSDF Project.
11	▪ The site is 8 ha in size; ▪ There is hydro available approximately 1.2 km from the site; ▪ The site is 2.2 km from the Plant Road and 3.4 km from WMA B; and ▪ Located in the Chalk Lake East drainage boundary.	Excluded: ▪ Area is less than 14 ha and not considered large enough to accommodate the NSDF Project.
11A (Alternate Site)	▪ The site is 40 ha in size; ▪ Slope is greater than 10% in some areas of the site; ▪ There is a small pond at the north end of the site; ▪ Several woodland pools are present on the site; ▪ There is hydro available approximately 2.2 km from the site at the Plant Road; ▪ The site is 3.4 km from WMA B; ▪ Portion of the site is partially located in Blanding's turtle potential candidate critical habitat zone; and ▪ Located in the Chalk Lake East drainage boundary.	Carried forward for further analysis.

Table 2.5.5-1: Potential Sites for the Project Considered by CNL

Site Number	Description	Rationale for Exclusion or Inclusion
12	▪ The site is 8 ha in size; ▪ Access to the site is poor (an old logging road which is not maintained is the only existing access); ▪ The site is surrounded by areas of bog (organic material) and surface water (ponds, marshes, etc.) which interrupt the usable areas; and ▪ Located in the Maskinonge Lake drainage boundary.	Excluded: ▪ Area is less than 14 ha and not considered large enough to accommodate the NSDF Project.
Sand Trench Disposal Facility (STDF) Site	▪ Centrally located within the CRL site; ▪ The site is bounded by wetland (bog), Twin Lakes, 233 Lake, and the Nitrate Plant and associated plume; ▪ The site overlaps critical Blanding's turtle habitat and is adjacent to a Great Blue Heron colony, a protected species under the Migratory Birds Convention Act; ▪ Located in the Maskinonge Lake drainage boundary.	Excluded: ▪ This area contains habitat of significant wildlife species (Blanding's Turtles); ▪ The site is not large enough to accommodate the NSDF Project.
East Mattawa Road (EMR) Site	▪ The site has a capacity of >30 ha in size; ▪ Close proximity to the CRL main campus; ▪ Water service, natural gas and power sources are available in close proximity; ▪ Located in the Perch Creek and Perch Lake Watershed. ▪ Located in close proximity to the Perch Lake Swamp wetlands;	Carried forward for further analysis

WMA = Waste Management Areas, STDF = Sand Trench Disposal Facility, EMR = East Mattawa Road

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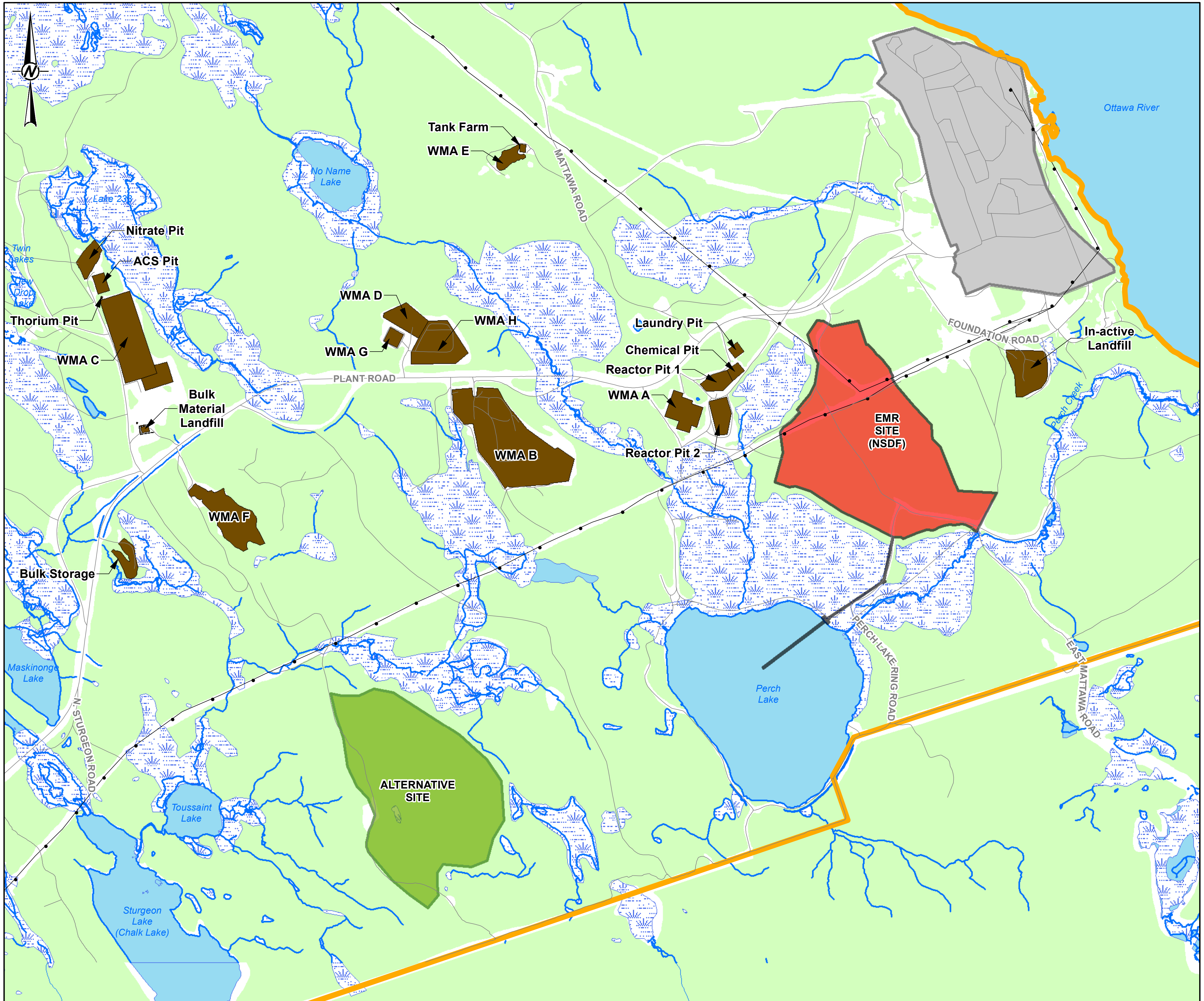

LEGEND

- ROADS
- RAILWAY
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- NSDF PROJECT
- ALTERNATE SITE
- CRL MAIN CAMPUS
- CRL SITE
- WASTE MANAGEMENT AREA (WMA) [1]

500 0 500

1:15,000 METRES

NOTE(S)

1. LIQUID DISPERSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

SITE OPTIONS EVALUATED FOR THE NEAR SURFACE DISPOSAL FACILITY PROJECT

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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2.5.5.1 East Mattawa Road

In general terms the EMR site is located on a ridge, that slopes away from the Ottawa River and towards the Perch Lake Basin, approximately 1.1 km from the Ottawa River and 500 m from the CRL main campus and is approximately 34 ha[1] in size (Figure 2.5.5-2). The northern boundary abuts Power Line Road and the southern boundary is just short of ER-3 (Emergency Road) and the Perch Lake Ring Road. On the western side, a 30 m setback from the Perch Lake Swamp wetlands forms the site boundary and to the east a local ridge line of the Ottawa Valley forms the boundary. The site boundary to the north is forested land between the hydro corridor and Plant Road. To the west and south is a low-lying marsh area, with the existing WMA A and B further northwest. The South East Mattawa Road leads to ER-3 (Emergency Road) and the Perch Lake Ring Road. To the east is forested land, which drops down to the main CRL site on the opposite side of the ridge.

2.5.5.1.1 Technical Feasibility

East Mattawa Road is one of three existing designated emergency evacuation routes from the CRL main campus. Access to the site is provided by both the ER-3 (Emergency Road) and the Emergency Route #3. Both access routes are regularly travelled and subject to routine maintenance. Emergency Route #3 has been re-routed as part of a previously planned upgrade to this road. Overall, access to the EMR site is well established and upgrades required for heavy equipment and truck traffic to the NSDF would be minimal.

Mandatory services (i.e., Class IV power, water for sanitary and process requirements, gas or other heating sources) can be readily accessed for the EMR site. The EMR site is approximately 500 m from the CRL main campus, which is the source of CRL's decommissioning work that will generate much of the waste. Overall, the services required to support the NSDF Project are all located much more proximate to the EMR site. A potential water source could be taken from 500 m from the EMR site, and a natural gas pipeline is installed along Plant Road at the juncture of EMR site. The EMR site is located within the Perch Creek and Perch Lake Watershed, which has been impacted by plumes emanating from the WMA A and the Liquid Dispersal Areas. As such, extensive environmental studies of contaminant hydrogeology have been completed in the last 60 years and continue to be ongoing as part of CNL's existing Environmental Management Plan thus a robust understanding of the Perch Creek and Perch Lake Watershed exists, and CNL has confidence in predictions of how radiological releases would behave. The Environmental Management Plan for the CRL site can easily be expanded to include monitoring and sampling locations for the NSDF Project.

2.5.5.1.2 Economic Feasibility

Both site areas' overburden is adequate and site clearing costs will be comparable between the sites as tree growth density characteristics are similar. Overall, the services required to support the NSDF Project are all located much more proximate to the EMR site. A potential water source could be taken from 500 m from the EMR site, and a natural gas pipeline is installed along Plant Road at the juncture of EMR.

[1] The EMR site considered during initial siting is approximately 34 ha. This site continued to be refined throughout the engineering and design process for the NSDF Project resulting in a footprint of approximately 37 ha for the NSDF Project site.

2.5.5.2 Alternate Site

The Alternate site is located within the Chalk Lake Basin, southeast of WMA F (Figure 2.5.5-2) and is approximately 37 ha in size. Access to the Alternate site is via the existing Port Hope Road, a narrow gravel road adjacent to the western border of the site. The existing access road to the site from the Plant Road is 2.2 km long and will require considerable upgrades to provide safe passage of heavy equipment and truck traffic.

2.5.5.2.1 Technical Feasibility

Electricity is available from along the Plant Road, as well as natural gas from the pipeline recently installed on the CRL site, but are approximately 2.2 km from the Alternate site. Water service is available at the CRL main campus, but a new feed will be needed. The proposed tie-in to the water supply will be approximately 5 km from the Alternate site and a pipeline and pumping station would be needed to deliver water uphill to the facility. Additional space is available to the area to the north of WMA F for use as a trainer/lay down areas (currently used to store marine containers) or future facility expansion. Space is also available south of the Alternate site, close to the border with Garrison Petawawa.

The Alternate site is located in a largely undeveloped area. As such, extensive modifications to CNL's existing Environmental Management Plan are needed to include monitoring and sampling locations for the NSDF Project as there is a lesser understanding of site characteristics for the alternate site.

2.5.5.2.2 Economic Feasibility

Both site areas' overburden is adequate and site clearing costs will be comparable between the sites as tree growth density characteristics are similar. The Alternate site will require considerable road upgrades for the 2.2 km route from the Plant Road to provide safe passage of heavy equipment and truck traffic. Electricity, natural gas and water supply would need to be brought in from a further away source. Overall, infrastructure costs are higher for the Alternate site as compared to the EMR site.

2.5.5.3 Environmental Effects

The EMR site is located within the Perch Creek and Perch Lake Watershed, which has been impacted by groundwater plumes emanating from the WMA A and the Liquid Dispersal Areas. Extensive environmental studies have been completed in the Perch Lake Swamp wetland complex, located to the west of the EMR site, to characterize the existing radiological contamination in the soil and vegetation. Of particular interest are the adjacent legacy Liquid Dispersal Areas and WMA A, which discharge contaminated groundwater into the Perch Lake Swamp wetlands creating an environmentally impacted site. The EMR site is in close proximity to existing brownfield waste sites, and as such, consolidates land uses. The Chalk Lake Basin, within which the Alternative site is located, contains no operating facilities, WMAs, or any known contamination, and is therefore unaffected by CRL activities. The WMA F is the nearest WMA located approximately 1.5 km the north of the Alternate site, in the Maskinonge Lake basin. The Alternate site is in a largely undeveloped area. There are no pre-existing plumes or contamination from WMAs in the vicinity of the Alternate site, thus introducing a new waste disposal area which is not contiguous with current CRL brownfield areas or impacted areas.

The EMR site is close to the CRL main campus, which is where the vast majority of waste from building decommissioning will be generated. The EMR site is approximately 4 km closer to the CRL main campus as compared to the Alternate site; trucks will travel approximately 6 to 7 km for delivering waste to the Alternate site from the CRL main campus. The increased transportation distance of wastes to the Alternate site would result in increased air emissions, and therefore greenhouse gases. Any dust created from the NSDF construction and operation on either site would be abated as per environmental protocols. Noise transmission to the

CRL main campus will be mitigated by the topography as the EMR site is situated on the lower side of the hill facing inland. The Alternate site would not be visible to traffic on Plant Road or at the CRL main campus; noise is not anticipated to be an issue as the area is isolated.

In 2016, geotechnical surveys were completed at the EMR site (Golder 2016). Ground surface elevations range at the EMR site from a low of approximately 160 masl within the low-lying and relatively flat terrain bordering the north side of Perch Lake, to a high of 196 masl along the crest of the ridge to the east of Emergency Road #3 that separates the Perch Creek and Perch Lake Watershed and the Ottawa River watershed. The overburden thickness at the site typically ranges from approximately 0 to 10 m, depending on bedrock topography. The surficial geology consists primarily of sands, underlain by dense sandy silt till which contains some cobbles and occasional boulders. Organic soils (e.g., peat) have been deposited in the low-lying and wetland areas.

Precipitation in the EMR site area recharges a shallow groundwater system that includes the overburden and the upper few metres of fractured bedrock. Groundwater levels range from about 0.5 m to more than 11.4 m depth, corresponding to elevations of between approximately 173 and 158 masl. Groundwater flow directions reflect the site topography with the overall direction being southwesterly from the ridge bounding the east side of the site and semi-radial from elevated lands within the bedrock bench. Within the low saturated lands to the west of the siting block, groundwater flow parallels the Perch Lake surface drainage. The crest of the ridge along the eastern side of the siting block is interpreted to roughly coincide with a groundwater (and surface water) divide between the Perch Creek and Perch Lake Watershed and the Ottawa River.

In 2014, geotechnical surveys were completed at the Alternate site (Golder 2016 [referred to as Block 11 in the report]). The Alternate site is reflective of the CRL site as a whole. The overburden thickness ranges from approximately 0 to 20 m depending on the bedrock topography. Generally, the overburden contains a thin layer of organic topsoil at the surface with a layer of loose sand, then compacted sand. The site is characterized by an undulating ground surface ranging from approximately 172 masl in the east and northeast to a low of approximately 115 masl in the wetland areas bordering Chalk (Sturgeon) Lake, which is located roughly 600 m to the southwest. Overall, the ground surface slopes to the west.

Precipitation falling on topographically high areas results in the recharge of the shallow-scale groundwater system that includes the overburden and the upper few metres of fractured bedrock. Groundwater levels beneath the Alternate site range from about 0.5 m to more than 9 m depth, corresponding to elevations of between roughly 164 and 150 masl. The southwestern part of the Alternate site is well drained, but much of the central portion of the area is low-lying terrain resulting in with seasonal accumulations of surface water and saturated ground.

The proposed EMR site is 1.1 km from the main channel of the Ottawa River, but groundwater passing below it, discharges to Perch Creek before draining to the Ottawa River, providing a flowpath distance of about 2.6 km. It is the transit time through the groundwater portion of the flowpath; however, that represents almost all of the average 7-year water residence time. By contrast, the Alternate site is about 3.5 km from the main channel of the Ottawa River, but about 850 m from Chalk Lake. Chalk Lake is a long narrow bay in the Ottawa River, and for the site evaluation it has been considered to be a part of the river. The groundwater residence time from the Alternate site to the location where the groundwater discharges to surface is about 2 years. Overland flow from the Alternate site’s groundwater discharge area passes through a small lake (Toussaint) before discharging to Chalk Lake, but this only adds a few months of mean residence time.

The predictions above are based on both measured and calculated data. The information for the EMR site is founded on observation of contaminant movement from the Reactor Pit #2 to Perch Lake and Perch Creek, (just west of the EMR site) over several decades, as well as calculations using groundwater gradients and soil characteristics arising from extensive study and site assessment. The predictions from the Alternate site are calculated based on gradient and soil characteristic data collected for the assessment of that site. In summary, the EMR site has a longer groundwater flowpath and slower groundwater flow velocities over most of the flowpath, compared to the Alternate site.

The EMR site is similar to the majority of the undisturbed forested areas of the CRL site in terms of terrestrial biodiversity. In the spring and summer of 2016, a biodiversity study was completed at both the EMR site and Alternate site. No butternut trees were found within the EMR site or in the surrounding area during the biodiversity surveys. Several bird species, including eastern whip-poor-will, eastern wood-pewee, wood thrush, golden-winged warbler and the Canada warbler were observed in the vicinity of the EMR site. Four bat species were also detected including the little brown myotis, northern myotis, the tri-coloured bat and eastern small-footed myotis.

Extensive environmental studies have been completed in the Perch Lake Swamp wetland complex (located to the west of the EMR site) to characterize the existing radiological contamination in the soil and vegetation. These wetlands are home to Blanding's and snapping turtles. Biodiversity studies to date by CNL do not indicate that Blanding's turtles are making extensive overland movement in this area during their migration as no individuals have been sighted on the road in this location. Although the EMR site does not appear to fragment the Blanding's turtle habitat, development at the EMR site may encroach on some portion of the species terrestrial habitat. The EMR site is located immediately adjacent to the Perch Lake Swamp wetland and, therefore, has an increased potential for indirect effects on terrestrial species that use this habitat.

The Alternate site is similar to the majority of the undisturbed portion of CRL site in terms of terrestrial biodiversity. Several songbirds were observed during the 2016 biodiversity surveys including Canada warbler, eastern wood-pewee and eastern whip-poor-will. Bat surveys confirmed the presence of little brown myotis, northern myotis, and the tri-coloured bat and eastern small-footed myotis. Blanding's turtles have been observed using the adjacent wetlands habitat and crossing Port Hope Road during their spring migration. The Alternate site encroaches on the Blanding's turtles travelling corridor within the CRL site, which would potentially cause a slight fragmentation between habitats and may increase the potential for road mortality. No Butternut trees were observed during the biodiversity surveys.

Similar mitigation for both site locations would be required to limit effects to terrestrial biodiversity. Mitigation includes the protection of migration pathways for Blanding's turtles, installation of bat boxes, tree removal before and after the migratory bird nesting period and environmental awareness training for Contractor personnel. In addition, erosion and sediment control practices (e.g., silt fences, runoff management) already in place at the CNL property will be used during construction around disturbed areas, and existing programs such as CNL's Management of Land and Habitat Procedure will be implemented. As well, all work on the site would be subject to a *Species At Risk Act* permit.

There are six archaeological sites previously recorded within 1 km of EMR site, but none are located directly within the proposed footprint. An archaeological assessment was completed at the EMR Site in 2016 to identify cultural resources, determine their significance and identify any mitigation that may be required. Test pits were excavated during Stage 2 and 3 archaeological assessment. As a result of these archaeological assessment, modifications to the NSDF Project footprint were made to avoid a homestead. Following Stage 2 and

Stage 3 excavations, two locations were identified for management of artefacts (i.e., Stage 4 assessment). An archaeological assessment was completed for the Alternate site in 2013 and 2014 and results indicate that there are no significant cultural resources within the areas surveyed (Swayze 2015).

In 2008, CNL developed an Archaeological Master Plan that resulted in a formal Cultural Resource Management (CRM) program at CNL. If during site preparation or construction activities, cultural material is identified, activities will be stopped and the CNL CRM specialist will be contacted.

Both alternatives would implement mitigation that provides for worker and public health and safety during all phases of the NSDF Project. In addition, mitigation implemented to protect the surface water environment, aquatic biodiversity and ecological health would be similar for both sites. Employment and business opportunities, and community well-being would also be similar for both site locations.

2.5.5.4 Summary

The comparative evaluation between facility location alternatives within the CRL site is provided in Table 2.5.5-2. As shown in the table, the EMR site is preferable for both economic and environmental reasons. In summary, the EMR site is adjacent to a Legacy WMA and in closer proximity to the existing waste operational areas. This represents a tighter consolidation of land uses and less effects on undeveloped areas. Extensive environmental studies have been completed in the Perch Creek and Perch Lake Watershed where the EMR site is located over the past decades, which adds additional confidence in how the facility will react with the natural environment. In addition, the Perch Creek and Perch Lake Watershed has been impacted by plumes emanating from the WMA A and the Liquid Dispersal Areas. There may be perceived increased risks of the EMR site as it is located closer to the Ottawa River; however, the groundwater transit time from the EMR site to nearest surface waterbody is estimated to be 5 to 15 years with an average transit time of approximately 7 years compared to approximately two years for the Alternate site.

Table 2.5.5-2: Evaluation of Alternatives - Site Selection

Criteria	Alternative 1 – EMR Site		Alternative 2 – Alternate Site	
Technical Feasibility				
Project Purpose	Both sites are technically feasible.			
Storage Capacity	The EMR site has sufficient area available to develop a facility with a storage capacity of 1,000,000 m^3.		The Alternate site has sufficient area available to develop a facility with a storage capacity of 1,000,000 m^3	
Monitoring Complexity	Extensive monitoring programs already exist in the vicinity of the EMR site; therefore, the existing Environmental Monitoring Plan for the CRL site can easily be expanded to include monitoring and sampling locations for the NSDF Project.		Limited monitoring is place at the Alternate Site. Significant expansion of CNL's existing Environmental Monitoring Plan would be required to include monitoring and sampling locations for the NSDF Project.	
Economic Feasibility				
Life Cycle Costs	The site is close to existing services and has the lowest costs to provide project site services and access routes.		There would be increased costs in extending services, including new roads, at the Alternate site.	

Table 2.5.5-2: Evaluation of Alternatives - Site Selection

Criteria	Alternative 1 – EMR Site		Alternative 2 – Alternate Site	
Environmental Effects				
Biophysical				
Environmental Setting	The EMR site is located in the Perch Creek and Perch Lake Watershed, which has been impacted by plumes emanating from the WMA A and the Liquid Dispersal Areas (i.e., brownfield site) and as such, consolidates waste land uses.		The Alternate site is located in the Chalk Lake basin, which is an undisturbed area with no previous contamination.	
Atmospheric Environment	The EMR is approximately 4 km closer to the CRL main campus as compared to the Alternate site.		The increased transportation distance of wastes to the Alternate site would result in slightly increased air emissions, and therefore greenhouse gases.	
Geological and Hydrogeological Environment	The groundwater transit time from the EMR site to nearest surface waterbody is calculated to be 5 to 15 years with an average transit time of approximately 7 years.		The groundwater transit time from the Alternate site to nearest surface waterbody is calculated to be 2 years.	
Surface Water Environment	No anticipated difference between alternatives.			
Aquatic Biodiversity	No anticipated difference between alternatives.			
Terrestrial Biodiversity	The EMR site is located immediately adjacent to the Perch Lake Swamp, and therefore has an increased potential for indirect effects on terrestrial species that use this habitat.		The Alternate site encroaches on the Blanding's turtles travelling corridor within the CRL site, which would potentially cause a slight fragmentation between habitats and increases the potential for increased road mortality.	
Ecological Health	No anticipated difference between alternatives.			
Social				
Socio-economics	No anticipated difference between alternatives.			
Land and Resource Use	An archaeological assessment was completed for the NSDF Project site. The site boundaries were adjusted to mitigate any potential impacts.		An archaeological assessment was previously completed and results indicate that there are no significant cultural resources within the areas surveyed.	
Social Acceptability	There may be perceived increased risks of the EMR site as it is located closer to the Ottawa River		Located further from the Ottawa River and may be perceived more favourably.	

Table 2.5.5-2: Evaluation of Alternatives - Site Selection

Criteria	Alternative 1 – EMR Site	Alternative 2 – Alternate Site
Human Health and Safety		
Public Health & Safety (construction and operations)	Both alternatives can be developed in a manner that protects public health and safety during construction and operations.	
Public Health & Safety (long-term)	Both alternatives can be developed in a manner that protects public health and safety in the long-term.	
Worker Health & Safety	Both alternatives can be developed in a manner that protects worker health and safety.	

Note:

Most Favourable → Favourable → Least Favourable

EMR = East Mattawa Road; WMA = Waste Management Area.

2.5.6 Leachate Management

Leachate is generated as water infiltrates through the ECM during operations (and to a much lesser extent during the post-closure phase). The operating period of the NSDF is 2024 to 2070, and wastewater treatment is required for the full duration of operations and plus several years following closure of the ECM and installation of the final cover. The average annual wastewater volume to be produced during operations is predicted to be approximately 11,000 m^3/yr. Another important hydraulic consideration is the maximum wastewater flow rate that must be received and processed by the WWTP. Leachate and decontamination water are produced at relatively low rates compared to contact stormwater, especially during major storm events. The maximum hydraulic flow rate was determined by back-to-back 100-year, 24-hour storm events (4,710 m^3) and was selected as a worst-case design condition for determining the required volume of wastewater to be treated.

A comparison of projected leachate concentrations and discharge targets show that several radionuclides and non-radionuclides may be present at concentrations in the wastewater that exceed discharge targets, and treatment for these designated contaminates of potential concern (COPC) will be required. The WWTP must therefore be designed for removal of radionuclides and selected non-radiological constituents (e.g., metals).

Three alternative means of leachate management were considered for meeting the above-mentioned design requirements for the NSDF Project:

1) Use of an existing wastewater treatment facility;

2) Construction of a new WWTP; and

3) No discharge through the use of a leachate evaporation pond.

2.5.6.1 Existing Waste Treatment Centre

This alternative considers sending the wastewater discharge to the existing WTC.

2.5.6.1.1 Technical Feasibility

The existing WTC at CRL was built more than 40 years ago to treat low-level radioactive liquid waste originating from reactor and site operations. The WTC is expected to reach its end life in the next decade and will not be available for the operating life of the NSDF Project (i.e., 2024 to 2070). In addition, although WTC has the capacity to treat the volume of leachate predicted to be generated, this kind of throughput would pose a reliability risk to NSDF Project operations even if there were reinvestment in WTC. An underground pipeline to bridge the 2 km distance between facilities would be required. The 2 km pipeline distance is longer than the distance to discharge points for the WWTP; and therefore, more costly. It is also not certain that WTC decontamination performance is sufficient to meet treated leachate discharge/infiltration requirements, and therefore WTC may not be fit for purpose. The WTC operations are labour and energy intensive ($7 M annually for the required throughput, exclusive of capital reinvestment). The WTC depends on powerhouse support (steam, steam condensate return in particular), and the powerhouse is slated for shutdown prior to 2025. For these reasons, the existing waste treatment facility is not a technically feasible option and is not further evaluated.

2.5.6.2 Wastewater Treatment Plant (New)

This alternative considers a new WWTP that would treat wastewater sources at the NSDF Project site, including contact stormwater and leachate generated from the ECM, equipment and personnel decontamination water, and laboratory wastewater.

2.5.6.2.1 Technical Feasibility

The proposal to build a new, stand-alone treatment plant would meet the Project purpose and would use the best demonstrated available technology that is economically achievable for removal of the COPC from the NSDF wastewater. Further, this alternative would have the capacity to treat the volume of leachate predicted to be generated over the operating life of the NSDF Project (i.e., 2024 to 2070) and not limit the ECM’s storage capacity over the long term. This alternative would have a design life of 50 years, after which the ECM would be sealed with the final cover and the volume of leachate would significantly decrease. Effluent monitoring will be required at the WWTP to ensure treated water meets effluent discharge targets.

2.5.6.3 No Discharge Option - Leachate Evaporation Pond

Evaporation ponds are artificial ponds with very large surface areas that are designed to efficiently evaporate water by sunlight and exposure to the ambient temperatures.

2.5.6.3.1 Technical Feasibility

Leachate evaporation ponds are used in hot dry climates and are not effective in the mid-continental climate of central Canada with no distinct dry season. Therefore, a leachate evaporation pond is not considered to be a technically feasible alternative and is not further evaluated.

2.5.6.4 Summary

The new WWTP is the only technically feasible option available to treat the leachate to be generated from the NSDF. The WTC is expected to reach its end life by end of the next decade and will not be available for the operating life of the NSDF Project (i.e., 2024 to 2070). Leachate evaporation ponds are used in hot dry climates and are not effective in the mid-continental climate of central Canada with no distinct dry season. As there is only one technical feasible alternative, potential environmental effects on VCs are not presented in this section; rather the potential environmental effects of the new WWTP are evaluated in the EIS.

2.5.7 Effluent Discharge Options

Following treatment in the WWTP, the treated effluent will need to be managed on-site or be discharged to the natural receiving environment. The estimated annual volume of the treated effluent to be discharged is approximately 11,000 m^3. Options for discharge of the treated effluent are:

- discharge to ground;
- discharge to surface water (i.e., Perch Creek, Perch Lake or the Ottawa River);
- co-discharge to the NSDF Stormwater System and to ground;
- discharge to ground and discharge to surface water; and
- No liquid discharge (i.e., thermal evaporator).

2.5.7.1 Discharge to Ground

Discharge of treated effluent to ground would entail the construction of an exfiltration gallery which would promote the exfiltration of treated water into the local groundwater regime. Discharge to ground utilizes the ground for retention capabilities allowing for radionuclide decay. The exfiltration gallery would be located within the NSDF Project site up-gradient of the East Swamp Wetland. The treated effluent, once discharged to ground, would be returned to the adjacent wetlands and eventually discharge to Perch Lake and the Ottawa River. Discharge to ground provides the added benefit of enabling control of recharging water to the wetlands. Further, an exfiltration gallery provides additional retention time for radioactive decay for tritium[2] that will be present in the effluent before discharge to the Perch Lake and Perch Creek receiving systems.

The exfiltration gallery would be designed to operate all year round. Winter conditions would be accounted for by doubling the calculated required design area of the gallery in line with the Ministry of Environment, Conservation and Parks *Stormwater Management Planning and Design Manual* (MOE 2003).

In the event that the gallery overflow pipe is activated, an overflow relief pipe is provided from the exfiltration gallery to route flows that exceed the exfiltration capacity of the gallery to the East Swamp. A rip rap stone dispersion pad is provided at the outlet point of the overflow culvert to dissipate the energy effluent discharged and reduce erosion. Further erosion protection is provided at the culvert outlet to mitigate the ponding of water on the east side of East Mattawa Road, thereby, mitigating erosion potential of both the roadway and disruption

[2] Tritium is of interest to the public and has a relatively short half-life of 12.3 years and therefore benefits from decay over transit time from the exfiltration gallery to Perch Lake.

of surface and subsurface infrastructure located downgradient of the exfiltration gallery and upstream of the East Swamp.

2.5.7.1.1 Technical Feasibility

Exfiltration galleries have been used as a low impact approach to water management and serve to replenish and maintain surface and groundwater levels. They have been used at several Ontario sites in various commercial and industrial applications.

The initial design consisted of an exfiltration gallery located within the NSDF Project site, located downhill from the WWTP. However, hydrogeological conditions at this location are such that the local soils and groundwater regime do not have capacity to accept peak flows from the WWTP at all times. The average WWTP discharge rate is higher than the infiltration capacity of the hosting soils, and the problem is amplified during storm events. Therefore, the current design of the exfiltration gallery cannot support the required flow from the WWTP and is not technically feasible. To address this, additional engineering options were considered including:

- alternative exfiltration locations on the NSDF Project site;
- alternative exfiltration location outside of the NSDF Project site; and
- discharge to an existing legacy liquid dispersal area adjacent to the NSDF Project site.

Alternative Locations on the NSDF Project Site

Space for additional groundwater exfiltration infrastructure on the NSDF Project site is limited due to the size and hydrogeological characteristics of soils at the NSDF Project site as well as wetland areas with environmentally sensitive natural features. Therefore, two additional locations within the NSDF Project site were evaluated. Hydrogeological modelling performed for these two sites indicates that both suffer from inundation challenges similar to that of the original location and will fall short of the required infiltration capacity, and therefore both these options were ruled out.

Alternative Locations off the NSDF Project Site

CNL also evaluated two locations outside the NSDF Project site, located to the northeast of the WWTP. The surrounding area for these locations is across the watershed line which drains to the Ottawa River, unlike the current site location which drains to the Perch Creek and Perch Lake Watershed. The watershed along the Ottawa River is less affected by CRL operations compared to the Perch Creek and Perch Lake Watershed which has been impacted by legacy WMA's and it is desirable to manage all treated effluent within the Perch Creek and Perch Lake Watershed. For this reason, the option was ruled out.

Discharge to Existing Legacy Liquid Dispersal Area

CNL also evaluated the option of discharging the treated effluent to an existing liquid dispersal area located adjacent to the NSDF Project site. This area was used from the 1950s to 2000 to manage untreated low-level liquid waste from CRL operations prior to the expansion of the CRL Waste Treatment Centre. The liquid dispersal area managed up to approximately 100,000 m^3 of low-level liquid waste annually.

Discharge to the existing liquid dispersal area would meet the project purpose and could manage the volume of leachate generated from the ECM. However, the discharge of NSDF treated effluent to this dispersal area would generate additional radiologically contaminated groundwater. Due to the existing contamination within the liquid dispersal area, this alternative is not technically feasible.

In summary, based on all the options evaluated above, the sole use of the exfiltration gallery is not sufficient to manage the peak flows from the WWTP at all times. Therefore, the exfiltration gallery on its own is not considered technically feasible. An exfiltration gallery may however be combined with other design options. These combination options are discussed in Section 2.5.7.3 (Co-discharge with NSDF Stormwater System and Discharge to Ground), and Section 2.5.7.6 (Discharge to Ground and Direct Discharge to Surface Water). Combination options were examined for multiple reasons including:

- The use of an exfiltration gallery is consistent with the design approach communicated to stakeholders and Indigenous peoples.
- The exfiltration gallery will have sufficient capacity during post-closure to handle reduced flows from the WWTP after the ECM is capped.
- The use of the exfiltration gallery as a primary discharge location is beneficial because it provides additional retention time for radioactive decay (e.g., tritium) and returns water to local wetlands

2.5.7.2 Discharge to Surface Water (Perch Creek, Perch Lake or the Ottawa River)

The direct discharge of the treated effluent to surface water would require the construction of a transfer line from the proposed new WWTP (Section 2.5.6.2) to a suitable waterbody. CNL investigated the feasibility of discharging directly to multiple waterbodies including Perch Creek, Perch Lake and the Ottawa River. Each of these discharge locations are discussed further in the sections below and the waterbodies are shown on Figure 2.5.5-1.

2.5.7.2.1 Discharge to Perch Creek

A discharge to Perch Creek was considered. However, the average effluent flow rate is approximately 10% of the low summer flow rate for Perch Creek and the maximum effluent flow rate is approximately 100% of the low summer flow rate for Perch Creek. Direct discharge to Perch Creek would not be expected to be assimilated (i.e., mixed) to the same extent as a larger body of water (e.g., Perch Lake) which could extend the mixing distance down to the Ottawa River depending of flow conditions. Therefore, this alternative was not considered technically feasible and is not evaluated further.

2.5.7.2.2 Discharge to Perch Lake

Constructing a transfer line from the proposed new WWTP to Perch Lake requires the consideration of routing a transfer line through potentially contaminated areas and potential disturbance of wetlands that support critical habitat for designated species at risk. CNL considered two route options:

1) **Transfer line Route 1 –** Transfer line Route 1 would run 1.6 km around the east side of the ECM along the Perch Lake Ring Road to Perch Lake. Pumping would be needed to a high point east of the ECM, from where the water will flow by gravity. This option would require the construction of a small pumping station.

2) **Transfer line Route 2 –** This route option would run 1.3 km around the north and west side of the ECM to Perch Lake. A gravity flow transfer line partly installed by horizontal directional drilling would be required to cross the East Swamp. Unlike Transfer line Route 1, pumping would not be needed.

Both options would be designed to convey the full flow when both treatment trains of the WWTP are operational and can be operated all year.

2.5.7.2.2.1 Technical Feasibility

The use of a transfer line to discharge treated effluent is widely used and effective, and standard mitigation are available to limit adverse effects and provide adequate provisions to protect the environment. Further, CNL currently monitors water quality within Perch Lake and any additional monitoring requirements would be incorporated into the existing monitoring program. Therefore, both route options are considered technically feasible.

2.5.7.2.2.2 Economic Feasibility

The capital and operation cost for the discharge of treated effluent to Perch Lake is expected to represent less than 1% of the costs for the overall project.

2.5.7.2.3 Discharge to Ottawa River

CNL currently discharges treated effluent and surface water via a number of outfalls and streams on the Ottawa River. This alternative considers sending the treated effluent from the WWTP to one of these existing discharge points along the Ottawa River. Any options would require the construction of a transfer line to transport the treated effluent from the WWTP to the ultimate discharge point to the Ottawa River. The transfer line to Ottawa River would be gravity-fed.

2.5.7.2.3.1 Technical Feasibility

There are existing discharge points along the Ottawa River that could handle the proposed discharge volume from the WWTP. The transfer line for some of the discharge points would require construction along the perimeter of the developed CRL site. Although existing underground infrastructure along the perimeter of the developed site adds complexity to construction; construction of a transfer line to the Ottawa River is technically feasible.

2.5.7.2.3.2 Economic Feasibility

The capital and operation cost for the discharge of treated effluent to Ottawa River is expected to represent less than 1% of the costs for the overall project.

2.5.7.3 Co-discharge with the NSDF Project Stormwater System and Discharge to Ground

As described in Section 2.5.7.1, if an exfiltration gallery is used, it must be complemented with other measures. One option considered is to use one or more of the three existing surface water management ponds on-site jointly with the exfiltration gallery. These ponds manage all non-contaminated surface water within the NSDF Project site and discharge to adjacent wetlands and will be dispersed by level spreaders to achieve even flow distribution to the wetland and control erosion.

2.5.7.3.1 Technical Feasibility

The surface water management ponds do not have the capacity to accommodate additional flows from back to back storm events given they were only designed for runoff volumes. The viability of enlarging the existing ponds or adding new ponds was assessed. However, there is insufficient space on the NSDF Project site to accommodate a new pond or enlarging the existing ponds. Therefore, this option was not considered technically feasible.

2.5.7.4 Discharge to Ground and Discharge to Surface Water

This alternative involves the combination of the discharge to ground (Section 2.5.7.1) with the direct discharge to either the Ottawa River (Section 2.5.7.2.3) or Perch Lake (Section 2.5.7.2.2) via a pipeline. For the discharge to Perch Lake, the two pipeline route options discussed in Section 2.5.7.2.3 were investigated as part of this alternative.

2.5.7.4.1 Technical Feasibility

The combination of discharge to ground with a direct discharge to surface water provides an additional discharge option when there is insufficient infiltration capacity at the exfiltration gallery. During post-closure, the ECM will be capped resulting in reduced flows from the WWTP and the exfiltration gallery will have sufficient capacity to manage all flows from the WWTP. As discussed in Sections 2.5.7.2.2 and 2.5.7.2.3, the discharge to either Perch Lake or Ottawa River are considered technically feasible. Further, both transfer line options for the discharge to Perch Lake are considered technically feasible. Therefore, discharge to ground combined with discharge to surface water (i.e., Perch Lake or the Ottawa River) is technically feasible.

2.5.7.4.2 Economic Feasibility

The capital and operation cost for the exfiltration gallery and the discharge of treated effluent to either Perch Lake or Ottawa River are expected to represent less than 1% of the costs for the overall project.

2.5.7.5 No Liquid Discharge (Thermal Evaporator)

Because of public concerns about liquid emissions, options to reduce or eliminate liquid emissions were considered. A thermal evaporator could be installed in the WWTP to evaporate the treated effluent and release it to atmosphere.

2.5.7.5.1 Technical Feasibility

The evaporator would be technically feasible for normal flow conditions but would not have the capacity to manage the flow from back-to-back storm events. It is also noted that this option would not eliminate the need for infrastructure to allow for liquid discharges of treated effluent during storm events. Therefore, this option was not considered technically feasible.

2.5.7.6 Environmental Effects

- Based on the review above, three effluent discharge options were considered technically and economically feasible:
- discharge to Perch Lake (Section 2.5.7.2.2);
- discharge to Ottawa River (Section 2.5.7.2.3); and
- discharge to ground and to surface water (Section 2.5.7.4).

The discharge to Perch Lake would require the construction of a new discharge to a waterbody; however, the discharge to the Ottawa River could use an existing outfall where the treated effluent could be combined with an existing discharge to the Ottawa River.

Potential effects to the atmospheric environment considered for all alternatives are related to nuisance noise from construction activities, and increased air and greenhouse gas emissions. Greenhouse gas emissions are expected to be of the same order of magnitude for all alternatives.

Potential effects to groundwater are limited to the option for combined discharge to ground and surface water. The exfiltration gallery would release the treated effluent to ground which would then infiltrate into the groundwater and migrate towards East Swamp Stream and ultimately Perch Lake.

The key pathways related to surface water and aquatic biodiversity include the construction of a new discharge point in a surface waterbody and the release of treated effluent directly to a surface waterbody or via groundwater. The discharge to the Ottawa River alternative includes options to discharge to an existing outfall which limits the construction related effects for the construction of the transfer line. The discharge to Perch Lake would require the construction of a new discharge point within Perch Lake. Design options would need to be considered to limit the resuspension of sediment during operations in Perch Lake due to a thick layer of fine, semi-liquid, highly organic mud lining the bottom of Perch Lake which is susceptible to re-suspension if disturbed. Appropriate mitigation would also be required during construction of the infrastructure to limit adverse disturbances to the Perch Lake shoreline, lakebed, and surrounding watershed.

If only an exfiltration gallery were used (Section 2.5.7.1) an overflow pipe would be required when there is insufficient infiltration capacity at the exfiltration gallery which could result in overland flow of treated effluent. The combination of the exfiltration gallery and discharge to Perch Lake would allow excess flow to be diverted to Perch Lake and eliminate the risk of overland flow at the exfiltration gallery.

All alternatives would result in small changes to surface water quality, which are not expected to result in adverse effects on aquatic biodiversity. The treated effluent will meet effluent discharge targets for protection of the environment and human health.

Discharge to surface water (Perch Lake or the Ottawa River) will require construction of a transfer line from the WWTP to the discharge location. Transfer lines are widely used and standard mitigation measures are available to limit adverse effects on the environment from construction.

A comparison of the environmental effects for the options of direct discharge to surface water compared to the option of discharge to ground combined with discharge to surface water is provided in Table 2.5.7-1.

A comparison of the environmental effects for the options of direct discharge to Perch Lake to the option of direct discharge to the Ottawa River is provided in Table 2.5.7-2.

2.5.7.6.1 Effluent Strategy Focus Group

The NSDF Project team hosted a Focus Group on the effluent discharge alternatives in late May 2019. As a result of feedback on the draft EIS with respect to the effluent management strategy, the NSDF Project chose to further evaluate solutions to manage effluent discharge from the NSDF Project. As a result of the expressed public interest in the protection of the Ottawa River, the NSDF Project decided that a focus group session would be beneficial to the options analysis process and serve as a good forum for members of the public to express their opinions.

Public participation within projects which trigger environmental assessments is critical and CNL considers all input received to ensure good decisions are made with respect to environmental stewardship. At the NSDF Effluent Strategy Focus Group, there was representation from a number of special interest groups including members of the public, local municipalities and non-government organizations. The approach implemented for the Focus Group session included:

- Targeted invite to representatives (or individuals) that expressed an interest in the measures the NSDF Project will take to protect the Ottawa River, as well as the environment in general. In order to ensure an effective and meaningful discussion, the NSDF Project requested for organizations to identify individual to participate who ideally had a background in environmental sciences, familiarity with effluent management practices and a general awareness of the proposed project.
- Provision of relevant background information including general project information, a description of the WWTP, and sharing of the NSDF Project effluent discharge targets as well as several related project links.
- A tour of the proposed NSDF Project site in order to ensure participants were familiar with the setting and environmental baseline conditions.
- Presentations during the focus group session included an overview of leachate treatment alternatives, calculated wastewater quantities, effluent discharge targets and a brief introduction to the alternative means assessment process within CEAA.
- Discussions by the participants were solicited by facilitating two exercises within the focus group session. The first exercise had the participants develop the evaluation criteria through identification of environmental components that were of importance to them followed by a multi-voting process to refine the criteria list as a group. The second exercise had the participants perform a relative evaluation of the effluent discharge options using focus group developed criteria. Participants were broken into two working groups for these exercises and then presented their findings for a round-table discussion.
- Individual survey forms were provided to the participants to provide reflection on their thoughts prior to and following group exercises.

The NSDF Project's intent of the focus group session was to take discussions into consideration for potential improvements to the facility design and incorporation into the final EIS. Although the NSDF Project described and presented the effluent discharge options, the NSDF Project's updated alternative means assessment was not shared with focus group participant so not to influence the discussion. General observations of the discussions included:

- The evaluation criteria developed by the focus group were similar to the NSDF Project developed criteria (presented within Section 2.5.1) thus indicating the NSDF Project's assessment criteria is representative of the public's environmental values. The evaluation criteria developed by the focus group included protection of aquatic life, quantity and quality of effluent discharge, changes in the physical environment as a result of the NSDF Project and public concern.
- During evaluation of the effluent discharge options, both focus groups unanimously rejected the option to discharge to the Ottawa River and scored the discharge to Perch Creek quite low. Additionally there was no interest in further consideration of the discharge to air option. The preferred option was discharge to groundwater although there was recognition this option needed to be in combination with a surface water discharge to Perch Lake due to reduced capacity of the exfiltration gallery under high groundwater elevation conditions during spring.
- Interestingly each focus group suggested additional options which are discussed below:
  - Reduce quantity of leachate and contact-water that requires treatment. A number of design optimizations were suggested in order to achieve this target including the potential to include a weather cover structure over the operating face of the disposal cell.
  - Combination of groundwater exfiltration and an artificial wetland as a receiving environment for the treated effluent.

The discussions from the focus group session are being considered by the NSDF Project team as potential mitigation measures of the NSDF Project's potential effects on the environment. Specifically, the NSDF project is discussing design options with Ducks Unlimited Canada to incorporate artificial wetland components into the exfiltration gallery and non-contact stormwater discharge systems. The use of the artificial wetland is considered design optimization – that is, the current design of the NSDF is such that objectives for effluent treatment and the stormwater ponds as outlined in the EIS can be met. The use of an artificial wetland could further enhance the current design as an improvement to the proposed treated effluent exfiltration gallery and stormwater ponds, which would further mitigate residual effects predicted on surface water quality as discussed in Section 5.4.2. The artificial wetland, if considered feasible, would be built within the footprint of the NSDF Project.

Additionally, weather cover structure designs are being evaluated for compatibility with the NSDF Project configuration and if feasible, could be implemented as a mitigation measure and operational optimization.

2.5.7.7 Summary

Three effluent discharge options were considered technically and economically feasible and each have comparable potential environmental effects including:

- discharge to Perch Lake (Section 2.5.7.2.2);
- discharge to Ottawa River (Section 2.5.7.2.3); and
- discharge to ground and discharge to surface water (Section 2.5.7.4).

Combined discharge to ground and surface water is beneficial because the exfiltration gallery provides additional retention time for radioactive decay (e.g., tritium) and replenishes water to the local wetlands. For this combined option, the water collected in the ECM as leachate would be treated and returned to the Perch Creek and Perch Lake Watershed (via the exfiltration gallery) consistent with existing conditions. In addition, the exfiltration gallery will have sufficient capacity as a standalone option during post-closure to manage the reduced flows from the WWTP after the ECM is capped.

For both the surface water discharge options (i.e., Perch Lake or Ottawa River), a transfer line would need to be constructed. For the Ottawa River option, the transfer line could connect to an existing outfall where the treated effluent could be combined with an existing discharge to the Ottawa River. Transfer lines are widely used and standard mitigation measures are available to limit adverse effects on the environment from construction.

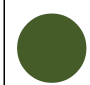
The treated effluent will meet effluent discharge targets protective of the environment and human health. While both surface water options are protective of environment and human health, direct discharge to the Ottawa River is expected to be perceived unfavourably by the public and Indigenous peoples. Discharge to Perch Lake is, therefore, the preferred of the two options.

A comparative evaluation of the discharge to surface water versus the discharge to ground combined with a discharge to surface water is provided in Table 2.5.7-1. A comparative evaluation of a discharge to Perch Lake versus Ottawa River is provided in Table 2.5.7-2.

Table 2.5.7-1: Evaluation of Alternatives - Effluent Discharge Options (Discharge to Surface Water vs. Discharge to Ground and Discharge to Surface Water)

Criteria	Alternative 1 – Discharge to Surface Water		Alternative 2 – Discharge to Ground and Discharge to Surface Water	
Technical Feasibility				
Project Purpose	Both alternatives meet the technical requirements.			
Storage Capacity	Neither of the alternatives will limit the storage capacity of the NSDF			
An Example of Best Available Technology	A pipeline and discharge to a surface waterbody is an example of a best available technology and widely used.	●	A pipeline and discharge to a surface waterbody is an example of a best available technology and widely used. An exfiltration gallery has been used previously but less extensively than a pipeline	●
Design Robustness	Pipelines are widely used and standard and effective mitigation and controls are available to limit adverse effects on the environment.	●	Pipelines are widely used and standard and effective mitigation and controls are available to limit adverse effects on the environment. The exfiltration gallery will also provide additional retention time for radioactive decay (e.g., tritium)	●
Monitoring Complexity	Both alternatives may require monitoring requirements; however, these monitoring programs are relatively straight-forward and similar programs are currently in place at the CRL site.			
Economic Feasibility				
Life Cycle Cost	Less than 1% of capital and operating costs of the overall project	●	Less than 1% of capital and operating costs of the overall project	●
Environmental Effects				
Biophysical				
Environmental Setting	Construction of a new outfall structure in Perch Lake.	●	Construction of a new outfall structure in Perch Lake.	●
Atmospheric Environment	Limited air emissions related to construction	●	Limited air emissions related to construction	●
Geological and Hydrogeological Environment	No discharges to groundwater and hence no impacts.	●	Discharge to ground replenishes local groundwater and the wetlands.	●
Surface Water Environment	No radionuclide decay (e.g., tritium) through groundwater.	●	Tritium discharges to surface water are reduced due to decay of tritium during groundwater transit.	●
Aquatic Biodiversity	Small changes to water quality which will not result in adverse effects on aquatic biodiversity.	●	Small changes to water quality which will not result in adverse effects on aquatic biodiversity.	●
Terrestrial Biodiversity	No anticipated difference between alternatives.			
Ecological Health	No anticipated difference between alternatives.			

Table 2.5.7-1: Evaluation of Alternatives - Effluent Discharge Options (Discharge to Surface Water vs. Discharge to Ground and Discharge to Surface Water)

Criteria	Alternative 1 – Discharge to Surface Water		Alternative 2 – Discharge to Ground and Discharge to Surface Water	
Social				
Socio-economic	No anticipated difference between alternatives.			
Land and Resource Use	No anticipated difference between alternatives.			
Social Acceptability	Direct discharge to Perch Lake may be a concern.		Discharge to ground provides additional retention time for radioactive decay (e.g., tritium) and replenishes local groundwater and the wetlands.	
Human Health and Safety				
Public Health & Safety (construction and operations)	All alternatives can be developed in a manner that protects public health and safety during construction and operations.			
Public Health & Safety (long-term)	All alternatives can be developed in a manner that protects public health and safety in the long-term.			
Worker Health & Safety	All alternatives can be developed in a manner that protects worker health and safety.			

Note:

Most Favourable Favourable Least Favourable

COPC = Contaminants of Potential Concern.

Table 2.5.7-2: Evaluation of Alternatives - Effluent Discharge Options (Discharge to Perch Lake vs. Discharge to Ottawa River)

Criteria	Alternative 1 – Discharge to Perch Lake	Alternative 2 – Discharge to Ottawa River
Technical Feasibility		
Project Purpose	Both alternatives meet the technical requirements.	
Storage Capacity	Neither of the alternatives will limit the storage capacity of the NSDF	
An Example of a Best Available Technology	A transfer line and discharge to a surface waterbody is an example of a best available technology and widely used.	A transfer line and discharge to a surface waterbody is an example of a best available technology and widely used.
Design Robustness	Transfer lines are widely used and standard and effective mitigation and controls are available to limit adverse effects on the environment.	Transfer lines are widely used and standard and effective mitigation and controls are available to limit adverse effects on the environment.
Monitoring Complexity	Both alternatives may necessitate additional monitoring requirements; however, these monitoring programs are relatively straight-forward and similar programs are currently in place at the CRL site.	
Economic Feasibility		
Life Cycle Cost	Less than 1% of capital and operating costs of the overall project	Less than 1% of capital and operating costs of the overall project
Environmental Effects		
Biophysical		
Environmental Setting	Construction of a new outfall structure in Perch Lake.	An existing outfall structure on the Ottawa River could be used
Atmospheric Environment	Limited air emissions related to construction	Limited air emissions related to construction
Geological and Hydrogeological Environment	No discharges to groundwater and hence no impacts.	No discharges to groundwater and hence no impacts.
Surface Water Environment	No radionuclide decay (e.g., tritium) through groundwater.	No radionuclide decay (e.g., tritium) through groundwater.
Aquatic Biodiversity	Small changes to water quality which will not result in adverse effects on aquatic biodiversity.	Small changes to water quality which will not result in adverse effects on aquatic biodiversity.
Terrestrial Biodiversity	No anticipated difference between alternatives.	
Ecological Health	No anticipated difference between alternatives.	
Social		
Socio-economic	No anticipated difference between alternatives.	
Land and Resource Use	No anticipated difference between alternatives.	

Table 2.5.7-2: Evaluation of Alternatives - Effluent Discharge Options (Discharge to Perch Lake vs. Discharge to Ottawa River)

Criteria	Alternative 1 – Discharge to Perch Lake		Alternative 2 – Discharge to Ottawa River	
Social Acceptability	Direct discharge to Perch Lake may be less of a concern		Protection of the Ottawa River is a high priority for the public. Discharge directly to Ottawa river is expected to be perceived unfavourably by the public and Indigenous peoples	
Human Health and Safety				
Public Health & Safety (construction and operations)	All alternatives can be developed in a manner that protects public health and safety during construction and operations.			
Public Health & Safety (long-term)	All alternatives can be developed in a manner that protects public health and safety in the long-term.			
Worker Health & Safety	All alternatives can be developed in a manner that protects worker health and safety.			

Note:

Most Favourable → Favourable → Least Favourable

COPC = Contaminants of Potential Concern.

2.5.8 Discharge Type

The total annual volume of contact surface water to be treated and discharged to the Perch Creek and Perch Lake Watershed is approximately 11,000 m^3. This represents less than 1 percent (%) of the annual average total outflow from Perch Lake of approximately 1,700,000 m^3. The current design for the planned discharge, is for treated effluent to be primarily discharged to the proposed exfiltration gallery, with excess volume to be directly discharged to Perch Lake, as necessary. Due to the conditions within the lake, an effective and reliable discharge system is required to distribute treated effluent into Perch Lake. Additionally, mitigation would be put in place for infrastructure associated with the direct discharge to Perch Lake to limit adverse disturbances to the shoreline, lakebed, and surrounding watershed.

To address the need for and effective and reliable discharge system, multiple engineering options were considered including:

- discharge by surface spray onto Perch Lake;
- piped outfall to Perch Lake (submerged outlet in Perch Lake);
- piped outfall to Perch Lake (above water discharge);
- submerged diffuser in Perch Lake (alignment along lakebed); and
- submerged diffuser in Perch Lake (diffuser suspended in water column).

2.5.8.1 Discharge by Surface Spray onto Perch Lake

A discharge by surface spray alternative would involve spraying treated effluent over the lake surface through a series of above-water on-lake or lake periphery discharge units. As such, this discharge option would only be possible in open water conditions (i.e., year-round operation is not possible). The associated infrastructure for this discharge would likely consist of a series of pipes that would extend some distance into the lake.

2.5.8.1.1 Technical Feasibility

The Project is designed to dispose of up to 1,000,000 m^3 of waste which will generate approximately 11,000 m^3 of treated effluent per year. As noted above, surface spray discharge onto Perch Lake would be viable only in open water conditions. However, there is insufficient capacity on the NSDF Project site to temporarily store treated effluent during the winter months (refer to Section 2.5.7.3 for additional details). Therefore, the selected design option must be able to operate year-round to ensure that the planned storage capacity of the ECM can be met. Therefore, this alternative is not technically feasible and is not carried forward for further analysis.

2.5.8.2 Piped Outfall to Perch Lake (Submerged Outlet in Perch Lake)

Treated effluent would be discharged into the lake below the water line through a single piped outlet. This system could therefore be expected to operate year-round. The pipe would extend some distance along the lakebed to a deeper zone of the lake and would be buried to maintain discharge depth below winter ice and to prevent pipe freezing. A stable lakebed or consolidated sediment would be required below the discharge point and around the pipeline where it extends into the lake below the shoreline and shallow sediment on the lake periphery. As long as the submerged discharge occurs at a suitable depth and treated effluent quality remains within appropriate water quality guidelines and/or site-specific benchmarks, this type of discharge may be undertaken under gravity flow discharge conditions.

2.5.8.2.1 Technical Feasibility

Discharge into Perch Lake through a piped outfall would be operationally simple. However, the installation would be dependent on finding a location in Perch Lake that would support the pipe (i.e., a suitable natural or engineered foundation) and would probably require a winter installation. This would require burial of the discharge pipe below the ice-cover depth at the shoreline and along the lakebed to prevent freezing. Depending on the outlet depth below the lake surface, year-round operation is feasible. Annual inspection and maintenance by divers would be required each spring to check and clear the piped outlet. This option could discharge the required annual volume and meet the discharge rates under gravity flow conditions. Based on the above, this alternative is technically feasible.

2.5.8.2.2 Economic Feasibility

The capital and operation cost for the discharge of treated effluent to Perch Lake via a submerged piped outfall is expected to represent less than 1% of the costs for the overall NSDF Project.

2.5.8.3 Piped Outfall to Perch Lake (Above Water Discharge)

Treated effluent would be discharged onto the lake surface through a pipe outfall, limiting the discharge to open water conditions (i.e., year-round operation is not possible). In this case, the outfall would extend over the lake and be located at or above the water line. Erosion of the shoreline and adjacent lakebed would be mitigated as necessary, depending on the configuration of the outfall structure and its location. The infrastructure to support the piped extension onto the lake may require anchoring within the shoreline and lake periphery (i.e., littoral zone). Anchoring would also require strong bed foundations, which may be limited within the littoral zone of the lake. This type of outfall could be undertaken under gravity flow discharge conditions if the outfall structure was stable and designed to reduce potential erosion risk.

2.5.8.3.1 Technical Feasibility

Similar to the surface spray alternative (Section 2.5.8.1), this alternative cannot operate year-round. Therefore, this proposed alternative is not technically feasible and is not further evaluated.

2.5.8.4 Submerged Diffuser in Perch Lake (Alignment along Lakebed)

A submerged diffuser would be located along the lakebed and anchored to the bed at various points along the submerged pipeline in a well-consolidated zone. This would prevent settlement of the outlet into the sediment layer and limit erosion of the lakebed. Treated effluent would be dispersed into the lake by a series of small-nozzle ports attached to the diffuser pipe by extension pipes. The length of the extension pipes would be determined by the target depth for discharge in the water column to optimize dispersion and reduce the risk of lakebed disturbance by the discharge. A relatively constant discharge is required for this option to actively disperse the discharge through the small discharge ports so as to avoid localized effluent concentrations around the diffuser; therefore, this option requires a pumped discharge condition to provide an appropriate mixing zone. This type of design would be installed within the lake at a depth below the ice cover in winter, allowing for year-round operation. The diffuser would need to be stable to optimize dispersion efficiency, so bed anchoring is critical to limit the potential for sediment mobilization during discharge. Anchors could potentially be placed in the clay layer below the soft sediment substrate.

2.5.8.4.1 Technical Feasibility

This option allows for year-round discharge, as the diffuser would be located in a zone within Perch Lake that is deep enough for the diffuser ports to be below ice and with sufficient water column height to allow maximized mixing within Perch Lake. Installation is considered challenging due to reported soft foundation conditions. This option requires discharge to be pumped to maintain discharge velocity. Annual inspection and maintenance by divers would be required each spring to check and clear the piped outlet, and to verify stability of the lakebed and anchors.

2.5.8.4.2 Economic Feasibility

The capital and operation cost for the discharge of treated effluent to Perch Lake via a submerged diffuser is expected to represent less than 1% of the costs for the overall NSDF Project.

2.5.8.5 Submerged Diffuser in Perch Lake (Diffuser Suspended in Water Column)

Instead of lying along the lakebed as described for Option 3a, this diffuser option extends into the lake with buoyancy support and is suspended in the water column. The buoyancy support for the pipeline extension would limit the application for this option to open water conditions. This diffuser option would also need to be located in a consolidated lakebed zone of Perch Lake, as stable anchoring is necessary along the pipeline and at the diffuser end of the pipe line to keep the diffuser at a constant depth. Anchors could potentially be placed in the clay layer below the sediment substrate.

2.5.8.5.1 Technical Feasibility

As described in Section 2.5.8.1, the selected design option must be able to operate year-round to ensure that the planned storage capacity of the ECM can be met. However, this alternative will be limited to open water conditions; therefore, this alternative is not technically feasible and is not carried forward for further analysis.

2.5.8.6 Environmental

Based on the review above, two effluent discharge options were considered technically and economically feasible including:

- piped outfall to Perch Lake with a submerged outlet (Section 2.5.8.2); and
- submerged diffuser in Perch Lake along the lakebed (Section 2.5.8.4).

Both alternatives are expected to have similar potential environmental effects, with the exception of pathways to surface water and aquatic biota. Within Perch Lake, the construction of either alternative will result in the disturbance of the lakebed sediment during the construction and operations phases. Mitigation will be required to limit resuspension of sediment during the construction and operations phases. The submerged diffuser is expected to result in less resuspension of sediment compared to a submerged piped outlet. Further, the submerged diffuser is expected to provide a more efficient mixing zone compared to a submerged piped outlet.

2.5.8.7 Summary

Two alternatives were considered technically and economically feasible for the discharge of treated effluent to Perch Lake. The comparative evaluation between these alternatives is provided in Table 2.5.8-1. Both alternatives will result in disturbance of the lakebed sediment during construction and operation which will require mitigation. However, the submerged diffuser is expected to limit these effects during operation. The piped outfall will also require regular maintenance to ensure that the outfall stays clear of sediment.

The submerged diffuser will provide a maximized mixing zone at the point of discharge. Based on the above, the submerged diffuser alternative is considered more favourable than the submerged piped outfall.

Table 2.5.8-1: Evaluation of Alternatives - Discharge Types

Criteria	Alternative 1 – Piped Outfall to Perch Lake (Submerged Outlet in Perch Lake)		Alternative 2 – Submerged Diffuser in Perch Lake (Alignment along Lakebed)	
Technical Feasibility				
Project Purpose	Both alternatives are technically feasible.			
Schedule	Both alternatives could be constructed to meet the NSDF Project start date.			
Storage Capacity	Neither alternative will limit the storage capacity of the NSDF			
Monitoring Complexity	The alternative will require monitoring to confirm that the treated effluent will meet effluent discharge targets. Monitoring and maintenance of the submerged outfall will be required to ensure it remains free of sediment	●	The alternative will require monitoring to confirm that the treated effluent will meet effluent discharge targets	●
Economic Feasibility				
Life Cycle Costs	Both alternatives are expected to be less than 1% of capital and operating costs of the overall NSDF Project			
Environmental Effects				
Biophysical				
Environmental Setting	Both alternatives will require construction within Perch Lake			
Atmospheric Environment	No anticipated difference between alternatives.			
Geological and Hydrogeological Environment	No anticipated difference between alternatives.			
Surface Water Environment	Alternative 2 will result in less resuspension of sediment will provide a more efficient mixing zone	●	The alternative will result in less resuspension of sediment and will provide a more efficient mixing zone compared to Alternative 1.	●
Aquatic Biodiversity	Alternative 2 will result in less resuspension of sediment will provide a more efficient mixing zone	●	The alternative will result in less resuspension of sediment and will provide a more efficient mixing zone compared to Alternative 1.	●
Terrestrial Biodiversity	No anticipated difference between alternatives.			
Ecological Health	No anticipated difference between alternatives.			
Social				
Socio-economics	No anticipated difference between alternatives.			
Land and Resource Use	No anticipated difference between alternatives.			
Social Acceptability	No anticipated difference between alternatives.			
Human Health and Safety				

Table 2.5.8-1: Evaluation of Alternatives - Discharge Types

Criteria	Alternative 1 – Piped Outfall to Perch Lake (Submerged Outlet in Perch Lake)	Alternative 2 – Submerged Diffuser in Perch Lake (Alignment along Lakebed)
Public Health & Safety (construction and operations)	Both alternatives can be developed in a manner that protects public health and safety during construction and operations.	
Public Health & Safety (long-term)	Both alternatives can be developed in a manner that protects public health and safety in the long-term.	
Worker Health & Safety	Both alternatives can be developed in a manner that protects worker health and safety.	

Note:

Most Favourable → Favourable → Least Favourable

2.5.9 Final Grade of the Facility

In relation to the near surface disposal designs referenced in IAEA guidance (SSG-29) (IAEA 2014), CNL considers the NSDF design to be an engineered structure constructed just below the grade but extending above the existing grade. However, variations in the final grade of the facility and the subsequent ECM floor elevation were evaluated as part of the design optimization completed for the NSDF Project (CNL 2016d). Three different final grade alternatives were developed and evaluated to determine the preferred ECM floor elevation including:

1) ECM Below Existing Grade;

2) ECM Above Existing Grade; and

3) Mid-range Grade.

The NSDF Design Requirements (CNL 2019d) also includes the following specific functional requirements of the ECM:

- The overall design of the ECM will be compatible with CRL site topography. The geometric profile and height of ECM shall be designed to ensure that ECM is not visible either from Ottawa River, plant road or CRL campus.
- The base of the ECM (i.e., top of the primary liner) shall be designed to maintain a minimum of 1.5 m above the seasonal high groundwater table.

2.5.9.1 ECM Below Existing Grade

The first alternative for the ECM design establishes the floor elevation to keep berm below the sight line from the CRL campus and to ensure the final ECM maintains the existing grade of the surrounding area (i.e., the ECM would be below grade).

2.5.9.1.1 Technical Feasibility

As noted above, one of the NSDF Design Requirements (CNL 2019d) is that the base of the ECM cannot go into the groundwater table. Even if the ECM floor were decreased to sit directly on top of the groundwater table at the NSDF Project site, the areal extent of the ECM would also need to increase to ensure that the required storage capacity of 1,000,000 m^3 can be met while also maintaining the existing grade of the surrounding area. However, additional space at the NSDF Project site is constrained and the ECM cannot be expanded further without encroaching on adjacent wetlands. Therefore, an ECM that maintains the existing grade of the surrounding area cannot meet the required storage capacity for the NSDF Project and is not technically feasible.

2.5.9.2 ECM Above Existing Grade Alternative

The second alternative for the ECM design establishes the floor elevation above bedrock which would result in a final facility grade above the existing grade of the surrounding area.

2.5.9.2.1 Technical Feasibility

As noted above, one of the NSDF Design Requirements (CNL 2019d) is to ensure that the ECM is not visible either from the Ottawa River, Plant Road or the CRL campus. If the ECM floor was situated on top of the bedrock at the NSDF Project site, the areal extent of the ECM would also need to increase to ensure that the required storage capacity of 1,000,000 m^3 can be met while ensuring the top of the ECM is not visible from the Ottawa River. However, additional space at the NSDF Project site is constrained and the ECM cannot be expanded further without encroaching on adjacent wetlands. Therefore, the above grade alternative cannot meet the required storage capacity for the NSDF Project and is not technically feasible.

2.5.9.3 Mid-range Grade Alternative

The third alternative for the ECM design establishes the ECM floor elevation partially into the bedrock and approximately 1.5 m above the groundwater table following completion of construction. The final facility grade is above the existing grade of the surrounding area; however it would not be visible from the Ottawa River, Plant Road or the CRL campus.

2.5.9.3.1 Technical Feasibility

This alternative would require excavation and blasting of bedrock to keep the berm heights lower and the elevation of the top of the ECM near the ridgeline at an elevation approximately 3 m below the sight line from the CRL campus. This design accommodates all NSDF design requirements and satisfies the storage capacity required and thus has been deemed technically feasible.

2.5.9.4 Summary

Of the three alternatives assessed for the ECM floor elevation and final grade of the facility, two of the alternatives (i.e., maintaining the existing grade and above grade alternatives) cannot meet the NSDF design requirements as well as accommodate the 1,000,000 m^3 of LLW storage capacity within the NSDF footprint which reflects the required wetland setbacks. Therefore, the ECM below the existing grade and ECM above existing grade alternatives have been deemed technically not feasible. The mid-range grade alternative was selected as the preferred ECM design, because this alternative is compliant with design requirements and can meet the required storage capacity.

2.6 Conclusion

The recommended alternative for the disposal of LLW based on the Alternative Means analysis is to build a NSDF at the CRL site on the EMR site. The preferred design is that of an ECM along with a new WWTP for leachate treatment. The preferred discharge is a combination of an exfiltration gallery and discharge to Perch Lake with a submerged diffuser. The most favourable alternative means are based upon consideration of technical, environmental and economic factors.

3.0 PROJECT DESCRIPTION

3.1 Introduction

This section provides a description of the main features of the Near Surface Disposal Facility (NSDF) for the disposal of solid low-level radioactive waste (LLW) at Chalk River Laboratories (CRL) (the 'NSDF Project'), and identifies the components (e.g., physical infrastructure such as the disposal facility and roads) and activities (e.g., placement of waste) related to the site preparation and construction, operations, closure, and post-closure phases. The NSDF Project is based on current engineering practice and precedents, and the experience of the engineering and environmental teams. Where components are still being designed, worst-case (i.e., conservative) assumptions have been applied.

3.1.1 Project Overview

The NSDF will be a waste disposal facility in the form of an engineered containment mound (ECM), with similar physical features to a hazardous waste landfill, but designed to nuclear standards. It will contain LLW and will be located within the approximately 4,000 ha Chalk River Laboratories (CRL) site. The CRL site is in Renfrew County, Ontario on the shore of the Ottawa River.

The NSDF will facilitate environmental remediation of the CRL site, which has housed decades of nuclear research and development. The Government of Canada's nuclear legacy liabilities have resulted from the nuclear operations, research and development performed at CNL for approximately 70 years. The majority of these liabilities are located at CRL and consist of shutdown nuclear facilities and radioisotope laboratories, radioactive wastes in interim storage, and contaminated lands. The overall clean-up mission will involve the decommissioning of more than 100 buildings that have reached the end of their useful lives, and the NSDF Project will provide safe disposal for the demolition waste, as well as some wastes from other sources.

The NSDF Project includes components and activities related to site preparation and construction, operations, closure, and post-closure, as well as long-term performance of the ECM for the responsible management of the waste. LLW material is suitable for disposal in engineered near surface facilities that provide robust isolation and containment for periods of up to a few hundred years in alignment with International Atomic Energy Agency (IAEA) standards and guidance. The LLW to be disposed at the NSDF Project will meet the Waste Acceptance Criteria (WAC) established to assure that it is acceptable for disposal at the NSDF Project to meet operational and post-closure safety requirements. The WAC and acceptance process are described in detail in Section 3.3.3.

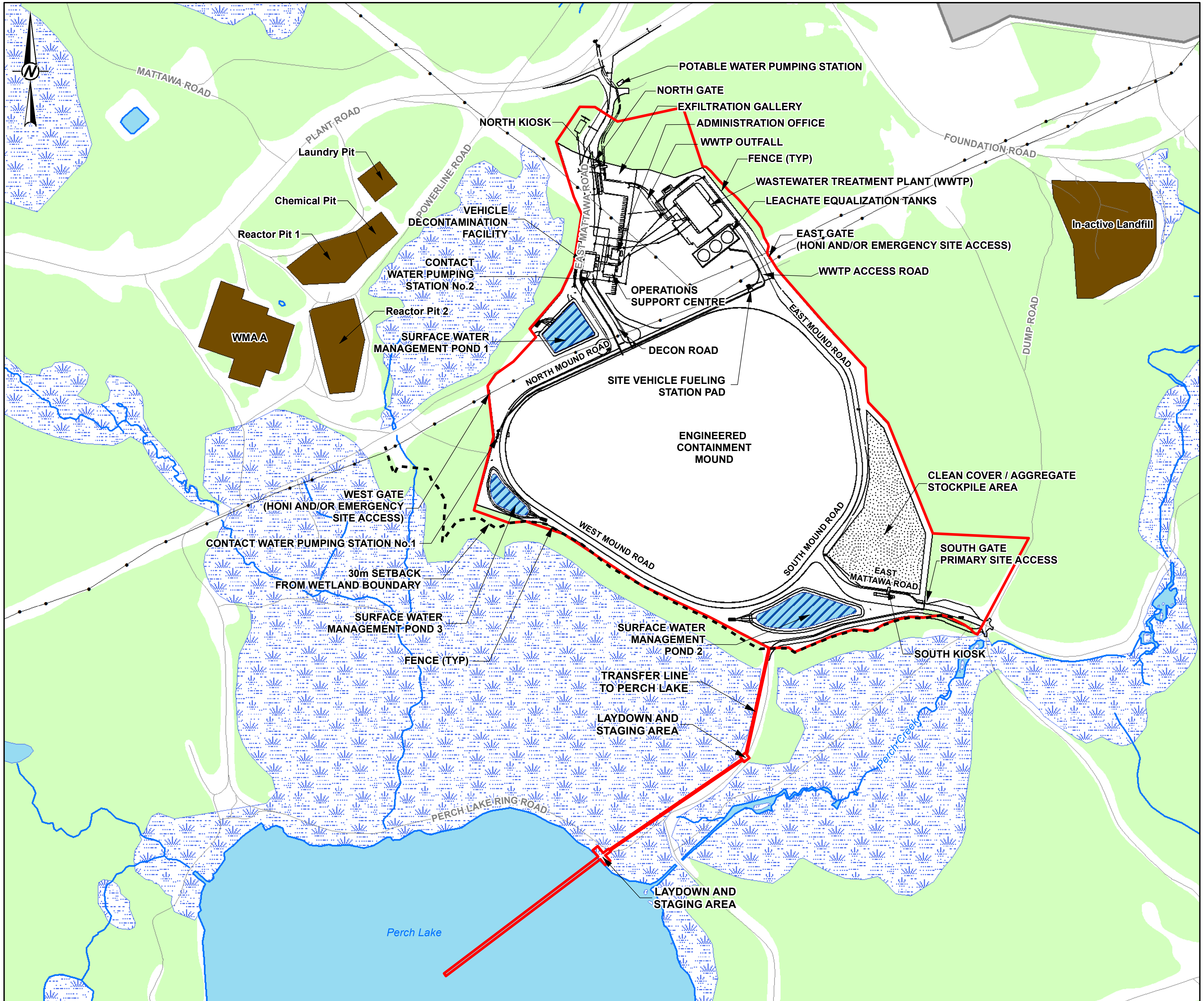
The ECM will contain ten waste disposal cells to be built progressively over the construction and operations phase of the Project, with only one active waste cell in operation at a time. The ten cells will have a total waste capacity of up to 1,000,000 m^3. The development of the facility and the placement of waste within the ECM will be completed in two phases. Phase 1 will have a capacity of 525,000 m^3 and will accommodate wastes currently in storage and wastes to be generated over the next 20 to 25 years. Phase 2 will expand the facility by 475,000 m^3 (for a total of 1,000,000 m^3) of wastes to be generated until the expected end of operations at the CRL site in approximately 2070. The NSDF Project has been designed considering best available technologies and industry practices, including those identified by the IAEA, where applicable. The project design and related requirements are described in Section 2.4.

While in operation, the NSDF will have a Wastewater Treatment Plant (WWTP) and several support facilities such as an administration building, an operations support center (which includes change rooms), weigh scales and a vehicle decontamination facility. These will be decommissioned and removed following the end of operations. The site will be permanently fenced and contain roads, utilities and surface water management ponds.
The following main physical components (e.g., structures) are to be constructed for the NSDF Project:

- engineered containment mound that will contain the LLW;
- WWTP that will treat leachate (see Section 14, glossary for definition), contact water (see Section 14, glossary for definition), and wastewater from on-going operations;
- support facilities that will enable operation (e.g., administrative buildings); and
- site infrastructure (e.g., utilities).

All physical components will be located within the NSDF Project site (Figure 3.1.1-1). These components and related activities are described in more detail in Section 3.4.

Following its closure, the mound will resemble a grassy outcrop built into an existing hillside. It will be approximately 18 m tall and will occupy a 17 ha footprint on the CRL site. The mound will not be visible from the CRL main campus or the Ottawa River.



LEGEND

- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- CRL MAIN CAMPUS
- NSDF PROJECT SITE
- WASTE MANAGEMENT AREA (WMA)[1]
- 30 m WETLAND SETBACK
- SURFACE WATER MANAGEMENT POND
- STOCKPILE AREA

100 0 100 200

1:6,000 METRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

NEAR SURFACE DISPOSAL FACILITY SITE LAYOUT

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0004	FINAL 2	3.1.1-1

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3.1.1.1 Alignment of NSDF to Regulatory and International Guidelines

This section provides a summary of how the NSDF Project has been designed to ensure the facility can be built, waste received, handled, and disposed of without undue risk to workers, the public and the environment, consistent with the design principles discussed in Section 2.4. The focus of this section is the safety features associated with the long-term performance of the ECM; however, these safety features are also present during operations.

The key safety features of the NSDF Project have addressed the IAEA design principles for radioactive waste disposal (IAEA 2011) in the following manner:

- **Multiple safety functions** – The ECM is designed with a number of engineered barriers to provide multiple layers of safety to support the long-term containment and isolation requirements. In accordance with the defence-in-depth principle, the safety performance of the NSDF Project is not dependent on any single safety function. The perimeter berm, the HDPE geomembrane cover system, and the double HDPE geomembrane liner system supported by a compacted clay liner contain individual components of natural and synthetic materials designed to work together to mitigate the release of contaminants into the environment for thousands of years. In addition to the engineered barriers, the NSDF Project site is well above the Ottawa River flood levels on a bedrock ridge that naturally forces water to flow in the opposite direction from the river. The NSDF Project design has taken into consideration the CRL site is in a region of minor to moderate seismic activity and will maintain protection of the environment in such events.
- **Containment of radioactive waste** – The ECM is designed to provide containment of the waste. Once the final cover system is installed, the waste material is expected to remain contained for at least the facility design life of 550 years, but likely much longer as demonstrated by the geomembrane testing (R. Kerry Rowe Inc. 2019) as well as natural and anthropogenic analogues. The site of the ECM allows for construction on bedrock and a robust seismic design basis of the perimeter berm contributes to the containment of the waste.
- **Isolation of radioactive waste** – The ECM is designed to isolate the waste from the environment for at least the 550-year design life, but likely much longer as demonstrated by the geomembrane testing (R. Kerry Rowe Inc. 2019). The ECM is designed specifically for the conditions of the NSDF Project site, with special considerations made for seismic design and diversion of precipitation. The siting of the NSDF Project on federally owned lands and the enforcement of land-use restrictions increases confidence that the waste will be undisturbed for hundreds of years after closure.
- **Surveillance and control of passive safety features** – The ECM design incorporates passive safety features. Following facility closure, during the post-closure phase, basic monitoring and inspections of the site will periodically occur to confirm that the facility is performing as expected (e.g., ensuring settlement is complete). The passive safety features perform their containment and isolation functions without intervention, and do not rely on a power source of any kind. The site of the ECM is in the Perch Creek and Perch Lake watershed, which has well-understood hydrogeological properties that lead to a good understanding of how any radionuclides released from the ECM after the design life will move in the environment. The siting of the NSDF Project on federally owned lands and the enforcement of land-use restrictions increases confidence that the waste will be undisturbed for hundreds of years after closure.

Furthermore, as a near surface disposal facility was chosen as CNL's preferred alternative, CNL has also incorporated guidance from IAEA's *Near Surface Disposal Facilities for Radioactive Waste Specific Safety Guide No. SSG-29* (IAEA 2014). SSG-29 provides guidance on the requirements of various NSDF Project activities, including design, waste acceptance, site preparation, construction, operations, closure, post-closure, institutional control, development of monitoring programs, and site security.

CNSC's *REGDOC-2.11 Framework for Radioactive Waste Management and Decommissioning in Canada* (CNSC 2018a) provides the framework for radioactive waste management and decommissioning in Canada. The following three bullets are directly applicable to the proposed long-term management of LLW in NSDF. A description of how the NSDF Project meets the guidance follows each bullet point.

- *Management of waste is commensurate with the hazard: The management of radioactive waste is commensurate with its radiological, chemical and biological hazard to the health and safety of persons and the environment, and to national security.*

The ECM is designed to contain and isolate the wastes from the environment for 550 years, after which, the radioactivity has decreased to levels close to the natural background concentrations. Since the NSDF Project only accepts LLW and most of the radioactivity; thus, the hazard, decays in the first 100 years after closure, the design of the NSDF Project is commensurate with the hazard.

- *The assessment of future impacts of radioactive waste on the health and safety of persons and the environment encompasses the period of time when the maximum impact is predicted to occur.*

The assessment of future impacts from the facility is performed in the Post-Closure Safety Assessment document (Arcadis and Quintessa 2020). CNL followed the guidance of CNSC's *REGDOC-2.11.1 Waste Management, Volume III: Assessing the Long-Term Safety of Radioactive Waste Management* (CNSC 2018b), to determine that a 10,000-year assessment timeframe is appropriate for the facility. This timeframe encompasses the duration of institutional control, the hazardous lifetime of the wastes and the design life of the facility barriers. Peak dose during the most reasonably anticipated evolution of the facility is 0.015 mSv/y at approximately 4100 years. The assessment timeframe is consistent with guidance of IAEA SSG-23 which states that safety assessment studies for near-surface disposal facilities typically consider timeframes of a few thousand years. It is also consistent with the facility being designed to withstand a 1-in-10,000-year seismic event.

- *The predicted impact on the health and safety of persons and the environment from the management of radioactive waste is no greater than the impact that is permissible in Canada at the time of the regulatory decision.*

A near surface design is appropriate since the public dose predicted for all plausible scenarios is less than the 1 mSv/a regulatory dose limit for members of the public, as prescribed in the *Radiation Protection Regulations*. In addition, the Normal Evolution Scenario of the PostSA meets the 0.3 mSv/a dose constraint as recommended by IAEA SSR-5 (IAEA 2011). In the pre-closure phase, the regulatory limit and dose constraint above are also met for public exposure.

The IAEA and CNSC guidance also recognizes that due to the very long time periods involved for a disposal facility, there are uncertainties in the assessment. Ways to enhance confidence in the safety features and provide an understanding of the disposal system include testing and evaluation of barrier materials and the use of anthropogenic and natural analogues.

CNL partnered with Queens University to perform a comprehensive HDPE geomembrane testing and evaluation program (R. Kerry Rowe Inc. 2019). The results of the program demonstrated that candidate HDPE geomembranes are not only expected to meet the 550-year design life of the facility, but is likely to have a design life of up to 2000 years.

Anthropogenic analogues refer to man-made structures that can be used to compare the predicted performance of the NSDF Project with structures that already exist. For example, there is a 13 m earthen mound in Newgrange, Ireland, which was constructed over 5000 years ago. Monks Mound in Collinsville, IL, USA, is a 30 m high earthen mound constructed over 1000 years ago. These structures were built with primitive engineering and construction methodologies, but have retained their structural stability for thousands of years. The NSDF will be constructed with modern construction and design methodologies, and is expected to perform as well or better than these two examples.

Natural analogues can also be used to evaluate the effectiveness of the natural materials contained in the ECM barrier systems. The compacted clay liner in the liner system of the ECM is a completely natural material. Natural deposits of clay have been studied at Cigar Lake in northern Saskatchewan (AECL 1995) with regard to the movement of uranium for the purposes of an HLW repository. The studies demonstrated that clay is an excellent barrier to the movement of water and the radioactive or chemical contaminants. The deposit provides analogue information relevant to the performance of clay-based barriers, and radionuclide migration in clay.

The use of analogues to support long-term safety assessment has its limitations. In particular, the materials and environmental conditions involved are somewhat different in the analogues compared to NSDF and its environment. This is typical of analogues; therefore, NSDF uses the above examples as an additional line of evidence complementing the safety assessments carried out.

3.1.2 Project Schedule

Pending regulatory approvals, Canadian Nuclear Laboratories (CNL) aims to have the ECM operational in 2024. The schedule for the NSDF Project is as follows:

- Site Preparation and Construction Phase = 2021 to 2023;
- Operations Phase = 2024 to 2070;
- Closure Phase = 2070 to 2100; and
- Post-closure Phase, with two discrete periods:
  - Institutional Control Period = 2100 to 2400 (300 years is used for planning purposes however the institutional control period will continue as long as necessary as determined by regulatory agencies); and
  - Post-Institutional Control Period = 2400 and beyond.

Each phase is described in more detail in Section 3.2.

The design life (i.e., the period of useful life intended by the designers) for the ECM is 550 years to meet the required time period to allow for radioactive decay of the waste placed in the facility (i.e., until it has decayed to levels that do not present a risk to the public and environment). The radioactivity concentration in the ECM will decrease about 2,000 times in the first 100 years, and then begin to approach background levels of concentration shortly thereafter. This correlates to design life criteria for similar mounds containing LLW in Canada (e.g., Port Hope and Port Granby Long-Term Waste Management Facilities).

3.1.3 Project Site Overview

The NSDF Project site will be approximately 37 ha, located within the CRL site boundary. The NSDF Project site is almost completely forested, with the western portion containing the Petawawa Research Forest tree plantation that was planted in the 1950s (Figure 1.0-1). The Petawawa Research Forest has confirmed that this plantation has not been active since the 1980s and is no longer required for research purposes.

The legacy Waste Management Area A, and four legacy Liquid Dispersal Areas (Reactor Pit 1, Reactor Pit 2, Chemical Pit and Laundry Pit) are located immediately to the northwest of the NSDF Project site, with the CRL main campus northeast of the NSDF Project site. Waste Management Area B, which is an operating waste management area, is located to the west of the NSDF Project site. There is also a non-radiological landfill to the east (Figures 1.0-1 and 3.1.1-1).

In general terms, the NSDF Project site is located on both sides of the existing East Mattawa Road, which bisects the site crossing north to south. The northern boundary of the NSDF Project site runs along Power Line Road and the southern boundary reaches ER-3 (Emergency Road) and Perch Lake Ring Road. On the western side, there is a 30 m setback from the Perch Lake wetlands that forms the site boundary, except where a proposed discharge line follows existing access roads through this area to reach Perch Lake. The boundary to the east is a local ridge line dividing the Perch Lake and Perch Creek watersheds. North of the NSDF Project site is forested land, a low-lying marsh area is to the west and south, with existing Waste Management Areas A and B further northwest. The East Mattawa Road leads to ER-3 (Emergency Road) and the Perch Creek Ring Road. To the east is forested land that drops down to the CRL main campus on the opposite side of a ridge.

The proposed location of the NSDF Project is within the Perch Creek and Perch Lake watershed, which is a small drainage system along the Ottawa River. The general topography of the NSDF Project site is defined by the ridge feature along the eastern boundary, approximately 197 m above sea level. The ridge slopes down approximately 40 m to the west to relatively flat terrain, which then drains into Perch Lake. The direction of the groundwater and surface water flow reflects the NSDF Project site topography. Groundwater levels range from approximately 0.06 m below ground surface (mbgs) to approximately 16 mbgs (see Section 5.3.2.4.2 for additional information). Surface and groundwater from this basin eventually drain to the Ottawa River, either via Perch Lake and Perch Creek, or directly through Perch Creek. The East Swamp Wetland to the northwest of the NSDF Project site drains via East Swamp Stream to the wetlands located to the south.

The surface geology of the NSDF Project site consists primarily of sands, with underlying dense sandy silt underlain by dense sandy silt till containing cobbles and boulders. Low-lying and wetland areas contain organic soils such as peat.

3.1.4 Project Design Changes

Since the submission of the draft Environmental Impact Statement to the CNSC in 2017 March, CNL has continued to refine the design of the NSDF Project. As part of this process and through engagement for the NSDF Project, the waste inventory proposed for disposal in the ECM has been revised to eliminate intermediate level waste. The NSDF Project will now only receive LLW. This design change will reduce the total radiological inventory disposed in the ECM and will reduce potential adverse effects on the environment from the NSDF Project.

CNL also identified that the proposed strategy to discharge all treated effluent to an exfiltration gallery will need to be supplemented due to limited infiltration capacity at the proposed location. The revised NSDF Project design now includes a transfer line and discharge to Perch Lake. This system has been designed and sized to be able to discharge all treated effluent to Perch Lake and operate year-round. This additional project component will eliminate the risk of overland flow at the exfiltration gallery which was identified as a concern by regulators.

Other design changes include:

- changes to the ECM design to improve the seismic stability of the ECM;
- modifications to the chemical storage in the WWTP to improve industrial safety;
- addition of two large fire water tanks to improve fire response at the NSDF Project;
- addition of hard-wired alarms and interlocks to improve the reliability of systems important to safety;
- modified cell layout; and
- changes to the WWTP storage tank specifications to ensure they would withstand a design-basis tornado.

3.2 Project Phases

The NSDF Project activities are planned to occur in the following phases: site preparation and construction, operations, closure, and post-closure. Regulatory approval will be required for the NSDF Project to progress from one phase to the next. An overview of each phase is provided below.

3.2.1 Construction Phase (including Site Preparation)

3.2.1.1 Site Preparation

Site preparation involves activities required to prepare the NSDF Project site for construction. This includes vegetation clearing (e.g., removal of trees), mobilization of the necessary construction equipment and completing large-scale earth moving activities (e.g., excavation, blasting, hauling of materials, and grading) using conventional earth-moving equipment such as bulldozers and excavators.

Site preparation will begin following receipt of approval of the environmental assessment and licencing decision, and will take approximately four months to complete. The preferred timing for completion of clearing and grubbing of vegetation on the NSDF Project site would be in early spring or fall 2021 to mitigate potential effects to migratory birds and other wildlife species (i.e., outside of sensitive breeding periods). NSDF Project site mobilization of construction equipment would occur in 2021 and the remaining site preparation activities (i.e., soil excavation, hauling and grading) would be completed between late 2021 and early 2022. Equipment required for site preparation will vary during construction. Estimated numbers are shown in Table 3.2.1-1.

Table 3.2.1-1: Estimates of Equipment Required for the NSDF Project Site Preparation and Construction Activities

Equipment	Estimated Quantity (units per day)
Rock Truck	10
Waste Transportation Vehicle	25
Water Truck	4
Excavator	10
Bulldozer	8
Grader	3
Roller (Soil Compaction)	4
Roller (Pavement Compaction)	1

Note: This is not an exhaustive list of equipment.

Specific activities associated with the NSDF Project site preparation include the following:

- implementing environmental protection measures as per the Environmental Protection Plan (e.g., silt and erosion fencing, dust monitoring, fuel and lubricants management);
- establishing exclusion and buffer zones (e.g., marking areas, such as wetlands, where activities are not permitted to occur);
- clearing and grubbing of vegetation (i.e., removal of vegetation including brush and trees, as well as the roots that may remain in the soil);
- excavating, removing and stockpiling of topsoil and overburden (e.g., soil and rocks above the bedrock) for later use for the ECM final cover system;
- blasting and excavation for the ECM;
- removal and/or stockpiling of waste rock (e.g., rock that cannot be reused in the construction of the ECM);
- excavating drainage ditches and surface water management ponds; and
- grading (e.g., creating the base) the NSDF Project site, including access roads, WWTP, laydown and stockpile areas, and various other building locations.

A 30 m buffer will be established along identified wetlands near the NSDF Project site; where the buffer cannot be maintained, appropriate measures will be established to address any risk of erosion. In addition to the wetlands buffer, a 5 m tree-line buffer will be established from the NSDF Project site to limit disturbance to vegetation and large tree roots at the tree-line. Buildings and structures will not be located within 5 m of this buffer zone to provide access for equipment around structures. A buffer zone will also be maintained between the ECM and the boundary of the NSDF Project site. This zone provides sufficient area surrounding the facility operations to allow environmental monitoring to be performed, to facilitate maintenance, and to allow implementation of contingency measures during an emergency.

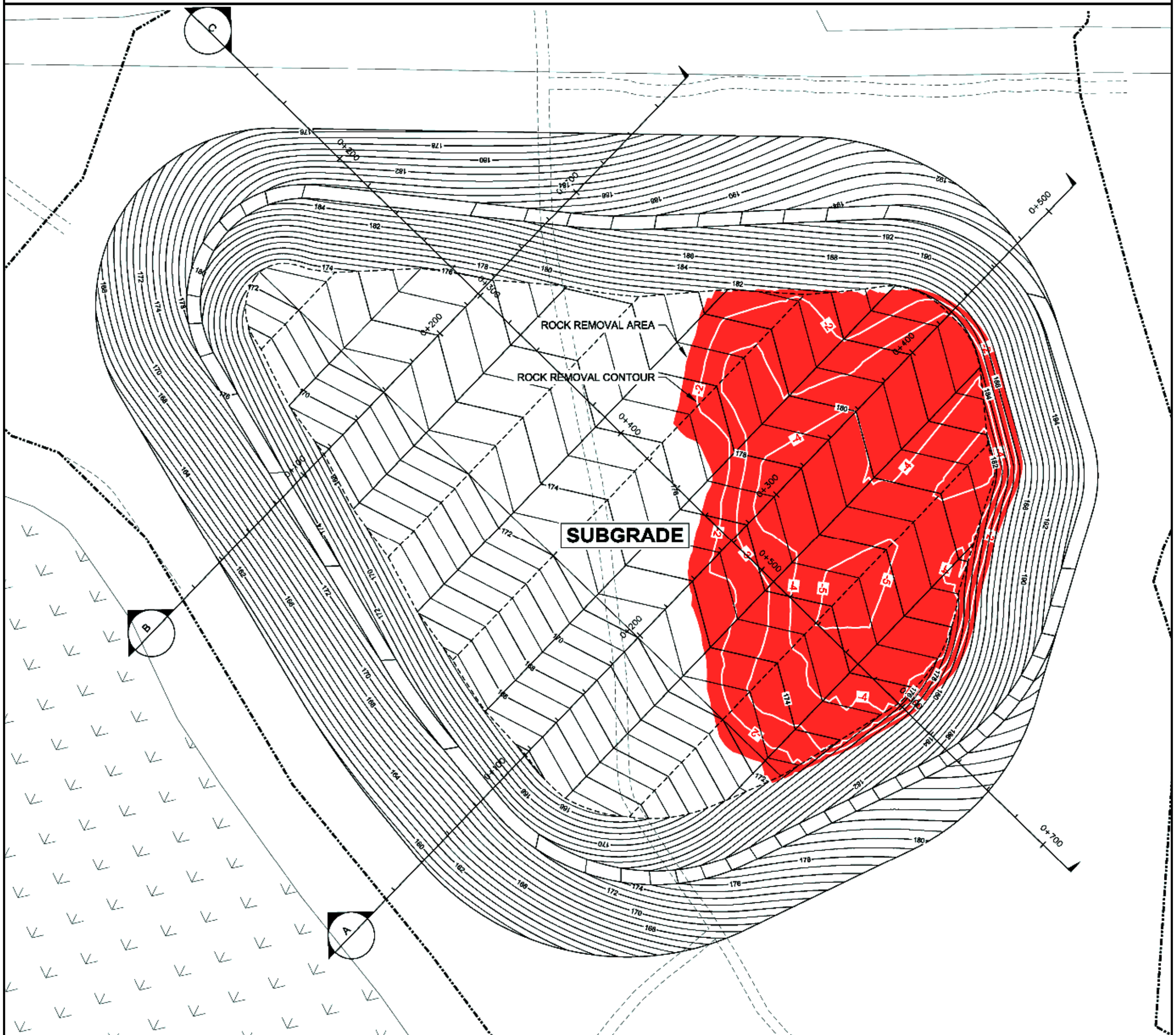
The total land area to be cleared is up to 37 ha, most of which is treed. Sampling has been completed of the vegetation and trees within the NSDF Project site as per CNL's Management of Land and Habitat procedure which confirmed the area is free of radiological contamination (AECL 2017). Roots, stumps, embedded logs and debris will be removed by grubbing and will be mulched, reused or otherwise dispositioned according to existing management practices.

Stripping of the soil will be required to remove topsoil and organic material, where necessary. Radiological surveys of soil and contamination have confirmed that the ECM footprint does not contain radiological concentrations above local background levels (CNL 2017a). The topsoil will be stored in piles for later use as final landscaping of the NSDF Project site, for application elsewhere on the CRL site, or for the ECM final cover system.

Excavation for the ECM, drainage ditches, and the surface water management ponds will be completed once the NSDF Project site has been cleared and topsoil removed. Grading will be completed for the WWTP, other building locations, and access roads.

Rock blasting will be required to complete site preparation activities for the NSDF Project site (Figure 3.2.1-1). Blasting activities will be carried out by qualified personnel, and in accordance with the Blasting Plan (to be developed) indicating the type of explosives to be used and the method of detonation. Additional guidance for the NSDF Project blasting limits will be obtained from the Ontario Provincial Standard Specification (OPSS) in the document *OPSS 120 – General Specification for the Use of Explosives* (OPSS 2014). Blasting activities will follow industry standard Best Management Practices, applicable federal regulations, and Fisheries and Oceans Canada guidelines for use of explosives. Storage and management of explosives will be done in accordance with the *Explosives Act* and supporting *Explosives Regulation, 2013*.

The anticipated quantities of blasted rock are approximately 170,000 m^3. There will also be an allowance made for additional trench blasting that may be required to facilitate utility runs. It is anticipated that most of the blasted rock will be recycled for use within the construction of the ECM. Rock that cannot be recycled for reuse will be stored on the CRL site.



REFERENCE(S)
1. CANADIAN NUCLEAR LABORATORIES 2019

CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
ROCK BLASTING LOCATIONS

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO/PR
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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3.2.1.2 Construction Phase

The construction phase (inclusive of the site preparation), is anticipated to start in 2021 pending the receipt of positive environmental assessment and licensing decisions. Construction activities are expected to take approximately two years to complete (i.e., complete by 2023). The construction season is expected to have a duration of approximately nine months per year.

The main components and activities associated with the construction phase include the following:

- vehicle traffic on-site including transportation of construction materials and soil spoils haulage to a soil storage area;
- ECM liner system construction, including construction of a berm that will form the outer boundary for most of the perimeter of the ECM and will function as a containment system;
- development of surface water management infrastructure (i.e., drainage ditches, culverts, ponds);
- management of surface water during construction;
- management of construction wastes (e.g., building materials, domestic wastes, cleaners, aerosol cans);
- on-site road and access development;
- construction and commissioning of the WWTP, including construction of WWTP treated effluent transfer and discharge system including an exfiltration gallery (similar to a septic system) and transfer line to Perch Lake;
- construction of support facilities (i.e., kiosks and vehicle weigh scales, administration building, operations support centre, vehicle decontamination facility, site vehicle refuelling station, and potable water pump station); and
- construction of site infrastructure (i.e., service elements [sanitary sewage disposal system, surface water management and utilities] and support elements [access roads, parking lots, site security, temporary storage area, and stockpile areas]).

The key physical components are the ECM, WWTP, support facilities, and site infrastructure. Construction methods for these will be consistent with the methods used for existing waste management areas, infrastructure, and support facilities on the CRL site.

The contractor will be the Constructor of the NSDF Project and will be responsible per CNL's Occupational Safety and Health Program (described in Section 3.5.2.4) to control or eliminate hazards in the field that may be encountered during NSDF Project site preparation and construction activities. An *Environmental Protection Plan* (AECOM 2018a) will also be implemented to reduce or eliminate environmental effects associated with these activities.

The *Environmental Protection Plan* (AECOM 2018a) will be similar to that in place for other CRL projects and includes measures such as water spraying to control dust, vehicle maintenance standards to reduce emissions, and implementation of erosion and sediment controls. Fuels, lubricants and chemicals required for mechanical construction equipment will be delivered to the NSDF Project site in appropriately qualified vehicles and/or containers and dispensed and used, all in compliance with applicable legislation, codes and practices. Proper handling, storage and disposal of these materials will be achieved through compliance with the Environmental Protection, Waste Management and Occupational Safety and Health Programs (each described in

Section 3.5.2). The use of designated locations for fueling, lubrication and servicing of equipment, inspection requirements, storage requirements and spill clean-up procedures will be included in these procedures.

Based on estimates of truck deliveries to the NSDF Project site during the 24-month construction period, approximately 200 shipments per day are anticipated during the nine-month construction season (i.e., approximately 15 trucks per hour for the daytime period, totalling 200 trucks per day during construction). The additional construction personnel requirements are expected to result in an additional 300 inbound and outbound trips to the site daily. Anticipated equipment required during the construction phase (including site preparation) is shown in Table 3.2.1-1.

The construction materials required for the NSDF Project are described in Section 3.4.1.11. The proposed layout of the facilities to be built is shown on Figure 3.1.1-1.

3.2.2 Operations Phase

The operations phase is anticipated to begin in 2024, following construction, and will end in approximately 2070 (i.e., the facility will be operating for approximately 50 years). Waste to be placed in the ECM will primarily originate from operations and environmental cleanup activities at the CRL site (including legacy radioactive wastes currently stored on the CRL site), from future operations, and from the demolition and decommissioning of structures at the CRL site. Less than 10% of the waste volumes to be placed in the ECM will be from off-site sources (e.g., other Atomic Energy of Canada Limited [AECL] sites such as Whiteshell Laboratories and commercial sources such as hospitals and universities).

The main components and activities associated with the operations phase include the following:

- phased development of disposal cells;
- verification and acceptance of wastes that meet the WAC;
- placement of LLW that meet the WAC in the ECM;
- progressive closure of disposal cells and installation of temporary (i.e., daily and interim) and final cover systems;
- supplementing CRL's existing Environmental Monitoring Program to include the follow-up monitoring program for the NSDF Project;
- operation of the WWTP and discharge of treated effluent;
- surface water management and erosion control;
- domestic waste management;
- petroleum storage and hazardous materials handling; and
- maintenance of infrastructure, facilities, and site services.

The NSDF Project has been designed to operate year-round. Subject to acceptable weather conditions, waste placement in the ECM may cease during periods of inclement weather such as high winds, major precipitation events, extreme cold periods, or inability to compact waste due to frozen conditions. Even if waste placement operations cease, other parts of the NSDF (e.g., the WWTP) may still operate.

It is estimated that there will be approximately 10 trucks per day during operations (i.e., there will be less than one truck per hour during operations for the daytime period). Anticipated equipment required during the operations phase is shown in Table 3.2.2-1.

Table 3.2.2-1: Estimated Typical Equipment Required During the Operations Phase

Equipment	Estimated Quantity (units per day)
Trucks in the engineered containment mound (shuttling full waste containers)	3
Transportation Vehicles (delivering waste to engineered containment mound)	10
Forklifts	2
Water Trucks	2
Track hoes	2
Bulldozer	3
Grader	1
Crane	1
Vehicles	10
Miscellaneous, for example: ■ Pumps, ■ Portable Generators ■ Air Compressors ■ Lights ■ Snow Removal Equipment	Various

Note: Assumes operations involves working in one disposal cell at a time.

The approach used for designing the NSDF Project has been to incorporate waste placement and site stabilization features into routine waste operations so that final closure activities are simplified and streamlined. For example, the interim cover and final cover system placement will progress as disposal cells are filled. The early placement of the final cover system over the disposal cells as they are closed during the operations phase will greatly increase the likelihood that the maximum anticipated settlement of the final cover system in these areas will occur during the operations phase. Closing and covering the disposal cells in phases will provide CNL the opportunity to observe the performance of the portions of cover system placed over time and take appropriate remedial action if required.

3.2.3 Closure Phase

The closure phase includes the following activities:

- installation of any remaining components of the final cover of the ECM;
- decommissioning of infrastructure and support facilities (with the exception of the WWTP and surface water management systems initially);
- remediation and grading of the NSDF Project site;
- continued operation of the WWTP and discharge of treated effluent; and
- on-going, long-term performance monitoring and inspection activities.

Closure activities are expected to start in 2070 and continue through to 2100, after which the NSDF Project will move to the post-closure phase. Most activities will be completed within the initial years of the closure phase, with the continued operation of the WWTP and performance monitoring through to 2100.

Final closure of the NSDF Project site is intended to achieve the following objectives:

- control, limit, or eliminate post-closure escape of radioactive and non-radioactive contaminants, including leachate, to the environment;
- result in an appropriate final cover slope over the ECM to limit settlement and achieve positive drainage off the ECM surface (e.g., water collects and flows to a lower elevation, away from the ECM surface) to limit infiltration, erosion, sediment transport and maintain cover stability;
- be compatible with the anticipated end use(s) and the planned future ownership of the NSDF Project site and surrounding area and the overall CRL site; and
- limit the need for future maintenance.

During the closure phase, decommissioning activities will be limited to those structures and systems not required for the post-closure phase. The preferred approach is to complete decommissioning in two phases. Phase 1 will include the decommissioning of the buildings and facilities that are no longer required once the operations phase is complete (e.g., vehicle decontamination facility). Phase 2 will include the buildings and facilities that are required for a period of time during the closure phase (e.g., WWTP).

Buildings and services will be designated for decommissioning and demolition after NSDF Project site operations deems them of no further use. The general approach for decommissioning and demolition of buildings at the CRL site will be completed in a planned, orderly way to limit impact on shared services and adjacent buildings or services. Structures will be decontaminated to the extent required to allow conventional demolition and enable waste materials to be reused, recycled or disposed of as conventional waste.

Decommissioning of the WWTP and all associated structures will be performed after the leachate quantity is able to be treated using a different technique or it becomes more cost-effective to send leachate to an alternate off-site facility. Once the ECM is closed, the volume of wastewater for treatment in the WWTP will reduce to a substantially smaller flow, as will the quantity of residual solids. The solid wastes generated during the decommissioning of the WWTP will be packaged to meet the future storage or disposal capability. Waste associated with demolition of the WWTP and associated facilities will be disposed of off-site as determined at the time of closure.

Planning for closure is an on-going process, and planning assumptions are expected to change over time. The *Preliminary Decommissioning Plan* (AECOM 2018b) for the NSDF Project is based on current information and describes the intended approach for decommissioning of all infrastructure, facilities, systems and components found on the CRL site. Periodic revisions of the *Preliminary Decommissioning Plan* (AECOM 2018b) for the NSDF will be completed as necessary to reflect changes through the lifecycle of the facility.

A *Closure Plan* (AECOM 2017; analogous to closure plan requirements for provincially regulated disposal facilities) has been developed for the NSDF Project and will be a living document that will be modified as needed to adapt to field conditions, programs, technology updates, and contingencies. An updated and revised Final Closure Plan for the NSDF Project will be prepared at the time of final closure based on actual, verified conditions through the end of the operations phase of the NSDF Project. The Final Closure Plan will have information on updated remaining waste volumes, projected final contours and associated remaining site life including a detailed implementation schedule. Information that will be considered in the revised/updated Final Closure Plan will include the final inventory disposed in the facility, types of waste, locations of waste, and other relevant information.

At the completion of closure, final radiological surveys of the surface will be performed and documented to demonstrate that the final end state for the site has been achieved in accordance with the criteria specified in the Final Closure Plan.

3.2.4 Post-closure Phase

The post-closure phase has two discrete periods: institutional control and post-institutional control.

The institutional control period includes implementation of controls throughout 2100 to 2400 (i.e., 300 years). During institutional control, inspection and surveillance activities will verify the integrity of the disposal facility system, while environmental monitoring activities will verify that the predicted performance continues to demonstrate compliance with the environmental assessment predictions.

The main components and activities associated with the post-closure phase of the NSDF Project include:

- on-going long-term monitoring to verify facility performance during the institutional control period as long as the appropriate regulatory agency deems necessary; and
- surveillance and inspection activities to verify integrity of the facility as long as the appropriate regulatory agency deems necessary.

The NSDF Project will be maintained during the institutional control period to meet the following performance requirements:

- prevent unacceptable dispersal of radioactive materials through environmental pathways (e.g., protecting groundwater from leachate);
- detect release of radioactivity early;
- confirm the final cover system can withstand damage from degradation over the design life;
- confirm the vegetated topsoil of final cover system does not erode at an unacceptable rate;
- maintain the final cover at an appropriate slope to mitigate the effects of settlement and achieve positive drainage off the ECM surface to limit infiltration, erosion, sediment transport and maintain cover stability;
- confirm that safety is provided by passive means (i.e., no active intervention necessary) during the post-closure phase;
- execute applicable environmental requirements with regard to monitoring, and surface water management systems and drainage features; and
- provide records for facility closure and for regulatory review.

Reporting requirements are subject to change based on changing conditions and regulatory requirements. Changes will primarily be made based on the extent that monitoring data confirms that the site and facilities are performing as projected and as required. This monitoring will be completed in accordance with the operational control monitoring and effluent verification monitoring program outlined in CNL's procedure for *Management and Monitoring of Emissions* (see Section 3.5.1.3; CNL 2018a).

As the post-closure period progresses, it is expected that much of the environmental sampling will be terminated or reduced, except for groundwater monitoring, which must be carried out to provide data to support long-term effects evaluation. After facility closure, the primary pathway for unintended radionuclide releases from the ECM to the environment would be through the groundwater. The groundwater monitoring program for the operational phase will be continued during the initial period after facility closure, but will gradually be reduced if no radionuclide or chemical constituent migrations are identified.

3.2.4.1 Maintenance

Once closed, the ECM will require regular monitoring and maintenance during the institutional control period to ensure its integrity and performance. During the first year immediately following final closure, post-closure inspection and maintenance activities are expected to be most frequent. Early detection of any concerns or deficiencies will be critical to a successful post-closure program. Inspection and maintenance activities will be designed to identify problems before they develop into a need for corrective action. If deficiencies are found, an appropriate course of action will be determined and executed with expediency to mitigate potential undesired effects. Less frequent maintenance and care is expected to be required as the post-closure period progresses.

Maintenance activities for the ECM will be primarily associated with limiting erosion from surface water runoff and ground settlement within the ECM. The finished surface of the ECM will be elevated from the surrounding terrain, which will limit the quantity of surface water entering the ECM from outside areas. The slopes within the ECM will be sufficient to promote drainage and the ECM surface water collection ditches and related components will be lined with erosion control measures so sediment transport and erosion will be reduced.

Construction, operation, and closure activities of the ECM will be designed to limit settlement (i.e., downward movement of the cover) and water infiltration; however, subsidence (i.e., gradual caving in or sinking) or slope instability could indicate differential settlement beneath the surface. The cover will be inspected for depressions, cracking, or other deformities in the cap shape for evidence of differential settlement.

Trees will not be allowed to establish on the final cover because their root systems could cause damage to the cover layers. For example, if the tree falls over due to wind, roots could disrupt low-permeability layers of the cover, resulting in an increase in their hydraulic conductivity (i.e., the ability for water to flow through the layer). Maintenance activities during the institutional control period will include removal of trees and other deep-rooted type vegetation and conducting physical inspections for animal burrows over the ECM surface. To reduce erosion and protect the ECM cover, the turf will need to be a healthy, uniform, close stand of grass that is free of noxious weeds and surface irregularities, with coverage exceeding 90%. Maintenance activities will use the access roads that are constructed around the perimeter of the landfill and the top of the perimeter berm.

Monitoring during the institutional control period will confirm the performance of the containment system, and if necessary, remedial actions will be taken. Examples of mitigation that would be implemented include:

- If erosion were present, the final cover would be repaired.
- If a localized breach of the final cover were present, the cover would be repaired and the leachate system would be periodically assessed and inspected.
- If there were multiple or and indeterminant number of breach locations in the final cover, another cover / cap system could be installed over the existing cover.

- If the monitoring wells detected abnormal performance results, additional wells could be installed and the monitoring frequency increased.
- Erosion of the perimeter berm would be mitigated by maintaining a healthy vegetation cover.

3.2.4.2 Institutional Controls

Institutional controls are anticipated to be required when transitioning from the end of the closure phase (i.e., the year 2100) to the post-closure period. Institutional controls are mechanisms designed to appropriately limit access to or uses of land and facilities, to protect cultural and natural resources, to maintain the physical security of facilities and to prevent or limit inadvertent human and environmental exposure to residual contaminants. Institutional controls include administrative and legal controls, and may also include certain physical controls (e.g., fences and gates).

Institutional controls are important in helping to protect engineered barrier systems by providing a means to ensure that the barriers remain effective, are not showing signs of degradation, and continue to limit the potential for being vandalized or damaged by outside elements (natural or human) in any way. The NSDF Project is designed to promote safety through passive means during post-closure but is complemented by active measures taken by CNL, such as maintenance, security and surveillance. The NSDF Project site security features will include signage, markers, fencing and gate. A chain-link fence will deter intruders and animals from site access. A control gate will be located on the north side of the NSDF Project site to allow personnel access for required maintenance and observation. Features will be maintained and cared for per manufacturer's specifications.

Institutional controls also include methods to preserve knowledge and to inform current and future generations of potential hazards and risks. Such administrative or legal controls help to reduce the potential for human exposure to contamination. The land use designation for the NSDF Project site is as a waste disposal facility. Upon closure, controls will be in place to limit land usage including recognition on the property title or deed to ensure the appropriate zoning restrictions and including buffer or attenuation zones. As the enduring federal entity, and owner of the assets and liabilities of CNL, AECL is committed to controlling and restricting the land use of the NSDF footprint for as long as necessary. While other areas of the CRL site may be reused, the NSDF Project site will continue to be restricted as a waste disposal facility.

Institutional controls work by limiting land or resource use by providing information to modify or guide human behavior at the site. The above are preliminary recommendations of institutional controls for the NSDF Project however these will be reassessed at the time of final closure of NSDF Project and will be updated as necessary during, and at the end of the institutional control period. They will address changes in jurisdiction of authority and changes in other requirements that may occur as they relate to final closure and post-closure care of the NSDF Project.

3.3 Waste Strategy

In the interest of effectively managing AECL's nuclear liabilities, CNL and AECL are working to identify strategies and solutions for waste management of the entire life cycle of all waste classifications from LLW, to intermediate level waste and high level waste. The NSDF Project is the proposed disposal strategy for CNL's LLW. As such, the following sections provide a summary of the waste inventory developed to inform the facility design and various safety assessments, a description of waste types and projected volumes and the WAC that will be employed to keep the facility within its environmental assessment predictions. Additional details regarding CNL's broader integrated waste strategy beyond the NSDF Project is provided in Section 2.2.

3.3.1 Waste Types, Volumes, and Inventory

Sources of the waste to be placed in the ECM will primarily originate from the CRL site and its revitalization plan, which involves the decommissioning of more than 100 buildings that have reached the end of their useful lives. A small percentage of the waste volume will come from off-site sources (e.g., Whiteshell Laboratories, commercial waste sources such as hospitals and universities), as shown on Figure 3.3.1-1.

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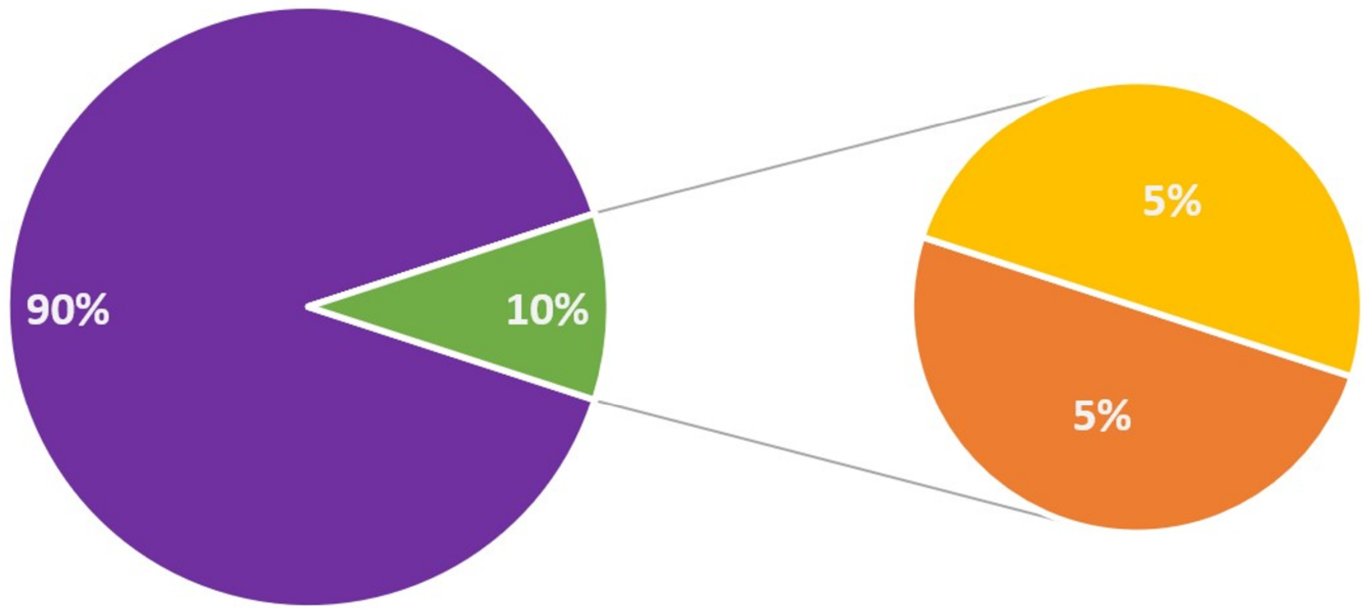

LEGEND

REFERENCE(S)
1. CANADIAN NUCLEAR LABORATORIES 2019

CLIENT	CANADIAN NUCLEAR LABORATORIES
CONSULTANT	GOLDER
DATE	NOVEMBER 2020
DESIGNED	PR
PREPARED	PR
REVIEWED	CS
APPROVED	AB
PROJECT	NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT CHALK RIVER, ONTARIO
TITLE	**SOURCE OF WASTES TO BE INCLUDED IN THE NSDF**
PROJECT NO.	1547525
CONTROL	0005
REV.	FINAL 2
FIGURE	**3.3.1-1**

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The wastes suitable for disposal in the ECM will include a wide range of bulk materials (e.g., demolition debris or soils) and packaged solid wastes (e.g., waste stored in containers or drums). These wastes have or will arise through CNL activities, including:

- demolition of existing and future buildings;
- remediation of contaminated soils and related structures;
- operational and legacy wastes currently in interim storage;
- commercial sourced inventories; and
- wastes from the continuing laboratory operations.

A large portion of the waste inventory planned for disposal from in the ECM will come from waste stored temporarily in the CRL waste management areas (WMA). However, the determination of which WMAs will undergo full remediation (i.e., waste excavated and transferred into the NSDF Project) has not been made. The remediation process, which includes an activity to determine remedial alternatives and select a remedial approach, is captured in CNL's Decommissioning and Demolition Program Description Document (CNL 2018b). In the alternatives evaluation for a specific WMA, a range of alternatives from full remediation to in-situ management through implementation of an engineered cover will be evaluated. This alternatives evaluation would need to demonstrate the preferred remedial approach could satisfy all regulatory and licensing requirements including those specified within REGDOC-2.11.1 Volume III (Assessing the Long-Term Safety of Radioactive Waste Management) (CNSC 2018b).

As per the most recent revision of the Comprehensive Decommissioning Plan (CPDP), the large-scale remediation projects, including the WMAs and impacted areas on the CRL site, are intended to be been brought forward to align with the proposed availability of the NSDF Project. For example, the conceptual schedule for the remediation of several WMAs currently impacting groundwater quality on the CRL site (i.e., WMA A, the Liquid Dispersal Area and WMA B sand trenches) have been advanced as much as 10 to15 years from the previous version and strategy. These historic WMAs have none to minimal engineered barriers to contain the inventory. Although the releases and groundwater impact from these WMAs is currently being managed, the risk of future releases and environmental impacts the inventory poses could be substantially reduced through improved containment and isolation of the source term. The NSDF Project is a purpose built disposal facility wherein the ECM design life of 550 years has been established to meet the required time period to allow for radiologic decay of the waste inventory.

Waste characteristic information (i.e., type and volume) is central to determining how waste will be handled, and is the basis for specific waste packaging, handling, and placement practices. In addition, for bulk wastes the waste constituents, such as concrete, wood, brick, and metal, must be described to an extent that allows assessment of waste placement efficiency, stability, and waste segregation strategies.

The expected properties of the future waste streams are based on projections using known wastes that have already been characterized. Waste characterization will continue throughout the operation of the NSDF; however, the waste properties and quantities are sufficiently defined to support the facility design. A range of radiological, chemical, and physical properties have been considered and included in the waste inventory. Only LLW, as defined in the Canadian Standards Association (CSA) standard for the nuclear industry *N292.0-19 General Principles for the Management of Radioactive Waste and Irradiated Fuel* (CSA Group 2019) and IAEA's general safety guide *GSG-1 Classification of Radioactive Waste* (IAEA 2009), will be accepted for disposal in NSDF. The following sections provide a summary of the waste types and expected volumes for each waste type.

3.3.1.1 NSDF Waste Types

CRL identifies and tracks several hundred waste sources in its waste tracking database. Wastes are categorized into six waste types based on physical characteristics. The six waste types are independent of their radiological and chemical characteristics, which are further defined in Sections 3.3.3.2 and 3.3.3.3. A description of each waste type is provided below:

- **Type 1 – Soil and Soil-like Waste:** Type 1 waste includes contaminated soils and other waste materials with characteristics similar to soil that can be placed within the mound with what would be required for the disposal of soil.
- **Type 2 – Comingled Radioactive Waste, Debris, Refuse, Soil, and Soil-Like Waste:** Type 2 waste includes wastes that are anticipated to be at least 50% soil or soil-like in nature.
- **Type 3 – Non-Soil-Like Waste:** Type 3 waste includes materials that can be excavated and handled as bulk materials but do not have the physical characteristics of soil and soil-like materials. These include process wastes, highly organic wastes, highly compressible wastes, flowing wastes and similar waste types.
- **Type 4 – Decommissioning and Demolition Waste:** Type 4 wastes include typical materials used in construction such as: concrete, asphalt, brick, lumber, structural steel, process equipment, piping, wood and other building materials produced by decommissioning and demolition activities.
- **Type 5 – Packaged Waste:** Type 5 waste refers to wastes contained in rigid packages. There are two types of rigid waste packages: Non-Leachate Controlled Waste Packages and Leachate Controlled Waste Packages. Liners and soft-sided waste packages are not considered Type 5 Waste. Non-Leachate Controlled Waste Packages include intermodal containers (e.g., 20-foot ISO container), steel waste boxes (e.g., B-25 boxes) and drums (e.g., 205 L drum). Leachate Controlled Waste Packages provide containment of the waste during the time the disposal cell is not covered with the final cover. Containment can also be provided using approved overpacks or waste processing methods.
- **Type 6 – Oversize Debris:** Type 6 waste includes waste that does not fall within the definition of waste Types 1 through 5, primarily by its size or shape. The Infrequently Performed Operations process is used to approve placement of Type 6 wastes (CNL 2019a).

3.3.1.2 Waste Volumes

Table 3.3.1-1 shows the estimated volume of each type of waste expected to be disposed of at the NSDF. The most abundant waste types by volume are decommissioning and demolition wastes (Type 4) and soil and soil-like wastes (Type 1). Waste types 1,2,3,4 and 6 constitute bulk waste, and type 5 is packaged waste. Approximately 87% of the wastes will be bulk unpackaged wastes and approximately 13% of the wastes will be packaged.

Table 3.3.1-1: Waste Types and Volumes

Waste Type Descriptor	Waste Volume (m^3)	Waste Type (%)
Bulk Waste	866,000	87
Type 1 – Soil and Soil-Like Waste		
Type 2 – Comingled Radioactive Waste, Debris, Refuse, Soil, and Soil-Like Waste		
Type 3 – Non-Soil-Like Waste		
Type 4 – Decommissioning and Demolition Waste		
Type 6 – Oversize Debris		
Packaged Waste	134,000	13
Type 5 – Packaged Waste		
Total	**1,000,000**	**100**

3.3.1.3 Waste Inventory

The NSDF Project will contain only LLW. NSDF will not contain high level radioactive wastes such as used nuclear fuels nor intermediate level waste such as irradiated reactor core components. LLW contains primarily short-lived radionuclides and restricts the amount of long-lived radionuclides; thus, isolation and containment are only required for periods of time up to a few hundred years. Long-lived radionuclides are included in the NSDF inventory as they are intrinsically part of the radiological fingerprints of waste streams at CRL and other CNL sites. It is not practical, technical, or economical, to separate the long-lived radionuclides from the waste streams, especially since many of the waste streams are in the form of soil and building debris. However, the concentrations of long-lived radionuclides that are proposed in the NSDF licensed inventory are limited, consistent with CSA N292.0 (CSA Group 2019) and IAEA GSG-1 (IAEA 2009) guidance. The ECM design life of 550 years has been established to meet the required time period to allow for radioactive decay of the waste inventory, illustrated on Figure 3.3.1-2. The radioactivity concentration in the ECM decreases about 2,000 times in the first 100 years, and begins to approach background levels of concentration shortly thereafter.

The radionuclides currently present on the proposed NSDF footprint are Naturally Occurring Radioactive Material (NORM) such as Potassium-40, Carbon-14, and the uranium and thorium decay chains (CNL 2017a). The natural background also includes Cesium-137 from atmospheric atomic weapons testing.

Although not all radionuclides proposed in the NSDF inventory are NORM, the purpose of comparing the NSDF total radioactivity concentration to the total natural background concentrations is to build confidence that the long-term hazard is acceptably low. This comparison provides an analogy by recognizing that long-lived radionuclides already exist in the environment without being a hazard. There is no requirement to meet background radioactivity levels in a disposal facility. The radiological inventory proposed for the NSDF, combined with the facility design, must ensure that doses to the public and risk to the environment remains below the regulatory limits. Radiological dose and environmental risk as a result of these long-lived radionuclides are discussed in Sections 5.7 and 5.8.

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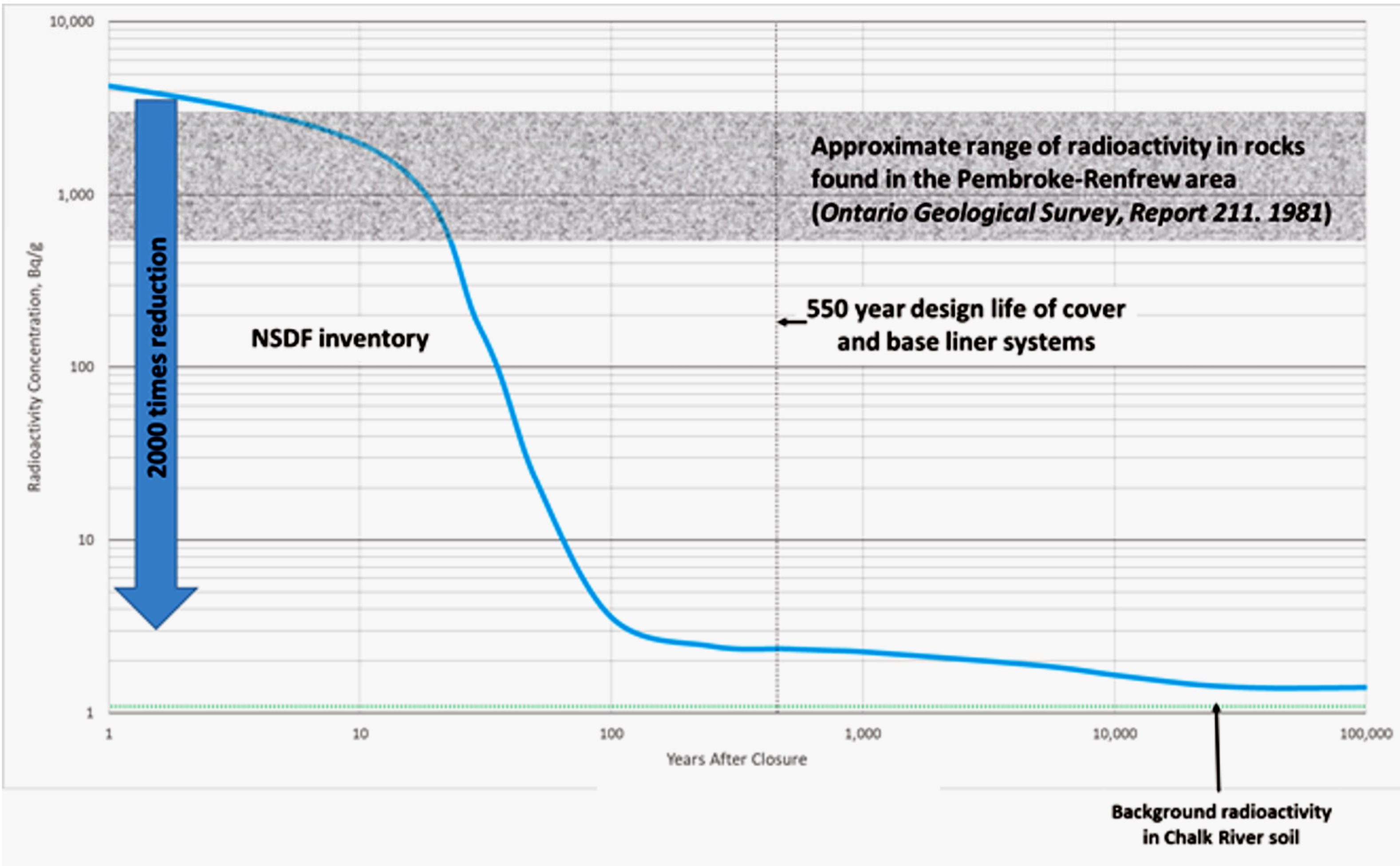

LEGEND

REFERENCE(S)

1. CANADIAN NUCLEAR LABORATORIES 2019

CLIENT
CANADIAN NUCLEAR LABORATORIES

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	PR
PREPARED	PR
REVIEWED	CS
APPROVED	AB

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
RADIOLOGIC DECAY OF THE NEAR SURFACE DISPOSAL FACILITY WASTE INVENTORY

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0005	FINAL 2	3.3.1-2

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An estimation of the total inventory is required for the safety assessments in which the inventory is tested against selected scenarios to determine the long-term consequences of the proposed facility. It also informs design criteria for NSDF Project components such as the WWTP.

The reference inventory (Table 3.3.1-2) establishes a representative radionuclide inventory by considering waste already in storage and waste forecasts from environmental remediation and decommissioning projects data to predict an assumed total volume of waste at the NSDF at time of closure. The NSDF Reference Inventory has been used to inform the design and safety analyses.

In the third iteration of the Post-Closure Safety Assessment (Arcadis and Quintessa, 2020), a recommendation was made to lower the maximum radioactivity of two radionuclides listed in the reference inventory, to support the claim that future public doses in the post-closure phase will be well below the long-term dose acceptance criteria. The Licensed Inventory is a modified reference inventory, and represents a maximum radiological inventory limit for the NSDF. The Licensed Inventory is part of the NSDF safety and licensing basis, and represents a maximum radiological inventory limit for the NSDF. In the Licensed Inventory, the radioactivity of both I-129 and Pu-239/Pu-240 were reduced to 58% of the reference inventory values. All LLW that is expected to be generated has been meticulously described, or “characterized”, before its generation to ensure the cumulative total inventory of the NSDF is tracked against the licensed inventory (Table 3.3.1-2).

Table 3.3.1-2: NSDF Reference Inventory and Licensed Inventory

Radionuclide	Half Life[(a)] (years)	Predominant Decay Emission	Reference Inventory		Licensed Inventory	
			Total Activity (Bq) at Emplacement	Total Activity (Bq) at Closure	Maximum Activity (Bq) at Placement	Maximum Activity (Bq) at Closure
Silver-108m	438	gamma	2.73×10^{10}	2.62×10^{10}	2.73×10^{10}	2.62×10^{10}
Americium-241	433	alpha/gamma	6.04×10^{10}	9.74×10^{10}	6.04×10^{10}	9.74×10^{10}
Americium-243	7,360	alpha	5.26×10^{7}	5.24×10^{7}	5.26×10^{7}	5.24×10^{7}
Carbon-14	5,700	beta	1.71×10^{12}	1.70×10^{12}	1.71×10^{12}	1.70×10^{12}
Chlorine-36	301,000	beta	3.97×10^{9}	3.97×10^{9}	3.97×10^{9}	3.97×10^{9}
Cobalt-60	5	beta/gamma	9.06×10^{16}	1.47×10^{16}	9.06×10^{16}	1.47×10^{16}
Cesium-135	2,300,000	beta	5.19×10^{8}	5.19×10^{8}	5.19×10^{8}	5.19×10^{8}
Cesium-137	30	beta/gamma	5.59×10^{12}	3.17×10^{12}	5.59×10^{12}	3.17×10^{12}
Hydrogen-3 (Tritium)	12	beta	8.91×10^{14}	2.79×10^{14}	8.91×10^{14}	2.79×10^{14}
Iodine-129	15,700,000	beta/gamma/x-ray	3.03×10^{10}	3.03×10^{10}	1.75×10^{10}	1.75×10^{10}
Molybdenum-93	4,000	x-ray	1.47×10^{5}	1.47×10^{5}	1.47×10^{5}	1.47×10^{5}
Niobium-94	20,300	beta/gamma	2.34×10^{10}	2.34×10^{10}	2.34×10^{10}	2.34×10^{10}
Nickel-59	76,000	x-ray	1.21×10^{9}	1.21×10^{9}	1.21×10^{9}	1.21×10^{9}
Nickel-63	101	beta	3.11×10^{11}	2.59×10^{11}	3.11×10^{11}	2.59×10^{11}
Neptunium-237	2,140,000	alpha/gamma	1.74×10^{7}	1.74×10^{7}	1.74×10^{7}	1.74×10^{7}
Plutonium-239[(b)]	24,100	alpha	8.77×10^{10}	8.76×10^{10}	5.07×10^{10}	5.06×10^{10}
Plutonium-240[(b)]	6,650	alpha				
Plutonium-241	14	beta	1.67×10^{12}	5.84×10^{11}	1.67×10^{12}	5.84×10^{11}
Plutonium-242	375,000	alpha	6.32×10^{07}	6.32×10^{7}	6.32×10^{7}	6.32×10^{7}
Radium-226	1,600	alpha/gamma	3.65×10^{10}	3.61×10^{10}	3.65×10^{10}	3.61×10^{10}

Table 3.3.1-2: NSDF Reference Inventory and Licensed Inventory

Radionuclide	Half Life[(a)] (years)	Predominant Decay Emission	Reference Inventory		Licensed Inventory	
			Total Activity (Bq) at Emplacement	Total Activity (Bq) at Closure	Maximum Activity (Bq) at Placement	Maximum Activity (Bq) at Closure
Selenium-79	327,000	beta	9.26×10^{7}	9.26×10^{7}	9.26×10^{7}	9.26×10^{7}
Tin-126	230,000	beta/gamma	1.24×10^{8}	1.24×10^{8}	1.24×10^{8}	1.24×10^{8}
Strontium-90	29	beta	6.05×10^{12}	3.35×10^{12}	6.05×10^{12}	3.35×10^{12}
Technetium-99	211,000	beta	3.16×10^{11}	3.16×10^{11}	3.16×10^{11}	3.16×10^{11}
Thorium-230	75,400	alpha	5.30×10^{9}	5.30×10^{9}	5.30×10^{9}	5.30×10^{9}
Thorium-232	14,000,000,000	alpha	2.70×10^{10}	2.70×10^{10}	2.70×10^{10}	2.70×10^{10}
Uranium-233	159,000	alpha	2.74×10^{8}	2.74×10^{8}	2.74×10^{8}	2.74×10^{8}
Uranium-234	246,000	alpha	6.88×10^{10}	6.88×10^{10}	6.88×10^{10}	6.88×10^{10}
Uranium-235	704,000,000	alpha/gamma	2.96×10^{9}	2.96×10^{9}	2.96×10^{9}	2.96×10^{9}
Uranium-238	4,470,000,000	alpha/gamma	7.57×10^{10}	7.57×10^{10}	7.57×10^{10}	7.57×10^{10}
Zirconium-93	1,610,000	beta	4.92×10^{11}	4.92×10^{11}	4.92×10^{11}	4.92×10^{11}

(a) Half-Lives are from the IAEA Live Chart of Nuclides (IAEA 2019).
(b) Reported as Pu-239/240 are these radionuclides are generally combined in laboratory analysis.
Bq = Becquerels; Bq/g = Becquerels per gram.

3.3.1.3.1 Non-radiological Waste Inventory

The NSDF will only accept radiologically contaminated material; however, these materials are made of a variety of metals, organics, and chemical compounds. As a land disposal facility, the NSDF will follow the guidelines of Ontario's *Regulation 347, General – Waste Management,* for acceptable quantities and concentrations of metals, organics, and chemical compounds to limit the leaching potential of the facility.

CNL has performed calculations to determine estimates of the amounts of metals, chemical compounds, and organic material present in the waste streams proposed for the NSDF. A summary of discrete metals and organics estimates is presented in Table 3.3.1-3.

Table 3.3.1-3: NSDF Non-radiological Inventory at the Time of Closure

Contaminated Material Type	Calculated Mass in the Facility at Closure (kg)
Aluminum	33,000
Copper	3,520,000
Iron (waste plus package material)	10,442,000
Lead	178,000
Organics (wood and dry radioactive waste, which includes cotton-based materials like mop heads and clothing)	80,339,000

3.3.2 Waste Approval, Verification and Acceptance

Waste generators will be approved through CNL's Waste Programs prior to acceptance of waste for disposal in the ECM. For waste to be accepted for disposal in the ECM, the waste generator will need to characterize the waste, complete and submit a Waste Profile and Waste Management Plan for review and approval, and apply for and receive approval to transport the waste to the NSDF site. Initial discussions between the waste generator and NSDF personnel regarding the waste will be essential to ensure that the waste acceptance process is accurate, complete and meets NSDF requirements.

As part of the waste acceptance process, CNL will verify the NSDF-bound waste against the submitted documentation. The verification may include:

- visual inspection of waste;
- visual inspection of waste package;
- non-destructive assays (e.g., inspection or evaluation); and/or
- destructive sampling and analysis.

Waste that is successfully verified will then be permitted to proceed to the unloading zone.

WAC non-conformances identified through the verification process as well as discrepancies between waste documentation and verification results will be managed through the Waste Certification process. These non-conformances could result in remedial actions ranging from a non-accepted waste shipment with minor anomalies (e.g., missing or incorrect documentation) that would remain in a quarantine area until the required correction is made and the verification and acceptance process can be completed, up to a non-accepted waste shipment with major anomalies (e.g., incorrect packaging) which would be returned to the waste generator's facility to complete the necessary corrective action.

3.3.3 Waste Acceptance Criteria

The NSDF WAC ensures CNL meets its responsibility as the licensee; that all waste received for disposal is in compliance with the design and licensing basis for the facility (CNL 2020c). Specific safety criteria are provided in the *Design Description* (AECOM 2019), this Environmental Impact Statement, the *Post-Closure Safety Assessment* (Arcadis and Quintessa 2020) and the *Safety Analysis Report* (CNL 2020b). Compliance with the NSDF safety criteria ensures the short-term and long-term protection of the public, the environment and workers.

Waste shall comply with all of the criteria in the WAC to be considered acceptable for disposal in the ECM. The physical, radiological and chemical characteristics of the acceptable waste are further defined below.

3.3.3.1 Physical Characteristics

The NSDF will only accept solid waste with no free liquids (e.g., liquids that readily separate from the solid portion of a waste) for disposal. Waste that has been solidified via stabilization (e.g., cementation) or pre-treatment may meet this requirement. Such waste will either be delivered to the ECM in the form of:

- Bulk materials (e.g., demolition debris including concrete rubble, masonry, and rebar).
- Packaged wastes (e.g., waste that is stored in containers or drums). The primary objective of waste packaging is to provide contamination control and radiation shielding for worker safety during handling and placement operations. A small percentage of packaging is also credited for containment to limit leachate generation. The properties of each container must be compatible with the enclosed waste.

As summarized in Table 3.3.1-1, the majority of the waste (approximately 87%) to be accepted in the ECM will be bulk materials (i.e., Types 1, 2, 3, 4 and 6), while packaged waste (Type 5) will comprise approximately 13% of the total waste volume. Both forms of waste must meet the WAC requirements for dimension and mass (i.e., size and weight) to assure safe handling and transportation.

3.3.3.2 Radiological Characteristics

LLW includes items such as soils from remediation activities, demolition debris from decommissioning work and general trash such as used personal protection clothing or equipment. These items are considered LLW because they became contaminated at some point with low levels of radioactivity. LLW mostly contains short-lived radioactivity (thus decays relatively quickly) and can be safely handled with limited precautions.

The radionuclide concentration limits for waste are provided in Table 3.3.3-1 below for a single radionuclide. In the case of a mixture of radionuclides, the sum of the component radionuclide limit fractions must not exceed 1 to demonstrate compliance to what is referred to as the "Sum of Fractions" rule. The calculation of the concentration limits shall exclude the mass of packaging and shielding.

Table 3.3.3-1: Radionuclide Concentration Limits in NSDF Waste

Limits for Bulk Waste & Non-Leachate Controlled Waste Packaged Waste	■ 100 Bq/g for alpha emitting radionuclides ■ 1,000 Bq/g for long-lived beta/gamma emitting radionuclides (half life >cesium-137) ■ 10,000 Bq/g for short-lived beta/gamma emitting radionuclides (half life ≤ cesium-137) ■ 100,000 Bq/g for tritium
Limits for Leachate Controlled Packaged Waste	■ 400 Bq/g for alpha emitting radionuclides ■ 10,000 Bq/g for long-lived beta/gamma emitting radionuclides (half life >cesium-137) ■ 10,000 Bq/g for cesium-137 ■ 10,000 Bq/g for strontium-90 ■ 10,000,000 Bq/g for tritium

Bq/g = Becquerels per gram.

Radiation dose rates and surface contamination on containers will meet CNL's Radiation Protection Program requirements. All waste received at the NSDF must meet the dose rate limits (CNL 2020a) listed in Table 3.3.3-2:

Table 3.3.3-2: Dose Rate Limits and Means of Handling and Transferring

Radiation Type	Dose Rates	Means of Handling and Transferring
Total gamma and neutron	≤0.5 mSv/h near contact **and** ≤0.01 mSv/h at a distance of 1 metre	Manual handling or mechanical means
Total gamma and neutron	>0.5 mSv/h to ≤2 mSv/h near contact **and** >0.01 mSv/h to ≤0.1 mSv/h at a distance of 1 metre	Mechanical means
Total gamma and neutron	>2 mSv/h near contact **or** >0.1 mSv/h at a distance of 1 metre	Handling and transferring is subject to Radiation Protection Programs controls, Infrequently Performed Operations (CNL 2019a) and assessment approval by the NSDF Facility Authority.
Beta	<10 mSv/h near contact	Based on total gamma and neutron dose rates

The maximum non-fixed surface contamination on the accessible surface of each waste package or transportation vehicles, averaged over 300 cm^2, must be less than 3.7 Becquerels per square centimetre (Bq/cm^2) for beta/gamma-emitters, and less than 0.37 Bq/cm^2 for alpha-emitters.

The vast majority of the fissionable material projected for placement in ECM is natural uranium; thus, posing minimal hazard as it exists inherently, or is caused by anthropogenic activities, in soils generated from environmental remediation activities or building materials generated from demolition and decommissioning. A very small amount of other fissionable material will exist in residual, unrecoverable amounts predominately as contamination on waste equipment, demolished structures and in soil as a result of nuclear fuel cycle activities. Concentration limits for fissionable material in the waste have been developed to ensure appropriate controls and mitigations in alignment with CNSC's *REGDOC-2.4.3 Nuclear Criticality Safety* (CNSC 2018c) are in place and to meet the requirements of CNL's Nuclear Criticality Safety Program, such that criticality safety can be assured (see Section 3.5.2.6).

3.3.3.3 Chemical Characteristics

The majority of LLW accepted in the ECM will be on-site building waste from decommissioning and soil and soil-like wastes from environmental remediation. As such, LLW may also contain chemical constituents of potential concern (COPCs), as residual contamination.

Waste placed in the ECM will meet the intent of land disposal and leachate requirements specified in Ontario's *Regulation 347, General – Waste Management*. This is a requirement of the WAC. The acceptance of waste into the ECM will be controlled through waste characterization and utilizing Ontario Regulation 347 limits. Waste that, not considering its radioactive component, is classified as hazardous waste is not permitted for disposal in the ECM, unless the hazardous waste has been treated using methods for land disposal described in Ontario Regulation 347.

3.4 Project Components and Activities

The following sections describe in detail the components and activities anticipated for the NSDF Project. Emphasis is placed on the systems, components, and activities of the NSDF Project that are expected to interact with the environment. All activities will be carried out in compliance with CNL's health, safety and environmental protection requirements.

3.4.1 Engineered Containment Mound

The primary component of the NSDF Project is the ECM, which will contain the wastes and isolate them from the surrounding environment. The ECM relies on passive safety features to provide containment and isolation of the waste. These ensure the safety and protection of individuals, society and the environment. The ECM passive safety features include:

- the base liner (a double-liner system) that provides containment of the waste and the leachate that is generated;
- final cover, that isolates the waste from the environment and human intrusion; and
- perimeter berm, that provides containment of the waste and the leachate that is generated and isolates the waste from the environment and human intrusion.

Containment and isolation of the waste allows radioactive decay to occur and delays the release of any contaminants to the environment. The base liner, final cover and perimeter berm constitute a multiple barrier system because:

- the different materials used in their design and construction have different chemical and physical properties that ensure the long life of these structures; and
- there is no common failure mode that would simultaneously fail all layers of the liner and cover (e.g., subsidence and seismic activity).

The ECM will consist of ten disposal cells, each designed for progressive construction, filling, and closure in sequence. Dividing the entire disposal area into ten cells provides for the preferred operation and closure sequence.

The disposal cells in the ECM will be filled in succession and as each cell is filled to capacity, the next cell will be prepared to accept waste. The average cell area will be 12,000 m^2; however, for the purposes of the modelling, a maximum capacity of 15,000 m^2 was used to calculate a maximum amount of leachate and contact water that could be expected to be generated from any cell. Within the ECM there will also be a 6,000 m^2 temporary waste storage pad for staging waste. The storage pad will be a gravel area that may be used to stage both bulk and packaged waste awaiting disposal.

A cross-section along the east-west axis through the ECM is provided on Figure 3.4.1-1. The figure illustrates the relative elevations of the existing grade, interpreted bedrock surface, ECM subgrade, ECM liner, and ECM final cover. Construction of the ECM will involve excavation below grade in the central portions of the facility, and placement of material above current grade along the exterior berms and in the southern-central portions of the facility. All overburden material will be removed in the area beneath the ECM berm, and the perimeter berm will be constructed on bedrock. Waste will be placed in the ECM between a base liner system and the cover system. Upon completion of the cover, the ECM will reach a maximum elevation of approximately 8 m above existing grade. The ECM will lie on overburden in the northwest region of the footprint. The maximum thickness of overburden underlying the ECM will be approximately 3 m.

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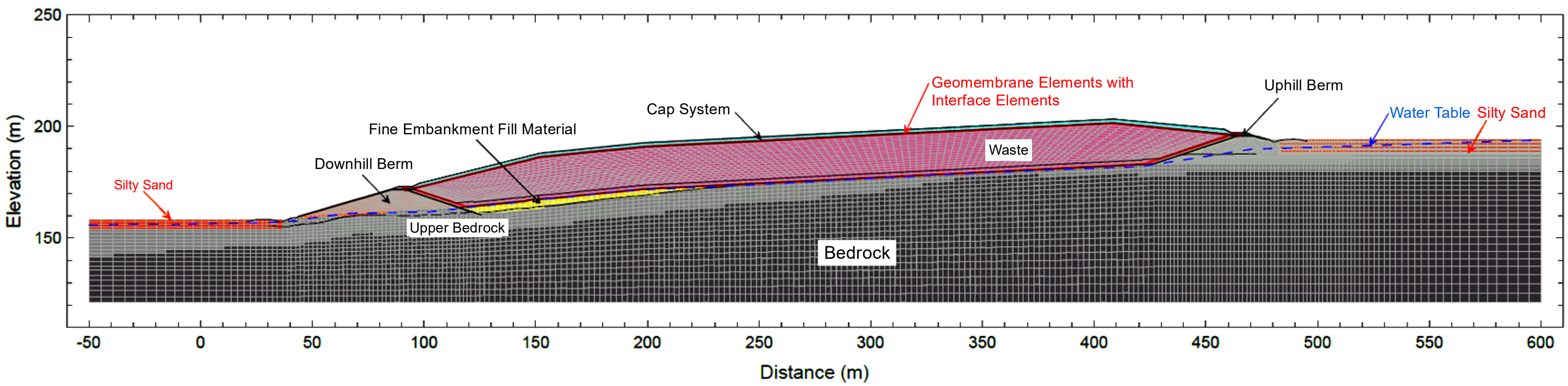


LEGEND

NOTE(S)
1. VERTICAL SCALE ON FIGURE IS EXAGGERATED

REFERENCE(S)
1. CANADIAN NUCLEAR LABORATORIES 2019

CLIENT
CANADIAN NUCLEAR LABORATORIES

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	PR
PREPARED	PR/CGE
REVIEWED	CS
APPROVED	AB

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
CROSS SECTION OF ENGINEERED CONTAINMENT MOUND

PROJECT NO.	CONTROL	FINAL	FIGURE
1547525	0005	FINAL 2	3.4.1-1

3.4.1.1 Containment Mound Fill Capacity

The construction and operation of the ECM will be accomplished in two phases. Phase 1 will include six cells providing a capacity to accommodate the disposal of 525,000 m^3 of waste (Figure 3.4.1-2). Phase 2 will include four cells providing a capacity of 475,000 m^3 to accommodate the remainder of the waste (Figure 3.4.1-3). A daily/interim cover (described in Sections 3.4.1.9.1 and 3.4.1.9.2) will use an industry-typical waste-to-soil ratio of 4:1 (i.e., 4 units of waste for every 1 unit of daily/interim cover soil), which will result in a total cover soil volume of 131,250 m^3 for Phase 1. As such, the design fill capacity for the Phase 1 mound volume is 656,250 m^3 (i.e., 525,000 m^3 of waste, plus 131,250 m^3 of daily/interim cover soil), and the design fill capacity for Phase 2 is 593,750 m^3 (i.e., 475,000 m^3 of waste, plus 118,750 m^3 of daily/interim cover soil).

The combined total capacity will be 1,250,000 m^3 of waste and daily/interim cover soil (i.e., 1,000,000 m^3 of waste, plus 250,000 m^3 of daily/interim cover soil). The design capacity for the ECM volume, as described above, does not include the final cover volume, base liner volume, or perimeter berm volume.

3.4.1.2 Disposal Cells

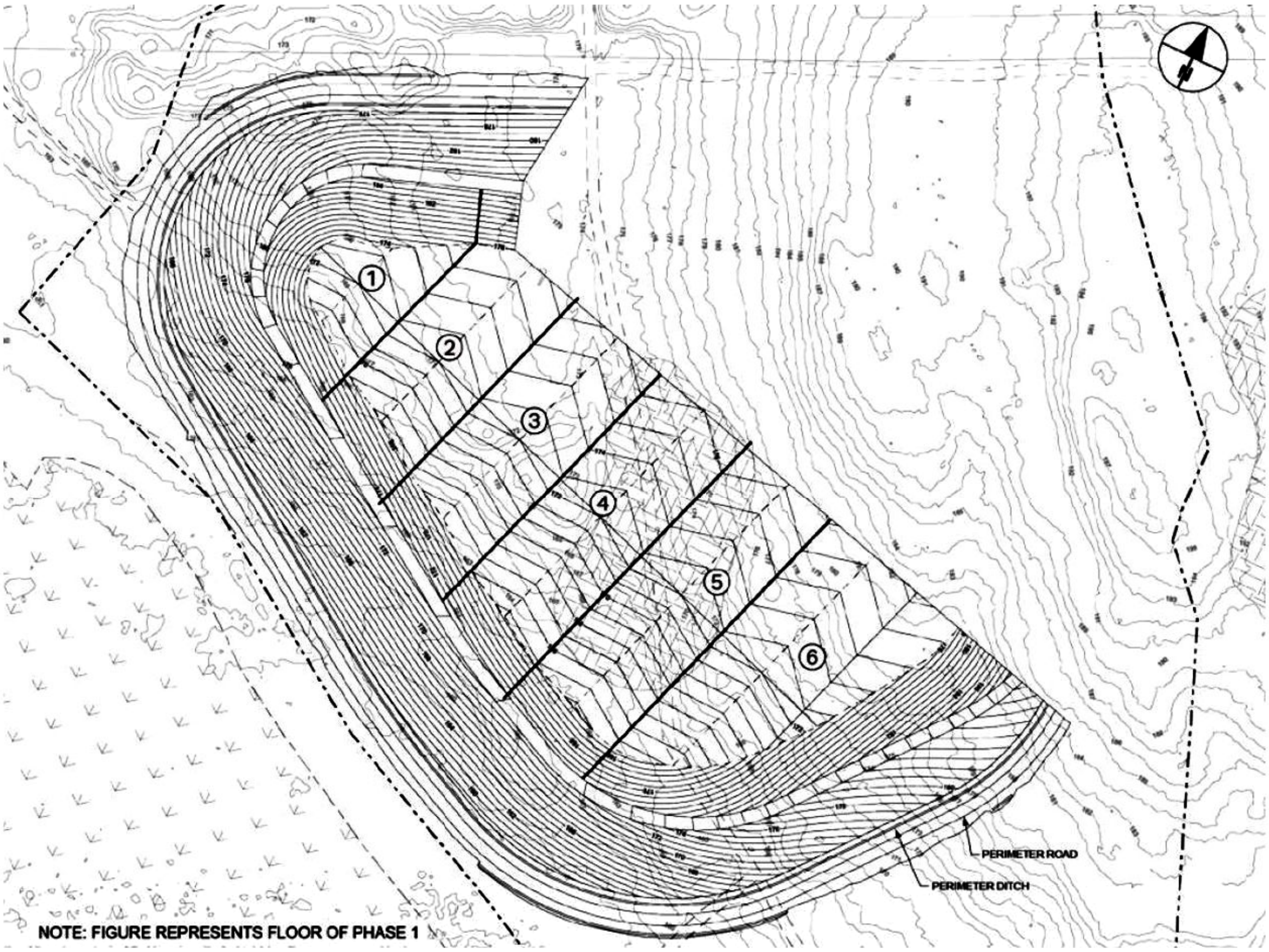
The ten contiguous cells will run parallel in rows. The maximum height of fill material, waste, and the final cover will be 18 m. The cells vary in size and have an average surface area of approximately 12,000 m^2. The cell design accounts for shielding requirements, WAC, and are located to provide operational flexibility accounting for variations in waste types and when the waste is produced.

Each cell will operate for approximately five years; however, the fill rate may vary especially during the initial operations. When a cell is nearly full, the subsequent cell will be prepared to receive waste. The filled cells will first be covered with the 0.3-m-thick first layer of the final cover and overlain by a sacrificial liner which allows precipitation falling on these surfaces to be treated as non-contact water (see Section 14 glossary for definition). When the final cover system is ready to be placed on top of the first layer of the final cover, the sacrificial liner will be removed. The final cover, containing a high-density polyethylene (HDPE) membrane, will be constructed in a sequential manner as the cells are filled (see Section 3.4.1.9.3).

3.4.1.3 Base Contours

The base contours for the ECM have been developed using a herringbone design with ridges and valleys to promote leachate transport to the leachate collection system for removal. The herringbone base contours, in conjunction with the spacing of the leachate collection pipes, will allow the drainage path for leachate to reach a collection pipe that is not more than 50 m long.

The base grade at the south end of the NSDF Project site will be a 10% slope, which transitions to a 5% slope over the remainder of the base. This configuration will be used because there is a bedrock plateau near the centre of the mound base and to maximize available volume for waste materials.



CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
PHASE 1 CELLS AND SEQUENCING PLAN

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0004	FINAL 2	3.4.1-2

REFERENCE(S)
1. FIGURE OBTAINED FROM B1550-505240-PLA-001 DELIVERABLE 14.2, REVISION 1

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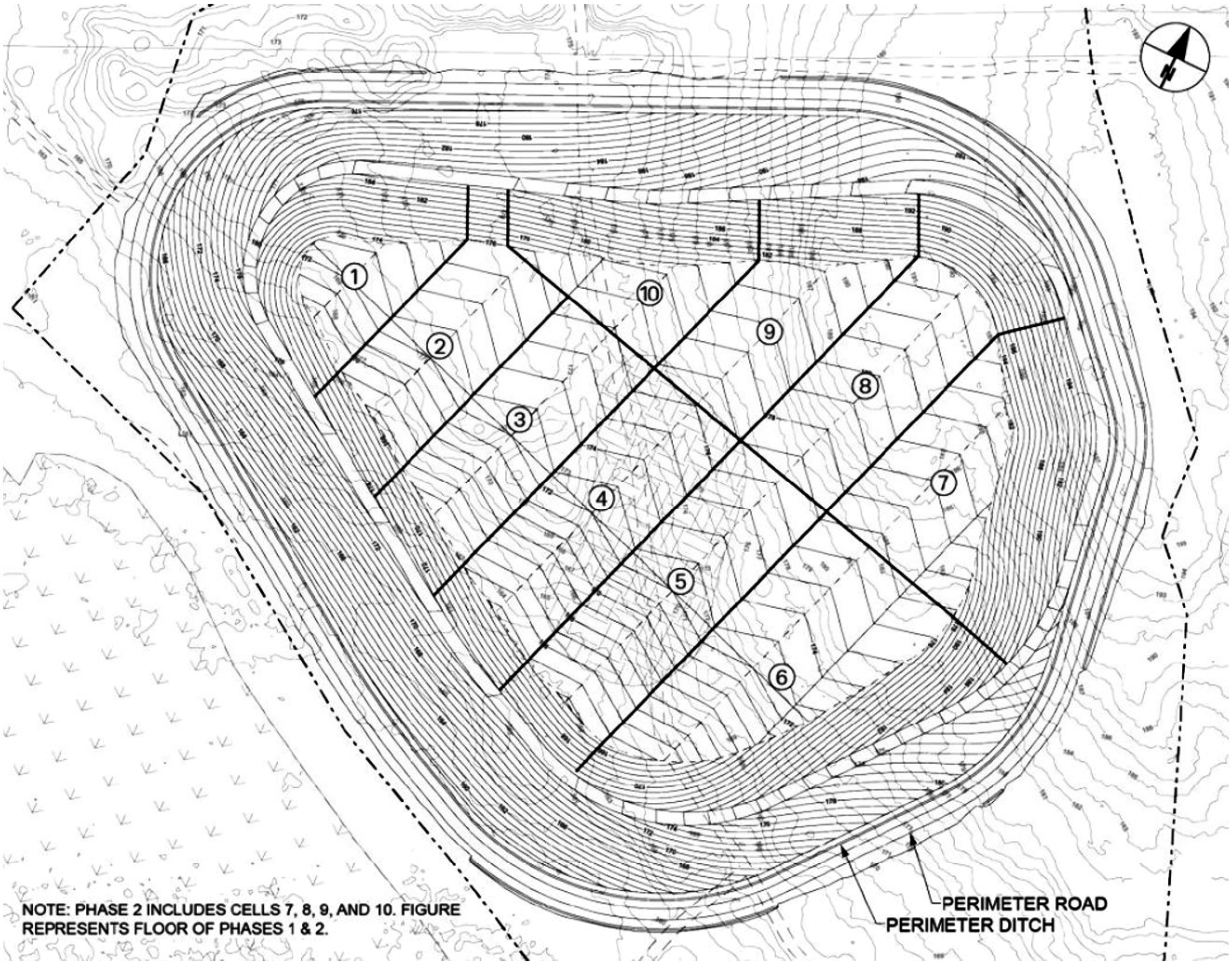


REFERENCE(S)
1. FIGURE OBTAINED FROM B1550-505240-PLA-001 DELIVERABLE 14.2, REVISION 1

CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
PHASE 2 CELLS AND SEQUENCING PLAN

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0004	FINAL 2	3.4.1-3

3.4.1.4 Base Liner System

The principle function of the base liner system is to contain leachate generated during and following operation of the ECM; thus, limiting the release of leachate to groundwater.

The base liner system includes both primary and secondary liner systems. The secondary liner system provides redundancy in case of premature degradation of the primary liner. The base liner system includes a combination of natural earthen materials and geosynthetic barrier systems to support the ECM 550-year design life. The combined thickness of the primary and secondary liners is 2.05 m. The base liner system includes the leachate collection system for transferring leachate to sumps and the leak detection system for transferring any primary liner system leakage to sumps.

The base liner system will be positioned on bedrock in the eastern region of the ECM near the bedrock ridge. The top of the ECM cannot be seen from the Ottawa River. Where the base liner is constructed on bedrock, 20 cm of granular bedding will be placed on the bedrock surface to facilitate the construction of the base liner system. Differential settlement may occur because a portion of the ECM will be founded on compacted engineered fill. Differential settlement has been assessed and is not expected to cause cracking of the compacted clay liner component of the base liner system or damage to the leachate collection system.

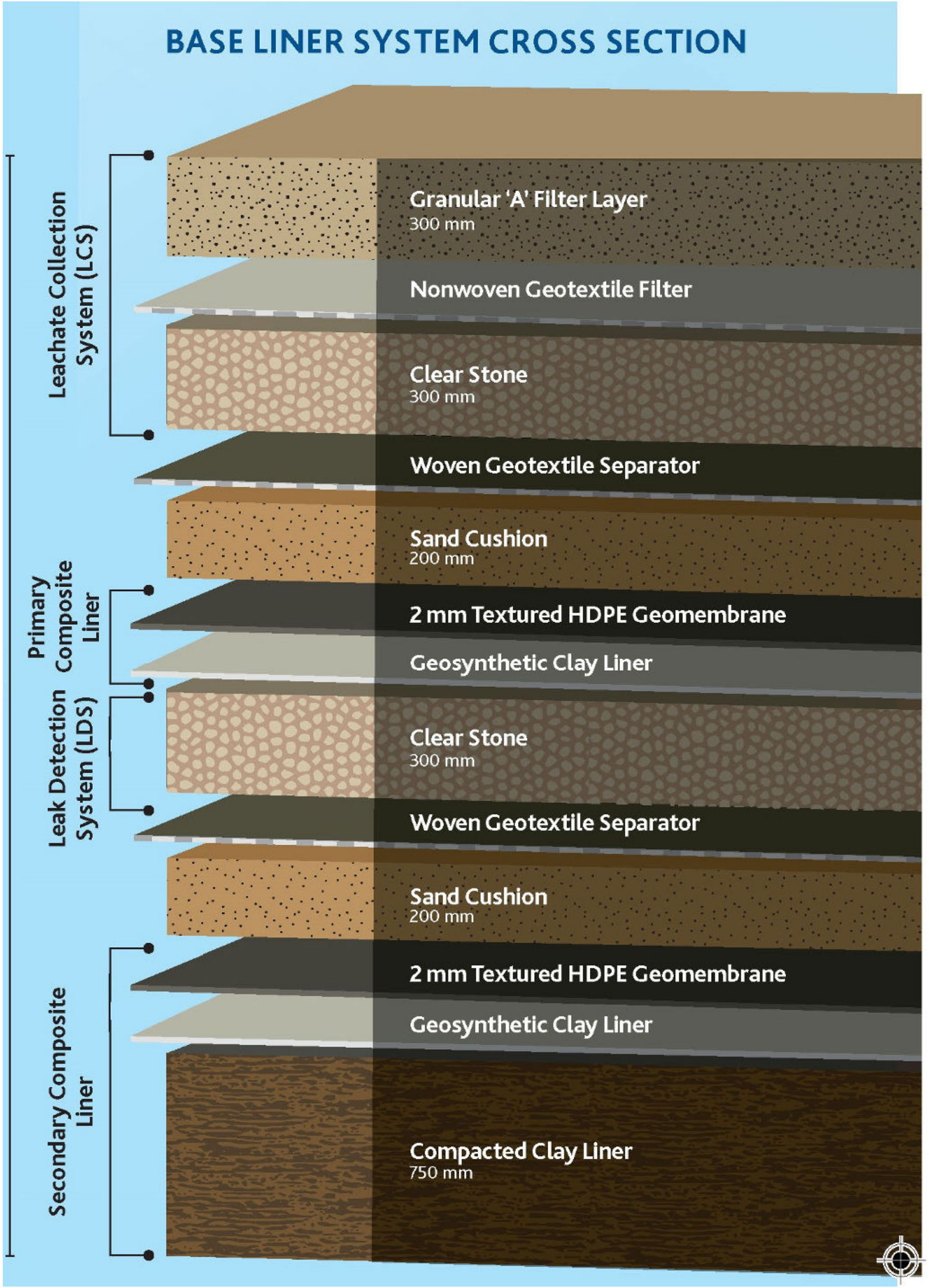
Component Layers

The schematic showing the base liner system cross-section is provided on Figure 3.4.1-4. Each of the base liner components are described in the following layers (from bottom to top).

- **Secondary Composite Liner and Leak Detection System**– The secondary liner is designed to contain leakage that may occur through the primary liner. It consists of a HDPE liner, geosynthetic clay liner and a compacted clay liner. The secondary composite liner protects the natural environment from leachate migration if the primary liner system fails. The leak detection system (LDS) component of the base liner system is a means of monitoring potential leakage of leachate through the primary liner and transferring leachate and condensate that accumulates to sumps for subsequent removal to the WWTP.
  - **Compacted Clay Liner** – The compacted clay liner provides hydraulic isolation from the geosphere. The compacted clay liner is a minimum 0.75 m thick and will be constructed on top of the finished subgrade to provide an additional layer of protection against the release of leachate to the environment.
  - **Geosynthetic Clay Liner** – geosynthetic clay liner to provide a composite barrier working with the overlying HDPE geomembrane to mitigate defects and/or damage in the HDPE geomembrane that might occur during construction or operations.
  - **Textured HDPE Geomembrane Liner** (2 mm thick [80-mil]) – Textured HDPE geomembrane liner serves as a barrier to the leachate from the granular drainage layer. The high-density polyethylene (HDPE) geomembrane included in the primary and secondary liner system is a proven material with a long design life (R. Kerry Rowe Inc. 2019). Based on the results from several studies conducted to evaluate the service life of HDPE geomembranes, the HDPE geomembranes installed in the final cover and base liner systems of the ECM are expected to perform as an effective barrier for the 550-year design life of the ECM.
  - **Sand Cushion Layer -** The sand cushion layers are included in the design to protect the underlying geomembranes and geosynthetic clay liners.

- **Woven Geotextile Separator -** Separates the clear stone layers from the sand cushions to maintain unobstructed drainage through the stone layers.
- **The Clear Stone Layer –** The clear stone secondary drainage layer will collect and drain leachate that may have leaked through the primary liner system. This layer is part of the LDS.

- **Primary Composite Liner and Leachate Collection System** – The primary liner component of the base liner system is designed to contain waste, collect leachate generated in the ECM and to prevent leakage of leachate to the underlying components of the base liner system. The primary liner will include a leachate collection system (LCS) to drain leachate to sumps. The leachate is then transferred to one of three collection tanks for treatment in the WWTP. The leachate collection and monitoring system design will provide access points for monitoring, inspections, maintenance, repairs and replacements. The top surface of the primary composite liner is designed to be at least 1.5 m above the water table.
  - **Geosynthetic Clay Liner** – See description above.
  - **Textured HDPE Geomembrane** – See description above.
  - **Sand Cushion Layer** – See description above.
  - **Woven Geotextile Separator** – See description above.
  - **Clear Stone Layer** – A clear stone granular drainage layer with a primary function of conveying leachate to one of five lined leachate collection sumps; this layer will form part of the LCS. Perforated collection pipes are also included in the LCS.
  - **Nonwoven Geotextile Filter -** Separates the clear stone layer from the granular A filter layer to maintain unobstructed drainage through the clear stone layer.
  - **Granular "A" Filter Layer** – The granular 'A' sand and gravel filter layer for limiting migration of fines from the overlying waste material into an underlying granular drainage layer.
- **Sacrificial Geomembrane and Cover Layer** – During construction, a temporary sacrificial geomembrane will be installed over the baseline system to divert stormwater to collection ponds in the ECM. A granular 'A' cover layer will be added for frost protection of the constructed base liner system. The sacrificial geomembrane and granular 'A' cover will be removed prior to waste placement.



REFERENCE(S)
1. CANADIAN NUCLEAR LABORATORIES 2019

CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
PROPOSED BASE LINER CROSS SECTION

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	PR
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0004	FINAL 2	3.4.1-4

3.4.1.5 Perimeter Berm

The primary function of the perimeter berm is to maintain the integrity of the ECM during operations and throughout the post-closure period. The perimeter berm is a robustly designed, passive safety feature of the ECM. The perimeter berm is a structural component that form the outer boundaries and sidewalls for most of the perimeter of the ECM and is an important part of the ECM containment system, preventing waste and leachate from reaching the environment.

The perimeter berm is constructed on bedrock from compacted free-draining fill (non-liquefiable soil). This construction ensures that no liquefaction will take place, and that the perimeter berm will continue to perform its containment and isolation function during and after the design basis earthquake.

The perimeter berm crest is designed to provide vehicle access to perform operations and monitoring at the ECM. The perimeter berm will provide a physical barrier to divert precipitation away from the ECM.

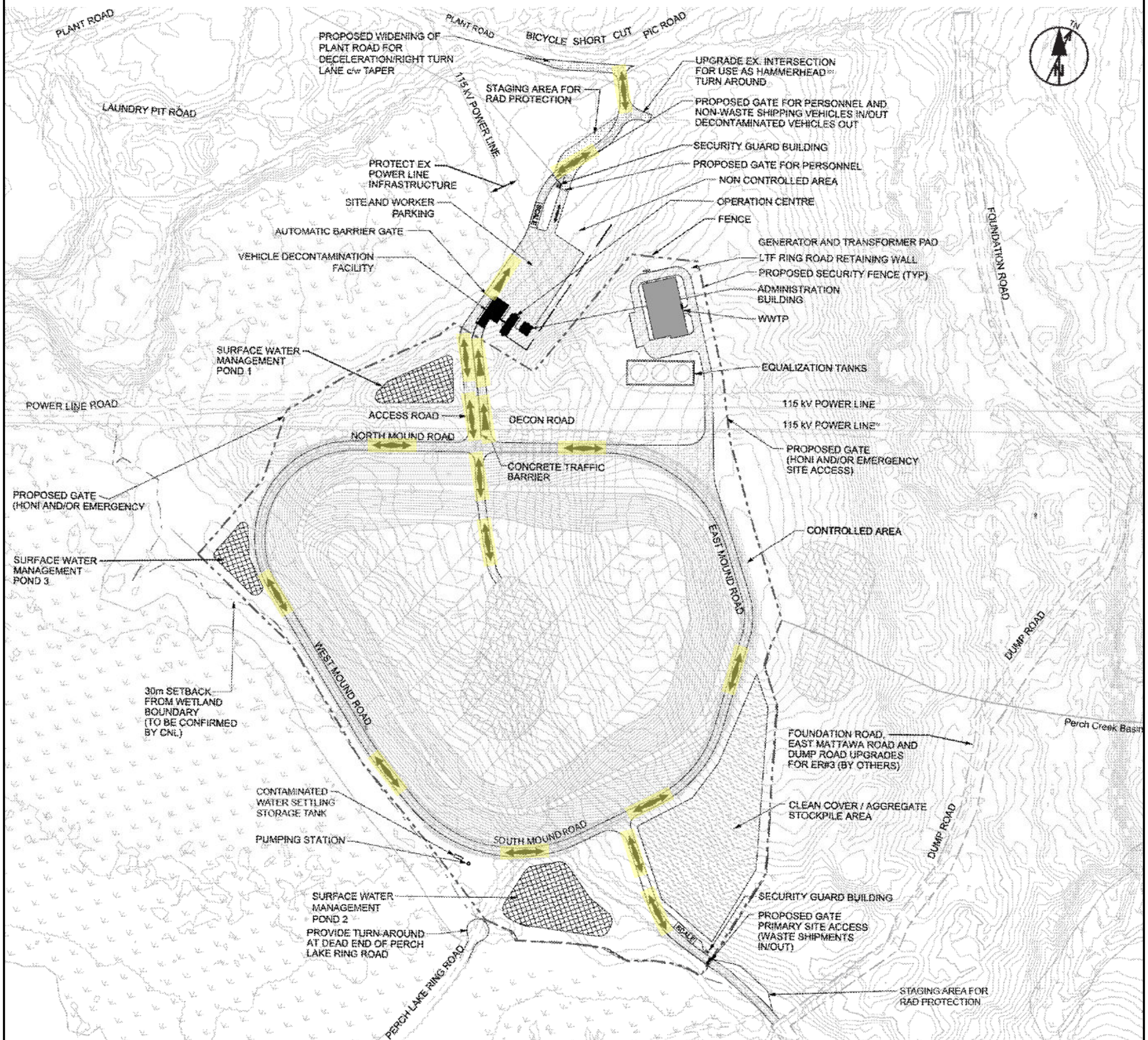
The perimeter berm side slopes will be 3 horizontal (H) to 1 vertical (V), with a 7 m width at the top. Heights of the perimeter berm will vary from 2 m to 15 m. The perimeter berm height is the height of compacted free-draining fill, and not the ECM perimeter sidewall height that contains the waste. Depending on the location around the ECM, the ECM perimeter sidewall consists of free-draining fill (compacted), bedrock, or a combination of the two. This is due to the sloping terrain and distribution of bedrock.

The perimeter berm will consist of three main geotechnical elements, each contributing to the soundness and integrity of the perimeter berm itself and the whole ECM. The inside of the perimeter berm will be covered with the various liner system layers (described in Section 3.4.1.4), while the outside will be covered with an intrusion barrier rockfill over HDPE geomembrane, geotextile cushion and geogrid. The top of the perimeter berm will be covered with a layer of granular A material, an HDPE geomembrane and geotextile cushion, with the top layer granular A becoming the top of perimeter berm road. A Slope Stability Analysis was completed and confirmed that the slope designs will satisfy minimum factor-of-safety requirements for stability.

3.4.1.6 Transfer of Waste to ECM

The Transportation Plan (Figure 3.4.1-5) for Phase 1 of the ECM involves waste transport vehicles entering the ECM from the south. The vehicles coming in will be weighed at the south kiosk and then will unload the waste into the active cell. After unloading, the vehicles will be scanned for radiation in a clean area of the ECM. Clean vehicles will exit the ECM to the south; however, contaminated vehicles will be routed to the north to the vehicle decontamination facility and exit to the north following decontamination. The vehicles will be weighed at either the north or south kiosk prior to leaving the site. This operation is anticipated to be very clean and most of the waste transport vehicles will be able to enter and exit to the south, without requiring decontamination.

After the first five cells are filled, the berm on the south side of the ECM will be constructed for finishing the 525,000 m^3 capacity ECM. Once this berm is constructed, the access to the ECM on the south will be closed. The only entrance into the ECM will then be from the north. After unloading, the vehicles will follow the same scanning and exit procedures as described above.



CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
TRANSPORTATION PLAN

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0004	FINAL 2	3.4.1-5

REFERENCE(S)
1. FIGURE OBTAINED FROM B1550-505240-PLA-001 DELIVERABLE 14.2, REVISION B

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3.4.1.7 Waste Placement

Waste will be placed in the active cell in the ECM using dedicated equipment intended to operate in contaminated areas. The dedicated waste placement equipment will include haul vehicles, cranes, bulldozers, compaction equipment, and other heavy equipment. The waste placement equipment used will depend on the types and quantities of wastes to be placed in the ECM. Methods of placement will include either: 1) the use of dedicated haul vehicles to transfer bulk waste directly into the cells, spread by bulldozers or other heavy equipment, and compacted by rollers or other compactors, or 2) the use of heavy equipment (e.g., a crane or forklift) to unload and place large debris waste components or waste packages directly into the cells.

Placement of waste will typically be from a clean ramp. Dedicated equipment, such as a bulldozer, within the cell will spread and compact the waste. This method will limit the potential to contaminate the vehicles bringing waste to the ECM.

Compaction equipment may include soil compactors, sheepsfoot rollers, or similar heavy equipment for Type 1, soil and soil-like waste, and Type 3, non-soil-like waste. A landfill compactor (similar to a Caterpillar 826) may be used for compaction of Type 2, comingled radioactive waste, if the waste is highly variable (heterogeneous) or contains large amounts of refuse or debris waste.

Water trucks will be used for moisture adjustment and dust control, as required.

A Waste Placement Mapping Plan will be developed to ensure accurate record-keeping and documentation of the cell and ECM development, as well as the placement locations of different wastes in the cells. This plan will specify a three-dimensional waste location recording system and methods for maintaining proper spacing of waste placed within the ECM. As waste is placed in the ECM, the locations/elevations will be documented, mapped and updated on a regular basis during the ECM operation.

3.4.1.7.1 Waste Placement Procedures

The waste placement procedures will be developed to maximize in-place density and to reduce void space, reducing the potential for future differential settlement of waste. Waste placement is planned on a year-round basis, subject to acceptable weather conditions. Waste placement may cease during periods of inclement weather such as high winds, major precipitation events, extreme cold periods, or inability to compact waste due to frozen conditions. A decision by CNL to curtail waste placement operations may be based on considerations for safety of workers and the public, the potential for release of contaminants, and the ability to meet engineering requirements for waste placement or compaction.

Initial Select Waste Layer

As each cell is constructed, the initial waste is placed as a 1 m-thick select waste layer that will consist of homogeneous Type 1 soil and soil-like waste. Select waste is waste that is free of large stones/boulders or other foreign materials and is relatively free draining (e.g., free of silts and clays). The purpose of the select material layer is to protect the leachate collection system and underlying composite base/sidewall liner components during subsequent waste placement. Equipment used to place the select waste layer will work from the perimeter of the cell, toward the center and only on top of previously placed waste. To prevent damage to the collection layer or other components of the composite base/sidewall liner, no equipment is permitted to operate directly on the surface of the leachate collection system layer.

Only low-ground-pressure equipment is used for construction, operations, and maintenance until the initial 1 m select waste layer is in place. Placement of debris, large bulky items, or packaged waste is not permitted within approximately 10 m of the sidewall slopes or within 1 m of the leachate collection and final cover systems.

Subsequent Waste Layers (Layer Thickness/heights)

Waste placement in each cell will proceed initially by unloading waste at the cell perimeter and grading it into position directly with bulldozers or similar heavy equipment. Waste is placed in operational layers of 3 m thickness against the berm sidewalls of the cell with the waste compacted in approximately 0.3 m layers. The initial operational layer is developed to a width of approximately 20 m from the sidewall of the cell and a minimum of 50 m in length. A second operational layer may be started on top of this. Waste placement continues in this manner until approximately five operational layers are placed, including the final 1 m select waste layer immediately under the final cover. The configuration of the ECM will allow almost parallel and symmetrical operational layers to be developed, since the design of the final cover parallels the floor in the major area of the landfill.

Actual fill sequence and placement procedures may vary based on the volume and type of incoming waste during the operations phase. As operations proceed, multiple ECM access roads and waste transfer areas are developed to support the multiple work faces of the operational layers. Waste handling or placement restrictions may be required due to the presence of contaminants in the waste material.

One of the main objectives of waste placement is to reduce empty space to limit the potential for the future differential settlement of the waste. Waste materials of high compressibility will not be placed in concentrated areas but are spread in thin layers over larger areas. Materials with no compressibility (such as demolition debris) will also be placed to avoid concentrated areas. Each layer of waste is graded to provide surface runoff from the waste within the disposal cell. Contact water and non-contact water is managed in accordance with the surface water management system (Section 3.4.4.5).

Dust Control during Waste Placement

Dust control is conducted to support waste placement operations in accordance with the *Dust Management Plan* (AECOM 2018c) during loading, transportation, placement and compaction operations. Work areas that have the potential for generating dust will require dust suppression techniques and monitoring. The primary dust control method will be water spraying or misting techniques (e.g., water trucks). Water application is controlled to avoid generation of free liquids. Water for dust suppression will be applied only to combat release of dust during operations. Care will be taken not to apply excessive water to the waste for dust suppression since water applied may become contact water that would need to be treated in the WWTP.

Fixatives (e.g., chemical suppressant) may also be used for dust control, or as daily/interim cover. The use of fixatives is reviewed prior to application for potential effects on leachate and contact water generated by the ECM.

Air quality is monitored for dust that may contain radiological and hazardous constituents to support worker and environmental protection as described in the *Environmental Protection Plan* (AECOM 2018a). Waste placement activities may be restricted or suspended if unacceptable amounts of dust are generated due to winds or other site conditions. All excavating, loading, hauling, and placement operations are suspended when wind speeds exceed the specified criterion.

Specific Waste Placement Requirements by Waste Type

The waste materials planned for disposal in the ECM have unique characteristics for unloading, placement, and compaction. Specific waste placement requirements pertaining to the six different waste types (as defined in Section 3.3.1.1) have been developed based on the individual characteristics of the waste. The handling and placement procedures are developed to ensure safe and secure placement of the waste so that it does not affect the integrity and long-term performance of the ECM.

3.4.1.8 Temporary Storage and Stockpiling Areas

During the operations phase both wastes and construction materials will need to be temporarily staged and/or stockpiled as they are placed within the ECM.

3.4.1.8.1 Temporary Storage, Waste Receiving and Processing Area

The TSWRPA is constructed within the footprint of the active cell or adjacent cell, and includes the drum and waste unloading platform (Figure 3.4.1-6). The TSWRPA facilitates the safe unloading and transfer of bulk and packaged waste for storage and or processing. The TSWRPA is constructed at grade, consisting of aggregate material provided to limit dust generation and facilitate contamination control. Dedicated vehicles will be used to transfer drummed wastes inside the ECM.

The temporary storage, waste receiving and processing area will be moved as necessary for the sequencing of the cells.

The TSWPRA will normally store wastes, and stored waste shall be placed in the ECM disposal cell within one year. The TSWRPA stores 800 m3 of waste, and is sized to promote efficient unloading between the dedicated site vehicles and waste transport vehicles, to minimize handling, and to limit the potential of dust generation.

No uncontained waste is stored in the TSWRPA. All waste is either in its transportation container or disposal container, or covered with daily cover. The only processing that is performed is staging of waste or container preparation for grouting in the ECM.

3.4.1.8.2 Clean Cover and Aggregate Stockpile Area

Clean cover/aggregate stockpile areas will be established both within and outside of the ECM to support waste placement operations. The clean cover/aggregate areas will be large enough to accommodate cell construction and waste operations including adequate space for haul vehicles and waste loading equipment to operate. They will also be large enough to store overburden removed during construction and to stage soil used for cover purposes. Erosion and sediment control measures will be applied to clean cover/aggregate areas.

Excavation of the ECM will generate approximately 560,000 m^3 of excavated soil. Approximately 365,000 m^3 of this amount will require interim or permanent storage during construction. The soil will be stored at a location on the CRL site managed by CRL Waste Operations.

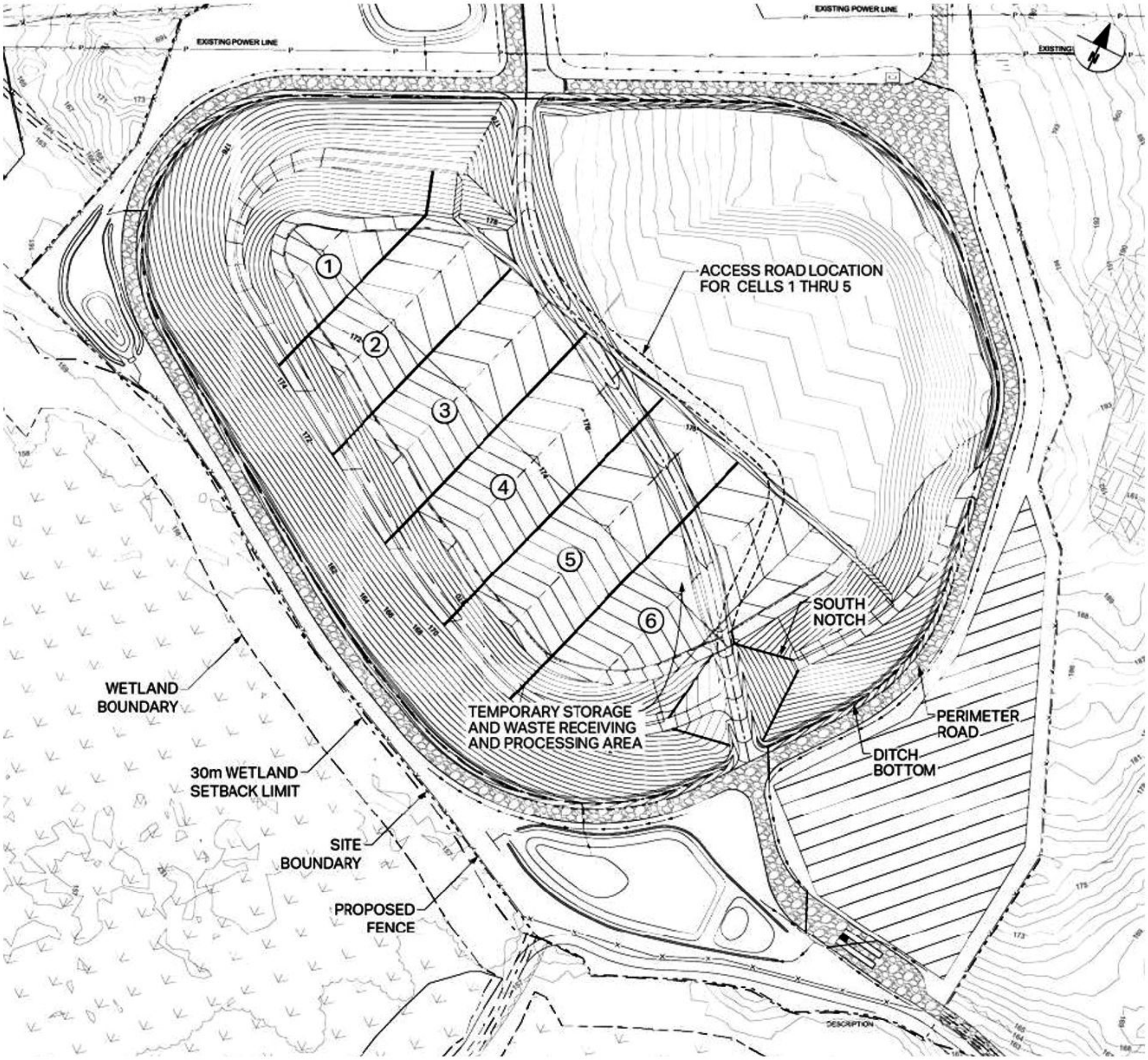
3.4.1.9 Disposal Cell Cover

Cover materials are used to reduce personnel radiation exposure or contact with contaminated materials, to control the release of fugitive dust from the surface of the waste, to promote non-contact surface water run-off, and minimize precipitation infiltration into the waste material. These cover materials include daily cover, interim cover and the final cover system. The time spent on the working face is limited and the working distance from the waste is maximized to the extent practical to maintain worker exposures As Low As Reasonably Achievable (ALARA). These approaches to reduce worker exposure are discussed in greater detail in Section 3.5.2.1.

3.4.1.9.1 Daily Cover

Daily cover is applied at the end of each work day over the active disposal area or the placed waste working face, to control the release of fugitive dust from the surface of the waste. Daily cover also fulfills a number of other functions such as reducing erosion of placed waste, reducing blowing litter, reducing odour, discouraging insect and vermin activity, improving equipment access to the active disposal area, and maintaining a more aesthetically pleasing site appearance.

The daily cover consists of 0.150 m layer of clean soil or an alternative daily cover material that is pre-approved for use including tarpaulin, fixative (crusting agent), or similar temporary cover system material. The daily cover, 0.150 m layer of soil, provides fire protection for the placed waste, from wind-blown sparks or embers released from a fire. If a tarpaulin or fixative is used as an alternate daily cover material, the tarpaulin or fixative must be fire rated, and classified as "fire proof”. Prior to using any fixative as an alternative daily cover material, the fixative must be verified to not adversely affect the WWTP treatment processes.



REFERENCE(S)
1. FIGURE OBTAINED FROM B1550-505240-PLA-001 DELIVERABLE 14.2, REVISION 1

CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
PHASE 1 PLAN WITH TEMPORARY STORAGE AND WASTE RECEIVING AND PROCESSING AREA

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0004	FINAL 2	3.4.1-6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
25mm

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3.4.1.9.2 Interim Cover

The interim cover consists of 0.3 m layer of clean soil or clean sand that is overlain by a sacrificial liner to promote non-contact surface water run-off, and minimize precipitation infiltration into the waste material. The interim cover is applied to:

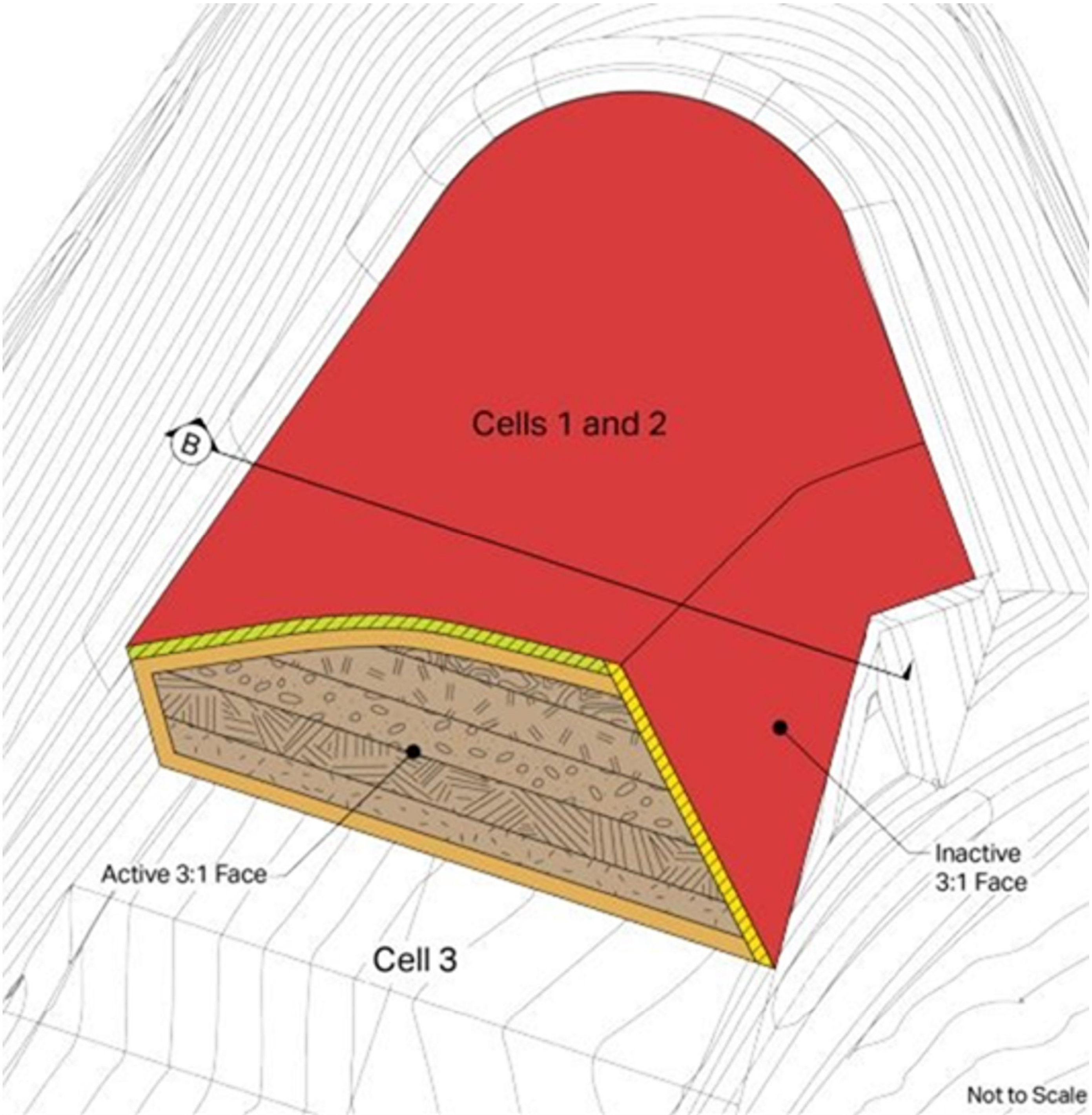
- Waste disposal areas that will remain inactive for more than 30 days and are not considered part of the active disposal area, but are scheduled to receive waste in the future.
- Waste disposal areas that have reached the design waste fill grade, and are not scheduled to receive additional waste and are awaiting installation of the final cover system.

The sacrificial liner is a 1.0 mm (40 mil) thick, double-sided, textured, white-surfaced (top side only) linear low-density polyethylene (LLDPE) geomembrane that is adequately anchored to prevent uplift by wind. In addition, the sacrificial liner is to be durable, have a suitable coefficient of expansion and be resistant to ultraviolet radiation damage.

Figure 3.4.1-7 shows the interim covers on waste disposal areas (inactive 3:1 face) that will remain inactive for more than 30 days and waste disposal areas (cell 1 and cell 2) that have reached the design waste fill grade.

The interim cover consisting of 0.3 m layer of clean soil overlain by a sacrificial liner is applied to waste disposal areas that will remain inactive for more than 30 days. The interim cover, including the clean soil layer and sacrificial liner, are removed prior to the resumption of waste placement, to the extent practical, to promote hydraulic connection between waste lifts.

The interim cover consisting of 0.3 m layer of clean sand overlain by a sacrificial liner is applied to waste disposal areas that have reached the design waste fill grade, and are awaiting installation of the final cover system. The interim cover is installed on the 1 m layer of select waste. The primary function of the sacrificial liner is to protect the 0.3 m layer of clean sand, first layer of the final cover system, against erosion, promote non-contact surface water run-off, and limit precipitation infiltration into the sand layer and underlying wastes prior to the installation of the remaining layers of the final cover system. The sacrificial liner is removed during the installation of the final cover system. The 0.3 m clean sand layer of the interim cover is not removed for the installation of the final cover system, and is regraded to eliminate low areas.



Legend:
- 0.3 m sand layer of the Interim Cover
- 0.3 m soil layer of the Interim Cover
- 1 m Select Waste layer
- Waste layers
- Sacrifical Liner of the Interim Cover

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CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
INTERIM COVERS

CONSULTANT
GOLDER

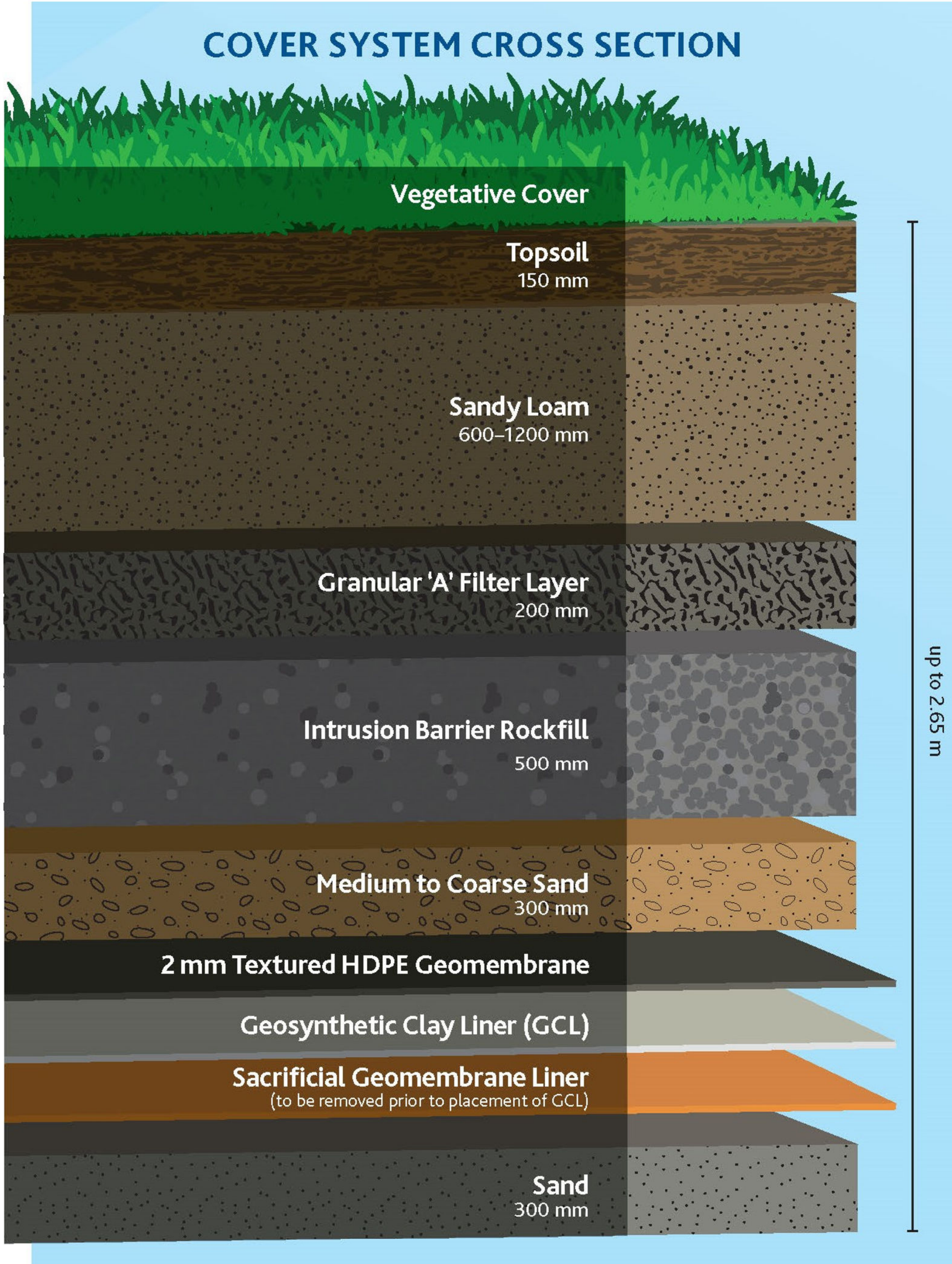
DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

REFERENCE(S)

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0004	FINAL 2	3.4.1-7

3.4.1.9.3 Final Cover

A final cover system has been designed for the entire surface of the completed containment mound to limit leachate generation. The final cover system will consist of an engineered multi-layer system with a minimum thickness of 2.05 m. A schematic of the cross-section of the final cover system is shown on Figure 3.4.1-8 and the cell sequencing plan is shown on Figure 3.4.1-2 and Figure 3.4.1-3. The final cover is designed to limit water infiltration, to direct infiltration and surface water away from the ECM waste placement area, and to resist degradation by surface geologic processes and biotic activity (e.g., prevent burrowing of animals) and inadvertent intruder attempts to access or excavate the waste cell. A series of drainage control features will be installed in conjunction with placement of final cover over the ECM.



CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
PROPOSED CROSSED-SECTION OF THE FINAL COVER SYSTEM

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	PR
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0004	FINAL 2	**3.4.1-8**

REFERENCE(S)
1. CANADIAN NUCLEAR LABORATORIES 2019

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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Component Layers

The final cover system incorporates the following layers (from bottom to top).

- **Sand** – A sand cover layer will be installed directly above the waste material to provide for a smooth, firm base surface for installation of the infiltration barrier component layers. This layer protects the infiltration barrier from damage by waste materials, such as exposed stones and demolition waste and provides a layer to promote lateral venting of landfill gas.
- **Sacrificial geomembrane liner** – In areas of the cell where top-of-waste final contours have been achieved, a sacrificial liner will be placed overtop the first layer of final cover until a sufficient area has been reached to warrant commencement of construction of the rest of the final cover system in this area. When the rest of the final cover system is ready to be placed on top of the first layer of the final cover, the sacrificial liner will be removed (prior to placement of the geosynthetic clay liner).
- **Infiltration barrier** – Two HDPE geomembrane components will be installed:
  - **Geosynthetic clay liner** – The first is a composite HDPE geomembrane/geosynthetic clay liner to provide an additional means of restricting infiltration, which is less susceptible to significant damage from freeze-thaw or potential long-term differential settlement.
  - **2 mm textured HDPE geomembrane** – The second is a textured, HDPE geomembrane liner to serve as the upper (primary) barrier against infiltration through the cover into the buried wastes.
- **Medium to coarse sand** – A cushion/drainage layer, consisting of medium to course sand will be installed above the HDPE geomembrane to provide, in conjunction with the underlying HDPE geomembrane. It provides lateral drainage of water that percolates through the upper layers of the final cover.
- **Intrusion barrier rockfill** – An intrusion barrier rockfill layer to deter burrowing animals and roots from deeper-rooted plant species reaching and possibly damaging the final cover lining system. It will also inhibit the roots from penetrating into and transporting contaminants from the waste fill. This rockfill layer would also help deter inadvertent future intrusion into the buried wastes by humans.
- **Granular ‘A’ filter layer** – The principal function of the Granular A (i.e., high-stability graded sand and gravel) filter layer above the intrusion barrier layer is to provide a natural filter layer to limit the possibility of fines migrating downward; reducing the potential for future clogging of the barrier layer. It also allows for some degree of lateral flow diversion within the cover system.
- **Vegetative cover / erosion protection** – Includes three main components:
  - A **sandy loam layer** to provide moisture retention for plant uptake and evapotranspiration. This layer also provides additional gamma radiation shielding, additional confining stress for the final cover lining system, and an insulating layer to help limit freeze-thaw effects.
  - A **topsoil layer** consisting of loam, sandy loam and/or sandy clay loam, augmented with nutrients to promote growth of a healthy stand of hardy grasses.
  - A **vegetative cover** to provide an aesthetically pleasing surface, enhance evapotranspiration and reduce the potential for erosion. The vegetation will be limited to grass species that are maintenance free and drought resistant. Maintenance activities during the institutional control period will include removal of trees and other deep rooted type vegetation, as well as conducting physical inspections for animal burrows over the ECM surface.

Sequencing

Any cell that has reached top-of-waste final contours and has received the initial layer of the final cover system, including a sacrificial liner, is considered non-radiological. Any precipitation falling on the top of this inactive area is then considered non-contact water and is routed to the appropriate surface water management pond for release to the ground and surface water.

When waste placement in cell 2 reaches the northwestern boundary of cell 1, the sacrificial liner will be removed. The first layer of the final cover will be re-graded to eliminate low areas and the remaining layers of the final cover will be placed on cell 1. This final cover sequencing scenario will continue through all six cells in Phase 1. Final cover placement and sequencing for Phase 2 cells will continue the same scenario as Phase 1, with final cover being placed on each cell as the waste is brought up to bottom of the final cover elevation with the placement of the 1 m select waste layer, to the cell boundary.

3.4.1.9.4 Landfill Gas Venting System

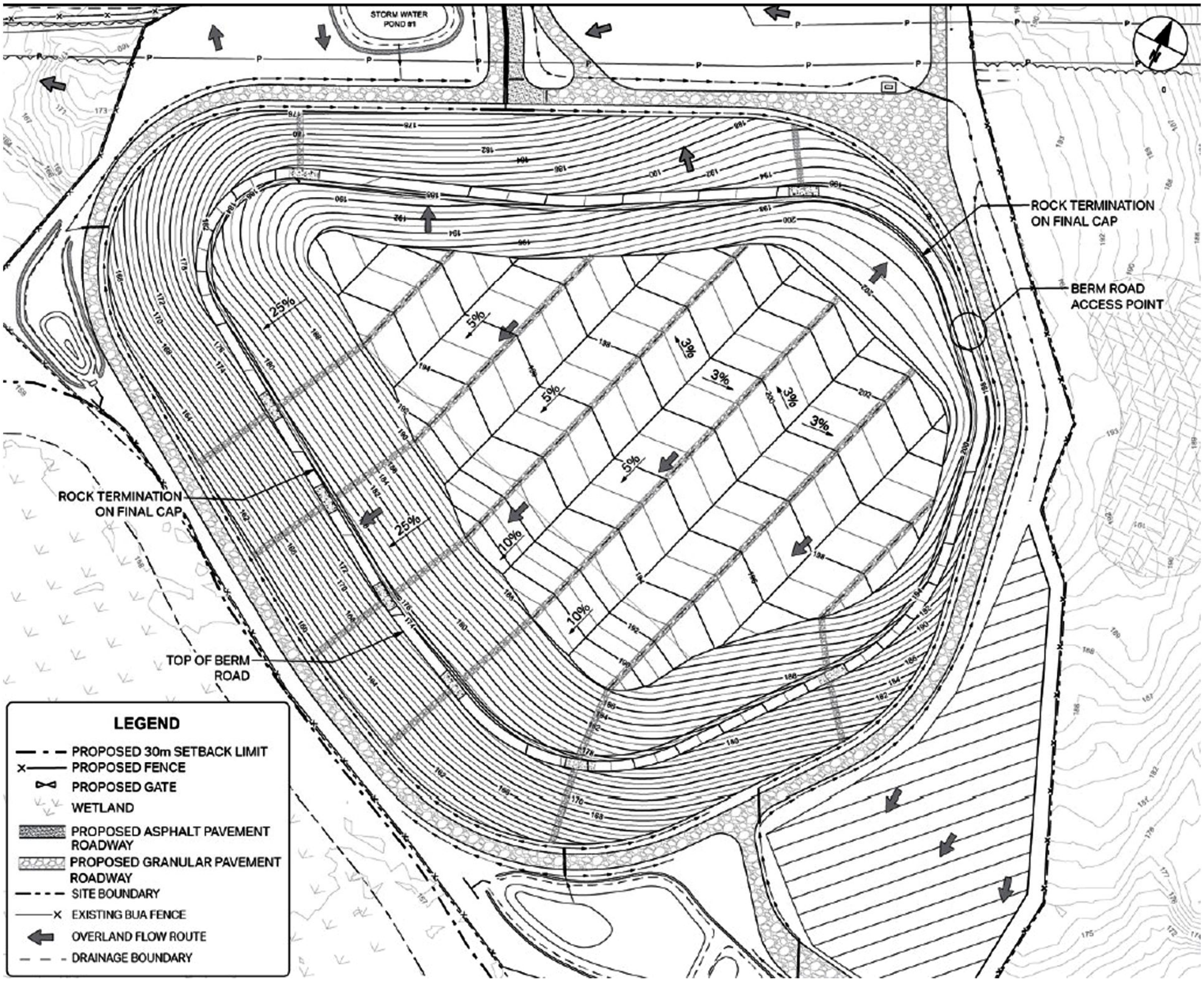
A passive landfill gas (LFG) venting system will also be installed in conjunction with the final cover construction as part of the final closure activities. The LFG venting system is designed to prevent excessive gas pressure under the low-permeability barrier components of the final cover, as excessive gas pressure could result in damage or disruption of the final cover system. LFG monitoring probes will be installed around the perimeter of the ECM and will be monitored periodically during the ECM post-closure phase to detect evidence of potential LFG migration away from the ECM.

3.4.1.10 Final Grading and Drainage Plan

The ECM Final Grading and Drainage Plan also includes collection ditches along the top of the ECM berm road to collect side slope drainage. The runoff from the collection ditches will be routed to the perimeter. Figure 3.4.1-9 provides the Final Grading and Drainage Plan for the ECM final cover system.

The final cover system will be sloped between 5% and 25%. The top slope also has a herringbone pattern similar to the base. This promotes surface water runoff, reduces infiltration into the ECM and minimizes erosion and sediment transport.

The perimeter road ditch will route the runoff it receives to one of three surface water ponds located outside the ECM perimeter road. These runoff controls are designed to minimize ponding of water into the closed ECM, erosion of the cover and underlying waste materials, destabilization of the ECM structure, and damage to access roads. The ECM surface water runoff controls will be maintained until the end of the institutional control period. Additional details on the surface water management plan for the NSDF Project site is provided in Section 3.4.4.5.



CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
FINAL GRADING AND DRAINAGE PLAN

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0004	FINAL 2	3.4.1-9

REFERENCE(S)
1. FIGURE OBTAINED FROM 232-508220-PLA-003 DELIVERABLE 14.5, REVISION 0

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3.4.1.11 Construction Materials

It is estimated that approximately 600,000 m^3 of various soil and granular materials (e.g., clay, sand, gravel and stone), plus an estimated 1,500,000 m^2 of geosynthetic products such as geomembranes (e.g., impervious synthetic sheets typically used for linings and covers), geotextiles (e.g., synthetic non-biodegradable fabrics), and geosynthetic clay liners (e.g., fabricated barriers consisting of bentonite clay or similar material supported by geotextiles or geomembranes) will be transported to the NSDF Project site. These will be used for construction of the ECM base liner (Table 3.4.1-1).

Table 3.4.1-1: Estimated Material Requirements for the Engineered Containment Mound Base Liner

Engineered Containment Mound	Clay (m^3)	Drainage Media (m^3)	Geomembrane (m^2)	Geotextile (m^2)
Phase 1	71,000	82,000	182,000	225,000
Phase 2	38,000	54,000	125,000	135,000
Total	109,000	136,000	307,000	360,000

A final cover system has been designed for the entire surface of the completed ECM. The estimated material requirements for the final cover are provided in Table 3.4.1-2. Final cover construction will result in similar delivery requirements as needed during the construction period.

Table 3.4.1-2: Estimated Material Requirements for the Engineered Containment Mound Final Cover – Phase 1

	Topsoil (m^3)	General Fill Soil (m^3)	Geotextile (m^2)	Coarse Stone (m^3)	Sand (m^3)	Geomembrane (m^2)	Geosynthetic Clay Liner (m^2)
Total	16,400	110,000	110,000	22,000	22,000	110,000	110,000

While other aspects of the ECM construction will involve additional materials, their quantities are generally not substantial relative to those associated with the base liner and final cover. An exception will be the requirement for the granular and earth fill materials for the perimeter berm and access road construction, which will total approximately 500,000 m^3 (approximately half this volume for Phase 1, and half for Phase 2).

The transportation route of NSDF Project site preparation and construction equipment and materials will be by public roads to the CRL site (e.g., Highway 17) and will pass through the Village of Chalk River. Based on estimates of truck deliveries to the NSDF Project site during the 24-month construction period, approximately 200 shipments per day are anticipated during the nine-month construction season (i.e., approximately 15 trucks per hour for the daytime period, totalling 200 trucks per day during construction). The additional construction personnel requirements are expected to result in an additional 300 inbound and outbound trips to the site daily. Transportation of equipment and construction materials will be scheduled during normal business and daylight hours to the greatest extent possible to limit inconvenience to local residents. Construction materials (e.g., processed granular materials and gravel, geosynthetic products and clay) will be transported to the NSDF Project site using standard highway haul vehicles. Within the CRL site, transport of site preparation and construction equipment, and construction materials to the NSDF Project site will be by Plant Road, which leads to the main site access road.

It is estimated that the entire amount of soil that will be excavated is 560,000 m^3. The sum of clean fill requiring interim or permanent storage during NSDF construction is 365,000 m^3, while the sum of topsoil is estimated at 47,000 m^3. In addition to the final cover system, the active cells will be temporarily covered on a daily basis and areas scheduled to receive additional waste at some future time will receive interim cover. This volume of excavated soil will be sufficient to meet the soil volume requirements for the daily/interim cover and for placement of the final cover. The expected volumes of soil to be redeployed is 130,000 m^3 of clean fill and 18,000 m^3 of topsoil. The transport of this excavated soil to the soil storage area on the CRL site and back to the NSDF Project site is expected to result in approximately 55,000 trips of close to 10 km (i.e., 5 km to the soil storage area and back). The impact of this interim management of soil spoils on the atmospheric environment is further clarified in Section 5.2.

3.4.1.12 Leachate Collection and Removal

The LCS immediately overlying the top (primary) liner component of the base lining system collects and removes leachate from the ECM throughout the operations phase and following final closure of the ECM. The LDS immediately overlies the bottom (secondary) composite liner. The LDS allows for the timely detection, collection, and removal of leachate that leaks through the primary liner system and/or condensate that might accumulate in the LDS during the operations phase or during the post-closure phase following final closure of the ECM.

Leachate will be removed from the LCS and LDS sumps and along with the contact water will be transferred to the collection tanks, from which it will be periodically transferred to the WWTP for treatment (see Section 3.4.2).

3.4.1.12.1 Leakage Rates and Leachate Flows

During the operations phase of the ECM, the maximum leachate generation rates are expected to occur. During this period, the ECM is open and is actively receiving waste. It was also assumed that contact water is generated from the temporary waste storage pad within the active cell.

It is expected that of the generation of leachate in the ECM will eventually trend toward zero over time. Residual moisture present within the buried waste material will drain to the LCS and LDS sumps and be removed. Before the WWTP is shut down, the long-term treatment needs for any leachate derived from the ECM will be evaluated. Low-flow mobile leachate removal equipment is expected to be adequate to remove leachate from the LCS and LDS sumps once the WWTP is shut down.

3.4.1.12.2 Leachate Monitoring

During the operations phase, flow rates of leachate removed from the LCS and LDS sumps will be measured, totalized and recorded. The integrity of the ECM primary liner system will be monitored by reviewing the rate of leachate collection in the LDS sumps and comparing it to baseline measurements of leachate collection in the LDS sumps.

3.4.1.12.3 Leachate Sampling and Analysis

An ECM leachate Sampling and Analysis Plan will be developed to collect baseline information to determine the profile for liquid that will be transferred to the WWTP for treatment. Sampling will allow for changes in leachate quality through time to be identified. The latter information will be used to inform and update the groundwater monitoring program for the ECM.

3.4.2 Wastewater Treatment

This section describes the facilities to be constructed and processes implemented to treat wastewater associated with the operation of the ECM. The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses best available technology that is economically achievable, and capable of meeting regulatory requirements. The WWTP for the NSDF Project will be a new, stand-alone facility with a new discharge. The design life for the WWTP is approximately 50 years. If the WWTP is required beyond its design life, the unit would be refurbished to enable continued treatment of leachate or other treatment options would be investigated.

3.4.2.1 Wastewater Quantity

Wastewater requiring treatment comes from three general sources at the NSDF Project: 1) leachate, 2) contact water and 3) wastewater from on-going operations at the WWTP, vehicle decontamination facility (see Section 3.4.3.4) and operations support centre facilities (see Section 3.4.3.3).

Leachate quantities were estimated based on a water balance calculation completed with the Hydrologic Evaluation of Landfill Performance model. The model estimates the amount of water infiltrating the ECM using information on soil characteristics, precipitation, temperature and humidity, site area, slopes and slope lengths. The Hydrologic Evaluation of Landfill Performance model was used to model the active open cell period, when the infiltration is greatest. Following active operations, each cell will be covered and infiltration will be reduced. Results from the one cell that was modelled are applied to each additional cell in succession to model the wastewater generation rate throughout the 50-year lifetime of the ECM.

Contact water is managed separately from non-contact water (discussed in Section 3.4.4.5) in the ECM during operations to minimize the quantity of water that needs to be treated in the WWTP. Contact water is collected in temporary contact water ponds or equivalent structures on a lined portion of the cell floor. The contact water pond has sufficient capacity to contain the volume of contact water generated during back-to-back 100-year, 24-hour storm events. The contact water ponds are moved within the ECM as necessary to support operations.

The average cell area is 12,000 m^2; however, for the purposes of the modelling, an upper bound capacity of 15,000 m^2 was used to provide a conservative amount of leachate and contact water that could be generated from any cell. Within the ECM there is a 6,000 m^2 temporary waste storage pad for staging waste. The storage pad is a gravel area that may be used to stage both bulk and packaged waste awaiting disposal. Precipitation that falls on the temporary storage pad will be treated as contact water and routed to the WWTP. Water that infiltrates through the storage pad will eventually flow into the leachate collection system, where it mixes with leachate from the active and closed waste cells. In addition, a combined total of 100 m^3/yr is included in the wastewater volume to account for vehicle and personnel decontamination facilities.

During the first year of operation, the ECM will have one active disposal cell and the temporary storage pad producing leachate and contact water. The average annual volume of wastewater expected to require treatment is about 11,000 m^3. Once Cell 1 has been closed, Cell 2 will be operational and will begin generating both leachate and contact water. This process will continue until all 10 cells have been developed and finally closed. The maximum average annual wastewater volume (11,230 m^3) will be produced during the years 45 to 50, when Cells 1 through 9 are filled and closed with final cover, and Cell 10 is active (Table 3.4.2-1). At the end of the 50-year operational life (and into the post-closure phase), the total leachate expected to be generated from the ECM is 45 m^3/yr.

Table 3.4.2-1: Average Annual Wastewater Volumes Generated Over the Life of the Engineered Containment Mound

Cell	Time (year)										
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50+
Cell 1 (m^3/yr)	Active 10,995	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 4.5
Cell 2 (m^3/yr)	n/a	Active 10,995	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 4.5
Cell 3 (m^3/yr)	n/a	n/a	Active 10,995	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 4.5
Cell 4 (m^3/yr)	n/a	n/a	n/a	Active 10,995	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 4.5
Cell 5 (m^3/yr)	n/a	n/a	n/a	n/a	Active 10,995	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 4.5
Cell 6 (m^3/yr)	n/a	n/a	n/a	n/a	n/a	Active 10,995	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 4.5
Cell 7 (m^3/yr)	n/a	n/a	n/a	n/a	n/a	n/a	Active 10,995	Final Cover 15	Final Cover 15	Final Cover 15	Final Cover 4.5
Cell 8 (m^3/yr)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Active 10,995	Final Cover 15	Final Cover 15	Final Cover 4.5
Cell 9 (m^3/yr)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Active 10,995	Final Cover 15	Final Cover 4.5
Cell 10 (m^3/yr)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Active 10,995	Final Cover 4.5
Decontamination Water (m^3/yr)	100	100	100	100	100	100	100	100	100	100	0
Total (m^3/yr)	**11,095**	**11,110**	**11,125**	**11,140**	**11,155**	**11,170**	**11,185**	**11,200**	**11,215**	**11,230**	**45**

n/a = not applicable.

Another important design consideration for the WWTP is the maximum wastewater flow rate to be received and processed by the WWTP. Leachate and decontamination wastewater are produced at relatively low rates compared to contact water, especially during major precipitation events. The projected average leachate flow from a single closed cell with final cover is 0.0017 m^3/hr. The projected average annual flow rate of decontamination wastewater is approximately 0.01 m^3/hr. The maximum flow rate was determined by evaluating the expected contact water volume that would be produced during back-to-back 100-year, 24-hour storm events. It is estimated that back-to-back 100-year, 24-hour storm events would produce a contact water volume of 4,710 m^3 at a maximum rate of 75 m^3/hr.

3.4.2.2 Wastewater Quality

Wastewater quality was predicted taking into consideration the WWTP flow rates, waste inventory and the design and behaviour of the ECM. The wastewater quality is managed by controlling what wastes are placed in the ECM. The WAC were developed to ensure only waste with acceptable physical, radiological, and chemical characteristics will be placed in the ECM (see Section 3.3.3).

The radiological and non-radiological constituents of potential concern (COPC) concentrations in leachate were calculated using a partitioning model that assumes that the ratio of the contaminant concentration in the waste to the contaminant concentration in the leachate is constant. Partitioning models are commonly used in radiological assessments to determine leaching characteristics of radionuclides and metals in soil and soil-like wastes. The partitioning factors were taken from the CSA Standard *N288.1-14 Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities* (CSA Group 2014). These factors conservatively estimate the leachate characteristics with the intention to avoid underestimating release rates and leachate concentrations.

Packaged wastes are assumed to initially contribute little to the leachate characteristics (i.e., packaged wastes are any wastes that are permanently disposed in containers such as drums or metal boxes). Some waste packages (5%) are assumed to fail immediately following placement in the ECM; these waste packages will no longer effectively isolate their contents from infiltrating water and will contribute to leachate quality. As time progresses, waste containers are assumed to fail at a rate of 1% per year due to corrosion. As more waste packages fail, more waste is available to contact infiltrating water and influence the leachate characteristics. The 1% annual degradation rate is based on measured corrosion rates of metal buried in moist soil.

The contact water is assumed to have very low COPC concentrations compared to the leachate because of the effects of daily waste cover and water management practices within the disposal cell. Precipitation that falls in the active cell will be routed away from waste in active disposal areas to the extent practicable to reduce contamination of the contact water. Decontamination wastewater from NSDF support facilities is assumed to have the same radiological and chemical characteristics as the wastewater from the ECM.

In the absence of quantitative information for some non-radiological COPCs, an alternative approach was taken using initial estimates of leachate concentrations based on the estimated upper limit of leachate characteristics predicted from groundwater modelling data at the CRL site and from information gathered from other sites. These values present a reasonable and conservative estimate of concentrations in wastewater, which provide a design basis for the WWTP.

The effluent concentrations were compared to effluent discharge targets based on protection of the environment and human health and are described in Section 3.4.2.5.1 (CNL 2019b). The effluent discharge targets were used to identify those constituents that may require treatment at the WWTP. Table 3.4.2-2 and Table 3.4.2-3 summarize the projected concentrations in wastewater for radionuclides and non-radiological COPCs, respectively. A comparison of projected wastewater concentrations and effluent release criteria shows that two radionuclides, strontium-90 and cobalt-60, are predicted to be present in wastewater at levels that exceed the respective effluent discharge targets. These two radionuclides will require treatment prior to discharge to meet the proposed effluent discharge targets (Table 3.4.2-2). Several non-radionuclide COPCs in the untreated effluent exceed or approach effluent release criteria, including aluminum, boron, cobalt, iron, manganese, anthracene, chloroform, chrysene, ethylene dibromide, and fluoranthene (Table 3.4.2-3). The majority of these constituents will require treatment prior to discharge to meet the proposed effluent discharge targets.

The maximum predicted concentrations in wastewater are derived from the contaminant inventory and are designed to be conservative. For a number of constituents such as nitrite, nitrate and sulphate, maximum predicted concentrations in untreated wastewater marginally exceed effluent discharge targets. Further, carbonaceous 5-day biochemical oxygen demand may require treatment to meet the proposed effluent discharge target. If sampling of wastewater during operations demonstrates that the concentrations of contaminants are approaching levels that need to be treated, the operation of the WWTP can be adjusted so that effluent discharge targets are met (for example by including the appropriate resin in the ion exchange columns).

Table 3.4.2-2: Radionuclide Concentrations in Wastewater and Effluent Discharge Target

Radionuclide	Maximum Predicted Concentration in Wastewater (Bq/L) Prior to Treatment	Effluent Discharge Target (Bq/L)	Treatment Required?
Ag-108m (metastable isotope silver-108)	0.00018	60	No
Am-241 (isotope Americium-241)	0.0028	0.7	No
Am-243 (isotope Americium-243)	0.0000017	0.7	No
C-14 (isotope carbon-14)	3.1	200	No
Cl-36 (isotope chlorine-36)	0.059	100	No
Co-60 (isotope cobalt-60)	1,300	40	Yes
Cs-135 (isotope cesium-135)	0.000041	70	No
Cs-137 (isotope cesium-137)	0.93	10	No
H-3 (isotope hydrogen-3 [Tritium])	140,000	360,000	No
I-129 (isotope Iodine-129)	0.091	1	No
Mo-93 (isotope molybdenum-93)	0.00000041	40	No
Nb-94 (isotope Niobium-94)	0.015	80	No
Ni-59 (isotope nickel-59)	0.00017	2,000	No
Ni-63 (isotope nickel-63)	0.044	900	No
Np-237 (isotope neptunium-237)	0.00000063	1	No
Pu-239 (isotope plutonium-239)	0.0044	0.6	No
Pu-241 (isotope plutonium-241)	0.079	30	No
Pu-242 (isotope plutonium-242)	0.000033	0.6	No
Ra-226 (isotope radium-226)	0.00064	0.5	No
Se-79 (isotope selenium-79)	0.000024	50	No
Sn-126 (isotope tin-126)	0.0000072	30	No
Sr-90 (isotope strontium-90)	9.6	5	Yes
Tc-99 (isotope technetium-99)	5.7	200	No
Th-230 (isotope thorium-230)	0.00022	0.7	No
Th-232 (isotope thorium-232)	0.00096	0.6	No
U-233 (isotope uranium-233)	0.000029	3	No
U-234 (isotope uranium-234)	0.0078	3	No
U-235 (isotope uranium-235)	0.00033	3	No
U-238 (isotope uranium-238)	0.0076	3	No
Zr-93 (isotope zirconium-93)	0.044	100	No

Bq/L = Becquerel per litre.

Table 3.4.2-3: Non-radionuclide Constituent Concentrations in Wastewater and Effluent Discharge Target

Constituent	Maximum Predicted Concentration in Wastewater (mg/L) Prior to Treatment	Effluent Discharge Target (mg/L)	Treatment Required?
Cations			
Aluminum	0.15	0.05	Yes
Antimony	0.00000033	0.02	No
Arsenic	0.00031	0.005	No
Barium	0.00071	0.004	No
Beryllium	0.0000019	0.011	No
Boron	0.12	0.2	Possible
Cadmium	0.0000029	0.00009	No
Calcium	100	116	No
Chromium (total)	0.00025	0.001(3)	No
Cobalt	0.0027	0.0009	Yes
Copper	0.0008	0.002	No
Iron	125	0.3	Yes
Lead	0.000024	0.001	No
Magnesium	68	82	No
Manganese	5.8	0.12	Yes
Mercury	0.0000023	0.000026	No
Molybdenum	0.0039	0.04	No
Nickel	0.000055	0.025	No
Potassium	26	53	No
Selenium	0.000048	0.001	No
Silica	5	*	No
Silver	0.0000032	0.0001	No
Sodium	100	680	No
Thallium	0.0000038	0.0003	No
Tin	0.00058	0.073	No
Uranium	0.00061	0.005	No
Vanadium	0.00043	0.006	No
Zinc	0.0016	0.007	No
Anions			
Bicarbonate Alkalinity as $CaCO_3$	542	*	*
Chloride	17	120	No**
Fluoride	0.12	0.12	No
Nitrate as NO_3	29.3	13(1)	Yes(1)
Nitrite as N	0.265	0.06(1)	Yes(1)
Phosphate as P	1.3	0.01	No(2)
Sulfate	270	128(1)	Yes(1)

Table 3.4.2-3: Non-radionuclide Constituent Concentrations in Wastewater and Effluent Discharge Target

Constituent	Maximum Predicted Concentration in Wastewater (mg/L) Prior to Treatment	Effluent Discharge Target (mg/L)	Treatment Required?
Organics			
Acetone	0.69	1.5	No
Anthracene	0.0000043	0.0000008	Yes
Benzene	0.0015	0.1	No
Benzo(a)pyrene	0.00000011	0.000015	No
Bis(2-ethylhexyl) phthalate	0.0000044	0.0006	No
Carbon tetrachloride	0.0029	0.0133	No
Chlorobenzene	0.00076	0.0013	No
Chloroform	0.0066	0.0018	Yes
Chrysene	0.00000037	0.0000001	Yes
1,4 Dichlorobenzene	0.00035	0.004	No
Dioxin	0.00000000000027	0.00000001	No
Ethylene-Diamine-Tetraacetic Acid	1	*	*
Ethylene dibromide	0.0081	0.005	Yes
Fluoranthene	0.0000013	0.0000008	Yes
Fluorene	0.0000078	0.0002	No
Furan	0.00000000000027	0.00000001	No
Methylene chloride	0.028	0.0981	No
Phenol	0.00057	0.004	No
Phenolic compounds – no chlorine	0.0007	0.004	No
PCBs	0.000000025	0.000001	No
Tannic acid	50	*	*
1,1,2,2 Tetrachloroethane	0.0014	0.07	No
Tetrachloroethylene	0.0014	0.05	No
1,1,2 Trichloroethylene	0.0022	0.8	No

Table 3.4.2-3: Non-radionuclide Constituent Concentrations in Wastewater and Effluent Discharge Target

Constituent	Maximum Predicted Concentration in Wastewater (mg/L) Prior to Treatment	Effluent Discharge Target (mg/L)	Treatment Required?
Other Constituents			
Carbonaceous 5-day biochemical oxygen demand	62	25	Yes
Petroleum hydrocarbons (C6-C10)	***	0.15	***
pH	+	6.5 to 9	+
Suspended solids	+	25	+

Source: CNL 2019c.

1) The concentration of nitrates and nitrites in the final effluent is predicted based on conservative assumptions and the actual concentration of the nitrate and nitrite in the effluent is expected to be less than the predictions. The flexibility of the WWTP design allows CNL to modify our treatment approach based upon the actual wastewater characteristics. CNL will sample the leachate before treatment begins and at several times during the treatment process to ensure that the treatment processes are working as expected. If they are not, CNL can make adjustments to the treatment strategy to deal with the unexpected waste constituents through the use of different ion exchange resins or chemistry changes. The treated effluent goes to a Final Effluent Tank where it is sampled and the sample is analysed prior to discharging the treated effluent. If the treated effluent does not meet the effluent discharge targets, it would be returned to the beginning of the WWTP process and go through the treatment process again to remove the species that exceed the effluent discharge targets. For sulphate, nitrate and nitrite, an anion exchange resin would be used to remove these species.
2) Similar to Note 1, the predicted concentration of phosphorus is based on conservative assumptions and the general discussion of the WWTP treatment approach applies to phosphorus. Specifically for phosphorus, it will be removed during the chemical precipitation step by the ferric chloride that is part of the normal treatment strategy. In the event that higher than normal phosphorus concentrations are observed in the wastewater feed to the WWTP treatment processes, the chemical precipitation step using ferric chloride can be optimized for phosphorus removal at this time. If the concentration of phosphorus in the Final Effluent Tank prior to discharge exceeds the discharge criterion, this liquid would be returned to the beginning of the process and undergo further treatment to remove it.
3) The Chromium (total) effluent discharge target is based on the Canadian Water Quality Guideline for Chromium (VI).

* = no limit established.

** = Present at an elevated concentration in groundwater used to estimate leachate characteristics; not expected to be present in excess in effluent limit in leachate.

*** = Not expected to be present in significant concentrations based on projected bulk waste characteristics.

+ May be present at concentrations exceeding the discharge requirement based on preliminary bulk waste characteristics.

Note: Additional constituents may be identified. Effluent discharge targets for these would be defined as required.

3.4.2.3 Leachate and Contact Water Transfer System

The leachate and contact water transfer system is comprised of gravity drains and two pumping stations. Sources of wastewater at the NSDF Project site include the ECM (generates leachate and contact water), the vehicle decontamination facility (generates decontamination wastewater), the operations support center (generates decontamination wastewater) and the WWTP (process related drains). Wastewater is transferred by gravity drain to one of two pump stations, which then pumps to the WWTP's collection tanks for eventual treatment.

The pump stations are cylindrical HDPE structures that provide dual containment by means of a 2,400 mm diameter cylindrical tank (carrier wall) installed inside of a 3,000 mm diameter cylindrical tank (containment wall). There is a leak detection system between the carrier wall and containment wall. If the leak detection system detects moisture, an alarm is generated and the tanks will be inspected.

A pipe in a pipe approach is used to provide dual containment between the pump station and the WWTP collection tanks.

3.4.2.4 Wastewater Treatment Plant and Process

The WWTP building houses the process systems for treating wastewater. The major processes, and other design features of the WWTP are described in the following sections. Process treatment technologies were selected based on a determination of best available technology that is economically achievable. A general description of the operating strategy for the WWTP process is summarized below.

- **Collection system** – This system provides initial storage for wastewater and is designed to contain a volume of contact water that could be produced from the largest cell of the ECM during a back-to-back, 100-year, 24-hour precipitation event, as well as leachate from closed cells, and wastewater produced from on-going site operations.
  - Three above-grade, covered collection tanks will be installed to provide the required volume. The collection tanks will be installed within a concrete secondary containment area designed to contain 110% of the volume of a single tank.
  - The accumulated dilute wastewater is sampled. If it meets all requirements for discharge, it may be transferred directly from the collection tank to the final effluent tank(s). If certain COPCs exceed discharge requirements, the wastewater will then be treated using some or all of the processes in the WWTP, depending on the specific COPCs in the wastewater.
- **Chemical precipitation system** – The purpose of this system is to precipitate COPCs so they can be filtered from the wastewater. Chemical precipitation has been identified by the U.S. Environmental Protection Agency as best available technology that is economically achievable for multiple radionuclides.
  - Each treatment train will include two chemical precipitation tanks operated in series (four tanks in total).
  - Ferric chloride, sodium sulphide, sodium hydroxide and sulphuric acid can be added to each chemical precipitation tank. Chemicals will be stored in segregated rooms within containment areas based on chemical compatibility, to avoid the mixing of incompatible chemicals in the event of a spill.
- **Membrane filtration system** – Membrane filtration provides nearly complete removal of suspended solids from the wastewater that has been treated in the chemical precipitation system. Recognized by the US Environmental Protection Agency to provide enhanced removal of multiple radionuclides; it was determined to be best available technology that is economically achievable for the WWTP.
  - Concentrated solids will be periodically pumped from the process tanks to the residuals storage and conditioning tanks. Each tank will have a capacity of approximately 80 m^3.
- **Polishing treatment system** – The system is designed for removal of radionuclides and metals that remain in the wastewater after the chemical precipitation and filtration system.
  - Each train of the polishing treatment system includes a pH adjustment tank, polishing system feed tank, three types of polishing filter media, a final pH adjustment tank, and an effluent storage tank.
  - The final effluent storage tanks enable the final effluent to be sampled prior to discharge, when operating the WWTP in batch mode. Final effluent will be discharged to the Perch Creek and Perch Lake Watershed either through an exfiltration gallery or by a transfer line discharge to Perch Lake (Section 3.4.2.6).

3.4.2.4.1 Residuals Management System

The residuals management system is designed for handling and dewatering of residuals produced as a by-product of wastewater treatment. Two types of residuals will be produced by the WWTP: dewatered residuals produced by the chemical precipitation process, and spent granular activated carbon (GAC) and ion exchange resin from the polishing system. For the liquid residuals, a filter press system will be used to remove the water and the dewatered residuals will be transported to the ECM for disposal.

When GAC and ion exchange resin are spent they must be replaced. Spent GAC and ion exchange resin are removed from the vessel using water to slurry the materials into a container for dewatering. The removed water will be discharged to the collection tanks for re-processing. After the water has been removed, the need for additional treatment or processing of spent GAC and ion exchange resin will be determined. Based on the results of sampling and analysis, solidification may be required to meet the WAC prior to disposal in the ECM.

The annual quantity of dewatered residuals is expected to be approximately 42 m^3/yr, and the annual quantity of spent GAC and ion exchange resin is expected to be approximately 47 m^3/yr. The amount of radionuclides in the dewatered residuals, and spent GAC and ion exchange resin, is expected to be well below the definition of LLW and will be acceptable for disposal in the ECM.

3.4.2.5 Treated Effluent Discharge Concentrations

3.4.2.5.1 Effluent Discharge Targets

Effluent discharge targets were developed for the WWTP and are based on protection of human health and the environment. The surface water quality assessment (Section 5.4.2) provides an assessment of the impact of WWTP effluent discharges on surface water quality.

Radiological Constituents

The WWTP effluent discharge targets for radionuclides are the maximum acceptable concentrations for drinking water and are derived using Health Canada Guidelines for Canadian Drinking Water Quality (Health Canada 2019). The use of drinking water concentrations for radionuclides is considered conservative as there is no public access to the Perch Creek and Perch Lake watershed where WWTP effluent discharges will occur. The method for calculation of the maximum acceptable concentrations is provided in Health Canada Guidelines for Canadian Drinking Water Quality (Health Canada 2019).

Due to the impracticality of treating the wastewater to remove tritium, CNL has instead placed stringent limits on the total amount of tritium that can be placed in the NSDF (see Table 3.3.1-2) and on the tritium concentration in individual waste shipments (see Table 3.3.3-1). By placing stringent controls on the amount of tritium being placed in the NSDF, emissions from the WWTP will meet the tritium effluent discharge targets. The discharge target for tritium of 360,000 Bq/L is based on maintaining tritium concentrations in Perch Creek which discharges to the Ottawa River, below the drinking water guideline of 7,000 Bq/L. Thus, no treatment method is necessary to reduce the activity of tritium in the wastewater since it is instead controlled through means to isolate the source.

Non-Radiological Constituents

The effluent discharge targets for non-radioactive constituents are based on the protection of aquatic life and may be lower or higher than drinking water criteria. The effluent discharge targets are gathered from a variety of sources including the Canadian Council of Ministers of the Environment (CCME) and Ontario Provincial Water Quality Objectives (PWQOs). If both federal and provincial criteria were available, the lower value was used to define the discharge target. The CCME guideline values are for the protection of aquatic life; the PWQOs were developed to ensure that water quality is satisfactory for aquatic life and recreation. Other reference documents were used when CCME or PWQOs were not available.

3.4.2.6 WWTP Treated Effluent Discharge Systems

The NSDF's WWTP treated effluent discharge systems are designed for the peak flow from the WWTP.
The preferred option is to discharge the treated effluent from the WWTP to the exfiltration gallery as this provides a longer transit time to the Ottawa River then discharge to Perch Lake. Under high groundwater elevation conditions, discharge to the Exfiltration Gallery is not possible and the treated effluent will be routed to Perch Lake. Figure 3.1.1-1 shows the two potential discharge locations. The estimated annual volume of the treated effluent to be discharged is approximately 11,000 m^3.

The exfiltration gallery design and transfer line to Perch Lake are described in Sections 3.4.2.6.1 and 3.4.2.6.2 below.

Groundwater monitoring in proximity to the exfiltration gallery has indicated that the groundwater elevation under spring conditions is near ground level. Groundwater flow modelling has also indicated that under high seasonal groundwater conditions discharge to the exfiltration gallery will result in flooding at the exfiltration gallery. It is therefore anticipated that under spring conditions all effluent will be discharged to Perch Lake to ensure that the water table remains below grade at the exfiltration gallery and there is no flooding. Under summer conditions when the water table is lower and the volume of wastewater generated is lower, effluent will be routed to the exfiltration gallery.

Real time groundwater monitoring wells will be installed in proximity to the exfiltration gallery and provide water table elevation. The water table elevation data will be used to determine when the treated effluent can be discharged to the exfiltration gallery.

3.4.2.6.1 Exfiltration Gallery

An exfiltration gallery has been designed at the discharge outlet to disperse the treated effluent into the local groundwater. The treated effluent, once discharged to ground, would be returned to the adjacent wetlands and eventually discharge to Perch Lake and the Ottawa River. The vegetation in the wetland will provide a level of tertiary treatment for non-radionuclide COPCs, through plant uptake, before discharge to the Perch Lake and Perch Creek receiving systems.

The location and footprint of the exfiltration gallery is maximized to approximately 1,000 m^2. The exfiltration gallery has been designed to operate year-round. Subject to acceptable weather conditions, waste placement in the ECM may cease during periods of inclement weather such as high winds, major precipitation events, extreme cold periods, or inability to compact waste due to frozen conditions. Even if waste placement operations cease, other parts of the NSDF (e.g., the WWTP) may still operate. Winter conditions have been accounted for by doubling the calculated required design area of the gallery in line with the *Stormwater Management Planning and Design Manual* (MOE 2003).

The average flow rate from the WWTP is 27.8 m^3/day of continuous flow, whereas the existing East Swamp Wetland average flow rate is 233 m^3/day. As such, the average flow rate discharged from the WWTP to the exfiltration gallery is roughly 12% of the existing average flow rate from the East Swamp Wetland.

3.4.2.6.2 Transfer Line Discharge to Perch Lake

In the event that the exfiltration gallery does not have sufficient capacity to manage the treated effluent (e.g., under high groundwater elevations), a portion of the treated effluent will be discharged directly to Perch Lake through a submerged diffuser. The transfer line to Perch Lake has the capacity to discharge all treated effluent to Perch Lake and operate year-round.

The discharge transfer line, which will be constructed using HDPE pipe, will extend south for approximately 1 km from the WWTP along the perimeter of the ECM and existing access roads before entering Perch Lake from the southeast (Figure 3.1.1-1). Horizontal directional drilling may be required to cross select areas during construction to minimize disturbance to wetlands. Pumps located within the WWTP will be used to discharge the treated effluent to Perch Lake.

The dual containment HDPE piping system includes leak detection stations. These stations are spaced at approximately 100 m intervals.

The transfer line will extend from the road through approximately 30 m of riparian marsh before open water. The total length of required pipe extending across riparian and open water areas of Perch Lake is 340 m. A shallow trench (2 m depth) will be excavated/dredged within the riparian/shoreline area for the installation of the discharge transfer line, and a foundation to support the discharge transfer line and diffuser will be installed with consideration of reducing any disturbance to the soft sediments. The treated effluent will be discharged through a submerged diffuser positioned in the deepest location near the centre of the lake and will be dispersed through the lake before discharging downstream via the Perch Lake weir.

3.4.3 Support Facilities

The NSDF Project will require various support facilities during construction, operation and maintenance. The facilities makeup will consist of both modular and permanent structures with associated construction features required for their use or installation. Support facilities will be designed for year-round operation.

The main support facilities consist of six structures of varying types and sizes including:

- north and south kiosks;
- administration building;
- operations support center;
- vehicle decontamination facility;
- site vehicle refueling station; and
- potable water pump station.

The facilities have been designed considering Leadership in Energy and Environmental Design principles and building for energy efficiency. Other support facilities, such as the Fire Water Pump station, will provide the remaining necessary services to the NSDF Project.

3.4.3.1 North and South Kiosks

The NSDF Project site will have two weigh scales, one on the north side and one on the south side (Figure 3.1.1-1). The south kiosk will be used for most incoming loaded waste transport vehicles for both loaded weight and empty weight. The north kiosk will be used by the trucks coming from Plant Road for loaded weight and empty weight. A kiosk will be located at each scale with computerized waste quantity tracking equipment. After unloading the waste, the waste transport vehicles will be monitored for contamination and decontaminated, if necessary.

3.4.3.2 Administration Building

The administration building is positioned off the main site access road. It will serve dedicated NSDF Project site personnel (non-construction workers) during operation and maintenance. The administration building includes office space, a meeting room, a records room, a washroom facility and a lunch room. The administration building will also include necessary minimum first aid equipment, per CNL's Occupational Health and Safety program and Canadian Labour Code requirements.

3.4.3.3 Operations Support Centre

The operations support centre building includes the necessary spaces required for the decontamination of the personnel working on-site and shower facilities after work. The building provides contaminated and clean change rooms and decontamination showers. The decontamination water is directed to the active drainage system and returned to the WWTP for processing. Service rooms for the facility (e.g., mechanical, electrical, janitorial and storage) are located outside of the contaminated zone. This facility will also house secondary first aid equipment to provide quick access for workers requiring decontamination.

3.4.3.4 Vehicle Decontamination Facility

The vehicle decontamination facility provides equipment and facilities for decontamination of vehicles and facility personnel when required. A support office, washroom and mechanical room to carry out light maintenance activities are also present in the building. The vehicle decontamination hall is separated from the rest of the building to prevent transmission of contamination. Contaminated water is transferred by the active drainage system to the WWTP for processing. The facility is sized to accommodate the decontamination of on-site vehicles and highway-legal vehicles. The vehicle decontamination facility will be enclosed, as NSDF Project waste placement activities are required to occur year-round, subject to acceptable weather conditions.

3.4.3.5 Site Vehicle Refueling Station

Located next to the northern ECM perimeter road at the WWTP Access Road the site vehicle refueling station will store bulk diesel for use in ECM construction equipment. It will be an unattended station with an automated fuel pump capable of metering fuel and logging consumption. The fueling area has been designed to protect the natural environment from fuel-related spills.

3.4.3.6 Potable Water Pump Station

The potable water pump station will be located at the north end of the NSDF Project site. This building will house a 15 m^3 potable water tank which is fed from a watermain delivering potable water from the CRL site. The building will also include potable water booster pumps, and a re-chlorination station.

3.4.4 Site Infrastructure

The design of the site infrastructure and support facilities will accommodate year-round operation during the NSDF Project construction and operations, and for the long-term monitoring and maintenance activities during the closure and post-closure phases.

The site infrastructure systems consist of the following:

- access roads;
- site security, including site perimeter fencing and boundary setbacks;
- Sanitary Sewage Disposal System (collection, conveyance, treatment and discharge);
- Surface Water Management (collection, conveyance, treatment and discharge); and
- utilities, including natural gas, power, telecommunication, data, and domestic water pump and distribution (e.g., potable water supply and fire water supply).

3.4.4.1 Access Roads

The NSDF Project site transportation network consists of primary and secondary access roads. Primary access roads provide two-way traffic. Secondary access roads facilitate both one- and two-way traffic.

There are two primary access roads to the site (Figure 3.1.1-1). The main waste shipment access road is from the ER-3 (Emergency Road)/East Mattawa Road intersection south of the NSDF Project site boundary. This road is proposed to be comprised of a granular pavement structure. This road will be used for waste shipments arriving to the NSDF Project site, as well as transport vehicles leaving the NSDF Project site, providing that vehicle decontamination is not required.

The other primary access road to the NSDF Project site is from Plant Road to the site boundary. This road is proposed to be an asphalt pavement structure from the Plant Road to the site boundary to limit dust generation in the vicinity of Plant Road. A right-turn/deceleration lane is proposed at the intersection with Plant Road to allow for slower moving vehicles to turn into the NSDF Project site without impeding eastbound traffic to the CRL main campus. This primary access road will be used for occasional waste deliveries to the NSDF Project site, but is mainly intended for employee access to the support facility buildings and material and equipment deliveries to the site.

Secondary site access roads generally consist of perimeter roads around the ECM and the WWTP. The secondary roads are proposed with granular pavement structures and are sized to facilitate two-way vehicular traffic around the site. Decon Road, linking the ECM to the vehicle decontamination facility, is proposed as an asphalt road and will be used by waste shipment vehicles or equipment that require decontamination.

3.4.4.2 Site and Worker Parking

Site and worker parking will be positioned near the administration office and the vehicle decontamination facility. This area will be large enough to accommodate vehicles from on-site personnel, visitors, and CRL site security. Parking areas will be constructed of granular material.

3.4.4.3 Site Security

The NSDF security will follow CRL's site security requirements and physical security plans. Access to the NSDF Project site will be exclusively from within the CRL site boundary and access to the CRL site is strictly controlled by security personnel. In addition, a security fence will be installed around the entire perimeter of the NSDF Project site to prevent unauthorized personnel from entering, and limit animal injury and contact during construction and waste placement operations. The perimeter fencing will be 2.4-m high, typically offset 1.0 m inside the NSDF boundary. A swing gate area will be provided at secondary access points (i.e., connections to maintenance roads and/or hydro transmission corridors) and automated gates are provided at the north and south entrances with security features to control access to and within the site. Fencing is anticipated to be chain-linked and include a below-ground portion, which will prevent turtle migration into the site.

3.4.4.4 Sanitary Sewage Disposal System

The NSDF's sanitary sewage disposal system has been designed to transfer the peak sewage flows generated by up to 65 full time employees at the NSDF Project site. The NSDF sanitary sewage will be managed through a gravity sewer network connected to a sewage disposal system. This system is completely separate from the ECM leachate and contact water transfer system for the on-site WWTP.

Two site sewage disposal systems are proposed to service the NSDF Project site, including:

- one primary sewage disposal system located at the north entrance to the NSDF Project site east of East Mattawa Road; and
- one secondary sewage disposal system adjacent to the South Entrance Kiosk to support only the South Kiosk.

Each of these two systems will contain a pump station, precast concrete septic tank and polyvinyl chloride piped leach field. The sanitary system uses a network of gravity sewers to convey sewage from the Vehicle Decontamination Facility, the Operations Support Center, the Administration Building, the North Kiosk, and the WWTP to a sanitary pumping station located near the north entry to the site. At the South Kiosk, sewage will discharge from the Kiosk through a septic tank to a septic field near the kiosk. There are no tie-ins to the CRL system. Sewage discharges to the sewage disposal systems will conform to CNL's Environmental Protection Program procedure, *Acceptability Criteria for Routine and Non-Routine Discharge of Liquids on the CRL Site* (CNL 2015).

3.4.4.5 Surface Water Management Collection, Conveyance, Treatment and Discharge

The surface water management system for the NSDF Project is designed to control non-contact water including limiting surface water from uncontaminated areas discharging into contaminated areas. Contact water that is collected from within the ECM is transferred to the WWTP for treatment (Section 3.4.2). The design of the surface water management system considers the accumulation of 1 m of snowfall in advance of a design storm event.

The surface water management system consists of four main elements:

- collection (i.e., site grading, inlets, catch basins);
- conveyance (i.e., internal ditches, sewers, culverts and external flow diversion ditches);
- treatment (i.e., settling/detention ponds); and
- outlet to receiving waters (i.e., East Swamp wetland).

The design of the surface water management system for the NSDF Project site is to achieve the following objectives:

- to mitigate erosion and intercept sediment during the construction phase to avoid transport off-site during wet weather events;
- to control the quantity of surface water discharge from the NSDF Project site to maintain pre-development peak flow rates; and
- to provide quality treatment of non-contact water from the ECM to meet the requirements of the Ontario Ministry of the Environment, Conservation and Parks by facilitating the settling of suspended sediment and ultimately protecting receiving watercourses and waterbodies.

During the construction phase, erosion and sediment control measures will be in place to mitigate the effects of sediment transport. The measures will include the use of erosion control blankets, as needed on steep slopes, check dams in ditches and swales, and the three proposed surface water management ponds that will be constructed to serve as interim sediment control facilities during construction, and then as stormwater management facilities during the operations, closure and post-closure periods. The ECM surface water runoff controls will be maintained until the end of the institutional control period. The ECM and external areas, including the WWTP, parking lots, administrative and maintenance buildings, and laydown areas will be subject to erosion and sediment control measures during construction.

During the construction phase, CNL anticipates an average water use of approximately 110 m^3/day to 150 m^3/day for construction activities (e.g., dust suppression, clay mixing and fire protection). Construction water use is expected to peak at approximately 750 m^3/day. Water usage will be lower during the winter season (December through to March) when construction will be less active. The water may also be used for commissioning activities including hydrostatic testing of the WWTP storage tanks, the leachate collection, and piping systems. Construction water will be sourced from the Ottawa River using an existing intake structure to fill temporary storage containers.

Site operations include surface water management for the ECM and all external areas. Surface water from all external areas will be transferred by drainage ditches, swales and culverts to surface water management ponds that will address water quality and water quantity criteria established for the wetland receiving waters and, ultimately, Perch Creek. Contact water drainage from the active cells of the ECM will be to the WWTP unless sampling and analysis demonstrates that the water in the contact water pond is suitable for discharge as non-contact water. Non-contact water drainage will be directed by gravity to the external surface water management system, or to temporary holding ponds within the ECM and then pumped to the external system and the three surface water management ponds.

3.4.4.5.1 ECM Surface Water Management

Contact and non-contact water ponds will be kept independent from each other by the ridge and valley configuration (herringbone-shape) in the base liner and use of temporary berms. The cells are oriented so that the ridge and valleys will naturally direct water to ponds located at the low point of each cell. The ponds will be positioned along the south edge of the ECM for Phase 1 as shown in Figure 3.4.4-1. In addition, berms will be installed along the cell ridges in the area of the ponds to provide the necessary pond structure, volume and provide separation for:

- Active disposal cell from the adjacent contact water pond;
- Contact water pond from the adjacent non-contact water ponds; and
- Each of the non-contact water ponds.

Phase 2 will be separated from Phase 1 by the ECM access road which keeps Phase 2 independent from Phase 1 and prevents inflow of contact water. Phase 2 non-contact water will drain to an internal control pond located at the north west corner of the ECM.

Non-contact water ponds will avoid contamination from adjacent operations by means of the following design features:

- Ponds will be positioned at the low points of each cell to provide a predictable drainage path;
- Ponds have been sized for the back to back 100-year, 24 hr storm event with 0.5 m freeboard based on the maximum cell area to prevent overtopping;
- Berms between ponds have been designed with a 3:1 slope to provide the necessary containment structure; and
- Ponds will be individually lined with an additional 2 mm geomembrane anchored to the berms to form a water tight structure for each cell.

The non-contact water collected in the ECM non-contact water ponds is pumped to the ECM perimeter ditches and drains to surface water management ponds 2 and 3 which are discussed in subsequent sections.

The purpose of the contact water pond is to receive contaminated water from the waste handling area as well as the adjacent waste disposal cell. The design and waste placement objectives (AECOM 2019b) promote flow to the contact water pond by:

- Installation of the sacrificial liner in the waste handling cell;
- Compacting the surface of the waste to maximize its in-place density to reduce infiltration; and
- Grading the waste in the active waste cell (minimum 2% slope), towards the contact water pond.•

As discussed in Section 3.4.2 the contact water collected in the ECM contact water ponds is pumped to the WWTP for treatment prior to discharge to the environment.

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LEGEND

NOTE(S)

REFERENCE(S)

1. CANADIAN NUCLEAR LABORATORIES 2020

CLIENT
CANADIAN NUCLEAR LABORATORIES

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	-
PREPARED	PR
REVIEWED	CS
APPROVED	AB

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
AERIAL OVER WASTEWATER TREATMENT PLANT

PROJECT NO.	CONTROL	FINAL	FIGURE
1547525	0005	FINAL 2	**3.4.4-1**

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3.4.4.5.2 Surface Water Management Ponds

The three surface water management ponds are provided to address the proposed layout and drainage patterns (Figure 3.4.4-2).

- Surface water management pond 1 is at the north end and will receive runoff from proposed buildings and parking lots. The outlet will be via channel and dispersion outlet (spreader), to the East Swamp wetland.
- Surface water management pond 2 is to the south and will receive runoff from the post-closure ECM and adjacent laydown/stockpile area. The outlet will be via channel and dispersion outlet (spreader) to the Perch Lake Swamp wetland complex.
- Surface water management pond 3 is to the west and will receive runoff from the post-closure ECM. The outlet will be via channel and dispersion outlet (spreader) to the Perch Lake Swamp wetland complex.

An internal control detention pond will be used during Phase 1 operations. This pond will be located along the northwest corner of the ECM in the Phase 2 area and will attenuate peak flows before transferring to surface water management pond 3.

The surface water management pond footprints reflect the overall storage required to control post-closure flows to predevelopment levels for the 2-year through to 100-year rainfall events at the site. This volume also contains the storage required for sediment control during construction and water quality control during operations. The design footprints typically assume a maximum 100-year operating water level at a 3 m depth with 1 m of freeboard that includes allowance for climate change impact projections and rain on snowmelt.

LEGEND

- SITE BOUNDARY
- DRAINAGE AREA BOUNDARY
- DITCH / SWALE FLOW DIRECTION
- BEDROCK OUTCROPPING
- WETLAND (TO BE CONFIRMED BY CNL)
- CULVERT
- OVERLAND FLOW ROUTE
- AREA (ha) / AREA NO. / CURVE NUMBER
- SWM POND 1 DRAINAGE AREA
- SWM POND 2 DRAINAGE AREA
- SWM POND 3 DRAINAGE AREA
- EXTERNAL DRAINAGE AREA

REFERENCE(S)

1. FIGURE OBTAINED FROM 232-508600-PLA-002 DELIVERABLE C4.2; REVISION 1

CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
SURFACE WATER MANAGEMENT PLAN

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0004	FINAL 2	3.4.4-2

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The target non-contact water quality objective is provided by Ministry of the Environment, Conservation and Parks Ontario Ministry of the Environment, Conservation and Parks in their *Stormwater Management Planning and Design Manual* (MOE 2003), which suggests a 60% total suspended solids (TSS) removal that provides a basic water quality treatment for discharge to a receiving wetland. Surface water management pond 1 will provide 80% TSS removal, surface water management pond 2 will provide 76% TSS removal and surface water management pond 3 will provide 60% TSS removal.

Mitigation measures will be implemented upstream and downstream of the surface water management ponds to minimize sediment loading. These will include:

- Design of the facility to resist heavy erosion during severe storm events. Conveyance structures such as ditches and swales will be vegetated, lined in rip-rap and contain check-dams and similar structures to trap sediment and reduce flow velocity.
- The impervious area of the SWMP catchments during operation and post-closure is relatively small. Geotextile and granular liners as well as vegetation cover will reduce the amount of solids entering the system from these surfaces. In addition, operational practices such as sweeping sand off asphalt surfaces, granular sealing of road shoulders and gravel surfaces and various dust suppression measures will reduce solids loading into the SWMP influent.

The surface water management pond outfall structures are within the NSDF site boundary and provide for approximately 35 m of dispersed overland flow and infiltration before the stormwater reaches the edge of the wetland. The edge of the wetlands are forested and only seasonally wet, providing additional distance for the stormwater to travel, pond and infiltrate before reaching East Swamp Stream located 200 m from SWMP 3 outfall and Perch Creek located 150 m from SWMP 2 outfall.

The surface water management ponds will be monitored for total suspended solids as described in Table 11.0-1 to ensure compliance with Environmental Protection Program requirements for total suspended solids in effluent discharge.

Road, sidewalk and parking lot winter maintenance activities that may release road salt to the environment, include snow plowing/shoveling and de-icing practices, salt and sand storage, and snow stockpiling, removal and disposal. The current winter maintenance practices outlined in the CRL *Salt Management Plan* (AECL 2013) provide effective measures to manage salt use within the NSDF Project site. The application of road salt on the NSDF Project site is to be minimized as salt residual within contact water and/or leachate may compromise the treatment effectiveness of the WWTP systems. Instead, alternative products such as a sand-stone mixture are being considered.

For each surface water management pond, the water level will be monitored to estimate the inflow and outflow of each pond. Visual inspections of the ponds will be completed to confirm that inlets and outlets are clear of debris and to confirm that there are no major erosion issues at the inlet or outlet. The berms and outlet structures will be visually inspected to identify any animal burrowing activity or active soil erosion. Inspections will also include an annual sediment level monitoring component to identify sediment clean-out requirements. Sediments will be extracted by excavation equipment and will be disposed of based on sediment sampling, testing, and classification according to Ministry of the Environment, Conservation and Parks standards or stockpiled, de-watered and reused on-site for ECM cover operations. The sediment removal assessment follows procedures identified in the *Stormwater Management Planning and Design Manual* (MOE 2003).

3.4.4.5.3 Drainage Ditches and Swales

All roads, including the perimeter road, have ditches that convey not only road drainage, but drainage from adjacent lands, to the surface water management ponds. These have been designed to convey the 25-year post-development peak design flow. Annual maintenance activities will identify any erosion problems. A maintenance review will be completed on a regular basis to confirm there are no major erosion issues.

3.4.4.5.4 Culverts and Sewers

Where drainage crosses roads, culverts are sized to convey the 25-year design event without road overtopping. A 900 mm storm sewer has been sized to convey the 100-year flow plus climate change to surface water management pond 1 in the vicinity of the administration building because adjacent land use, property and road limits preclude the use of a ditch. Annual maintenance activities will identify any erosion or blockage problems. A maintenance review will be completed on a regular basis to confirm there are no major erosion or blockage issues at the culvert and sewer inlet or outlet.

3.4.4.5.5 Flowpaths

Major system (i.e., 100 year) flow routes follow the road system and ditches to the relevant surface water management ponds. The probable maximum precipitation flow generally follows the major system route using the road, related ditches and adjacent lands. Even when the probable maximum precipitation flow will exceed the surface water management ponds attenuation capacity, one of the design objectives is that inlet and emergency outlet structures adjacent to the surface water management ponds will be able to convey this flow safely.

3.4.4.5.6 Outlets

The major flow system for all three surface water management ponds will discharge to adjacent wetlands and will be dispersed by level spreaders to achieve even flow distribution to the wetlands. Current surface water management pond outlet locations are limited by the site boundary (greater than 5 m separation required) so that there is no discharge from the spreader directly to the wetlands. Local topography between the level spreader and the wetlands, as well as any setbacks, has influenced the location of the level spreaders on-site. Annual maintenance activities will identify any erosion problems. In addition, a maintenance review will be completed on a regular basis to confirm there are no major erosion issues at the dispersion outlets.

3.4.4.6 Utilities

The following site utilities will be required to facilitate the NSDF Project construction, operation and maintenance:

- potable water service for human consumption and staff decontamination facilities;
- service water for vehicle decontamination facilities, and WWTP operations if required;
- electricity for site facilities for lighting; ventilation and air conditioning; and other power uses;
- natural gas for heating; and
- telephone and internet access for communication and CNL surveillance equipment (such as security cameras).

The water distribution system is designed to supply water to meet the potable and service water demands at the NSDF Project site and supply and maintain sufficient pressures to meet the NSDF's operational requirements. All buildings and facilities, with the exception of the south kiosk, will be provided with potable water service for various uses, which include but are not limited to showers, toilets, eyewash stations, faucets, floor/equipment wash down, and process applications. The south kiosk is serviced by a water storage tank within the kiosk. The NSDF's watermain will tie into the CNL potable water network. All watermains will be equipped with cathodic protection on all metal appurtenances; cathodic protection monitoring stations and tracer wire will be supplied. The watermain will be provided frost protection by locating it below the frost line.

Fire protection at the NSDF Project site will be provided through two on-site underground fire water holding tanks. The tanks have been designed and will operate in a duty/standby manner. Each tank will have a capacity of 403 m^3. This capacity will be sufficient to provide 2 hours of fire water supply through a dry fire main system to on-site hydrants.

3.4.5 Management of Waste Generated by the Project

All wastes that arise as a result of the construction, operations, and closure phases will be safely managed and in accordance with CNL's Waste Management Program. The CNL Waste Management Program prescribes that management of waste at CNL-operated sites is completed in a safe and environmentally responsible manner that meets or exceeds CNL's Safety and Health Policy, CNL's Environment Policy, as well as applicable regulations and standards, and limits current and future environmental effects and liabilities. Facilities and activities within these sites are planned, developed and operated or conducted in a manner that reduces both the volume and the level of hazard of all wastes that are generated during the entire life cycle of the facility or activity. Under the Waste Management Program, wastes are managed in accordance with CNL's procedure for *Management of Waste* (CNL 2019d).

3.4.6 Human Resource Requirements

The construction, operations, closure and post-closure phases of the NSDF Project will require administrative and supervisor staff, engineering and environmental monitoring personnel, technical support staff and construction workers. Table 3.4.6-1 summarizes the expected averaged labour requirements during construction, operations, closure and post-closure, including contractors. The construction is planned over two years and has a variable labour force depending on the number of parallel activities being performed. The averaged labour force over the duration of the construction phase is approximately 225 full time equivalents, with the peak labour force expected to be close to 300 personnel (Table 3.4.6-1).

Limited maintenance and inspection will occur in off-shift hours. Operations occur over a 50-year period, with an average labour force of 65 full time equivalents (although this will be adjusted based on operational demand). Closure and Post-closure labour force requirements will be substantially less than requirements for the operations phase.

Table 3.4.6-1: Summary of Labour Force Requirements for the Near Surface Disposal Facility Project During Construction and Operation

Project Phase	Labour Force	Types of Positions
Construction	Peak manpower of 300 personnel over a 2-year period	■ Administrative and Supervisor Staff ■ Construction Management ■ Engineering/Technical Support Staff ■ Equipment Operators ■ Skilled Trades ■ General Labour ■ Environmental Monitoring ■ Owner Representatives ■ Truck Drivers
Operations	65 full time equivalents (although this will be adjusted based on operational demand)	■ Administrative and Supervisor Staff ■ Mechanical/Technician ■ Engineering/Technical Support Staff ■ Equipment Operators ■ Environmental Monitoring ■ Truck Drivers (transport of waste)

3.5 Application of Existing Policies, Objectives, and Programs

The following sections outline CNL's existing health, safety, security and environmental policies, objectives and programs that will be applicable to all phases of the NSDF Project. CNL will implement these policies on the NSDF Project through project-specific plans and procedures (e.g., Environmental Protection Plan, Radiation Protection Plan, Blasting Plan).

3.5.1 Existing Policies and Procedures

3.5.1.1 Environmental Policy

CNL has an *Environment Policy* (CNL 2017b) that considers the protection of the environment as an integral component of its decision-making in all phases of its business activities, including product development, project planning, project implementation, operations and decommissioning. CNL also focuses its environmental efforts on limiting nuclear legacy obligations for future generations. CNL's *Environmental Policy* (CNL 2017b) applies to all aspects of CNL's activities as following:

- To practice responsible environmental management.
- To be committed to pollution prevention.
- To set environmental objectives and targets to support continual improvement of their environmental performance.
- To set sustainability objectives and targets for energy efficiency, clean energy utilization, waste management and conservation of resources to support continual improvement of their performance.
- To comply with environmental laws, requirements and recognized standards and guidelines applicable to their activities.
- To review the impacts of their activities, facilities, projects, services and products on the environment.
- To seek to develop and improve technologies to advance environmental protection and clean air solutions.
- To promote public and employee awareness of this policy and their environmental performance.

3.5.1.1.1 Environmental Plan

The *Environmental Plan* is a report that is issued annually (CNL 2019e). It describes the strategic environmental objectives for CNL sites. The *Environmental Plan* currently includes the following initiatives (CNL 2019f).

- Manage legacy radioactive waste.
- Upgrade or construct new infrastructure related to current operations.
- Manage and monitor emissions.
- Build new infrastructure.
- Implement sustainability/green initiatives for energy management, waste management and conservation of resources to continually improve performance.

3.5.1.2 Safety Policies and Objectives

CNL has established several corporate policies relevant to employee, public and environmental safety. The following policies will be followed for all NSDF Project activities:

- Quality (June 2019);
- Safety and Health (February 2019);
- Environment (March 2018);
- Nuclear Safety (March 2018); and
- Security (June 2019).

The following safety objectives will be followed for all NSDF Project activities:

a) Radiation exposures to facility staff, on-site personnel, and the off-site public resulting from the normal facility operation, Anticipated Operational Occurrences and credible accidents are:
   - below the regulatory limits, as per the *Radiation Protection Regulations*;
   - As Low As Reasonably Achievable, social and economic factors taken into account (ALARA); and
   - as per CNL's Radiation Protection Requirements.

b) Radioactive releases and radiation exposures to the facility staff, on-site personnel, and the most exposed group of the off-site public resulting from abnormal events will be addressed with the defence-in-depth philosophy. Doses will be:
   - first prevented;
   - mitigated; and
   - accommodated through design, operating procedures, training, and administrative controls.

c) Releases of radiological substances to the environment will be first prevented, then mitigated, and then accommodated such that exposures are limited and are ALARA.

3.5.1.3 Procedure for Management and Monitoring of Emissions

Emissions and effluents from the NSDF Project during the construction, operations, and closure phases will be managed according to CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018a). This procedure defines the key requirements, responsibilities, and processes for the management of radioactive and non-radioactive emissions at CNL operated sites. This document expands on regulatory requirements for the effective management of these emissions, and involves the following activities:

- identification and assessment of emission pathways;
- control and treatment of emissions;
- operational control monitoring; and
- effluent verification monitoring.

Identification and assessment of emission pathways involves identifying routes by which radioactive and non-radioactive contaminants are likely to be emitted to the atmosphere, wastewaters, ground or groundwater, or to off-site municipal sewer systems from CRL facilities during routine and non-routine events. The type and quantities of these contaminants to be emitted are characterized, and subsequently assessed for the likelihood of exceeding regulatory and internal emissions limits, the magnitude and likelihood of effects to the public, the potential for adverse effects to the environment, and the potential for public concern.

Control and treatment of emissions includes identifying mitigation to prevent, reduce, or limit release of emissions to the environment. To the extent practical, airborne and waterborne effluent containing contaminants are managed separately from non-contaminated effluent. Preventive maintenance programs are implemented to reduce the likelihood of system failures, and appropriate systems are in place to provide timely warning in the event of a failure or degradation of control and treatment systems. Operational control monitoring is completed to evaluate whether emission control and treatment systems are functioning as intended.

Effluent verification monitoring is intended to verify that emissions are below regulatory limits and includes measuring or estimating nuclear substances and hazardous substances being released into the environment by a site or facility. An effluent verification monitoring program is established for the monitoring of radioactive and non-radioactive emissions. The overall effluent verification monitoring program for the CRL site is applicable to the NSDF Project; specifically, the Air Verification Monitoring Program and Liquid Verification Monitoring Program will be expanded to include the NSDF Project.

As well, a passive LFG venting system will be constructed during installation of the ECM final cover system and will be monitored periodically during the ECM post-closure phase to detect evidence of potential LFG migration away from the ECM (described in Section 3.4.1.9.4).

Monitoring of the treated effluent discharge from the WWTP will be completed in accordance with CNL's procedure for *Management and Monitoring of Emissions*. The Operational Control Monitoring Program for the CRL site will be expanded to include the NSDF Project, and will achieve the following objectives:

- to provide feedback to facility operators on system performance with respect to emissions to the environment within a time frame consistent with routine operational control decisions;
- to confirm the adequacy of controls on emissions from the source;

- to provide timely indication to facility operators of abnormal emissions that may be in excess of emission limits to initiate corrective action, incident reporting, quantitative monitoring, investigations or emergency actions as appropriate; and
- to differentiate sources of abnormal emissions where there is more than one facility, system or subsystem that discharges to the environment through a single or common effluent stream.

Leachate monitoring will be conducted at the ECM. The leachate monitoring program will be designed to characterize the leachate quality as the ECM is operated, and to ascertain unique indicator constituents that are representative of the leachate characteristics.

Environmental monitoring is performed to assist in determining the effect of emissions in the environment surrounding a site or facility and consists of measuring or estimating nuclear substances and hazardous substances present in the environment. CNL's maintains a comprehensive Environmental Monitoring Program for the CRL site to verify that radiation doses to members of the public as a result of radioactive releases from the CRL site remain ALARA. The program demonstrates that releases from the CRL site do not exceed regulatory limits and serves to verify that radioactive and non-radioactive releases do not pose hazards to human health and the environment. Monitoring is completed through routine collection and analysis of environmental samples from numerous locations within the CRL site, as well as in the surrounding communities. The Environmental Management Plan (EMP) for the CRL site will be expanded to include monitoring and sampling locations for the NSDF Project.

3.5.2 Existing Health, Safety, Security and Environmental Programs

To demonstrate compliance with regulatory commitments related to health, safety and security, CNL has developed a number of programs outlining corporate expectations.

The following presents an overview of CNL's existing programs related to environment, safety and security. CNL is responsible for and committed to providing for the health and safety of its employees and the public and the protection of the environment. These programs include, but are not limited to:

- Radiation Protection Program.
- Environmental Protection Program.
- Waste Management Program.
- Occupational Safety and Health Program.
- Emergency Preparedness Program.
- Nuclear Criticality Safety Program.
- Physical Security Program.
- Nuclear Materials and Safeguards Management Compliance Program.
- Fire Protection Program.
- Quality Assurance Program.
- Human Performance.
- Transportation of Dangerous Goods.

The above-mentioned programs will be implemented during all phases of the NSDF Project. A brief description of each program is provided in the following sections.

3.5.2.1 Radiation Protection Program

CNL's Radiation Protection Program is designed and implemented so that CNL complies with, or exceeds, the level of radiation safety that is required by the relevant regulations pursuant to the *Nuclear Safety and Control Act* and CNL's Health and Safety Policy.

The fundamental objectives of the CNL Radiation Protection Program are to:

- limit the doses to less than the regulatory limits;
- limit doses to employees and members of the public to levels as low as reasonably achievable, social and economic factors being taken into account (ALARA principle); and
- prevent detrimental non-stochastic (deterministic) health effects caused in employees and members of the public by CNL's use of radiation. At all CRL facilities, these objectives are achieved through facility design, staff training, administrative exposure control procedures, contamination control requirements, and work planning and supervision. A combination of Action Levels and dose management tools are used to keep radiation doses to employees below regulatory limits and ALARA.

CNL's ALARA program takes into consideration CNSC's regulatory guide to the ALARA principle (CNSC 2004) in the design of the NSDF Project. This program is used for the planning and control of radiological work, and includes guidelines and procedures for initiating, analyzing, planning, scheduling, executing and closing out radiological work so that radiation exposures and the risk of unplanned exposures are kept ALARA. All new and non-routine activities (activities that will introduce any new or non-routine radiological aspects, hazards or safety concerns) require analysis by CNL's ALARA review process.

The ALARA principle for the NSDF Project design will be achieved by implementing zoning and access control measures, providing process equipment segregation, establishment of radiation alarms and through operator training and approved procedures. Further reduction in operating staff doses is achieved by limiting releases through periodic inspection and preventive maintenance of equipment. This principle applies throughout the life cycle of the NSDF Project, from design to decommissioning.

3.5.2.2 Environmental Protection Program

CNL's Environmental Protection Program provides compliance with applicable environmental regulatory requirements and requirements that CNL has adopted as a matter of policy. The program is registered under ISO 14001 and is designed to provide for the protection of the environment and the public in relation to CNL's activities. The Environmental Protection Program incorporates the following key elements of the ISO 14001 Environmental Management System Standard:

Planning

- Identification and determination of significance of those environmental aspects associated with CNL's activities.
- Establishment of environmental objectives and targets.
- Development of appropriate plans and/or programs to achieve the objectives and targets.

Implementation and Operation

- Defining and documenting appropriate roles and responsibilities.
- Establishment and maintenance of operational controls over environmental aspects.

Checking and Corrective Action

- Monitoring to verify environmental performance and compliance.
- Maintaining non-conformance and corrective and preventative action procedures.

Management Review

- Periodic review by CNL's management to ensure the on-going suitability, adequacy and effectiveness of the Environmental Management System.

CNL maintains a comprehensive EMP at the CRL site. The EMP operates under the direction of CNL's Environmental Protection Program to achieve the following primary objectives:

- To assess the level of risk on human health and safety, and the potential biological effects in the environment of the contaminants of concern arising from the facility.
- To demonstrate compliance with limits on the concentration and/or intensity of contaminants and physical stressors in the environment or their effect on the environment.
- To check, independently of effluent monitoring, on the effectiveness of contaminant and effluent control, and provide public assurance of the effectiveness of containment and effluent control.
- Provide an indication of unusual or unforeseen conditions that might require corrective action or additional monitoring.
- To verify predictions made in the Environmental Risk Assessment, Derived Release Limit model, and/or environmental assessments, refine the models used, and reduce the uncertainty in predictions made by these assessments and models.

The EMP is also designed to provide data required to support site remediation programs, site operations, or to plan for future stages of the site lifecycle (e.g., decommissioning); to provide resources and data that can be of value during the response to an accident or upset, and in the recovery from such an event; to demonstrate due diligence; and to meet stakeholder commitments. The design of the EMP takes into account the facilities and processes at the CRL site, actual emissions from the site at present and in the past, the environmental pathways leading to radiation dose to critical groups, as well as various other scientific, historic, and public considerations. The EMP for the CRL site will be expanded to include monitoring and sampling locations for the NSDF Project.

The NSDF Project Environmental Protection Plan will establish guidelines for safe and environmentally sound management of the facility during construction. During operations, this plan will establish guidelines to prevent unacceptable dispersal of radioactive and non-radioactive materials through environmental pathways and provides mechanisms for early detection of releases of radioactivity, as well as monitoring for both radioactive and non-radioactive emissions. This plan will also include information on how long-term behaviours of the waste are evaluated with respect to environmental protection.

3.5.2.3 Waste Management Program

Waste Management Program includes requirements and processes to ensure that CNL activities that involve planning for, handling, transporting, processing, storage and disposal of wastes are performed in a manner that complies with applicable regulatory and licence requirements and protects workers, the public and the environment. This Program will integrate the requirements for waste producers and Waste Operations authorities. The Waste Management Plan at CRL includes identification of waste inventory and the characteristics of the waste (radiological and hazardous non-radiological), waste segregation waste packaging and transfer requirements, and the plan for storage or disposal of the wastes. The Waste Management Plan developed for the NSDF Project provides the plan for managing the waste generated during the construction, operations, and decommissioning of the NSDF in accordance with CRL waste management requirements.

3.5.2.4 Occupational Safety and Health Program

CNL's Occupational Safety and Health Program is designed to provide for the protection of workers and public health and safety in relation to CNL activities. CNL and its contactors will meet all applicable health and safety legislative requirements. CNL requires that contractors and their subcontractors maintain a level of safety equivalent to that of CNL employees while on-site.

All activities related to the NSDF Project construction will be performed according to the contractor's approved Health, Safety, Security and Environment Plan, which will be compliant with the *Occupational Health and Safety Act*. An Integrated Work Control process for all non-routine work involving potential health and safety hazards ensures that hazards are evaluated and appropriate protective measures are taken.

3.5.2.5 Emergency Preparedness Program

Emergency Preparedness Program comprises planning and response elements to provide that processes are in place to control and mitigate the consequences of an emergency (whether related to a nuclear/radiological or conventional incident) both on- and off-site. In accordance with the Ontario Nuclear Emergency Plan, the program includes infrastructure, assigned response staff and other resources, and periodic exercises to test and demonstrate emergency preparedness. The Emergency Preparedness Program takes into consideration guidance provided in the CNSC's *REGDOC-2.10.1 Nuclear Emergency Preparedness and Response* (CNSC 2016).

3.5.2.6 Nuclear Criticality Safety Program

Nuclear Criticality Safety Program is intended to prevent criticality accidents through appropriate design, analysis, operations, and decommissioning of facilities involving fissionable materials. The program applies to activities involving the use, processing, transfer, storage and disposal of fissionable materials. It requires that criticality safety analysis be conducted and that processes and procedures be established to provide assurance that a sufficient safety margin is established. The Nuclear Criticality Safety Program takes into consideration recommendations and guidance provided in the Federal Nuclear Emergency Plan (Health Canada 2014).

3.5.2.7 Physical Security Program

Physical Security Program is intended to provide continuous security coverage of the CRL site, in compliance with *Nuclear Safety and Control Act* legislation and federal government security policy. The program provides physical protection against unauthorized access and malicious damage to nuclear facilities, non-nuclear facilities, and specified nuclear materials used, processed, stored or possessed by CNL at the site.

3.5.2.8 Nuclear Materials and Safeguards Management Compliance Program

Nuclear Materials and Safeguards Management Compliance Program is intended to manage and safeguard nuclear materials in CNL's custody, in compliance with applicable laws and standards. The program provides assurance that CNL's activities are meeting Canada's commitment under the Nuclear Non-proliferation Treaty.

3.5.2.9 Fire Protection Program

Fire Protection Program is dedicated to the delivery of a compliant Fire Protection program that will provide the highest level of fire and life safety to all CNL employees and facilities. The objectives of the Fire Protection Program include preventing fire losses, providing responsible fire protection management, demonstrating compliance to applicable fire protection codes and standards, and providing reliable facilities from a fire protection perspective. The Fire Protection Program provides services including developing fire prevention processes and conducting fire safety inspections. Fire hazard analyses, code compliance reviews and fire protection screenings are also conducted as part of the program.

3.5.2.10 Quality Assurance Program

The Quality Assurance Program is designed to enable CNL to provide effective and efficient product delivery in full compliance with applicable statutory and regulatory requirements through the provision of quality services. The quality services range from:

- The deployment of Quality Assurance Representatives (QARs) to support Project and Operational activities throughout their lifecycle.
- The assessment, evaluation and on-going oversight to existing or prospective supplier's quality assurance programs.
- The provision of personnel, separate from the executing organization, to perform independent inspection and verification activities to the applicable quality code or standard.
- The provision of various quality programs such as Calibration, Real-Time programmable Electronic Systems, Analytical, Scientific and Design Software Program, Counterfeit, Fraudulent, and Suspect Items Program, or Foreign Material Exclusion Program.
- The planning and execution of quality audits to ensure industry standard requirements applicable to CNL's Management System are met. Additionally, the responsible group also act as the point of contact for 2nd/3rd-party audits/assessment by certification/accreditation bodies and customers.

CNL is committed to conducting all operations in a safe and responsible manner in compliance with the CNL Management System.

3.5.2.11 Human Performance

The Human Performance Program assists all employees to anticipate, manage, and monitor the effects of variability in human performance on organizational outcomes. The Human Performance Program supports the implementation of and promotes the CNL Nuclear Safety Policy and the *Institute of Nuclear Power Operations Traits of a Healthy Nuclear Safety Culture* (INPO 2013). The guiding principles of the Human Performance Program are that:

- organizational values influence individual behaviours;
- performance is based on reinforcement and self-motivation;
- people are fallible, and even the best make mistakes; and
- error-likely situations are predictable and preventable, only if they are recognised.

Goals of the Human Performance Program are to:

- improve the understanding of the effect that Human Performance has on event rates;
- aid management in reducing the frequency and severity of adverse events resulting from human error;
- support employees in recognizing error-likely circumstances and applying measures to reduce the likelihood of significant events;
- meet human performance licensing requirements and assist CNL in achieving and sustaining a healthy nuclear safety culture; and
- increase engagement of all Lines to promote the internalization of Human Performance principles.

Employees receive appropriate training on the application of the principles of Human Performance through the Human Performance Fundamentals course that is a required course and offered in the New Employee Orientation.

3.5.2.12 Transportation of Dangerous Goods

The Transportation of Dangerous Goods Program is intended to provide an operational framework for the safe transport of dangerous goods by conforming to all applicable laws, regulations, company policies and procedures. It enables an effective, consistent and comprehensive application of international standards.
The Transportation of Dangerous Goods Program applies to all modes of transport and all locations where CNL is responsible as the consignor (shipper), consignee (receiver), carrier or material owner of dangerous goods off-site. Dangerous goods include explosives, gases, flammable liquids, flammable solids, oxidizing substances and organic peroxides, toxic and infectious, radioactive material, corrosives and miscellaneous.

4.0 PUBLIC AND STAKEHOLDER ENGAGEMENT

Public and Indigenous engagement is a key component of the environmental assessment process and reflects the corporate social responsibility of Canadian Nuclear Laboratories (CNL). Indigenous engagement for the Near Surface Disposal Facility (NSDF) for the disposal of solid low-level radioactive waste at Chalk River Laboratories (CRL) (the 'NSDF Project') is discussed in Section 6.2 of the Environmental Impact Statement (EIS). Section 4.0 summarizes CNL's past and proposed public and stakeholder engagement initiatives, including documentation of meetings, presentation materials, discussion topics and outcomes, and relevant agreements. These activities are intended to fulfil the requirements for public engagement under the *Canadian Environmental Assessment Act, 2012* and the *Nuclear Safety and Control Act.* This section describes past, on-going and proposed public and stakeholder engagement activities and events in accordance with the Generic EIS Guidelines developed by the Canadian Nuclear Safety Commission (CNSC 2016), which state:

> *…the EIS will describe the ongoing and proposed participation activities that the proponent will undertake or that it has already conducted on the project. It will describe efforts made to distribute project information, as well information and materials that were distributed during the public consultation process. The EIS will indicate the methods used, where the consultation was held, the persons and organizations consulted, the concerns voiced and the extent to which this information was incorporated in the design of the project as well as in the EIS. The EIS will provide a summary of key issues raised related to the Project and its potential environmental effects, as well as describe any outstanding issues and ways to address them.*

In addition, CNSC and Canadian Environmental Assessment Agency guidance documents require that the following topics are to be included as part of public engagement activities:

- current Project information (CNSC 2016 Section 2.3);
- alternative means (The Agency 2015);
- Valued Components (VCs; CNSC 2016 Section 5.2.1);
- spatial and temporal boundaries (CNSC 2016 Section 5.2.2); and
- follow-up monitoring program (CNSC 2016 Section 12).

This section summarizes the public engagement activities undertaken for the NSDF Project that fulfill the requirements above.

4.1 Engagement Objectives

CNL is required to ensure that Project information is made available to local and host communities and stakeholder groups through a variety of mechanisms to ensure accessibility of information. Communication activities are conducted in support of this requirement; CNL's specific engagement objectives include:

1) initiating and maintaining two-way communication channels between CNL and host communities and stakeholder groups, determining the best methods for communicating Project information and facilitating input at appropriate junctures in the NSDF Project schedule, so that stakeholder feedback can be integrated into the Project planning and design, as appropriate;

2) developing meaningful, user-friendly information and communication products geared for host communities and stakeholders, ensuring accessible and current information on Project activities;

3) demonstrating CNL's long-term commitment and approach to safely and responsibly managing radioactive waste and decommissioning activities for the benefit of the future generations;

4) informing and educating host communities and stakeholders about nuclear decommissioning, environmental remediation and radioactive waste management; and

5) meeting all regulatory-based communication and engagement requirements.

CNL has employed a variety of methods and activities to achieve the stated objectives.

CNL has completed three stakeholder engagement reports representing the various time periods that the NSDF Project has spanned (Stakeholder Engagement Technical Supporting Documents [TSDs] 1, 2, 3; CNL 2017a,b, 2019a). These TSDs detail the engagement methods and activities through which the engagement objectives described above were achieved. These methods and activities provided valuable feedback for the NSDF Project to incorporate, as presented in Section 4.3. Their respective identification and period of applicability are defined below.

1) Environmental Assessment Stakeholder Activities Report – NSDF and NPD Closure Projects, March 2017 (August to December 2016) (CNL 2017a).

2) Stakeholder Activities Report – Near Surface Disposal Facility (NSDF), November 2017 (January to July 2017) (CNL 2017b).

3) Stakeholder Engagement Report – Near Surface Disposal Facility (NSDF), October 2019 (August 2017 to June 2019) (CNL 2019a).

4.1.1 Evaluation

The engagement objectives discussed above in Section 4.1 are used to measure the effectiveness of communication activities as well as the evolving nature of the communication strategy of the NSDF Project through events and activities. CNL evaluates several public engagement indicators including: level of participant satisfaction, audience representation, level of engagement with subject matter experts, level of understanding of the NSDF Project, and level of increased project understanding of community and stakeholder issues.

Through the use of various flexible modes of communication and public engagement, CNL has been able to engage a wider audience (demographically and geographically) who may have a stake in the development of the NSDF Project. By enabling two-way dialogue and implementing these accessible engagement mechanisms in the planning of the NSDF Project, CNL was able to adapt and respond to stakeholders' changing need for information. The NSDF Project's routine self-assessment of its public engagement activities, as well as public feedback, will enable CNL to continuously evaluate the effectiveness of its engagement efforts.

CNL has provided a summary evaluation of the NSDF communication program against each of the objectives in Section 4.1.

Objective 1: Initiating and maintaining two-way communication channels between CNL and host communities and stakeholder groups, determining the best methods for communicating project information and facilitating input at appropriate junctures in the project schedule.

CNL has initiated and maintained a progressive number of communication channels between CNL host communities and stakeholder groups.

Since CNL first initiated dialogue on the Near Surface Disposal Facility (NSDF) at an Environmental Stewardship Council (ESC) meeting in 2015 October, CNL has adapted and evolved techniques for communicating project information and facilitating input.

Two early techniques included providing regular updates at ESC meetings and hosting public information sessions in local communities.

Updates to the ESC have been consistently maintained at each of the three annual ESC meetings over the past four years.

In response to public feedback, public information sessions which were originally held in seven local communities in 2016, were expanded geographically to include two more communities, Arnprior and L'Isle-aux-Allumettes (Chapeau).

Finally, the format of the public information evolved in 2018 into an online webinar, held on a quarterly basis. This adaption was in response to continued interest in having more information available in French, in Quebec and in the Ottawa-Gatineau region. The newer online webinar format ensures accessibility for stakeholders in a wide range of places and for both French and English speaking stakeholders.

Other feedback on engagement techniques emphasized the need to create on-going channels of communications with the local community of scientific experts. In response, CNL established semi-monthly Breakfast Briefings in Deep River and more recently Pembroke, as well.

CNL has also coordinated a focus group on effluent discharge to evaluate the project’s plan.

CNL has started to offer one on one meetings with intervenors, with simultaneous translation if applicable.

The feedback that was used to evolve these techniques was obtained through both comments on the draft EIS and through feedback shared directly with CNL, through surveys, email and the online feedback forms.

Both hard copy and online feedback forms have been provided while email has also been a common tool used by stakeholders to engage with CNL and the NSDF Project. Feedback continues to be provided through CNL’s ever-expanding email distribution list (used to disseminate information, project milestones and timeline activities), social media, media, telephone, ESC, Ottawa Valley Economic Development, council meetings, meetings with Service Clubs and at public events.

CNL continues to receive, track and assess feedback for future planning.

Objective 2: Developing meaningful, user-friendly information and communication products geared for host communities and stakeholders, ensuring accessible and current information on project activities.

CNL has developed a variety of simple, user-friendly communications products that are accessible and meaningful to a broad audience in both official languages.

One example of this is the first NSDF overview infographic, which was posted online in 2017 and still has the highest number of downloads of all online NSDF content, after the draft Environmental Impact Statement (EIS). This was developed to address public concern that messaging around the NSDF was too technical. The infographic helped to simplify an overview of the project.

Due to the popularity of this infographic, CNL produced three additional infographics to help tell the story of the proposed NSDF.

The use of video was also essential to user-friendly and accessible communications. Online webinars were posted to YouTube. CNL created three videos on themes that were discerned from public feedback, including a video on what would happen to water effluent. One way CNL tested that the video – Water Management within the NSDF – was accessible, was by showing it to the ESC as a focus group to determine how useful and user-friendly the product was.

Another innovative way that CNL has communicated the NSDF Project includes the use of physical models. CNL had three different physical models created to support stakeholder understanding of the facility. In 2017, scale models of both the base and cover liners were created and used at public information sessions, public events and CNL's Open House in 2017. A third model, which was a 3D rendition of the proposed facility, went on a "tour" through the local communities with a residency at municipal offices in Deep River, Laurentian Hills and Petawawa, where the public could view what the proposed facility would look like.

In order to address accessibility feedback, document repositories have been functionally created by providing the EIS at local libraries and municipal offices.

Online content has also been updated and continually refreshed and reorganized, while at the same time maintaining old content to ensure transparency with stakeholders. CNL has consistently been responsive to feedback on online content. One comment early in the project was that the posters used at public information sessions should be made available online. All public open house posters are now posted to CNL's external website.

To ensure ease of understanding and user-friendliness and provision of meaningful information, CNL also adheres to internal and external standards on communications. Communications products like presentations align with CNL Corporate Branding Guidelines. Communication activities are audited annually through CNL's environmental protection program's ISO: 14001 certification.

Objective 3: Demonstrating CNL's long-term commitment and approach to safely and cost-effectively reducing Canada's nuclear legacy liabilities.

To demonstrate CNL's long-term commitment and approach to safely and cost-effectively reducing Canada's nuclear legacy liabilities in relation to the NSDF Project, CNL has focused on refining its messaging.

To this end, CNL has attempted to share the story of why the NSDF is needed and how it is part of the solution to safely reducing Canada's nuclear legacies. To this end, some communication focused on the relationship between the revitalization of the Chalk River Laboratories and its connection with the necessary remediation of the site and the NSDF Project.

In the context of the NSDF Project, CNL has provided more information on existing waste management practices and planned initiatives (such as the Integrated Waste Strategy) to communities and stakeholder groups than ever before.

Information on current waste storage and waste management has been woven into presentations, posters and online content related to the NSDF Project.

Site tours related to the NSDF Project, that have included members of the public, elected officials and media, visit legacy waste management areas as well as the proposed NSDF site, to provide perspective that the NSDF Project is an enabling facility to help with remediation of impacted areas at the CRL site.

Objective 4: Informing and educating host communities and stakeholders about nuclear decommissioning, environmental remediation and radioactive waste management.

At both a basic level and a technical level, CNL has informed and educated host communities and stakeholders about environmental remediation and radioactive waste management.

In particular, presentations prepared for stakeholder groups have included detail on existing waste management practices at CNL as well as information on what types of waste are proposed to be disposed of in the NSDF.

An infographic CNL produced (which is available online) also responds to questions on what kinds of waste is destined for the proposed NSDF.

CNL has also shared information on what specific impacts the NSDF would have on the public in terms of radiation dose. This has been achieved with a user-friendly “peak dose” graphic used in presentations with stakeholder groups and other communications products.

Some public feedback on the Project has showed that project communications and information need to be simple and clear enough for non-technical audiences to understand. CNL has strived to make language and communications tools as accessible as possible. For instance, the use of video and infographics has encouraged wide understanding of the Project.

Another way that CNL attempts to share information with a broad audience is through annual public events and activities. CNL regularly attends events like DownTown Connect in Pembroke and Petawawa Showcase, the Ottawa Valley’s largest home show.

Local high school students get a chance to learn about CNL’s waste management practices and how the proposed NSDF fits into the long-term plan on the annual Take Our Kids to Work Day event at Chalk River Laboratories. At annual public events in the community, CNL representatives regularly share updates on the NSDF Project and use communications products, such as the base and cover liner models and 3D models.

There has also been public feedback that has shown a strong interest in having technical and scientific information about the Project made available to the public.

One way that CNL has addressed this is to have third party expertise provide information on the project. Dr. Kerry Rowe from Queen’s University was invited to share details on the testing his laboratories performed on the material used for construction of the liners. Dr. Rowe shared a presentation at one of the semi-monthly Breakfast

Briefings in Deep River. A video with Dr. Rowe discussing the NSDF was also posted online to the NSDF webpage and CNL's YouTube channel.

Objective 5: Meeting all regulatory-based communication and engagement requirements.

CNL has aligned its stakeholder engagement strategy with regulatory requirements.

CNL began stakeholder engagement in support of the NSDF Project in 2015 October when CNL leadership introduced the project at the final ESC meeting for that year. By the end of 2016, engagement activities were fully underway. For more than four years CNL has modelled its engagement on the regulatory requirements found in REGDOC 3.2.1 Public Information and Disclosure as well as other CNSC guidance, such as the Generic Guidelines for the Preparation of an Environmental Impact Statement. The goals of CNL's stakeholder engagement program, outlined in the Near Surface Disposal Facility Stakeholder Engagement Report (CNL 2019a), are aligned with both the REGDOC 3.2.1 and CNL's Public Information and Disclosure Program (CNL 2020).

4.2 Engagement Methods and Activities

Engagement activities commenced on October 29, 2015, with the introduction of CNL's near- and longer-term plans, including high-level introduction to the NSDF Project, to the CNL Environmental Stewardship Council (ESC; Section 4.2.1.1). This section details Project-specific engagement methods and activities, which include the following:

- presentations to various stakeholders (members of the public, industry, elected officials and employees);
- publishing and updating Project-specific webpage content;
- posting and publishing Project-specific fact sheets;
- publishing and distributing *Contact* community newsletter;
- conducting NSDF Project site visits;
- conducting Project-specific public information sessions
- conducting Project-specific employee information sessions;
- publishing and distributing *Voyageur* CNL internal newsletter;
- participation in public events;
- increased transparency with interested members of the media – hosted journalists on-site for interviews and presentations on the Project (i.e., Radio-Canada's Decouvertes, Presse Canadienne, Carleton Master's Journalism students);
- “detect and correct” media relations (i.e., letters to the editor aimed at correcting inaccurate statements in articles, disseminating factual information);
- increased use of social media, including webinars, posting Project-specific videos to YouTube;
- advertising campaign in support of public information sessions (online, intranet, newspapers, flyer insert, radio public service announcement, social media, paid Facebook advertising);

- distribution of factsheets and comment cards to local municipal offices in Ontario and Quebec, to function as an information repository and support public input; and
- emails to stakeholders including notifications of the draft EIS submission and responses to questions submitted.

Project materials were prepared and distributed in both French and English. The following subsections outline specific engagement methods and activities already undertaken for the Project up to June 20, 2019. Engagement activities will continue as part of the environmental assessment process. The final EIS or the Commission Member Document (prepared to support the Commission Hearing) will include an update on public engagement activities and feedback.

4.2.1 Presentations / Site Tours

CNL uses presentations to help inform and educate stakeholders on the NSDF Project. These presentations have triggered discussion that help to inform the Project through the regulatory process.

As part of its Public Information Program (CNL 2020), CNL periodically hosts stakeholder visits to the NSDF Project site. These visits provide an opportunity for information sharing and open dialogue about the Project between CNL and stakeholders. These visits are used as one of several means of engaging with stakeholders.

4.2.1.1 Environmental Stewardship Council Meeting – October 2015

Established in 2006, the ESC meets three times annually with the objective of building working relationships and creating opportunities for open dialogue between various stakeholder groups, local communities and CNL. These conversations are integral in providing CNL with a wide range of viewpoints. During independently facilitated meetings, ESC members are presented with information about CNL and CNL's environmental practices, and have the opportunity to ask questions and discuss the information presented. Each meeting is documented (i.e., presentations and actions) and members are asked to take meeting information back to their respective constituents, organizations and communities.

On October 29, 2015, the NSDF Project was first introduced to the members of the ESC as a part of a Decommissioning and Waste Management update. The ESC has received regular Project updates at subsequent meetings since October 2015.

See Stakeholder Engagement TSD 1 (CNL 2017a).
Stakeholder(s): Local elected officials, local environmental organizations, and local non-governmental organizations (NGO)s.

4.2.1.2 Environmental Stewardship Council Meeting – June 2016

ESC members were given an NSDF project overview presentation, which included alternative means assessment and site selection considerations. Members also visited the proposed NSDF Project site and had the opportunity to ask questions related to the project.

See Stakeholder Engagement TSD 1 (CNL 2017a).
Stakeholder(s): Local elected officials, local environmental organizations and local NGOs.

4.2.1.3 World Nuclear University Site Visit – July 2016

The World Nuclear University is an organization that provides training to young professionals in the nuclear industry. The World Nuclear University brings an international industry perspective with participants from more than 20 countries.

Every year during its six-week summer session, the World Nuclear University arranges tours of the local nuclear institutions in the host country. In 2016, the World Nuclear University was hosted in Ottawa, and on July 15, 2016, 80 nuclear industry representatives / students toured CNL's Chalk River Laboratories (CRL) and Nuclear Power Demonstration (NPD) sites. Students were able to tour the NSDF Project site where subject matter experts presented on the proposed facility. Comment cards on the NSDF Project were provided to this group to receive international nuclear industry feedback.

See Stakeholder Engagement TSD 1 (CNL 2017a).
Stakeholder(s): Industry.

4.2.1.4 Non-governmental Organizations Site Visit – July 2016

Northwatch, the Canadian Environmental Law Association and the Concerned Citizens of Renfrew County represent three stakeholder groups interested in the environmental assessment activities for the NSDF Project. Northwatch and Canadian Environmental Law Association also participated in the CNSC request for comments on the Project description and provided their comments.

The group visited the NSDF Project site and had the opportunity to discuss their questions and concerns with subject matter experts.

See Stakeholder Engagement TSD 1 (CNL 2017a).
Stakeholder(s): NGOs.

4.2.1.5 Organization of Canadian Nuclear Industries Suppliers' Day – September 2016

On September 8, 2016, the Organization of Canadian Nuclear Industries Suppliers Day was held at the CRL site. This event was open to Organization of Canadian Nuclear Industries members and local non-member companies and provided an opportunity for CNL to engage representatives from more than 45 companies in the Canadian nuclear supply chain. A presentation on CNL decommissioning and waste management initiatives informed the industry participants about the plan for the NSDF Project.

See Stakeholder Engagement TSD 1 (CNL 2017a).
Stakeholder(s): Industry.

4.2.1.6 Nuclear Waste Management, Decommissioning and Environmental Restoration Conference Presentation – September 2016

At this industry conference, hosted by the Canadian Nuclear Society (CNS) and held in Ottawa, between September 11 and 14, 2016, a presentation on the NSDF Project was given. This presentation was an opportunity to inform, educate and receive feedback within the nuclear industry.

See Stakeholder Engagement TSD 1 (CNL 2017a).
Stakeholder(s): Industry, local elected officials.

4.2.1.7 Canadian Nuclear Society Site Visit – September 2016

A group of 19 individuals from the CNS Conference on Nuclear Waste Management, Decommissioning and Environmental Restoration visited the CRL site on September 15, 2016. The site visit provided an opportunity to elicit feedback on the NSDF Project from a cross-section of the nuclear industry. The site visit included a tour of the NSDF Project site.

See Stakeholder Engagement TSD 1 (CNL 2017a).
Stakeholder(s): Industry.

4.2.1.8 Environmental Stewardship Council Meeting – October 2016

On October 13, 2016, the ESC was briefed biodiversity findings and mitigation, archaeological findings, waste types and waste acceptance criteria, design updates and project schedule. Following these updates, members had the opportunity to seek clarification and raise any concerns they had with the NSDF Project.

See Stakeholder Engagement TSD 1 (CNL 2017a).
Stakeholder(s): Local elected officials, local environmental organizations and local NGOs.

4.2.1.9 Near Surface Disposal Facility Industry Day – November 2016

On November 8, 2016, the NSDF Project team hosted an industry day in Ottawa to introduce the NSDF Project and plans to construction companies so they could gain understanding of the NSDF Project and possible future construction opportunities.

See Stakeholder Engagement TSD 1 (CNL 2017a).
Stakeholder(s): Construction industry representatives.

4.2.1.10 Renfrew County Council Meeting, Presentation and Site Visit – December 2016

On December 12, 2016, CNL hosted the Renfrew County Council. The meeting included an overview presentation of CNL, as well as a specific presentation on the NSDF Project and a site tour. It provided an opportunity to offer updated information to council and answer questions.

See Stakeholder Engagement TSD 1 (CNL 2017a).
Stakeholder(s): Local elected officials.

4.2.1.11 Local Elected Officials Meeting and Presentation – December 2016

On December 12, 2016, CNL hosted the local elected officials for a site tour and presentation. The meeting included an overview presentation of CNL, as well as a specific presentation on the NSDF Project. It provided an opportunity to offer updated information to local elected officials and answer questions.

See Stakeholder Engagement TSD 1 (CNL 2017a).
Stakeholder(s): Local elected officials.

4.2.1.12 Ottawa Valley Economic Development Meeting – December 2016

The Ottawa Valley Economic Development Committee is composed of economic development officers from the local municipalities, as well key regional employers, for example, Canadian Forces Base Petawawa, CNL and Algonquin College. Ottawa Valley Economic Development holds bi-monthly meetings to discuss economic issues and opportunities throughout Ottawa Valley and Eastern Ontario. On December 15, 2016, CNL hosted a meeting which included a presentation on the NSDF Project.

See Stakeholder Engagement TSD 1 (CNL 2017a).
Stakeholder(s): Municipality, Industry.

4.2.1.13 Meeting and Project Briefing with Pontiac Member of Parliament – December 2016

At the request of the Pontiac Member of Parliament (MP), CNL attended a meeting at the MP's constituency office in Campbell's Bay, Quebec. The meeting, held on December 21, 2016, briefed the MP on the NSDF Project and enabled the MP to discuss the NSDF Project with CNL.

See Stakeholder Engagement TSD 1 (CNL 2017a).
Stakeholder(s): Local elected officials.

4.2.1.14 Technical Discussion Meeting – January 2017

A meeting to discuss technical aspects of the NSDF Project with former employees (alumni) and other members of the local scientific community was held on January 19, 2017, in Deep River, Ontario. This meeting was planned in response to a request from a local community member, who assisted in coordinating the discussion.

See Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Public within local community, industry.

4.2.1.15 Presentation and Meeting with Renfrew County Council – January 2017

On January 25, 2017, CNL representatives met with the Renfrew County Council. The meeting included more in-depth updates on the NSDF Project. It also provided CNL with an opportunity to answer questions.

See the Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Local elected officials.

4.2.1.16 Presentation to the Town of Deep River – January 2017

On January 25, 2017, CNL representatives presented to the Deep River Town Council at an open council meeting. The presentation was an overview of CNL activities with specific updates on the NSDF Project. It also provided an opportunity to answer questions from local government and members of the public.

See Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Local elected officials, public within the local and host communities.

4.2.1.17 Presentation to the Upper Ottawa Valley Chamber of Commerce – January 2017

On January 27, 2017, CNL representatives presented to the Upper Ottawa Valley Chamber of Commerce at the organization's annual general meeting in Pembroke, Ontario. The presentation was an overview of CNL activities with specific updates on the NSDF Project. It also provided an opportunity to answer questions from the local business community and share information on CNL's economic impact.

See Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Public within local and host communities.

4.2.1.18 Presentation to the Eastern Ontario Wardens' Caucus – January 2017

On January 31, 2017, CNL representatives attended the Rural Ontario Municipal Association conference and presented to the Eastern Ontario Wardens' Caucus on CNL's activities, with a specific look at the NSDF Project. It led to a presentation to the United Counties of Prescott Russell in February 2017.

See Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Local elected officials.

4.2.1.19 Presentation to the United Counties of Prescott Russell – February 2017

CNL representatives attended the United Counties of Prescott and Russell's council meeting, by invitation, on February 8, 2017. The presentation included an overview of CNL, with a focus on the NSDF Project and the NPD Closure Project.

See Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Local elected officials, media.

4.2.1.20 Presentation to Pontiac Regional County Municipality – February 2017

CNL representatives attended the council meeting of the Pontiac Regional Municipal Council (*Municipalité régionale de comté* [MRC]) on February 14, 2017. The presentation included an overview of CNL, with a focus on the NSDF Project and the NPD Closure Project.

See Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Local elected officials.

4.2.1.21 Environmental Stewardship Council Meeting – March 2017

On March 23, 2017, one of the three annual ESC meetings was held. Members were briefed on highlights of the draft EIS submission, design progress and next steps, waste inventory and waste acceptance criteria. Following these updates, members had the opportunity to seek clarification and raise any concerns they had with the NSDF Project.

See Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Local elected officials, local environmental organizations and local NGOs.

4.2.1.22 Sheenboro Municipal Council Meeting and Presentation – April 2017

CNL representatives attended the Municipality of Sheenboro's council meeting on April 3, 2017. The presentation included an overview of CNL, with a focus on the NSDF Project and the NPD Closure Project.

See Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Local elected officials, members of the public.

4.2.1.23 Pembroke City Council Meeting and Presentation – April 2017

CNL representatives attended the City of Pembroke's council meeting on April 18, 2017. The presentation included an overview of CNL, with a focus on the NSDF Project and the NPD Closure Project.

See the Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Local elected officials, members of the public.

4.2.1.24 Laurentian Hills Town Council Meeting and Presentation – April 2017

CNL representatives attended the Town of Laurentian Hill's council meeting on April 19, 2017. The presentation included an overview of CNL, with a focus on the NSDF Project and the NPD Closure Project.

See Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Local elected officials, members of the public.

4.2.1.25 Arnprior Town Council Meeting and Presentation – April 2017

CNL representatives attended the Town of Arnprior's council meeting on April 24, 2017. The presentation included an overview of CNL, with a focus on the NSDF Project.

See Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Local elected officials, members of the public.

4.2.1.26 Petawawa Town Council Meeting and Presentation – May 2017

CNL representatives attended the Town of Petawawa's council meeting on May 1, 2017. The presentation included an overview of CNL, with a focus on the NSDF Project and the NPD Closure Project.

See Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Local elected officials, members of the public.

4.2.1.27 L'Isle-Aux-Allumettes Town Council Meeting and Presentation – May 2017

CNL representatives attended the Town of L'Isle-Aux-Allumette's council meeting on May 2, 2017. The presentation included an overview of CNL, with a focus on the NSDF Project and the NPD Closure Project.

See Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Local elected officials, members of the public.

4.2.1.28 Environmental Stewardship Council Meeting – June 2017

On June 22, 2017, the ESC was briefed on CNSC/CNL administrative protocol update, review of alternative means, NSDF benchmarking, biodiversity and archeological field activities, communication and engagement activities. Members were also given a second presentation detailing the NSDF waste acceptance criteria. Following these updates, members had the opportunity to seek clarification and raise any concerns they had with the NSDF Project.

See Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Local elected officials, local environmental organizations and local NGOs.

4.2.1.29 Pontiac Regional County Municipality Council Site Visit – July 2017

On July 11, 2017, the MRC Pontiac council visited the CRL site and had a presentation on the NSDF Project and site visit. Following the presentation and tour, members had the opportunity to seek clarification and raise any concerns they had with the NSDF Project.

See Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Local elected officials.

4.2.1.30 Old Fort Williams Cottagers' Association Meeting and Presentation – July 2017

On July 15, 2017, CNL staff gave a presentation on the NSDF Project to members of the Old Fort Williams Cottagers' Association. Following the presentation, members had the opportunity to seek clarification and raise any concerns they had with the NSDF Project.

See Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Concerned members of the public.

4.2.1.31 Bloc Québécois Leader Mme Ouellette Presentation and Site Visit – August 2017

On August 10, 2017, Mme Ouellette came to the CRL site for a CNL overview presentation with a focus on the NSDF Project and NPD Closure Project. Following the presentation, Mme Ouellette had a tour of site and had the opportunity to seek clarification and raise any concerns the Bloc Québécois had with the NSDF Project. A reporter with the Canadian Press also attended and reported on the meeting.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Elected official, media.

4.2.1.32 Nuclear Energy Agency Presentation and Site Visit – October 2017

On October 3, 2017, Nuclear Energy Agency staff came to the CRL site for a CNL overview presentation with a focus on the NSDF Project and NPD Closure Project. They had a tour of site and the opportunity to seek clarification and raise any concerns they had with the NSDF Project.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Nuclear industry.

4.2.1.33 Environmental Stewardship Council Meeting – October 2017

On October 26, 2017, the ESC was briefed on the NSDF design completion, and the removal of Intermediate Level Waste from the NSDF. A second presentation was giver to members on the proposed valued components of the NSDF Project. During this meeting, members took a walking tour of the Chalk River campus to gain an understanding of the buildings that would be demolished and destined for the prosed NSDF if they meet the new waste acceptance criteria. Following these updates, members had the opportunity to seek clarification and raise any concerns they had with the NSDF Project.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Local elected officials, local Indigenous peoples, local environmental organizations and local NGOs.

4.2.1.34 Take Our Kids to Work Day – November 2017

CNL participates annually in Take Our Kids to Work Day for students in grade nine to introduce them to different careers and areas of work. Approximately 80 students come to the CRL site. On November 1, 2017, a presentation and tour component were included about the NSDF Project.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Employees, general public (students).

4.2.1.35 Ottawa Riverkeeper Presentation and Site Tour – November 2017

On November 16, 2017, Ottawa Riverkeeper, a charitable organization advocating for the Ottawa River watershed, came to the CRL site for a tour with presentations on the NSDF Project. Attendees had the opportunity to seek clarification and raise any concerns they had with subject matter experts available to answer their questions.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Local environmental organizations.

4.2.1.36 Near Surface Disposal Facility Technical Discussion Meeting Day 1 – December 2017

A meeting to discuss technical aspects of the NSDF Project with former employees (alumni) and other members of the local scientific community was held on December 6, 2017, in Deep River, Ontario. This meeting was planned in response to a request from a local community member, who assisted in coordinating the discussion.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Concerned public, industry, alumni, elected officials.

4.2.1.37 Near Surface Disposal Facility Technical Discussion Meeting Day 2 – December 2017

A meeting to discuss technical aspects of the NSDF Project with former employees (alumni) and other members of the local scientific community was held on December 14, 2017, in Deep River, Ontario. This meeting was planned in response to a request from a local community member, who assisted in coordinating the discussion.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Concerned public, industry, alumni, elected officials.

4.2.1.38 Meeting with Hull-Aylmer Member of Parliament Greg Fergus – February 2018

At the request of MP Fergus, NSDF Project staff met with him on February 26, 2018, to discuss the Project. This gave him the opportunity to gain understanding of the NSDF Project and seek clarification on issues his constituents had brought up to him.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Government officials.

4.2.1.39 Town Hall with Hull-Aylmer Member of Parliament Greg Fergus – March 2018

At the request of MP Fergus, CNL staff presented at a town hall meeting in Gatineau on March 5, 2018. This gave Gatineau constituents the opportunity to gain understanding of the NSDF Project and seek clarification on areas they had concerns with.

See Stakeholder Engagement TSD 3 (CNL 2019).
Stakeholder(s): Government officials, members of the public.

4.2.1.40 Nuclear Footprints Program Presentation and Site Tour – March 2018

As a part of an international program, participants travelled to different nuclear facilities in Canada to learn about Canada's nuclear industry. Participants had a tour and presentation on March 6, 2018, to discuss the NSDF Project. On March 7, 2018, the participants had a breakfast panel with local elected officials and members of CNL staff to further discuss the projects and gain perspective from host community leaders.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): International industry, local elected officials.

4.2.1.41 Member of Ontario Provincial Parliament John Yakabuski Site Visit – April 2018

MPP Yakabuski attended a meeting at the Deep River offices of CNL on April 3, 2018, to learn about the NSDF Project and NPD Closure Project. He had the opportunity to speak directly with subject matter experts about concerns constituents had raised to him and gain understanding of the projects and CNSC processes that are being adhered to for the proposed projects.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Government official.

4.2.1.42 Member of Parliament Will Amos Site Visit – April 2018

MP Amos attended the CRL site on April 4, 2018, to learn about the NSDF Project and NPD Closure Project. He had the opportunity to tour the NSDF Project site and speak directly with subject matter experts about concerns constituents had raised to him. He also had the opportunity to gain understanding of the projects and CNSC processes that are being adhered to for the proposed projects.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Government official.

4.2.1.43 Environmental Stewardship Council Meeting – April 2018

On April 5, 2018, the ESC was briefed on the updated project schedule, completion of stage 3 and 4 archeological assessments, design improvements based on feedback and key stakeholder issues relevant to the NSDF performance assessment. Following these updates, members had the opportunity to seek clarification and raise any concerns they had with the NSDF Project.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Local elected officials, local environmental organizations and local NGOs.

4.2.1.44 Canadian Nuclear Workers Council (CNWC) Presentation – June 2018

On June 19, 2018, members of the CNWC (collective voice of organized labour in Canada's Nuclear Industries) were given a presentation on the NSDF Project. Following the presentation, members had the opportunity to seek clarification and raise any concerns they had with the NSDF Project.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Industry.

4.2.1.45 Environmental Stewardship Council Meeting – June 2018

On June 21, 2018, the ESC was briefed on common themes identified from the federal and public comments submitted on the draft EIS, these included proximity to the river, waste acceptance criteria, international standards, facility design and follow-up monitoring programs. During this presentation, an ESC action was addressed on comparing the NSDF to similar facilities that have been capped/closed for over ten years. Following these updates, members had the opportunity to seek clarification and raise any concerns they had with the NSDF Project.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Local elected officials, local environmental organizations and local NGOs.

4.2.1.46 Eastern Ontario Water Works Association Conference – October 2018

On October 24, 2018, CNL staff attended the Eastern Ontario Water Works Association Conference to present on the NSDF Project and the NPD Closure Project. The presentation offered attendees information about both projects and the opportunity to gain understanding of what is being proposed as well as opportunity to ask questions.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Municipal water works professionals.

4.2.1.47 Environmental Stewardship Council Meeting – October 2018

On October 18, 2018, the ESC was briefed on project timeline and planning basis, treated effluent transfer design with a review of considerations and benefits of the proposed change. Following these updates, members had the opportunity to seek clarification and raise any concerns they had with the NSDF Project.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Local elected officials, local environmental organizations and local NGOs.

4.2.1.48 Carleton University Journalism Master's Students Presentation and Site Visit – November 2018

On November 28, 2018, two master's students, who were writing a piece for the media, from Carleton University were given a CNL overview presentation with a focus on the NSDF Project and the NPD Closure Project. Following the presentations, the students went on a site tour and had the opportunity to seek clarification and raise any concerns they had with the projects.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Academia (media).

4.2.1.49 Warden Jane Toller and Pontiac Regional County Municipality Staff Presentation and Site Visit – December 2018

On December 11, 2018, Warden Jane Toller and MRC Pontiac staff were given a CNL overview presentation with a focus on the NSDF Project and the NPD Closure Project. Following the presentations, they went on a site tour and had the opportunity to seek clarification and raise any concerns they had with the NSDF Projects.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Local elected officials.

4.2.1.50 Renfrew and Pontiac Counties Elected Officials Information Day – February 2019

On February 15, 2019, local elected officials from both Renfrew and Pontiac counties were invited to the CRL site for updates and presentations on CNL and the NSDF Project and NPD Closure Project. Officials were also invited to tour the CRL site. Throughout the day, officials had the opportunity to seek clarification and raise any concerns they had with the projects and ask questions about CNL.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Local elected officials.

4.2.1.51 Meeting with Representatives of the Government of Quebec – February 2019

On February 28, 2019, CNL staff from the NSDF Project and the NPD Closure Project went to Quebec City to meet with representatives from the Government of Quebec to discuss the NSDF Project and NPD Closure Project. Throughout the day, representatives had the opportunity to seek clarification and raise any concerns they had with the projects.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Government of Quebec officials.

4.2.1.52 Carleton University Civil and Environmental Engineering Students Presentation and Site Tour – March 2019

On March 8, 2019, students from Carleton University visited the CRL site for a tour and presentations on CNL and the NSDF Project and NPD Closure Project. Throughout the day, the students had the opportunity to seek clarification and raise any concerns they had with the projects and ask questions about CNL.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Academia (engineering students).

4.2.1.53 Environmental Stewardship Council Meeting – March 2019

On March 28, 2019, the ESC was briefed on geomembrane testing program, enabling activities including the final archeological assessment and turtle road mortality plan. During this presentation two ESC actions were covered on the revised NSDF study area and the detailed inventory of the NSDF. ESC members were the first audience for the NSDF water video which detailed how risk from precipitation would be mitigated. Following these updates, members had the opportunity to seek clarification and raise any concerns they had with the NSDF Project.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Local elected officials, local environmental organizations and local NGOs.

4.2.1.54 Breakfast Briefing – April 2019

Bi-monthly Breakfast Briefings were introduced in 2019 April. The Breakfast Briefings offer an opportunity for Alumni and interested members of the public to gain a further technical understanding of the NSDF project. On April 24, 2019, the NSDF team presented on *Factors affecting radioactive waste disposal decisions,* and attendees had the opportunity to seek clarification and raise any concerns they had with NSDF Project subject matter experts.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Alumni, Interested members of the public, local elected officials.

4.2.1.55 Presentation to Laurentian Valley Township Council – May 2019

On May 07, 2019, project staff attended the Laurentian Valley Township's council meeting and gave a presentation on the NSDF project. Council members had the opportunity to seek clarification and raise any concerns they had with the project.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Local elected officials.

4.2.1.56 NSDF Effluent Discharge Alternatives Focus Group – May 2019

On May 10, 2019, CNL invited members of different interest groups to participate in a focus group discussing effluent discharge alternatives for the proposed NSDF. Members input and discussion was used to determine options and path forward for the proposed effluent discharge options analysis process.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Alumni, local environmental organizations.

4.2.1.57 Hill Times Journalist Presentation and Site Visit – May 2019

On May 27, a journalist from the Hill Times was given an overview presentation with a focus on the proposed NSDF project. Following the presentation, the journalist had the opportunity to interview project staff for a piece and had the opportunity to seek clarification and ask any questions he had about the project.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Media.

4.2.1.58 Moderated Forum with City of Gatineau Councillor Duggan – May 2019

On May 30, at the invitation of Mike Duggan, City Councillor for the City of Gatineau, CNL attended a moderated forum for the public in Gatineau, Quebec, to share information about CNL, in particular, the proposed NSDF and the NPD Closure Project. Council members and members of the public had the opportunity to seek clarification and raise any concerns they had with the project. NSDF Project subject matter experts were in attendance.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Members of the public, elected officials

4.2.1.59 Environmental Stewardship Council Meeting – June 2019

On June 20, 2019, the ESC was briefed on ESC actions that had been addressed. They were then given project update, project justification and CRL clean-up plan presentations. Following these updates, members had the opportunity to seek clarification and raise any concerns they had with the NSDF Project.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Local elected officials, local environmental organizations and local NGOs.

4.2.1.60 Breakfast Briefing – June 2019

The bi-monthly Breakfast Briefings offer an opportunity for Alumni and interested members of the public to gain a further technical understanding of the NSDF project. On June 26, 2019, Dr. Kerry Rowe (Queen's University) presented on *A barrier system for a 550 design life,* and attendees had the opportunity to seek clarification and raise any concerns they had with NSDF Project subject matter experts.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Alumni, Interested members of the public.

4.2.2 Webinars

Beginning in October 2018, webinar sessions were introduced as another way to increase accessibility and to disseminate information to the public and answer their questions (Table 4.2.2-1). Webinars are the evolution of the Public Information Sessions (see Section 4.2.2.1), as turnout to the face to face poster sessions was limited. CNL remains available to provide a community based public information session when there is an expressed interest from stakeholders. The webinars were conducted from the CRL site, but they were accessible to anyone with internet access. The webinar updates were designed to provide an overview and quarterly updates of the NPD Closure Project and the NSDF Project. They provided updated information and addressed questions from the public, based on the themes from public review of the draft EIS. Webinar sessions also provided access for members of the public to ask their questions directly to the staff members taking part in the webinar through an online forum. Beginning in March 2018 webinars were conducted in both official languages. All videos were uploaded to the CNL YouTube channel after broadcast.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): General public

Table 4.2.2-1: Webinars on the Near Surface Disposal Facility Project to Date

Date	NSDF/NPD	NSDF Topics
October 17, 2018	NSDF/NPD	▪ Engineering and Design ▪ Waste Acceptance Criteria ▪ Long-term Performance ▪ Protection of the Ottawa River
March 20, 2019	NSDF/NPD	▪ Justification for the NSDF Project ▪ Proposed Inventory ▪ Geomembrane Performance ▪ Archeological Significance

4.2.2.1 Public Information Sessions

Public information sessions were conducted in June/July 2016, October 2016 and April/May 2017 to help CNL inform, educate and solicit feedback from members of the local and host communities surrounding the NSDF Project site.

The topics presented at the public poster board sessions began with a description of the Project and facility (including an area map), the proposed Project timeline, Valued Components (VCs) (soliciting feedback from visitors on which VCs are important to them) and an overview of the environmental assessment process and regulatory approvals required.

As sessions progressed and feedback was received, the poster boards and presentation materials were developed to address the questions and concerns that were heard and to present the additional Project information that was available. For example, to-scale model tubes depicting the base layers and top cover layers of the engineered containment mound were created to help the public visualize what the layers will be. A significant effort was made to share updated information that responded to specific areas of interest and to provide a broader context of how the project fits into CNL's overarching goals.

Subject matter experts in different areas of interest such as groundwater monitoring, species at risk and project design were available at the sessions to answer questions and engage in one-on-one dialogue with event guests. See Stakeholder Engagement TSD 3 (CNL 2019a) for a complete list of subject matter experts.

The locations of the public information sessions were chosen based on proximity to the NSDF Project site and population size, with a few sessions also added in specific locations where they were requested. Dates and locations of public information sessions are summarized in Table 4.2.2-2.

Table 4.2.2-2: Public Information Session Dates and Locations

Date	Location	Date	Location
June 20, 2016	Rapides-des-Joachims	October 26, 2016	Chalk River
June 21, 2016	Deep River	October 27, 2016	Petawawa
June 22, 2016	Stonecliffe	April 20, 2017	Deep River
June 29, 2016	Sheenboro	April 24, 2017	Stonecliffe
July 6, 2016	Pembroke	April 25, 2017	Chalk River

Table 4.2.2-2: Public Information Session Dates and Locations

Date	Location	Date	Location
July 7, 2016	Petawawa	April 26, 2017	Rapides-des-Joachims
July 12, 2016	Chalk River	May 1, 2017	Petawawa
October 17, 2016	Rapides-des-Joachims	May 2, 2017	Sheenboro
October 18, 2016	Deep River	May 3, 2017	Pembroke
October 19, 2016	Stonecliffe	May 9, 2017	Arnprior

See Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): Local and host communities, local elected officials.

4.2.2.2 Poster Boards

The poster boards were created with content specific to the NSDF Project. They were developed with the intent to educate and prompt discussion about the NSDF Project. The poster boards were used to support tactics such as presentations, public information sessions, employee information sessions, site visits and public events.

Throughout the iterations of the information sessions CNL created several new informational poster boards with updated information to share with the local communities. The posters were set out to describe the narrative of why CNL is planning the NSDF Project and how CNL is proposing to execute the NSDF Project. As the NSDF Project evolved the content of the poster boards also evolved to convey updated information and address different issues as they became prevalent as areas of concern for the public. The poster boards were a versatile tactic used in conjunction with other tactics such as presentations, videos, visual and tactile examples. The poster boards have been used during public information sessions, the employee information sessions, site visits and community events, such as the Petawawa Showcase.

Poster board topics included:

- CRL site revitalization;
- What will the facility look like?
- a safe solution;
- the EIS;
- proposed waste solution;
- disposal site selection;
- safe by design;
- waste streams;
- cultural resource management;
- What you told us;
- CNL protecting the environment;

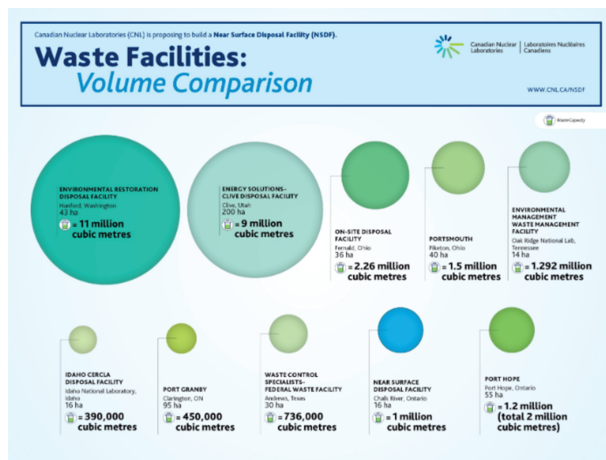
- CNL regulatory oversight;
- Project description;
- disposal facility graphic representation;
- proposed disposal facility locations;
- VCs;
- biodiversity; and
- What is an environmental assessment?

See the Stakeholder Engagement TSD 2 (CNL 2017b).
Stakeholder(s): General public

4.2.2.3 Communications Materials at Public Information Sessions

Communications materials at the public information sessions were provided in several formats:

- informational poster boards;
- Project factsheets/infographics;
- Project description;
- environmental monitoring reports;
- informational videos;
- visual aids (to scale tubes, sample pieces of liners); and
- feedback forms.



Example of a Near Surface Disposal Facility Infographic

4.2.3 Employee Engagement

To reach internal stakeholders, a variety of tactics were employed to disseminate information to employees, including employee information sessions, articles and videos on myCNL (intranet site), all-staff meetings and presentations held for the NSDF Project.

Stakeholder(s): Employees.

Canadian Nuclear Laboratories Staff Member Answering Questions at an Internal Information Session

4.2.3.1 Employee Information Sessions – June 2016

On June 21 and 24, 2016, employee information sessions were held in Deep River and at the CRL site, respectively, for employees to learn about the NSDF Project and NPD Closure Project. These internal events were similar to the public information sessions, with the same communications products used and a similar level of access with subject matter experts for the NSDF Project.

See Stakeholder Engagement TSD 2 (CNL 2017b).

4.2.3.2 Employee Information Sessions – November 2016

On November 16 and 17, 2016, employee information sessions were held in Deep River at the CRL site, respectively, for employees to learn about the NSDF Project and NPD Closure Project. These internal events were similar to the public information sessions, with the same communications products used and a similar level of access with subject matter experts for the NSDF Project.

See Stakeholder Engagement TSD 2 (CNL 2017b).

4.2.3.3 Canadian Nuclear Laboratories All-Staff Meeting – March 2017

On March 28, 2017, CNL hosted an all-staff meeting in the CRL cafeteria with live feeds to all other site locations to present to staff about the NSDF Project. Following the presentation, members of staff had the opportunity to seek clarification and raise any concerns they had with the Project.

See Stakeholder Engagement TSD 2 (CNL 2017b).

4.2.3.4 myCNL TV – Near Surface Disposal Facility – May 2018

In a similar fashion to the webinars (Section 4.2.2.1), on May 18, 2018, a broadcast was done through the CNL intranet to provide staff with an update on the NSDF Project. Staff had the opportunity to gain understanding of the Project and send in questions to be answered during the broadcast.

See Stakeholder Engagement TSD 3 (CNL 2019a).

4.2.3.5 Near Surface Disposal Facility 3-D Model – February 2019

A 3-D model of the NSDF Project site was built and put on display on the CRL site along with informational banners and a video to increase staffs understanding of the NSDF Project.

See Stakeholder Engagement TSD 3 (CNL 2019a).

4.2.3.6 New Employee Orientation – On-going

All CNL employees take part in a week-long orientation when they start their roles. As a part of the orientation, a presentation is given that introduces three major projects (one being the NSDF Project) to the employees. This gives new employees a firsthand introduction to the projects and the ability to ask any questions they have directly.

4.2.4 Community Events and Conferences

One tactic to support the stated communications objectives of initiating two-way communications and informing and educating was to have CNL representatives attend community events local to the NSDF Project site as well as industry conferences to expand the reach of stakeholders beyond the local community. Attendance at each event is described in the following sections.

Stakeholder(s): General public, local elected officials, industry, local environmental organizations and local NGOs.

4.2.4.1 Rotary Club of North Renfrew – Annual Dinner – July 2016

CNL was invited to present at the Rotary Club of North Renfrew's Annual Dinner. The President and CEO presented on CNL's Vision 2026 with a focus on the NSDF Project on July 20, 2016. There were no questions and comments related to the NSDF Project.

See the Stakeholder Engagement TSD 1 (CNL 2017a).

4.2.4.2 Petawawa Showcase – September 2016

CNL attended Petawawa Showcase September 23 – 25, 2016. It is the Ottawa Valley's largest spring and fall home, consumer and leisure show in September. The event drew approximately 10,000 visitors from across the Ottawa Valley and western Quebec. To ensure visibility, CNL secured a 20 by 20-foot exhibitor space. Informational posters on the NSDF Project were displayed and subject matter experts described Project activities, facilitated discussion about the Project and responded to public inquiries.

4.2.4.3 Canadian Nuclear Association Annual Conference – February 2017

CNL has a presence at the Canadian Nuclear Association conference every year. At the conference held on February 22 – 24, 2017, CNL had information on the company and both the NSDF Project and NPD Closure Project on interactive touch screens, as well as informational handouts on both projects at the booth.

4.2.4.4 Petawawa Showcase – April 2017

On April 28 – 30, 2017, CNL had an exhibit booth at Petawawa Showcase. CNL annually attends Spring Showcase, as it is one of the largest community events in the Ottawa Valley. The event gives CNL a direct means to discuss CNL and the NSDF Project and NPD Closure Project with members of the general public who otherwise may not engage with the company. General questions, concerns and rumours can be addressed directly with those who have an interest.

4.2.4.5 Canadian Nuclear Society Annual Conference – June 2017

CNL has a presence at the CNS conference every year. At the conference held on June 4 – 7, 2017, CNL had information on the company and both the NSDF Project and NPD Closure Project on interactive touch screens, as well as informational handouts on both projects at the booth.

4.2.4.6 Canadian Nuclear Laboratories Open House – August 2017

On August 12, 2017, CNL hosted an Open House on the CRL site. The Open House had over 2,000 people register and as a part of the day presentations and site tours of the NSDF Project site were offered. Interested attendees could learn about the project, see the proposed site and seek clarification from subject matter experts.

4.2.4.7 Renfrew County Plowing Match – September 2017

On September 16, 2017, CNL attended the Renfrew County Ploughing Match. Interested attendees could learn about the NSDF Project and seek clarification from subject matter experts with regard to their concerns. Additionally, informational handouts were available at the booth.

4.2.4.8 Canadian Nuclear Association Annual Conference – February 2018

CNL has a presence at the Canadian Nuclear Association conference annually. At the conference on February 21 – 23, 2018, CNL had information on both the NSDF Project and NPD Closure Project on interactive touch screens, as well as informational handouts at the booth.

4.2.4.9 Waste Management Symposium – March 2018

On March 18 – 22, 2018, CNL attended the Waste Management Symposium and had information on CNL and both the NSDF Project and NPD Closure Project on informational handouts at the booth. Subject matter experts also attended to discuss the projects as part of conference sessions. A paper titled "*Identification of Waste Streams and Chemicals of Concern for CNL's Near Surface Disposal Facility"* was presented as a part of the conference proceedings.

4.2.4.10 Petawawa Showcase – April 2018

On April 27 – 29, 2018, CNL had an exhibit booth at Petawawa Showcase. CNL annually attends Spring Showcase, as it is one of the largest community events in the Ottawa Valley. The event gives CNL a direct means to discuss CNL and the projects with members of the general public who otherwise may not engage with the company. General questions, concerns and rumours can be addressed directly with those who have an interest.

4.2.4.11 CNL Downtown Connect Pembroke – May 2018

On May 11 – 12, 2018, CNL had an exhibit booth at Downtown Connect Pembroke. CNL annually attends Downtown Connect as it is one of the largest community events in the Ottawa Valley. CNL The event gives CNL a direct means to discuss CNL and the projects with members of the general public who otherwise may not engage with the company. General questions, concerns and rumours can be addressed directly with those who have an interest.

4.2.4.12 Canadian Nuclear Society Annual Conference – June 2018

CNL has a presence at the CNS conference every year. At the conference held on June 3 – 7, 2018, CNL had information on the company and both the NSDF Project and NPD Closure Project on interactive touch screens, as well as informational handouts on both projects at the booth.

4.2.4.13 Canadian Nuclear Association Annual Conference – February/March 2019

CNL has a presence at the Canadian Nuclear Association conference annually. At the conference on February 28 – March 02, 2019, CNL had information on both the NSDF Project and NPD Closure Project on interactive touch screens, as well as informational handouts at the booth.

4.2.4.14 Near Surface Disposal Facility 3-D Model – February/March 2019

A 3-D model of the NSDF Project site was built and put on display in the Deep River Town Hall for two weeks along with informational banners and a video to give members of CNL's "host community" more information on the NSDF Project. At the Deep River location, NSDF Project staff were available Monday to Friday during lunch hours.

4.2.4.15 Near Surface Disposal Facility 3-D Model – March/April 2019

A 3-D model of the NSDF Project site was built and put on display in the Laurentian Valley for two weeks along with informational banners and a video to give community members more information on the NSDF Project.

4.2.4.16 NSDF 3D Model – May 2019

A 3-dimensional model of the proposed NSDF and proposed CRL site location was constructed and put on display in the Town of Petawawa office for two weeks along with informational banners and a video to give community members more information on the NSDF Project.

4.2.4.17 Downtown Connect Pembroke – May 2019

On May 10 – 11, 2019, CNL had an exhibit booth at Downtown Connect Pembroke. CNL annually attends Downtown Connect Pembroke as it is one of the largest community events in the Ottawa Valley. It gives CNL a direct means to discuss CNL and the proposed NSDF project with members of the general public that otherwise may not engage with us. General questions, concerns and rumours can be addressed directly with those that have an interest.

4.2.4.18 Canadian Nuclear Society (CNS) Conference – June 2019

CNL has a presence at the CNS conference every year. At the conference held on June 23 – 27, 2019, CNL had information on the company and both the NSDF Project and NPD Closure Project on interactive touch screens, as well as informational handouts on both projects at the booth. CNL

4.2.5 Webpage Content

CNL has established a Project-specific webpage: www.cnl.ca/NSDF. Quick links have been added to the landing page, raising Project visibility and making it easier to access the appropriate pages. Since August 2016, updated information has been added to the Project webpage, and webpage activity continues to be tracked and analyzed using Google Analytics.

See Stakeholder Engagement TSD 3 (CNL 2019a).

The webpage has been updated with new content as it becomes available. Frequently asked questions, Project infographics, informational videos, a Project description, the draft EIS, poster boards, quick facts, the Project timeline and public comments on the draft EIS broken down into themes have all been added to the NSDF Project webpage.

In an effort to improve EIS supporting document access and transparency CNL continues to post key EIS technical support documents and any revisions and updates to these documents as they become available. In addition, starting March 2019 CNL has committed to posting all external project presentations to the NSDF Project webpage.

On the project web page, there are mechanisms for the user to share feedback on the project through an online submission form and a "mailto" hyperlink that sends an email into the CNL Corporate Communications general mail box. All submissions are recorded as a part of public feedback and receive a reply from a CNL representative.

See Stakeholder Engagement TSD 3 (CNL2019a).
Stakeholder(s): All stakeholders.

4.2.6 Infographics/Fact Sheets

Two infographics, or fact sheets, were created and made available online and in hard copy to better convey information in a succinct digestible format for members of the public. The first was 10 facts about the proposed NSDF and the second was a volume comparison to put the proposed amount of waste in perspective.

The infographics are published on the web page and has been used at Public Information Sessions, Open Houses, and many other community events. The NSDF Project infographics have proven to be an effective method for relaying some technical aspects of the project in a simplistic format that the general public can understand.

In addition, copies of the fact sheets have been sent to seven local municipal offices to function as an information repository, as recommended by the CSA (CSA Group 2014), and to support greater awareness in local host communities.

See Stakeholder Engagement TSD 1 (CNL 2017a) and TSD 3 (CNL 2019a).
Stakeholder(s): All stakeholders.

4.2.7 Newsletters

CNL's *Voyageur* newsletter is an internal newsletter that is distributed across all CNL sites monthly.
When applicable, Project updates and articles have been included. The newsletter is available in hard copy and through the CNL intranet site.

See Stakeholder Engagement TSD 3 (CNL 2019a).
Stakeholder(s): Employees.

CNL's *CONTACT* newsletter is published and mailed to approximately 55,000 residences in the Renfrew and Pontiac counties and is available on www.cnl.ca. This publication informs the reader on activities undertaken at CNL's various sites and profiles CNL's community activities.

The Summer 2016 issue of *CONTACT* focused on CNL's major projects, including the NSDF Project, and related environmental assessment activities.

Each subsequent newsletter has had a NSDF Project update included in it.

See the Stakeholder Engagement TSD 1 (CNL 2017a) and TSD 3 (CNL2019a).
Stakeholder(s): Local and host communities.

4.2.8 Email

Emails have been used to connect with internal and external stakeholders, as well as with NGOs. In particular, emails were sent out to promote different events, to advise of the public comment period on the draft EIS and to provide responses to questions submitted electronically. Stakeholders are encouraged to be added to an email distribution list to receive notices of upcoming events related to NSDF (webinars, breakfast briefings, etc.).

See the Stakeholder Engagement TSD 3 (CNL2019a).
Stakeholder(s): Local and host communities, local elected officials, media, Indigenous peoples.

4.2.9 Advertising

As different events and engagement opportunities were planned, CNL utilized advertising to announce and increase awareness of the events. Advertising is undertaken in specific regions that would have an interest due to their proximity to the CRL site. Different forms of advertising have been utilized to reach the interested public through their preferred method of intake.

4.2.9.1 Advertising Methods

- advertisements posted on CNL.ca landing page and the Project-specific webpage (www.cnl.ca/nsdf);
- advertisements included in online version of CNL's *Contact* newsletter when applicable;
- newspaper advertisements (see Table 4.2.9-1 for circulation of main newspapers utilized);
- radio advertisements – CNL has dedicated public service announcement spots on Star 96.7, when applicable, it was used to advertise specific project events; and
- paid Facebook advertising via a "boosted post" (see Section 4.2.9).

Table 4.2.9-1: Newspaper Circulation Numbers

Newspaper	Circulation
North Renfrew Times	4,000
Pontiac Journal (bi-weekly)	9,400
Shawville Equity	4,046
The Valley Gazette	2,300
Eganville Leader	6,200
Renfrew Mercury	13,394
Arnprior Chronicle	8,130
Petawawa Post	13,225
The News	29,000
Daily Observer	3,000
Flyer Insert	30,000

4.2.9.2 Public Service Announcements

CNL has had dedicated spots on the local radio station, Star 96.7, based in Pembroke, ON, for over 10 years. CNL utilizes these to promote local events and not-for-profit organizations; however, when there are events such as public information sessions, public service announcements are used for advertising. The public service announcements run on the radio station four times a day and reach an average of 35,000 listeners.

See Stakeholder Engagement TSD 3 (CNL 2019a).

4.2.9.3 Intranet – myCNL

The internal website has been used to communicate with internal stakeholders with updates on the project and publicizing events related to the project. Updates and events on the NSDF Project were shared on myCNL to educate, inform and provide updates on the project to employees.

See Stakeholder Engagement TSD 3 (CNL 2019a).

4.2.10 Social Media

Social media is used to inform, educate, promote awareness for all CNL activities including NSDF Project events and to receive feedback on the NSDF Project. CNL has used web-based analytics to determine how online users utilize different CNL company social media platforms. This enables CNL to assess which platforms are more effective in engaging the largest audience (followers) and the widest geographic reach (location) while also evaluating the overall usefulness of social media as a medium of public dialogue. Seven videos covering topics such as "why the NSDF?", "responsible water management" and Project updates have been uploaded to YouTube. The videos have been added in an effort to make information and technical information more accessible. Facebook is CNL's largest platform, where the company sees the strongest engagement through "comments, shares and likes" of posts. When CNL wished to raise the profile of project events or information, "boosted" posts were used to target by location and demographics. "Boosted" posts are paid posts through Facebook. Twitter has not been used as broadly as Tweets have been found to receive very little traction, and CNL has a comparatively much larger Facebook following. While numbers are significantly larger on LinkedIn, the demographics are far more industry based, rather than general public. Therefore, CNL utilizes LinkedIn, but in a much lower capacity than Facebook to ensure engagement is a balanced approach with general public in comparison to those actively part of the nuclear industry. See Table 4.2.10-1 for follower/subscriber numbers.

CNL's social media channels continue to gain followers and build communication through multiple social media accounts, including recently adding an Instagram account.

Table 4.2.10-1: Canadian Nuclear Laboratories Social Media Account Details

Social	Link	Followers
Facebook	www.facebook.com/CanadianNuclearLaboratories	3,306
Twitter	www.twitter.com/CNL_LNC	1,046
YouTube	www.youtube.com/channel/UC2GCEfZQgsURh4t_QZ-JwCw	271
Instagram	www.instagram.com/canadiannuclearlaboratories/	147
LinkedIn	www.linkedin.com/company/canadian-nuclear-laboratories/	10,296

Followers as of October 28, 2019.

See Stakeholder Engagement TSD 3 (CNL 2019a).

4.2.11 Media

During the summer of 2017 coverage of the NSDF project grew significantly with detractors of the project gaining traction in their messaging. However, CNL began actively utilizing a “detect and correct” method in sending in responses to articles that held misinformation. This method proved effective in getting more factual information out and overall has lead to more balanced coverage with some media outlets now reaching out to CNL for information about the project before printing articles.

CNL has responded to and sought media coverage much more actively. Through this more active approach there has been a decline in negative/inaccurate coverage of the project.

See Stakeholder Engagement TSD 3 (CNL2019a).

4.2.12 Document Repository

Canadian Nuclear Laboratories made four hard copies of the draft EIS publicly available, functionally creating a document repository for the draft EIS volumes. One hard copy of the draft EIS was available at the Deep River Public Library, two copies were made available through two separate branches of the Laurentian Hills Public Library and a French version of the draft EIS was made available through the Rapides-des-Joachim municipal offices. CNL commits to providing hard copies of the final EIS in the same locations.

4.2.13 Release of Documents

When requested supporting documents were provided to different groups and individuals to aid in their review of the draft EIS. An email was sent to more than 200 individual and group stakeholders offering information on the NSDF Project upon request.

To ease accessibility and transparency of the project, supporting documents were uploaded onto the NSDF pages of www.cnl.ca. These technical documents are available for any interested member of the public to download.

See Stakeholder Engagement TSD 3 (CNL2019a).

4.2.14 Participant Funding

The CNSC offered participant funding through its Participant Funding Program to assist members of the public, Indigenous peoples and other stakeholders in participating in the environmental assessment, licence application review and CNSC hearing processes for the NSDF Project. Recipients provide value-added and relevant information that contributes to a better understanding of the anticipated effects of the NSDF Project. Recipients also participate in the CNSC’s proceedings for this Project. The CNSC’s decision on who has received funding to participate is available in the CNSC Participant Funding Program Decision: CNL NSDF Project. Information on participant funding for the NSDF Project is available online: http://nuclearsafety.gc.ca/eng/the-commission/participant-funding-program/opportunities/pfp-funding-for-near-surface-disposal-facility-project.cfm.

Information on the CNSC Participant Funding Program is relevant to CNL’s stakeholder engagement efforts as it identifies individuals or groups who have expressed interest in the NSDF Project and a desire to proactively learn more. CNL has made it a priority to engage directly with recipients of participant funding due to their expressed interest in the NSDF Project.

4.3 Feedback

The engagement activities discussed in this section provide CNL with an opportunity for dialogue with public on their concerns with respect to the NSDF Project. This feedback helps CNL gauge public views and points out areas where CNL can improve elements of the NSDF Project or EIS on current project information, alternative means, valued components, spatial and temporal boundaries and follow-up monitoring program. This section summarizes the key themes that have been raised during outreach activities, including web inquiries and formal feedback on the draft EIS. It also demonstrates how CNL has responded and, when possible, incorporated this feedback into the development and design of the NSDF Project as well as the final EIS. Additionally, the project has posted these key themes and how they will be incorporated into the final EIS on the NSDF Project webpage.

Table 4.2.14-1 presents a comparison of the themes identified through public engagement (informal feedback) and those identified through formal public comments during review of the draft EIS. At a high level, public engagement feedback tends to be informal and based around general areas of interest such as “what and why,” whereas the formal feedback centred more on technical aspects of the NSDF Project such as “how.”

Table 4.2.14-1: Theme Comparison

Themes from Public Engagement	Themes from Formal Public Comment Period on Draft EIS
	Justification of the Project
Waste acceptance criteria	Waste Inventory
Origins of material for disposal in the NSDF facility	
Engineering containment mound construction materials	Design/engineering
	Long-term accountability
	Alternative means assessment (including site selection)
Future impact of natural disasters and climate change on the Project	Environmental events (e.g., flooding, earthquakes)
Seismic qualifications vs. seismic activity	
Water quality monitoring for groundwater and the Ottawa River	Protection of the Ottawa River

EIS = Environmental Impact Statement.

4.3.1 Informal Public Engagement Feedback

The Stakeholder Engagement TSDs (CNL 2017a, CNL 2017b and CNL 2019a) summarize feedback received during NSDF Project public engagement outreach activities. Table 4.3.1-1 provides input from NSDF Project engagement activities that was used to identify the key issues raised during the informal engagement process and demonstrates how the public influenced the scope of the environmental assessment. The relevant interests raised during public engagement activities are also recognized within the respective environmental analysis of Section 5.

Table 4.3.1-1: Summary of Interest Raised During Public Engagement Activities that Influenced the Scope of the Environmental Assessment

Interest Expressed During Public Engagement	Incorporation of Public Key Issues into the Final EIS
Information on monitoring air contamination, including dust.	The monitoring program proposed for air quality includes monitoring of fugitive dust emissions and is described in Section 5.2.1. Fugitive Dust Monitoring is captured through the implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and air verification monitoring. In addition, the *Dust Management Plan* (AECOM 2018) to be implemented for the NSDF Project will include information on dust mitigation and monitoring for the NSDF Project.
Potential for changes in groundwater quality to affect uses downstream of the ECM	Potential changes in groundwater quality from the NSDF Project were evaluated in the hydrogeology assessment described in Section 5.3.2 and included potential changes from construction activities (e.g., erosion and blasting activities), changes from treated effluent discharge from the WWTP and leakage from the ECM during the post-closure phase following decommissioning of the WWTP.
Treatment of leachate and wastewater	The design of the NSDF includes capture and treatment of wastewater (including leachate) from the ECM as described in Section 3.4.2. The potential changes in groundwater and surface water quality, as well as the ambient radioactivity in the environment, as a result of the treated effluent discharges are discussed in Sections 5.3.2, 5.4.2 and 5.7 respectively.
Potential leakage of leachate from the ECM	Potential leakage of leachate from the ECM during operations will be mitigated through the design and implementation of a composite base liner system, a leachate detection system and a leak collection system as discussed in Section 3.4.1. Potential leakage from the ECM during the operations and post-closure phases is considered in the hydrogeology assessment (Section 5.3.2) as well as the human and ecological health assessments (Sections 5.7 and 5.8).
Long-term monitoring of groundwater	A conceptual long-term monitoring program for the NSDF Project as it relates to groundwater has been developed and evaluated in the hydrogeology assessment described in Section 5.3.2. A detailed monitoring program will be provided in the follow-up monitoring report to be submitted as a part of the license application.
Potential for contamination in the Ottawa River from the NSDF Project.	The original spatial boundaries of the surface water assessment in the draft EIS were selected to include consideration of potential effects to the Ottawa River. As described in Section 5.4.2 surface water quality modelling was completed to estimate contaminant concentrations within the Perch Creek basin, which flows directly into the Ottawa River. Meeting effluent discharge targets within the Perch Creek basin is considered to be protective of the Ottawa River. In response to comments received from the public, the Regional Study Area for surface water in the final EIS was expanded further to include a reach of the Ottawa River extending 8 km downstream of the CRL site. Additionally, in response to public concerns, receptors downstream of the CRL site in Sheenboro and Ottawa-Gatineau were explicitly modeled in the PostSA and the results summarized in Section 5.8.
Effects to fish from potential for contamination in the Ottawa River from the NSDF Project.	The original spatial boundaries of the surface water assessment in the draft EIS were selected to include consideration of potential effects to the Ottawa River. As described in Section 5.4.2 surface water quality modelling was completed to estimate contaminant concentrations and compared to aquatic quality guidelines. As discussed in Section 5.5 meeting aquatic quality guidelines within the Perch Creek and Perch Lake Watershed is considered to be protective of fish in the Ottawa River. In response to comments received from the public, the Regional Study Area for surface water in the final EIS was expanded further to include a reach of the Ottawa River extending 8 km downstream of the CRL site. Therefore, effects to fish within the Regional Study area is consider in the human and ecological health assessments (Sections 5.7 and 5.8).
Potential for radioactivity from gases from the capped facility	Potential changes in air quality from the NSDF Project were evaluated in the human and ecological health assessment (Sections 5.7 and 5.8) during the pre-closure and post-closure phases.

Table 4.3.1-1: Summary of Interest Raised During Public Engagement Activities that Influenced the Scope of the Environmental Assessment

Interest Expressed During Public Engagement	Incorporation of Public Key Issues into the Final EIS
Inclusion of migratory birds in the assessment	Because of their ecological importance and because they are protected by federal legislation (*Migratory Birds Convention Act, 1994* [MBCA]), the suite of migratory birds with the potential to be affected by the NSDF Project was included as a terrestrial biodiversity VC in Section 5.6. Some individual migratory bird species that are federally listed species at risk were also included as VCs assessed at the species level.
Inclusion of bird and other species at risk in the assessment	The species-level assessment in Section 5.6 focused on species identified on Schedule 1 of the federal *Species at Risk Act* (SARA). Species at risk evaluated in the assessment include Canada warbler, eastern whip-poor-will, eastern wood pewee, wood thrush and golden-winged warbler, bats, Blanding's turtle, eastern milksnake and monarch butterfly. Most of the species-level VCs identified for the terrestrial biodiversity assessment are also useful indicators for broader groups of species.
Concern over the conversion of terrestrial habitat	Sections 5.6 includes an evaluation of the change in habitat availability and habitat distribution in the vicinity of the Project is completed for each of the wildlife species selected as VCs.
Concern with road mortality to Blanding's turtle and what can be done to reduce this risk	Increased risk of injury/mortality of Blanding's turtle on roads is a key interaction evaluated as part of the residual effects assessment in Section 5.6. Mitigation to be implemented to reduce this risk is described and monitoring programs are recommended for Blanding's turtle.
Indigenous and non-Indigenous interest expressed in relation to potential effects on fish and fish harvesting due to concerns of potential contamination or radioactive seepage into Perch Creek, the Ottawa River and other waterbodies from the NSDF Project.	The original spatial boundaries of the land use assessment in the draft EIS were selected to include consideration of potential effects on water quality and include the aquatics study areas. CNL continues to monitor the aquatic environment extensively, specifically Perch Creek. The NSDF Project has used recent modelling to understand the potential for effects within the Perch Creek basin. Existing land use with regards to fishing is described in Section 5.9.4.1.3.2 (outdoor tourism and recreation) and existing traditional land use with regard to fishing is described in Section 6.4.4.1. Potential effects on these VCs are assessed in Section 5.9.5 and Section 6.4.5. CNL conducts monitoring of fish in the Ottawa River for radioactive contamination as part of its Environmental Monitoring Program. In response to concerns received the Regional Study Area for the land use assessment in the final EIS was expanded further to include a reach of the Ottawa River extending 8 km downstream of the CRL site. To address potential future safety concerns of Indigenous peoples, the PostSA explicitly modeled a Self-Sufficient Indigenous Group receptor and is summarized in Section 6.6.
Interest expressed in relation to potential effects on recreational activities (i.e., boating and swimming) due to concerns of potential contamination or radioactive seepage into the Ottawa River and other waterbodies from the NSDF Project.	The land use assessment included outdoor tourism and recreation as a VC. The spatial boundaries for the land use assessment include consideration of potential effects to the aquatic environment, and specifically include the aquatics study areas. CNL continues to monitor the aquatic environment extensively. The NSDF Project has used recent modelling to understand the potential for effects within the Perch Creek basin. CNL conducts environmental monitoring for tritium and other radionuclides in environmental media including fish from the Ottawa River. Outdoor tourism and recreation is addressed in Section 5.9.4.1.3. In response to comments received from the public, the Regional Study Area for the land use assessment in the final EIS was expanded further to include a reach of the Ottawa River extending 8 km downstream of the CRL site. Additionally, in response to public concerns, receptors downstream of the CRL site in Sheenboro and Ottawa-Gatineau were explicitly modeled in the PostSA and the results summarized in Section 5.8.

Table 4.3.1-1: Summary of Interest Raised During Public Engagement Activities that Influenced the Scope of the Environmental Assessment

Interest Expressed During Public Engagement	Incorporation of Public Key Issues into the Final EIS
Will consideration be given to provide jobs or buy material, such as sand that could be delivered by barge, to the closest full-time residents to the site, in Sheenboro QC?	▪ Industries throughout the County of Renfrew and the Ottawa area in Ontario and the Region of Outouais in Quebec, are anticipated to supply the NSDF Project with many of the required goods and services (e.g., manufacturing, wholesale, transport) be. CNL will competitively procure material and services for the NSDF Project (see Section 5.10.6.2.1). ▪ The construction workforce is anticipated to be sourced from firms within the County of Renfrew and the Ottawa area in Ontario and the Region of Outaouais (which includes the Municipality of Sheenboro and City of Gatineau) in Quebec. Canadian Nuclear Laboratories employment opportunities that may arise due to NSDF Project activities will be posted on the vendor portal at www.cnl.ca website (see Section 5.10.6.2.1).

WWTP = Wastewater Treatment Plant; ECM = engineered containment mound; EIS = Environmental Impact Statement; CRL = Chalk River Laboratories; VC = valued component; PostSA = Post-closure Safety Assessment.

4.3.2 Formal Public Comments Feedback

In addition to the informal feedback that the public engagement outreach and activities offer, the environmental assessment process provides an opportunity for formal feedback from the public. This process began with the formal public and Indigenous comment period on the NSDF Project Description in May 2016. Followed by a formal public and Indigenous comment period on the draft EIS for the proposed NSDF Project from May 2017 until August 2017. Comments from members of the public, Indigenous peoples and non-governmental organizations on the draft EIS were consolidated by the CNSC (as the responsible authority) and received by CNL. The CNL prepared responses to the formal comments which will be submitted to the CNSC and posted on the CEAA Registry under project #80122. Through analysis of all formal public comments, key themes were identified. Table 4.3.2-1includes a summary of the key themes and how they were incorporated into the final EIS.

Table 4.3.2-1: Incorporation of Public Key Issues into the Draft Environmental Impact Statement

Themes from Formal Public Comment Period on Draft EIS	Incorporation of Public Key Issues into the Final EIS
Justification for the Project	Section 2.3 (Purpose of the Project) has been revised to improve the clarity on the justification for the project. The development of a near surface disposal facility for solid low-level radioactive waste at the CRL site will reduce potential risks associated with AECL's legacy wastes liabilities. The NSDF Project would enable the remediation of historically contaminated lands and legacy waste management areas, as well as the decommissioning of outdated infrastructure to facilitate the CRL site revitalization. The current CRL waste management practice is to safely store radioactive waste on-site in individual facilities in accordance with current licence conditions. However, appropriate nuclear waste management includes full life cycle management from generation to disposal. The NSDF Project will accommodate the permanent disposal of current and future low-level radioactive waste at the site.

Table 4.3.2-1: Incorporation of Public Key Issues into the Draft Environmental Impact Statement

Themes from Formal Public Comment Period on Draft EIS	Incorporation of Public Key Issues into the Final EIS
Waste inventory	▪ The original inventory proposed for NSDF Project in the draft EIS included a small fraction of intermediate-level waste. In response to comments received from the public, CNL made a commitment to limit the inventory to solid low-level radioactive waste only. This change has been reflected in the final EIS (Section 3.3), as well as supporting modeling and assessments such as the PostSA, and the revised Waste Acceptance Criteria. ▪ Consistent with IAEA classification of radioactive waste (GSG-1), low-level waste contains primarily short-lived radionuclides and restricts the amount of long-lived radionuclides thus requiring isolation and containment for periods of time up to a few hundred years. The engineered containment mound design life of 500 years has been established to meet the required time period to allow for radiologic decay of the waste inventory. ▪ Low-level waste includes items such as soils from remediation activities, demolition debris from decommissioning work and general trash such as used personal protection clothing or equipment. These items are considered low-level waste as they have become contaminated at some point with low levels of radioactivity. Low-level waste mostly contains short-lived radioactivity (thus decays relatively quickly) and can be safely handled with limited precautions. ▪ An estimation of the total inventory is required to inform the safety assessments where the inventory is tested against selected scenarios to determine the long-term consequences of the proposed facility. It also informs design criteria such as the Wastewater Treatment Plant (WWTP). ▪ The reference inventory identified in Section 3.3.1 establishes a representative radionuclide inventory by extrapolating waste already currently in storage, as well as waste forecasts from environmental remediation projects and decommissioning projects data to an assumed total volume of the NSDF at time of closure. All waste that is expected to be generated is meticulously described, or "characterized" before its generations to ensure the cumulative total inventory of NSDF is tracked against the licensed inventory.
Design/engineering	▪ At the time of submission of the draft EIS, CNL had completed the preliminary design of the NSDF. Since then, CNL has continued development of the design of the engineered containment mound, WWTP and supporting facilities. While the overall design has generally remained the same, several improvements have been made in many cases as a result of the decision to include only low-level radioactive waste, but also in response to valuable public and Indigenous input. An increase in detail and explanation of the engineered containment mound and wastewater treatment plan has been included in Section 3. CNL has also made the NSDF Design Description available for download on the NSDF Project website as well as summarized the intended operation of the NSDF in the YouTube video "NSDF Responsible Water Management". ▪ A number of comments were received questioning CNL's confidence in the 550-year design-life of the engineered containment mound, a key component of which is are the High Density Polyethylene (HDPE) Geomembranes (GMB). Dr. Kerry Rowe, a globally recognized expert in geomembrane systems based at Queens University has undertaken testing of the NSDF geomembrane and provided the scientific evidence to demonstrate with confidence that 550-year service-life will be met. Methods for testing and data analyses were performed in accordance with applicable standards and have been published in a number of peer-reviewed journals. ▪ To ensure the integrity of the HDPE materials and quality of installation, the project will apply a Construction Quality Assurance (CQA) program. The CQA Program will include confirmatory tests and inspection by qualified personnel prior to and during liner installation. The design also includes systems to monitor and detect any leakage.
Long-term accountability	As discussed in updates to Section 3, as the owner of the CRL site and of the associated liabilities, Atomic Energy of Canada Limited (AECL) - a federal Crown corporation - will ensure that the site is safely managed and controlled for as long as necessary.

Table 4.3.2-1: Incorporation of Public Key Issues into the Draft Environmental Impact Statement

Themes from Formal Public Comment Period on Draft EIS	Incorporation of Public Key Issues into the Final EIS
Alternative means assessment (including site selection)	The revised EIS will have an expanded Alternative Means in Section 2 to better clarify the process that was followed to determine the NSDF location and design features. Based on questions and comments received, a summary of some of key information is provided below. ▪ *Why the Chalk River site?* Chalk River Laboratories is the most suitable host site as more than 90% of the waste to be managed in the NSDF is already on the CRL site. This location for the facility avoids the time, cost and risk in transporting the waste to another location and reduce the unnecessary generation of tons of greenhouse gas emissions. ▪ *Why the East Mattawa Road Location on the Chalk River Site?* The chosen East Mattawa Road (EMR) site is closest to the CRL main campus and therefore closest to the mandatory support services (e.g., electricity, water, heat). It is located within the Perch Lake drainage basin, which has been impacted by other historic waste management practices. Groundwater flow and contaminant migration at CRL site has been studied for over six decades and the Perch Lake Basin is well understood, better enabling CNL to mitigate any potential impacts from the NSDF facility. Placing the NSDF at the EMR site allows us to consolidate it within an area that is currently affected by historic and on-going operations. The Alternate site is in a largely undeveloped area, which means it is an unaffected, natural site. There are no pre-existing plumes or contamination from waste storage in the vicinity of the Alternate site. CNL and AECL would prefer to retain the Alternate site as a largely undeveloped area, providing protected habitat for species at risk such as the Blanding's Turtle and bats. ▪ *Why a near surface disposal facility?* Near surface disposal facilities, as proposed for the NSDF project, are suitable for the disposal of low-level waste as noted by IAEA guidance. An engineered containment mound design is a best available technology in consideration of the proposed waste stream which the vast majority is impacted soils and demolition debris. NSDF has been sited and designed to provide features that are aimed at the isolation of the radioactive waste from people and the environment.
Environmental events (e.g., flooding, earthquakes)	Section 10 (Effects of the Environment on the Project) describes how the design basis of NSDF has considered all environmental events that are likely to occur within the assessment timeframe. Other disruptive environmental events have been further analyzed in the safety assessments, considering both during the operations phase (SAR) and post-closure (PostSA). ▪ Earthquakes: The analysis has shown that the design of the engineered containment mound is robust and can withstand a 1:10,000-year earthquake. Design changes to the engineered containment mound have been made to mitigate liquefaction potential. A replacement of the liquefiable soils with graded granular material from the bedrock excavation at site was considered as an optimal solution and included in the design of the engineered containment mound. ▪ Tornadoes: The design of the WWTP has been made more robust to withstand potential tornadoes and high winds. ▪ Precipitation: The design basis increases the capacity for the collection tanks for the WWTP to accommodate for 100-year back to back storm events. ▪ Flooding: The base of the proposed NSDF is located approximately 163 metres above sea level, which is approximately 50 metres above the current water levels of the Ottawa River. Local residents can be assured that the proposed site is situated well outside of a flood plain. The Ottawa River posed no flooding threat to the Chalk River Laboratories site or its operations during the 2019 high-water conditions, nor would it have impacted the NSDF.

Table 4.3.2-1: Incorporation of Public Key Issues into the Draft Environmental Impact Statement

Themes from Formal Public Comment Period on Draft EIS	Incorporation of Public Key Issues into the Final EIS
Protection of the Ottawa River	■ As discussed in Section 3 (Project Description), the proposed facility has been designed to ensure leachate and wastewater are controlled as well as treated to meet effluent discharge targets that have been developed to be protective of the public and environment health. Additionally, waste emplacement plans have been developed to minimize the generation of wastewater during operation of the engineered containment mound. CNL has also summarized the intended operation of the NSDF in the YouTube video “NSDF Responsible Water Management”. ■ A state of the art WWTP has been designed to remove both radiological and chemical contaminants. CNL has performed pilot testing of the proposed wastewater treatment process utilizing simulated wastewater representative of what we expect to collect and treat when the NSDF is in operation. Through pilot testing we have demonstrated that we can achieve the effluent discharge targets. Furthermore, the plant is designed for batch releases, which means all liquid effluent must be sampled and proven to meet our targets before discharge. ■ CNL is providing the necessary evidence and the science-based explanation that supports placing the facility at the Chalk River location as captured in updates to Sections 5.4.1 (Hydrology), 5.4.2 (Surface Water Quality), 5.5 (Aquatic Environment), 5.9 (Land and Resource Use) and 6.0 (Indigenous Interests) of the EIS. In response to concerns received the Regional Study Area for the land use assessment in the final EIS was expanded further to include a reach of the Ottawa River extending 8 km downstream of the CRL site. In response to comments received from the public, receptors downstream of the CRL site in Sheenboro and Ottawa-Gatineau were explicitly modeled in the PostSA and the results summarized in Section 5.8. ■ Lastly CNL’s environmental and effluent monitoring program will be expanded to include the NSDF WWTP effluent, surface water in the Perch Lake Basin, and groundwater to confirm performance of the engineered containment mound and on-going monitoring of the Ottawa River.

AECL = Atomic Energy of Canada Limited; CRL = Chalk River Laboratories; PostSA = Post-closure Safety Assessment; EIS = Environmental Impact Statement; IAEA = International Atomic Energy Agency; HDPE = High Density Polyethylene; EMR = East Mattawa Road; SAR = Safety Analysis Report.

Through the wide range of communications strategies undertaken, the NSDF project has continued to collect valuable input from stakeholders on current project information, alternative means, valued components, spatial and temporal boundaries, follow-up monitoring program and has incorporated informal and formal feedback into the final EIS. The project is continually developing and strives to maintain transparency and open communication with the general public as the project moves forwards. Feedback will continue to be tracked, collected and incorporated (when possible) as a part of the engagement activities into the future.

4.4 Planned Future Engagements

CNL has additional engagements planned throughout the environmental assessment process for which the records and feedback will be summarized in the final revision of the EIS (or Commission Member Document). Planned future engagements may include but are not limited to the following:

- annual conferences;
- annual public events (i.e., Petawawa Showcase, Downtown Connect);
- Renfrew County Municipal Councils – Project overview/updates;

- quarterly Project update webinars;
- quarterly website review and content update (note: new information will be updated as it becomes available);
- CRL ESC meeting – Project updates;
- CNL corporate kiosk/storefront – Project information;
- NSDF Project update letter/ invitation to intervenors;
- bi-monthly Project breakfast briefings;
- CONTACT newsletter; and
- informational videos.

4.5 Conclusions

Methods employed to date have helped to inform, educate and discuss the NSDF Project with stakeholders, and have enabled the public to provide valuable feedback into the Project. CNL will continue stakeholder engagement efforts to support growth in awareness and understanding of the NSDF Project.

There will always remain those in the public whose perception of nuclear waste remains negative and whose perception of the actual risk posed by the NSDF will remain grossly out of skew. CNL understands that it is an impossible task to convince all publics that the NSDF represents a safe and modern facility for the management of low-level nuclear liabilities at CNL sites. This however will not stop CNL from continuing to educate the public on the safe management of nuclear waste now and into the future, because it is the right thing to do.

CNL makes it a priority to build public awareness, understanding and a supportive appreciation of the laboratories value and relevance to Canadians. CNL works to ensure that the general public, Indigenous peoples, news media, and other stakeholders are informed about the on-going activities at all CNL sites. While there is a stigma/fear of nuclear present in the general public, CNL continues to develop relationships and programs, as a part of the Public Information Program, to educate different demographics of the population about the perceived risk vs. the actual risk of nuclear.

CNL has proactively addressed the key issues raised by stakeholders, in many cases resolving those concerns. However, there remain persistent negative issues including the perception of a potential negative effect of the NSDF Project on the Ottawa River and other off-site effects. Follow-up monitoring will be used to verify predictions made in the final EIS, which will be communicated through CNL's Public Information Program (CNL 2020). CNL will continue with these efforts to inform the public on the NSDF Project and address the perception of risk.

Continuing to provide information as it becomes available will encourage transparency, and further feedback, which can assist CNL in understanding and incorporating stakeholder perspectives into Project planning, future communications and the environmental assessment process.

5.0 ENVIRONMENTAL EFFECTS

5.1 Environmental Assessment Approach

The environmental assessment process is an important tool for integrating environmental and social factors into project planning and decision making. The goals of the environmental assessment process are to:

- promote sustainable development;
- engage Indigenous peoples, the public and government agencies; and
- identify appropriate mitigation to reduce the overall biophysical, economic, social, heritage and health effects of the Near Surface Disposal Facility (NSDF) Project.

More specifically, environmental assessment is a process used to predict environmental effects of proposed initiatives before they are carried out. An environmental assessment:

- identifies potential adverse environmental effects;
- proposes measures to mitigate adverse environmental effects;
- predicts whether there will be significant adverse environmental effects after mitigation measures are implemented; and
- includes a follow-up monitoring program to verify the accuracy of the environmental assessment and the effectiveness of the mitigation measures.

This section describes the scope and approach of the environmental assessment implemented for the NSDF Project. The environmental assessment approach applied to disciplines (e.g., atmospheric environment, hydrogeology, terrestrial biodiversity, human health and socio-economic environment) includes the following main activities (where applicable), with further detail on each provided in Sections 5.1.1 to 5.1.9 and Section 6.0:

- **Step 1** – Define the scope of the assessment, including input received from regulatory agencies and engagement activities.
  - Identify the Valued Components (VCs) for each discipline that the assessment will focus on, and the associated measurement indicators and assessment endpoints for VCs.
  - Define spatial (e.g., geographic extent of the project activities and effects) and temporal (e.g., timelines for the project phases and effects) boundaries, and assessment cases used to evaluate effects.
- **Step 2** – Describe the existing conditions, including the cumulative effects of previous and existing developments for each VC.
- **Step 3** – Evaluate Project interaction and mitigation by conducting a pathway analysis to identify Project components or activities with a potential to create a residual effect, and describe the mitigation developed for removing pathways or limiting effects. In the assessment for some disciplines, no primary pathways for effects are identified, and the assessment proceeds directly to Step 7.

- **Step 4** – Conduct an analysis for each VC to predict residual effects from the NSDF Project.
  - Conduct an assessment for each VC to predict the cumulative effects of previous and existing projects and activities, the NSDF Project and potential future projects that have been proposed but not yet approved (if applicable).
- **Step 5** – Evaluate and describe the level of certainty that can be placed on predicted residual effects and the methods used to manage uncertainty.
- **Step 6** – Classify and determine the significance of predicted residual effects, including cumulative effects from the NSDF Project and potential future projects that have been proposed but not yet approved (if applicable).
- **Step 7** – Identify monitoring and follow-up programs to confirm the effects predictions and address uncertainty.
- **Step 8** – Present a consolidated summary of conclusions and outcomes of the assessment.

Generally, this approach is consistently applied across disciplines, with some modifications, where appropriate. For example, VCs are defined for all disciplines, and there is consistency in the determination of spatial and temporal boundaries for the effects analysis. Similarly, the methods for identifying interactions that link the NSDF Project to potential effects on VCs are consistent. Details specific to each discipline are provided in their respective sections of the Environmental Impact Statement (EIS).

In contrast, the methods for analyzing, classifying (e.g., magnitude and duration) and predicting environmental significance of residual effects can differ among disciplines. For example, human effects from a specific project are difficult to isolate from the on-going processes of interdependent social, cultural and economic change. Evolving social trends, government policy and programming decisions and individual choice all have effects that will be concurrent with potential NSDF Project effects. Biophysical disciplines (e.g., hydrogeology, aquatic environment and terrestrial environment) are influenced simultaneously by natural and human-related factors. However, for many biophysical disciplines, effects specific to the NSDF Project can be quantified (e.g., incremental changes to ground and surface water quality, air quality and fish and wildlife habitat). Because the socio-economic status of different communities, subpopulations and individuals may vary, a socio-economic effect may have both positive aspects and negative aspects, whereas an effect on a biophysical discipline is typically constrained to being negative or positive.

5.1.1 Scope of the Assessment

As described in Section 1.4, the *Generic Guidelines for the Preparation of an Environmental Impact Statement* (Generic EIS Guidelines) developed by the Canadian Nuclear Safety Commission (CNSC 2016) provides an outline of the information to be included in the EIS, along with a high-level description of the methods to be implemented for the environmental assessment.

The scope of the environmental assessment, where applicable, incorporates input received from regulatory agencies, Indigenous peoples (Section 6.0) and the public (Section 4.0) through the review of the draft EIS and advice provided in guidance documents relevant to environmental assessment practice (Section 1.4).

Input from engagement for the NSDF Project is used to identify the key issues that were raised during the engagement process (Section 4.0 and 6.0). Issues identified during community information sessions and considered in the development of the EIS are summarized in CNL's Indigenous Engagement Report (CNL 2020) and CNL's Stakeholder's Activity Reports (CNL 2017a,b, 2019). Comments received, the responses prepared and the degree to which these comments are considered resolved are also presented in CNL's Indigenous Engagement Report (CNL 2020) and CNL's Stakeholder's Activity Report – Near Surface Disposal Facility (CNL 2019). These issues and the response to these issues are presented under the "Scope of the Assessment" heading within each discipline section, and helped to guide the scope and development of the assessment for each discipline.

The EIS also relies on multiple key technical support documents as described in Section 1.5 (Structure of this Document) and as shown on Figure 1.5.1-1.

5.1.2 Valued Components

VCs refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community or the public (The Agency 2018a). Because this assessment is for a designated project, as described in the *Canadian Environmental Assessment Act, 2012* (CEAA 2012), and is regulated by the CNSC, VC selection considered guidance from Appendix A of the CNSC's *REGDOC-2.9.1 Environmental Protection: Environmental Principles, Assessments and Protection Measures* (CNSC 2017). The selection of appropriate VCs allows the assessment to be focused on those aspects of the natural and human environment that are of greatest importance to society and species conservation.

The list of VCs selected for the NSDF Project considered a number of factors, including:

- presence, abundance and distribution within or relevance to the area associated with the NSDF Project;
- potential for interaction with the NSDF Project and sensitivity to effects;
- species conservation status or concern (e.g., rarity, sensitivity and uniqueness);
- ecological and socio-economic value to communities, government agencies and the public;
- traditional, cultural and heritage importance to Indigenous peoples; and
- experience with similar projects, including the EIS completed in 2010 for the National Research Universal Reactor Long-term Management Project at the Chalk River Laboratories (CRL) property (SENES 2010).

VCs were selected with due consideration of the results of baseline studies and subsequent consultation, with a focus on criteria used to evaluate the potential significance of residual effects. The rationale for discipline-specific VC selection is described in Sections 5.2 to 5.10, under the "Valued Components" subheading. The final list of VCs and rationale for inclusion in the effects assessment for the NSDF Project is provided in Table 5.1.2-1. Accidents and malfunctions for the NSDF Project are discussed separately in Section 7.0 and are not listed in Table 5.1.2-1 below.

Table 5.1.2-1: Valued Components Selected for the Effects Assessment

Discipline	Valued Component	Rationale for Selection
Atmospheric Environment	Air Quality	■ Air quality is selected as a VC as emissions from the NSDF Project activities have the potential to alter the existing air quality regime. ■ Changes in air quality can affect human health, aquatic and terrestrial biodiversity.
	Greenhouse Gases	■ This VC, assessed through incremental changes in emissions of a group of gases, considers the potential of the NSDF Project to contribute to climate change.
Geological and Hydrogeological Environment	Geology*	■ Characteristics of geology, such as soil quality and quantity, bedrock and geomorphology, are important components that interact with other VCs (e.g., hydrogeology, hydrology and surface water quality) and if changed by NSDF Project activities, these characteristics could affect terrestrial and aquatic biodiversity.
	Groundwater quantity* and quality*	■ Characteristics of hydrogeology, such as groundwater quantity and quality are important components that interact with other VCs (e.g., hydrology and surface water quality) and if changed by NSDF Project activities, these characteristics could affect terrestrial and aquatic biodiversity, and human health including future use (e.g., human intrusion).
Surface Water Environment	Hydrology*	■ The NSDF Project may affect existing availability of the spatial and temporal distribution of water quantity for aquatic and terrestrial biodiversity, which can in turn affect land and resource use. ■ Societal values concerning changes in water quantity (i.e., watersheds) are an important consideration in understanding potential effects of the NSDF Project.
	Surface Water Quality*	■ Water quality to support aquatic and human health is defined by the concentration or value of various physical and chemical constituents[(a)] of water, such as temperature, suspended particulate matter, major ions (e.g., chloride, potassium), nutrients (e.g., nitrogen, phosphorus), metals, and trace organic compounds, and radiological compounds that occur in dissolved or soluble form (e.g., aluminum and iron) and suspended matter (comprising inorganic or organic material). ■ Changes in the quality of water can affect aquatic and terrestrial sustainability and biodiversity, and the use of water for recreational purposes or as a drinking water source for people and wildlife. ■ Societal values concerning changes in water quality (i.e., Ottawa River) are an important consideration in understanding potential effects of the NSDF Project.
Aquatic Environment	Perch Creek and Perch Lake Watershed Fish Habitat (i.e., Fish Habitat)[(a)]	■ Wetlands, lakes, streams and rivers provide a diversity of functions for life history stages of fish species and forage fish species. ■ The NSDF Project may affect existing availability of the spatial and temporal distribution of habitat, which can subsequently affect land and resource use.
	Perch Creek and Perch Lake Watershed Fish Community (i.e., Fish Community)[(a)]	■ Up to 15 species have been documented within the Perch Creek and Perch Lake Watershed, some of which may use habitat in the Ottawa River at the mouth of Perch Creek. ■ Species in potentially affected waters are protected under the *Fisheries Act*., for example, Northern Pike (*Esox lucius*), Brown Bullhead (*Ameiurus nebulosus*) and supporting forage fish species. ■ Societal values concerning changes in local fisheries species are an important consideration in understanding potential effects of the NSDF Project.

Table 5.1.2-1: Valued Components Selected for the Effects Assessment

Discipline	Valued Component	Rationale for Selection
Aquatic Environment	Fish Species of Conservation Concern	■ The Lake Sturgeon (*Acipenser fulvescens*) population in the Ottawa River is designated as Threatened by COSEWIC; threats to the Lake Sturgeon include overexploitation, dams, habitat degradation, contaminants and introduced species; commercial fishing was the most significant factor that caused the historical decline of populations. ■ American Eel (*Anguilla rostrata*) is designated as Threatened by COSEWIC; threats include dams which can impede upstream migration of juvenile eels; impeded access to the Ottawa River, Lake Ontario and Lake Champlain resulted in substantial cumulative loss of formerly productive rearing habitat in the St. Lawrence River watershed. ■ The Northern Brook Lamprey (*Ichthyomyzon fossor*) population in the Ottawa River is designated as special concern under Schedule 1 of SARA; lampricide (chemical used to target lamprey larvae) use to manage invasive Sea Lamprey (*Petromyzon marinus*) is the main threat for Northern Brook Lamprey. ■ River Redhorse (*Moxostoma carinatum*) is designated as special concern under Schedule 1 of SARA; principal threats are habitat degradation through siltation, agricultural and urban pollution, and instream barriers such as dams, which restrict access to spawning areas and can change flow regimes during spawning periods.
Terrestrial Environment	Vegetation communities	■ This VC broadly captures effects on terrestrial biodiversity. ■ The NSDF Project is associated with footprint effects that will remove vegetation and result in physical losses of some vegetation communities (and related wildlife habitat).
	Migratory birds	■ Migratory birds and their nests are protected under the federal MBCA. ■ There are numerous migratory bird species that breed, nest or could be present year-round in the vicinity of the Project. There is the potential for migratory birds to be indirectly and directly affected by the Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads or loss of eggs in nests during tree clearing). ■ Comment on the Project Description received by a member of the public specifically requested assessment of this VC.
	Canada warbler	■ Canada warbler (*Cardellina canadensis*) is federally listed as Threatened under SARA and is protected under the MBCA. It has legal individual and habitat protection provisions under SARA and individual and nest protection under the MBCA. ■ The CRL site is federally owned; therefore, this species is afforded protection of critical habitat because it is listed as Threatened on Schedule 1 of SARA. Critical habitat has not yet been defined for this species in the federal recovery strategy. ■ There is the potential for Canada warbler to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads or loss of eggs in nests during tree clearing). ■ Canada warbler is an avian species VC recorded within the LSA that represents a guild of early successional habitat specialists requiring coniferous, deciduous, moist mixed forest and regenerating habitats.

Table 5.1.2-1: Valued Components Selected for the Effects Assessment

Discipline	Valued Component	Rationale for Selection
Terrestrial Environment	Eastern whip-poor-will	■ Eastern whip-poor-will (*Antrostomus vociferus*) is federally listed as Threatened under SARA and is protected under the MBCA. It has legal individual and habitat protection provisions under SARA and individual and nest protection under the MBCA. ■ The CRL site is federally owned; therefore, this species is afforded protection of critical habitat because it is listed as Threatened on Schedule 1 of SARA. Critical habitat has been partially defined for this species in the federal recovery strategy (ECCC 2018a). ■ There is the potential for eastern whip-poor-will to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads or loss of eggs in nests during tree clearing). ■ Eastern whip-poor-will is a keystone avian species VC recorded within the LSA that represents a guild of aerial insectivores requiring open forest/edge habitat in drier deciduous and coniferous habitats.
	Eastern wood-pewee	■ Eastern wood-pewee (*Contopus virens*) is federally listed as Special Concern under SARA and is protected under the MBCA. It has legal individual and nest protection under the MBCA. ■ The CRL site is federally owned; therefore, Section 65 of SARA requires that habitat is managed for conservation of this species because it is listed as Special Concern on Schedule 1 of SARA. ■ There is the potential for eastern wood-pewee to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads or loss of eggs in nests during tree clearing). ■ Eastern wood-pewee is an avian species VC recorded within the LSA that represents a guild of forest edge habitat species.
	Golden-winged warbler	■ Golden-winged warbler (*Vermivora chrysoptera*) is federally listed as Threatened under SARA and is protected under the MBCA. It has legal individual and habitat protection provisions under SARA and individual and nest protection under the MBCA. ■ The CRL site is federally owned; therefore, this species is afforded protection of critical habitat because it is listed as Threatened on Schedule 1 of SARA. Critical habitat has been partially defined for this species in the federal recovery strategy. ■ There is the potential for golden-winged warbler to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads or loss of eggs in nests during tree clearing). ■ Golden-winged warbler is a keystone avian species VC recorded within the LSA that represents a guild of edge habitat specialists.

Table 5.1.2-1: Valued Components Selected for the Effects Assessment

Discipline	Valued Component	Rationale for Selection
Terrestrial Environment	Wood thrush	■ Wood thrush (*Hylocichla mustelina*) is federally listed as Threatened under SARA and is protected under the MBCA. It has legal individual and habitat protection provisions under SARA and individual and nest protection under the MBCA. ■ The CRL site is federally owned; therefore, this species is afforded protection of critical habitat because it is listed as Threatened on Schedule 1 of SARA. Critical habitat has not yet been defined for this species in the absence of a federal recovery strategy due to recent (2017) listing. ■ There is the potential for wood thrush to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads or loss of eggs in nests during tree clearing). ■ Wood thrush is an avian species VC recorded within the LSA that represents a guild of deciduous and mixedwood forest habitat specialists.
	Bats ■ Little brown myotis ■ Northern myotis ■ Tri-colored bat	■ Little brown myotis (*Myotis lucifugus*), northern myotis (*Myotis septentrionalis*) and tri-colored bat (*Perimyotis subflavus*) have observation records within the LSA. All three bat species are federally listed as Endangered and have legal individual protection provisions under SARA. ■ The CRL site is federally owned; therefore, these bat species are afforded protection of critical habitat because they are listed as Endangered on Schedule 1 of SARA. Critical habitat has only partially been defined for hibernacula (i.e., overwintering sites), as the largest threat to these species is associated with that habitat. The destruction of maternity roosts is also a potential threat to bat populations. Hibernacula have not been found in the study areas and are unlikely to occur in the SSA. Maternity roosts are likely present and have the potential to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (i.e., loss of roosting bats during tree clearing). ■ There is the potential for bats to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss (loss of roost trees) and mortality (i.e., loss of pre-volant juveniles in maternity roosts during tree clearing). ■ The bats VC represents small mammal species recorded in the LSA that rely on standing dead trees (e.g., snags) for part of their life history (maternity roosting, diurnal roosting and evening roosting).

Table 5.1.2-1: Valued Components Selected for the Effects Assessment

Discipline	Valued Component	Rationale for Selection
Terrestrial Environment	Blanding's turtle	■ The Great Lakes / St. Lawrence population of Blanding's turtle (*Emydoidea blandingii*) is federally listed as Threatened and has legal individual and habitat protection provisions under SARA. COSEWIC (2016) has assessed the population as Endangered. ■ The CRL site is federally owned; therefore, this species is afforded protection of critical habitat because it is listed as Threatened on Schedule 1 of SARA. Critical habitat has been identified within the CRL site based on the partial definition in the recovery strategy (ECCC 2018b). Grid squares that have been identified as containing critical habitat for Blanding's turtle are intersected by the NSDF Project (ECCC 2017). ■ There is the potential for Blanding's turtle to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads and overwinter mortality from changes in the hydrology in wetlands). ■ The Blanding's turtle is represented through effects on species at risk in the terrestrial environment. This species further acts as an indicator species representing reptile species (e.g., snapping turtle) that use a variety of wetland habitats for hibernation, mating, foraging, thermoregulation, staging prior to nesting and for movement. They use upland, relatively open areas with suitable substrate for nesting, overland migration, thermoregulation and foraging. Blanding's turtles display fidelity to their overwintering sites and nesting sites (i.e., use the same habitat year after year). ■ Comments and questions raised at public information sessions unambiguously expressed value of the Blanding's turtle.
	Eastern milksnake	■ Eastern milksnake (*Lampropeltis triangulum*) has not been observed within the LSA but is potentially present because it has been confirmed elsewhere on the CRL site. It is federally listed as Special Concern on Schedule 1 under SARA. ■ There is the potential for eastern milksnake to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads). ■ The CRL site is federally owned; therefore, Section 65 of SARA requires that habitat is managed for conservation of this species because it is listed as Special Concern on Schedule 1 of SARA. ■ Eastern milksnake represents reptile species that use a variety of microhabitats. The eastern milksnake is known to congregate in hibernacula over winter.
	Monarch butterfly	■ Monarch butterfly (*Danaus plexippus*) has not been observed within the LSA but is potentially present because it has been confirmed elsewhere on the CRL site. It is federally listed as Special Concern and is considered Endangered by COSEWIC. ■ There is the potential for the monarch butterfly to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads or loss of individuals during vegetation clearing). ■ The CRL site is federally owned. Although species listed as Special Concern are not afforded the same degree of legal protection as higher threat levels, Section 65 of SARA requires that a management plan be developed that includes measures for the conservation of the species and their habitats. ■ The iconic migratory butterfly relies on milkweed and represents other insects that use a variety of open habitats during the summer and early fall.

Table 5.1.2-1: Valued Components Selected for the Effects Assessment

Discipline	Valued Component	Indicator Species	Justification for Inclusion in Exposure Assessment
Ambient Radioactivity and Ecological Health	A list of VCs was developed from those documented to occur in the vicinity of the SSA, have potential for exposure, play a key role in the food web, and represent a variety of habits and trophic levels. To determine the potential effect of radiological emissions on the environment, a smaller group of indicator species was chosen to represent VCs selected for assessment. The indicator species listed below includes those species identified and assessed for terrestrial and aquatic biodiversity effects.		
	Valued Component	**Indicator Species**	**Justification for Inclusion in Exposure Assessment**
	Crustaceans	■ Benthic invertegbrates	■ Indicator species for changes in sediment quality
	Crustaceans	■ Zooplankton	■ Indicator species for changes in water quality
	Fish and Fish Habitat (Small Pelagic forage [omnivores])	■ Bluntnose Minnow	■ Present in Perch Creek, represents small pelagic fish
	Fish and Fish Habitat (Small -Benthivorous)	■ Black Bullhead	■ Present in Perch Creek, represents small benthivorous fish
	Fish (Large - Carnivorous)	■ Northern Pike	■ Present in Perch Lake, represents Large Carnivorous fish
	Vegetation Communities (Aquatic)	■ Reed (food for predators)	■ Present in the wetlands in the LSA, represents aquatic vegetation communities, food chain
	Vegetation Communities (Terrestrial)	■ Red maple	■ Present in the LSA, represents terrestrial vegetation communities
	Pollinator	■ Monarch butterfly	■ Present in the LSA, represents Pollinators
	Terrestrial Invertebrate	■ Earthworm	■ Indicator species for changes in soil quality
	Bats (Small - Insectivores)	■ Little brown myotis	■ Present in the LSA, represents small insectivores
	Small – Herbivore	■ Meadow vole	■ Present in the LSA, represents small herbivorous mammals
	Large – Herbivore	■ White-tailed deer	■ Present in the LSA, represents large herbivorous mammals, public interest
	Large - Herbivore	■ Moose	■ Present in the LSA, make use of aquatic habitat, represents large herbivorous mammals, Indigenous interest
	Small – Omnivorous	■ Short-tailed shrew	■ Present in the LSA, represents small omnivorous mammals
	Large – Omnivorous	■ Black bear	■ Present in the LSA, represents large omnivorous mammals, public interest
	Large - Carnivorous	■ Eastern wolf	■ Present in the LSA, represents large carnivorous mammals, public interest
	Turtle (Semi-terrestrial)	■ Snapping turtle	■ Present in the LSA, represents semi-terrestrial reptiles (turtle)
	Snake (Semi-terrestrial)	■ Common watersnake	■ Present in the LSA, represents semi-terrestrial reptiles (snake)

Table 5.1.2-1: Valued Components Selected for the Effects Assessment

Discipline	Valued Component	Rationale for Selection	
	Valued Component	**Indicator Species**	**Justification for Inclusion in Exposure Assessment**
Ambient Radioactivity and Ecological Health	Snake (Terrestrial)	■ Eastern milksnake	■ Present in the LSA, represents terrestrial reptiles (snake)
	Frog (Semi-aquatic)	■ Green frog	■ Present in the wetlands in the LSA, represents semi-aquatic amphibians
	Migratory birds (Small – Insectivores)	■ Canada warbler	■ Present in the LSA, represents small insectivore birds
	Migratory birds (Large Insectivores)	■ Eastern whip-poor-will	■ Present in the LSA, represents large insectivore birds
	Migratory birds (Small Omnivores)	■ Purple finch	■ Present in the LSA, represents small omnivore birds
	Large Omnivores	■ Ruffed grouse	■ Present in the LSA, represents large omnivore birds
	Small Carnivores	■ Belted kingfisher	■ Present in the LSA, represents small carnivore birds
	Raptors (Large Carnivores)	■ Bald eagle	■ Present in the LSA, represents large carnivore birds, public interest
	Waterfowl (Small semi-aquatic)	■ Mallard	■ Present in the LSA, represents small semi-aquatic birds, public interest
	Large semi-aquatic	■ Great blue heron	■ Present in the LSA, represents large semi-aquatic birds, public interest
Human Health	Worker	■ Potential external and internal radionuclide exposure; potential non-radionuclide exposure from the NSDF Project.	
	Public ■ Residential ■ Seasonal	■ Potential exposure to airborne and waterborne radiological emissions; potential non-radionuclide exposure from the NSDF Project.	
	Self-Sufficient Indigenous Peoples	■ Potential exposure to airborne and waterborne radiological emissions; potential non-radionuclide exposure from the NSDF Project. ■ This group represents Indigenous peoples, including adults and children, using area that surrounds the ECM, including Perch Creek and the Ottawa River, for hunting and gathering during the Post-closure phase. ■ This receptor was assessed as part of the Sensitivity Analysis Case in the Post-Closure Safety Assessment (Arcadis and Quintessa 2020).	
Socio-economic Environment	Labour Market	■ Local workforce and communities are interested in long-term employment opportunities that will be generated through the NSDF Project. ■ Income generation is perceived as a Project benefit by local workforce, businesses and communities.	
	Economic Development	■ The NSDF Project will contribute to local and regional economies, through direct procurement, as well as indirect investment in other business activities.	
	Government Finances	■ The NSDF Project will generate incremental tax revenues for all levels of government.	
	Housing and Accommodations	■ Potential in-migration of workers (and families) for the NSDF Project could increase the demand for permanent housing or temporary accommodations.	

Table 5.1.2-1: Valued Components Selected for the Effects Assessment

Discipline	Valued Component	Rationale for Selection
Socio-economic Environment	Services and Infrastructure	■ Potential in-migration of workers (and families) for the NSDF Project could increase the demand for community services (i.e., schools, community health, protection and emergency services) and community infrastructure (i.e., water supply and traffic).
	Quality of Life	■ Project activities (i.e., changes in air quality, ambient noise, increases in traffic volume and visual disturbances) could affect worker and local public quality of life.
	Public Safety	■ Public safety is a concern near the NSDF Project. Hazards include transport of heavy equipment and supplies to the site and other hazards typical of industrial facilities.
Land and Resource Use	Land Tenure and Other Registered Interests	■ Project construction and operation must demonstrate compatibility with existing land use direction as expressed by responsible authorities based on a qualitative comparison of the Project with established land and resource designations in plans, policies and bylaws. ■ Land users and responsible authorities need to understand if the Project will affect access routes / access to commercial land and resource use areas (e.g., for existing mining, forestry and agriculture). ■ Land users and responsible authorities need to understand if the Project will affect the availability of commercial land and resource use opportunities.
	Outdoor Recreation and Tourism	■ The Project has the potential to affect the access to outdoor tourism and recreational land and resource use opportunities associated with parks and protected areas, fishing, hunting, trapping and non-consumptive tourism and recreation. ■ The Project has the potential to affect the quality and quantity of outdoor tourism and recreation land use opportunities.
	Archaeological Sites	■ Archaeological sites are an important aspect of the cultural heritage of Indigenous peoples. Archaeological sites are the focus of the archaeology discipline as archaeological sites are identified and protected by the *Ontario Heritage Act*.
Indigenous Interests - Tradition al land and resource use	Traditional land and resource use by Indigenous peoples	■ Trapping, hunting, fishing and gathering where traditional and are modern-day land and resource use activities are practised by Indigenous peoples in the Ottawa Valley. These activities provide important links to cultural continuity and traditional way of life. These activities are protected under Section 35 of the *Constitution Act*, which identifies that existing Indigenous and treaty rights of the Indigenous peoples of Canada are recognized and affirmed. For Métis people, the rights were affirmed in the courts in 2003 (R. v. Powley) confirming that Métis can assert Indigenous rights under Section 35 of the *Constitution Act*. ■ Indigenous peoples place a high degree of value on specific sites of cultural, historical, spiritual, social or ecological significance. These sites may have broader cultural significance related to the practice of formal or informal ceremonies at or near these sites.

Note: VCs denoted with an '*' indicate a valued component that does not have an assessment endpoint.

(a) The surface water quality assessment addresses only the non-radiological constituents of water; the assessment of radiological constituents is provided in Section 5.7 Ambient Radioactivity.

(b) Includes contributing watercourses and waterbodies within the Perch Creek and Perch Lake Watershed, including Perch Lake, Perch Creek, East Swamp Stream, and Main Stream.

R. v. Powley [2003] 2 SCR 207, 2003 SCC 43.
https://scc-csc.lexum.com/scc-csc/scc-csc/en/item/2076/index.do?r=AAAAAQAGcG93bGV5AAAAAAAAAQ

VC = valued component; NSDF = Near Surface Disposal Facility; CRL = Chalk River Laboratories; LSA = local study area; RSA = regional study area; SARA = *Species at Risk Act*; SSA = site study area; MBCA = *Migratory Birds Convention Act, 1994*; COSEWIC = Committee on the Status of Endangered Wildlife in Canada.

Assessment endpoints are qualitative expressions used to assess the significance of residual effects on VCs and represent the key properties of the VC that should be protected for future human generations (i.e., incorporating sustainability). For example, self-sustaining and ecologically effective fish and wildlife populations, continued land use opportunities and protection of archaeological resources may be assessment endpoints for fish and wildlife, land use and tenure and archaeological resources, respectively. Assessment endpoints are typically not quantifiable and require the identification of one or more measurement indicators that can be directly linked to the assessment endpoint.

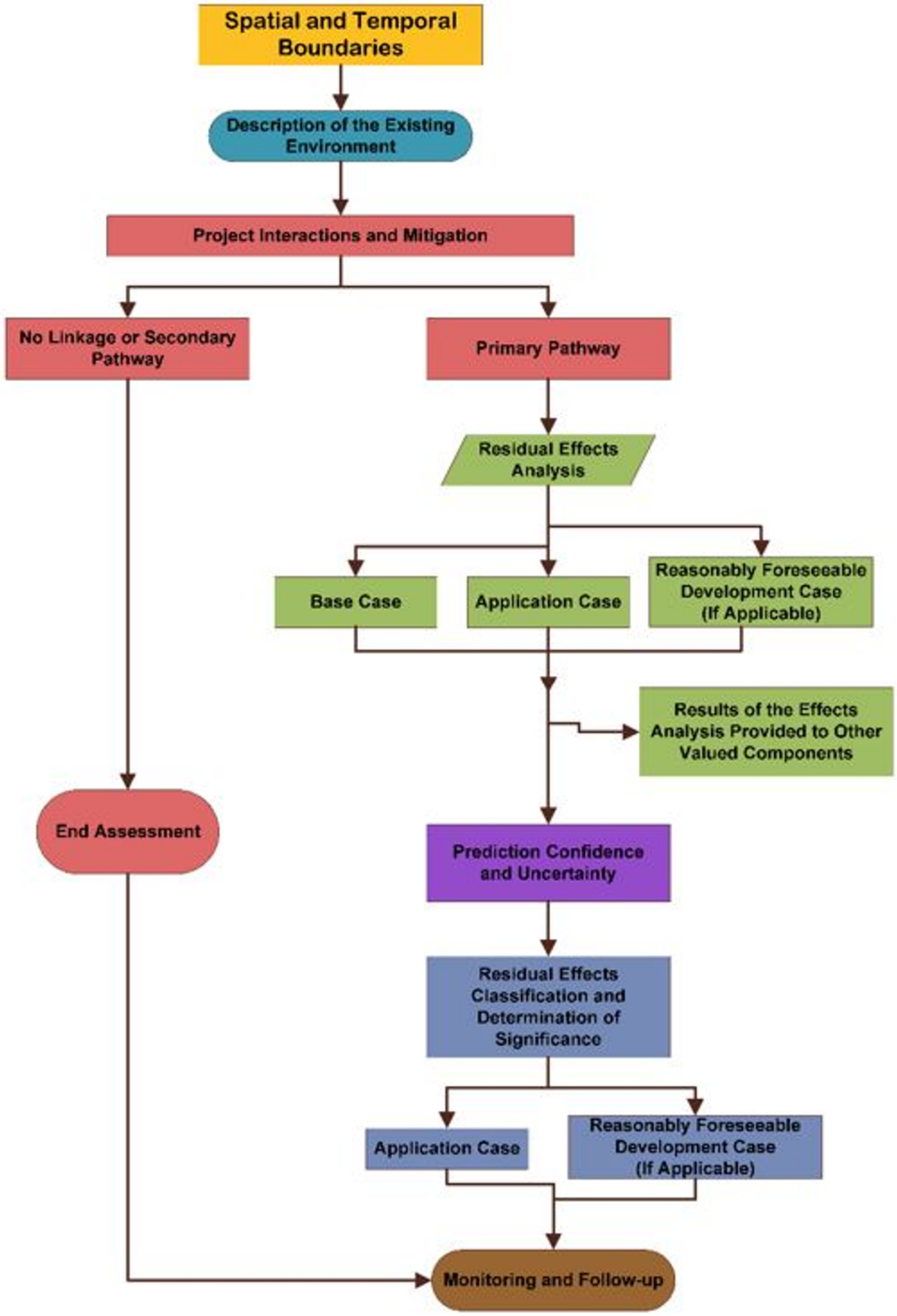
Measurement indicators represent properties of the environment and VCs that, when changed, could result in or contribute to an effect on assessment endpoints. Measurement indicators may be quantitative (e.g., concentrations of metals in surface water) or qualitative (e.g., movement and behaviour of wildlife from disturbance to habitat). Measurement indicators also provide the primary factors for discussing the uncertainty of effects on VCs and, subsequently, are key variables for study in potential follow-up and monitoring programs.

The significance of effects from the NSDF Project on VCs is evaluated by linking **changes** in measurement indicators to **effects** on the assessment endpoints. For example, changes in habitat quantity and quality (measurement indicators) are used to assess the significance of residual effects from the NSDF Project on the ability of a wildlife population to remain self-sustaining and ecologically effective (an assessment endpoint).

All VCs have measurement indicators, but not every VC has an assessment endpoint. For example, VCs such as geology, hydrogeology and surface water quality are considered as measurement indicators for other VCs, and do not have an assessment endpoint (i.e., they may be referred to as pathway or intermediate components). Intermediate components are considered to be important aspects of the natural and human environment, and are evaluated in the EIS to determine how they may influence assessment endpoints. The evaluation includes an analysis of changes in measurement indicators for the intermediate components. The results of the analysis are provided to other disciplines (e.g., aquatic and terrestrial environment and human health) for inclusion in their residual effects analysis.

VCs with no assessment endpoint are still analyzed for Project-specific and cumulative (if applicable) changes in measurement indicators. The changes are characterized in terms of magnitude, duration and geographic extent, but are not classified using rankings for effects criteria. For example, the magnitude of change in hydrological flows may be described as the relative change from baseline, but this change would not be classified (or ranked) as low, moderate, or high. This ranking would be reserved for the classification of residual effects and determination of significance for those VCs with assessment endpoints.

In summary, the same systematic and rigorous approach is applied to VCs with and without assessment endpoints, except that effects on VCs without explicit assessment endpoints are not classified using effects criteria or evaluated for significance. The environmental assessment approach for VCs with assessment endpoints is illustrated on Figure 5.1.2-1, and the approach for VCs with no assessment endpoints is illustrated on Figure 5.1.2-2. The assessment approach is described further in Sections 5.1.3 to 5.1.9.



REFERENCE(S)

CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
ENVIRONMENTAL ASSESSMENT APPROACH FOR VALUED COMPONENTS WITH AN ASSESSMENT ENDPOINT

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	PR
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	**5.1.2-1**

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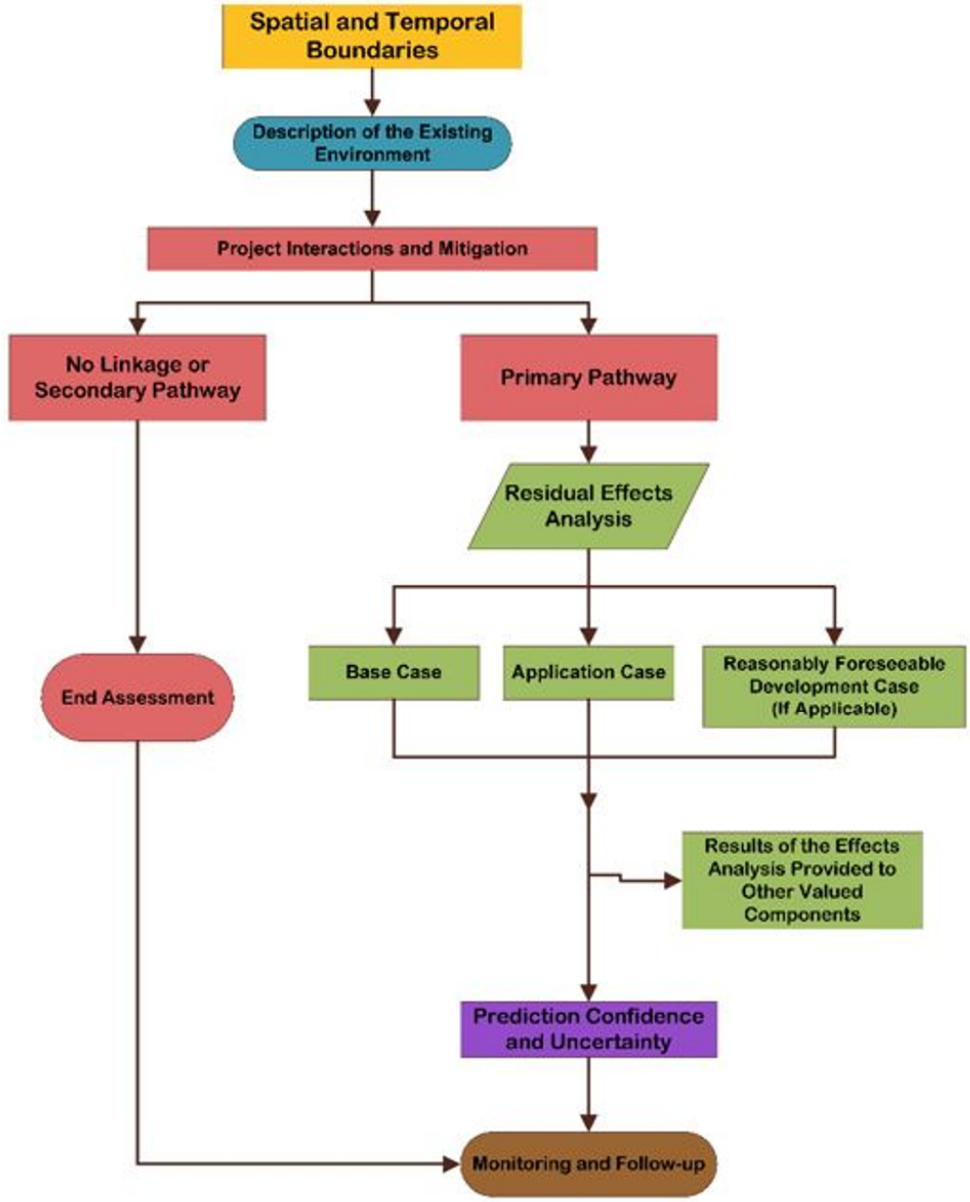

REFERENCE(S)

CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
ENVIRONMENTAL ASSESSMENT APPROACH FOR VALUED COMPONENTS WITHOUT AN ASSESSMENT ENDPOINT

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	PR
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APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.1.2-2

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5.1.3 Assessment Boundaries

Assessment boundaries define the geographic and temporal limits of the analysis of effects from the NSDF Project on the environment. These boundaries encompass the areas within which (spatial boundaries) and times during which (temporal boundaries) the NSDF Project, and in combination with previous, existing and reasonably foreseeable developments, is expected to interact with the VCs.

5.1.3.1 Spatial Boundaries

Defining the geographic extent of the study areas for each discipline is a key element of the environmental assessment process. Spatial boundaries are selected to be appropriate for each discipline (e.g., hydrogeology, surface water environment, terrestrial biodiversity and socio-economics), and associated VCs, using the following criteria:

- physical extent of the NSDF Project;
- physical extent of Project-related effects; and
- physical extent of key environmental systems (e.g., watershed boundary of potentially affected streams).

Individuals, populations and communities function within the environment at different spatial and temporal scales (Wiens 1989). In addition, the response of physical, chemical and biological processes to changes in the environment can occur across several spatial scales at the same time (Holling 1992; Levin 1992). This environmental assessment has adopted a multiscale approach for describing baseline conditions (existing environment) and predicting effects from the NSDF Project on VCs because the responses of physical, biological, cultural and economic properties to natural and human-induced disturbance will be unique and will occur across different scales.

For this EIS, data collected at the NSDF Project site and within the CRL site were used to provide measures of baseline environmental conditions and predict the direct and indirect changes from the NSDF Project on VCs (e.g., changes to terrestrial habitat from the physical footprint). Data collected at larger scales (i.e., outside of the CRL site) were used to measure broader-scale baseline environmental conditions. These data also provide regional context for the maximum predicted geographic extent of combined direct and indirect effects from the NSDF Project on VCs (e.g., changes to downstream water quality, or changes to regional employment and incomes). Cumulative effects from the NSDF Project in combination with previous, existing and reasonably foreseeable developments are assessed at the regional spatial scale.

Consistent with the Generic EIS Guidelines (CNSC 2016), the following spatial scales are considered by each discipline.

- **Site Study Area (SSA):** The SSA is the NSDF Project footprint (i.e., where Project activities would be undertaken, including the NSDF Project's proposed facilities, buildings and infrastructure).
- **Local Study Area (LSA):** The LSA is selected in consideration of the NSDF Project footprint and the spatial extent of potential direct effects of the Project on the VCs. The LSA is selected to represent an area that is likely to be directly affected by the Project, helping to identify Project-specific effects (rather than cumulative effects of the Project in combination with other projects in the region).
- **Regional Study Area (RSA):** The RSA is defined as the area within which the maximum geographical extent of potential indirect effects of the Project may interact with the effects of other existing or reasonably foreseeable developments.

The spatial boundary for the study areas considered by each discipline and the rationale for their selection are identified in Sections 5.2 through 5.10 under the “Assessment Boundaries” heading. The study areas are illustrated on maps of appropriate scale that are also included in Sections 5.2 through 5.10 under the “Assessment Boundaries” heading.

5.1.3.2 Temporal Boundaries

Temporal boundaries (i.e., project phases) establish the timeframe during which NSDF Project effects are assessed. The temporal boundary represents the timeframe during which project activities are actively occurring, and does include the duration of predicted residual effects. The duration of an effect is defined as the amount of time between the start and end of a Project activity or stressor (which is related to the project phases) plus the time required for the residual effect to be reversed. In some cases, a residual effect may be irreversible within the temporal boundaries of the Project (e.g., a residual effect that lasts for thousands of years). The following phases were identified for the NSDF Project.

- **Construction phase**: This phase includes site preparation and all activities associated with the construction of the NSDF Project. This phase includes activities such as installing the necessary supporting and/or ancillary facilities and infrastructure to facilitate NSDF Project operations, inactive commissioning and systems testing and transportation of construction materials. Construction activities are expected take place from 2021 to 2023.
- **Operations phase**: This phase includes all activities associated with waste placement, water management, Wastewater Treatment Plant (WWTP) operations, vehicle movements into and from the SSA and maintenance activities. Operations activities are expected to last approximately 50 years (i.e., 2024 to 2070).
- **Closure phase**: This phase includes activities necessary to complete the installation of the final cover and implementation of long-term monitoring. Closure activities are expected to start in 2070 and continue through to 2100, after which the NSDF Project will transfer into the post-closure phase.
- **Post-closure phase**: This phase has two discrete periods: institutional control and post-institutional control. The institutional control period includes implementation of controls throughout 2100 to 2400 (i.e., 300 years). During institutional control, environmental monitoring will be completed as required to confirm that the final cover is functioning as intended and to demonstrate compliance with the environmental assessment predictions. Post-institutional control occurs after year 2400 and continues indefinitely.

Baseline studies associated with each VC identify temporal variation (e.g., annual or seasonal changes in water flow or habitat use, or trends over time in populations and employment) and other biophysical constraints relevant to the assessment of the NSDF Project. The final selection of temporal boundaries is discipline-specific and includes consideration of the phases described above. For some VCs, residual effects are assessed for all phases of the NSDF Project but not necessarily for each specific phase. For example, effects on wildlife begin during the construction phase with the removal and alteration of habitat (i.e., results in direct and indirect changes) and continue through the operations phase and for a period after the closure phase until reversed, unless determined to be irreversible or permanent. Therefore, effects on wildlife are analyzed and predicted from construction through closure phases, which generates the maximum potential spatial and temporal extent of effects, and provides confident and ecologically relevant effects predictions.

Alternatively, for some VCs, the assessment was completed for those phases of the NSDF Project where predicted effects would be expected to peak (e.g., most air quality effects from emissions occur during construction) or at several key points in time. These points in time may include several periods within or among

Project phases. For example, evaluating surface water quality predictions at specific times that represent key milestones throughout the life of the NSDF Project. For other VCs, the assessment of effects may continue beyond the closure phase.

The temporal boundaries identified for cumulative effects assessments are specific to the VCs being assessed. Temporal boundaries include the duration of residual effects from previous and existing developments that overlap with residual effects of the NSDF Project and the period during which the residual effects from reasonably foreseeable developments (RFDs) will overlap with residual effects from the NSDF Project. The temporal boundaries considered by each discipline are identified in Sections 5.2 through 5.10 under the “Assessment Boundaries” heading.

5.1.3.3 Assessment Cases

This section provides a brief description of the assessment cases considered in the EIS. The assessment cases are discipline-specific and consist of the following:

- **Base Case**: This scenario represents existing conditions and characterizes combined effects from previous and existing developments and activities. The Base Case reflects the effects of existing disturbances, such as forestry, transportation, agricultural, mining and residential and recreational development. Current effects from the existing CRL facilities and operations, for example, are considered part of the Base Case.
- **Application Case**: This scenario represents predictions of the effects of the Base Case combined with the effects that may result from the NSDF Project.
- **Reasonably Foreseeable Developments (RFD) Case**: This scenario represents predictions of the cumulative effects of the Application Case, which includes the Base Case, plus projects that are currently under application review or that have officially entered a regulatory application process and are, therefore, considered reasonably foreseeable. In addition, effects from the future decommissioning and environmental remediation activities to be completed at the CRL site are also considered as part of the RFD Case.

5.1.4 Description of the Environment

To provide a basis for evaluating potential changes of the NSDF Project, the “Description of the Environment” subsection for each discipline assessment includes a description of the baseline conditions. Baseline studies are completed to develop an understanding of the existing physical, biological and social conditions that may be influenced by the NSDF Project and are used to prepare a Base Case. The Base Case includes the cumulative effects from all previous and existing developments in the study area of a VC. Existing environment or baseline conditions represent the historical and current environmental selection pressures that have shaped the observed patterns in VCs. Environmental selection pressures include natural (e.g., weather, predation and competition) and human-related factors (e.g., mineral development, forestry and traditional and sport hunting and fishing).

Existing conditions are described recognizing that conditions typically fluctuate depending on which selection pressures are currently driving changes to the VC and system. The fluctuations are generated by variation in natural factors (natural variation) and variation associated with human influences. The Base Case thus describes the existing environment without the implementation of the NSDF Project, and is used to provide an understanding of the physical, biological and social conditions that may be influenced by the NSDF Project.

Information sources included published and unpublished material and baseline and other monitoring data collected by CNL. This information was reviewed and analyzed to determine the presence of data gaps. Baseline field studies were then planned and carried out to fill the identified gaps. Relevant existing data from previous studies and the results of the recent baseline field programs are presented in the discipline-specific sections. Traditional knowledge, including Indigenous traditional knowledge, if available, was included in the baseline information.

The methods and results of the data collection described above that are directly relevant to the assessment of Project effects are summarized in the "Description of the Environment" subsections in Sections 5.2 through 5.10.

5.1.5 Project Interactions and Mitigation

Interactions (linkages) between Project components or activities and the corresponding potential changes to measurement indicators are identified by a pathway analysis that is then used to focus the residual effects assessment for the VCs. The first part of the analysis is to identify all pathways by which a Project component or activity could cause a potential effect. Each pathway is initially considered to have a linkage to potential effects on VCs. For an effect to occur, there has to be a Project component or activity that results in a detectable change to the measurement indicators and a correspondent effect on a VC.

Project Activity → Effects Pathway that Results in a Detectable Change in a Measurement Indicator or Intermediate Component → Effect on the Assessment Endpoint of a VC

The development of the potential pathways is followed by the screening of potential pathways to determine if mitigation is required, and if so, the development of environmental design features and mitigation that can be incorporated into the NSDF Project to remove a pathway (i.e., eliminate the potential effect) or limit (i.e., mitigate) adverse effects on VCs. Environmental design features and mitigation include engineering design elements, environmental best practices, management policies and procedures and spill response and emergency contingency plans. The description of environmental design features and mitigation will be specific to each discipline and the associated VCs. Any uncertainty associated with the effectiveness of proposed mitigation actions will be noted.

The purpose of the pathway analysis is to focus the residual effects analysis on linkages that require a more comprehensive assessment of effects on VCs, or those pathways that are likely to result in residual effects on a VC. Pathways are determined to have no linkage, a secondary (minor) linkage, or a primary linkage using scientific knowledge, logic, experience with similar developments and the effectiveness of environmental design features. Each potential pathway is evaluated and described as follows:

- **No linkage**: Analysis of the potential pathway reveals that there is no valid linkage between the NSDF Project and the VC, or the pathway is removed by environmental design features or mitigation so that the NSDF Project would not be expected to result in a measurable environmental change and would therefore have no residual effect on a VC relative to existing conditions or guideline values.
- **Secondary**: The pathway could result in a measurable minor environmental change, but would have a negligible residual effect on a VC relative to existing conditions or guideline values, and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable developments to cause a significant effect.
- **Primary**: The pathway is likely to result in an environmental change that could contribute to residual effects on a VC relative to existing conditions.

Pathways with no linkage to a VC, either because there was no linkage initially or because environmental design features or mitigation will remove the pathway, are not advanced for further assessment. Pathways that are assessed to be secondary and demonstrated to have a negligible residual effect on a VC through simple qualitative or semi-quantitative evaluation of the pathway are also not advanced for further assessment. In summary, pathways determined to have no linkage to a VC or those that are considered secondary are not expected to result in environmentally significant effects on the assessment endpoint of VCs, individually or cumulatively. Primary pathways require further effects analysis and classification to determine the environmental significance of the NSDF Project effects on VCs. Appendix 5.1-1 presents a matrix summarizing NSDF Project–environment interactions for each VC that are determined to be no linkage, secondary, or primary, after consideration of environmental design features and mitigation.

5.1.6 Residual Effects Analysis

The residual effects analysis is based on the NSDF Project–environment interactions that are determined to be primary in the pathway analysis. For primary pathways that require a residual effects analysis, the concept of assessment cases is applied to estimate the incremental and cumulative effects from the NSDF Project, as well as previous, existing and reasonably foreseeable developments. The residual effects analysis is completed for the Application Case and the RFD Case.

5.1.6.1 Application Case

This Application Case represents predictions of the cumulative effects of the existing environment combined with the effects that may result from the NSDF Project. The residual effects analysis for the Application Case is based on residual Project-specific (incremental) effects that are evaluated to be primary in the pathway analysis. The environmental design features and mitigation identified in Section 5.1.5 will be described in this section. Thus, the residual effects analysis will consider all primary pathways that will likely result in detectable changes in measurement indicators, and subsequent residual effects on VCs, after implementing environmental design features and mitigation. The Application Case represents effects predictions of the projects represented in the existing environment (Base Case) combined with the effects that may result from the NSDF Project.

The Application Case represents predictions of the cumulative effects of the developments in the Base Case combined with the effects from the NSDF Project. Where relevant, this case was used to identify the incremental changes from the NSDF Project that are predicted to occur between the Base Case and the Application Case. The residual effects analysis considers the proposed environmental design features and mitigation identified in Section 5.1.5.

The temporal boundary of the Application Case begins with the anticipated first year of construction of the NSDF Project, and continues until the predicted effects are reversed. For several VCs, the temporal extent of some effects likely will be greater than the lifespan of the NSDF Project because the effects will not be reversible until after closure. For other VCs, the effects may be determined to be irreversible within the temporal boundary of the Application Case. Such effects may be permanent or the duration of the effect may not be known, except that it is expected to be extremely lengthy (i.e., more than 100 years past closure).

Results of the effects analyses for the Application Case are used to describe the magnitude, duration and geographic extent of the predicted changes to measurement indicators and residual effects on VC assessment endpoints. Expected changes are expressed quantitatively (i.e., numerically), wherever possible. For example, the magnitude of the effect may be expressed in absolute or percentage values above or below baseline conditions or a guideline value. The duration, including reversibility, of the effect typically is described in years relative to the phases of development of the NSDF Project and the spatial extent of effects is typically expressed in area or distance from the NSDF Project. In addition, the direction, frequency, reversibility, probability and context of effects are described, where applicable. Rankings such as short-term duration or moderate magnitude are not used in the effects analysis. These rankings are applied to the classification of effects and determination of significance, where definitions of these rankings are provided.

Effects on social, economic and cultural properties include positive and negative changes to employment, training and education, family income, traditional land use, family and community cohesion and long-term social, cultural and economic sustainability. Some of these measurement indicators can be analyzed quantitatively (e.g., number of jobs created and estimated income levels). Other indicators such as community cohesion and traditional land use are more difficult to quantify, and involve information from public engagement, literature, examples from similar projects under similar conditions, and scientific knowledge and experience. The effects analysis considers the interactions among the unique and common attributes, challenges and opportunities related to social, cultural and economic measurement indicators.

5.1.7 Prediction Confidence and Uncertainty

The purpose of an environmental assessment is to predict the future conditions of the biophysical and human environments as a result of a proposed project or development. Because the biophysical and human environment changes naturally and continually through time and across space, most assessments of effects embody some degree of uncertainty. The purpose of the uncertainty sections of the assessment is to identify the key sources of uncertainty and to discuss how uncertainty is addressed to increase the level of confidence that effects will not be worse than predicted. Confidence in effects analyses can be related to many elements, including the following:

- adequacy of the baseline data for providing an understanding of the existing conditions and future changes unrelated to the NSDF Project (e.g., rate and extent of future developments, climate change or catastrophic events);
- model inputs (e.g., changes in chemical concentration in water over time and space);
- understanding of Project-related effects on complex ecosystems that contain interactions across different scales of time and space (e.g., how and why the NSDF Project will influence wildlife);
- limited knowledge and experience with the type of effect in the system;
- knowledge of the effectiveness of the environmental design features for reducing or removing effects (e.g., environmental performance of the base liner);
- uncertainties associated with the exact location, physical footprint and activity level of the NSDF Project, as well as the timing, nature and rate of future developments in the RFD Case; and
- uncertainties in the direction, magnitude and spatial extent of future fluctuations in ecological, cultural and socio-economic variables, independent of effects from the NSDF Project and other developments.

Uncertainty in these elements can decrease confidence in the prediction of environmental significance. Discipline studies use quantitative methods, such as sensitivity analyses, or qualitative discussion to assess prediction confidence to the extent reasonable. Assumptions for statistical tests, and details on models that were used as part of the assessment, are discussed within each discipline of study. Where possible, methods are used to reduce uncertainty and increase the level of confidence in effects predictions, as shown in the following examples:

- using the results from several models and analyses to help reduce bias and increase precision in prediction; and
- using data from effects monitoring programs and literature as inputs for models rather than strictly hypothetical or theoretical values.

In addition, a conservative approach was implemented when information is limited so that effects are typically overestimated (e.g., defining the key input variables so that the result is a conservatively high effects prediction). Where appropriate, residual uncertainty is addressed by additional mitigation and in monitoring and follow-up programs. Each discipline of study includes a discussion of how uncertainty is addressed and provides a qualitative evaluation of the resulting level of confidence, which is included in the residual effects classification and determination of significance discussions.

5.1.7.1 Reasonably Foreseeable Development Case

The RFD Case includes the Application Case plus additional RFDs in the region that have not yet been approved. Developments and activities that are currently under application review or have officially entered a regulatory application process were considered reasonably foreseeable. This section describes the general methods used to predict whether the cumulative effects from the NSDF Project, in combination with previous, existing and reasonably foreseeable developments and activities are likely to result in environmental, social, economic, heritage and health effects, taking into account the mitigation actions proposed in the EIS.

The CEAA 2012 requires that each environmental assessment of a designated project take into account any cumulative environmental effects that are likely to result from the designated project in combination with the environmental effects of other physical activities that have been or will be carried out (The Agency 2015). Cumulative effects such as those that are likely from a reviewable project, combined with the effects from previous, existing and reasonably foreseeable future developments that are sufficiently certain to proceed. Therefore, the RFD Case represents predictions made about the cumulative effects of the Application Case, which includes the Base Case, plus projects that are currently under application review or that have officially entered a regulatory application process, and are therefore, considered reasonably foreseeable.

The RFD Case includes the predicted duration of residual effects from the NSDF Project, plus other previous, existing and future developments and activities. Thus, the minimum temporal boundary for the Application Case and the RFD Case is the expected lifespan of the NSDF Project, which, like the Base Case, includes a range of conditions over time. The difference between the Application Case and the RFD Case is that the Application Case considers the incremental effects from the NSDF Project in isolation of potential future land use activities.

The VCs requiring an analysis under the RFD Case are determined by understanding whether the residual effects from the NSDF Project and one or more additional developments (or activities) overlap or interact with the temporal or spatial distribution of the VC. Where potential cumulative effects from the RFD Case are identified for these VCs, these effects will be assessed using the same approach used for the NSDF Project-specific effects analysis (Section 5.1.6.1).

The analysis for the RFD Case is quantitative where possible and qualitative where necessary. The analysis is quantitative for those future projects that could be assigned a location, a physical footprint (i.e., known or hypothetical) on the landscape and information about project emissions (e.g., to air and water). The analysis is qualitative for developments that did not have this information. For all RFDs, the EIS uses the most current information available for the location, size and type of activity associated with a project.

5.1.8 Residual Effects Classification and Determination of Significance

5.1.8.1 Residual Effects Classification

The purpose of the residual effects classification is to describe the residual incremental and cumulative adverse effects from the NSDF Project and other developments on VCs using a common set of criteria. The classification criteria provide definitions that permit a clear, thorough and unambiguous classification of residual effects such that reviewers and readers can follow and apply the logic used in the assessment and reach the same classification for a given residual effect. The residual effects classification is then used to make significance determinations. The intent of the environmental assessment is to predict if the NSDF Project is likely to cause a significant adverse (i.e., negative) effect on the environment or to cause public concern.

The classification of residual adverse effects and the determination of significance are completed for those VCs that have assessment endpoints, and where residual adverse effects are predicted. The residual effects classification takes into consideration additional mitigation identified (if applicable) in the residual effects assessment. The results of the classification are used to determine the significance of predicted adverse effects.

Effects are classified using the criteria listed below, which follow the Generic EIS Guidelines (CNSC 2016) and the Agency's *Determining Whether a Designated Project is Likely to Cause Significant Adverse Environmental Effects under the Canadian Environmental Assessment Act, 2012* (The Agency 2018b). Specific definitions for the classification criteria have been developed for each VC or discipline of study.

Direction: Direction indicates whether the residual effect on a VC is negative (i.e., less favourable), positive (i.e., improvement), or neutral (i.e., no change). Neutral and positive changes are not assessed for significance.

Magnitude: Magnitude is a measure of the intensity of a residual effect, or the degree of change caused by the NSDF Project (and other developments, if applicable) relative to baseline conditions, guidelines, or threshold values. Magnitude is typically classified into three scales: negligible to low, moderate and high. The scales of magnitude are specific to each VC or discipline of study, and incorporate the geographic extent and duration of residual effects in context of the properties of VC assessment endpoints. Where possible, magnitude is reported in absolute and in relative terms.

Geographic extent: This criterion refers to the spatial extent of the effect, and is different from the spatial boundary (i.e., study area) for the residual effects analysis. The spatial boundary for the residual effects analysis represents the maximum area used for the assessment, and is related to the spatial distribution and movement of VCs. The geographic extent of residual effects can occur on multiple scales within the spatial boundary of the assessment. Geographic extent refers to the area affected, and is often categorized into three scales of local, regional and beyond regional.

Duration: Duration is defined as the amount of time (usually in years) from the beginning of a residual effect on when the residual effect to a VC is reversed and is expressed relative to Project phases. Duration has two components. It is the amount of time between the start and end of a Project activity or stressor (which is related to Project development phases), plus the time required for the residual effect to be reversed.

Reversibility: After removal of the NSDF Project activity or stressor, reversibility is the likelihood that the NSDF Project will no longer influence a VC in a future predicted period. Reversibility usually has only two alternatives: reversible or irreversible. The period is provided for reversibility (i.e., duration) if a residual effect is reversible. Permanent residual effects are considered irreversible.

Frequency: Frequency refers to how often a residual effect will occur and may be expressed as isolated, periodic, or continuous. Frequency is explained more fully by identifying when the residual effect occurs (e.g., once at the beginning of the NSDF Project). Timing was not included as a separate criterion. If the frequency is periodic, then the length of time between occurrences and the seasonality of occurrences (if present) is discussed.

Likelihood: Likelihood is the probability of an effect occurring and is described in parallel with uncertainty. This criterion may be influenced by a variety of factors, such as the likelihood of disturbance occurring or the likelihood of mitigation being successful. Four classification categories are typically used: unlikely, possible, likely and highly likely.

The specific definitions applied to the above classification criteria for each VC or discipline of study are based on the ecological or socio-economic processes and properties of the VC or discipline of study. Although some professional judgement or experienced opinion is inevitable in determining the scales for effects predictions, the residual effects, to the extent possible, are classified using scientific principles, established guidelines, thresholds or target values, and supporting evidence.

5.1.8.2 Determination of Significance

The residual effects classification of primary pathways and the associated predicted changes in measurement indicators provide the foundation for determining the significance of incremental and cumulative effects from the NSDF Project and other previous, existing and reasonably foreseeable developments on VC assessment endpoints. For some VCs, there may be no RFD Case and the assessment is limited to determining the significance of residual effects from the NSDF Project and previous and existing developments (i.e., Application Case). For those VCs that may be influenced by forecasted future developments, the assessment includes classifying and determining the significance of cumulative effects from all previous, existing and reasonably foreseeable developments, including the NSDF Project (i.e., RFD Case). The classification of residual adverse effects and the determination of significance are completed only for those VCs that have assessment endpoints. Although the neutral and positive residual effects associated with the NSDF Project are reported in this section, they are not assessed for significance.

Magnitude is the primary criterion used to determine the significance of effects on VCs. Where possible and appropriate, established guidelines, thresholds and screening values are used to support the classification of the predicted amount of change in measurement indicators and associated effects on VC assessment endpoints. For some disciplines and VCs, such as aquatic health effects to fish, guideline or threshold values are known with reasonable certainty, which increases confidence in effects predictions and significance determinations. For other VCs of the biophysical and human environments, social and ecological benchmarks or effects thresholds are not known with reasonable certainty, which decreases confidence in determining the significance of predicted effects. For example, critical thresholds and screening levels for measurement indicators such as habitat quality, quantity and connectivity and ecologically effective population sizes are frequently not available for plant, fish and wildlife species. Because of the uncertainty regarding the effects of development on VCs, magnitude classification is conducted conservatively to increase confidence that effects will not be under-estimated. Furthermore, the determination of significance considers the level of confidence in the effects predictions.

Magnitude also considers the geographic extent and duration of residual effects that are specific to VC assessment endpoints. For example, the magnitude of an effect on a fish or wildlife VC from changes in habitat availability and connectivity depends on the spatial extent (e.g., amount of area or proportion of the population) and duration of the changes in habitat (e.g., how long populations using that habitat may be adversely affected). Duration includes consideration of reversibility; a reversible effect from development does not result in a permanent adverse effect and therefore may be considered to be of lower magnitude. The duration of residual effects to VCs with high resilience (ability to recover from disturbance) would be expected to be shorter relative to VCs with lower resilience to disturbance.

Frequency is considered a modifier when determining significance, where applicable. For example, the magnitude of the effect from the loss of individuals from a wildlife population due to collisions with vehicles will depend partially on how often animal-vehicle collisions occur over the life of a project. For some effects, such as the physical loss of habitat from the NSDF Project, the likelihood is high and has little influence on the significance of effects (i.e., the decline in habitat is certain and significance depends on the amount of change over space and time [magnitude]). Alternately, the magnitude of an effect may vary from low to high depending on the probability of different projected outcomes of climate change and the degree of success in actions implemented to mitigate effects from climate change. Likelihood is also considered a modifier, but it is applied after significance is determined.

The evaluation of significance for biophysical VCs considers the entire set of primary pathways that influence a particular assessment endpoint; thus, significance is not explicitly assigned to each pathway. Rather, the relative contribution of each pathway is used to determine the significance of potential adverse effects of the NSDF Project and other developments on an assessment endpoint. This approach is known as a “weight of evidence” approach (i.e., an evaluation of the persuasiveness of the collective evidence). For example, a pathway with a high magnitude (which would include a large geographic extent and a long-term duration) is given more weight in determining significance relative to pathways with smaller scale effects. The relative effect from each pathway is discussed; however, pathways that are predicted to have the greatest influence on effects to assessment endpoints are assumed to contribute the most to the determination of significance. This method is used to identify predicted residual adverse effects that have sufficient magnitude, duration and geographic extent to result in significant adverse effects on VC assessment endpoints.

Classification of residual effects and determination of significance for the human environment generally follow the methods used for biophysical VCs. However, there are some differences in the selection and definition of effects criteria. For socio-economic VCs, direction, magnitude, geographic extent and duration are the criteria used to classify effects and evaluate the significance of changes to assessment endpoints. The assessment of significance considers the scale of these criteria (e.g., low magnitude, regional geographic extent and long-term duration) and scientific knowledge and experience, which is based on the context of the communities involved, and the informed value and judgement of interested and affected organizations and specialists. The level of significance takes into consideration the effectiveness of the proposed mitigation (i.e., policies, practices and investments) and benefit enhancement programs to limit negative effects and foster positive effects on the continued persistence of long-term sustainable social, cultural and economic features of the human environment.

Details on the approach and methods for classifying residual effects and determining significance on VCs of the biophysical and human environments are provided in the applicable discipline sections of the EIS. The definition of a significant effect is specific to each discipline and will be provided in each discipline section. Significance is determined for the residual adverse effects of the NSDF Project overall, for the cumulative residual adverse effects from the NSDF Project and previous and existing developments (Application Case), and for the NSDF

Project and previous, existing and reasonably foreseeable developments (RFD Case). The following is a summary of some of the key factors considered in the determination of significance on VCs of the biophysical and human environments:

- Magnitude is the primary criterion used to determine significance, with geographic extent and duration (which implies reversibility) providing important context for assigning magnitude.
- Frequency and likelihood act as modifiers for determining significance, where applicable.
- The degree of uncertainty in the effects estimates also influences the classification of magnitude and the determination of significance. Where uncertainty was high and the effect from the Project might be either significant or not significant, the assessment conservatively identified the effect as significant and provided additional follow-up actions to reduce uncertainty.

5.1.9 Monitoring and Follow-up

In the EIS, monitoring programs are proposed to address the uncertainties associated with the effects predictions and the performance of mitigation. In general, monitoring is used to verify the effects predictions, identify any unanticipated effects and provide for the implementation of adaptive management to limit these effects. Typically, monitoring includes one or more of the following categories, which may be applied during the development of the NSDF Project:

- **Compliance monitoring**: monitoring activities, procedures and programs undertaken to confirm the implementation of approved design standards, mitigation and conditions of approval and company commitments (e.g., inspecting the installation of a silt fence).
- **Environmental monitoring**: monitoring to track conditions or issues during the development lifespan of the NSDF Project, and to subsequently provide for the implementation of adaptive management (e.g., monitoring of treated wastewater discharge quality and volumes).
- **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., monitoring of downstream lakes for aquatic effects). Results from these programs can be used to increase the certainty of effect predictions in future environmental assessments.

Proposed monitoring and follow-up programs are discussed in each discipline section of the EIS and, upon Project approval, will be included in CNL’s Environmental Protection Program or other appropriate CNL management, monitoring, or reporting programs. Where relevant, conceptual monitoring programs will be proposed to deal with the uncertainties associated with the effect predictions and mitigation.

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5.2 Atmospheric Environment

This section of the Environmental Impact Statement (EIS) for the Canadian Nuclear Laboratories (CNL) Near Surface Disposal Facility (NSDF) Project seeks to understand and characterize potential residual effects of the NSDF Project and other previous, existing, and reasonably foreseeable developments on the atmospheric environment. As part of the assessment, the following subsections present an assessment of the atmospheric environmental effects of the NSDF Project. Section 5.2.1 focuses on air quality and Section 5.2.2 focuses on greenhouse gas (GHG) emissions. Radiological emissions are not included within this section and instead are discussed in Section 5.7 Ambient Radioactivity and Ecological Health.

There are no sensitive receptors[1] in the vicinity of the NSDF Project that would experience nuisance effects from the construction and operations phases of the NSDF Project due to noise and vibration. The nearest dwelling to the NSDF Project site is located approximately 3 km away. The *NSDF Project Construction-Related Road Traffic on Human Receptors* (Golder 2018) was been completed to understand the potential for indirect effects of noise from NSDF Project traffic on adjacent land users; the results are discussed in Section 5.10 Socio-economic Environment. A discussion of potential indirect effects from noise and vibrations and supporting information is also provided in Sections 5.5 Aquatic Environment and 5.6 Terrestrial Environment.

5.2.1 Air Quality

5.2.1.1 Scope of the Assessment

The air quality assessment focusses on predicting changes in indicator compound emissions and comparison of these changes to the applicable guidelines and standards (see Section 5.2.1.4). The indicator compounds relevant to the NSDF Project include suspended particulate matter (SPM), particles nominally smaller than 10 µm in diameter (PM_{10}), particles nominally smaller than 2.5 µm in diameter ($PM_{2.5}$), carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxides (NO_x) expressed as nitrogen dioxide (NO_2). Emissions of particulates (SPM, PM_{10}, and $PM_{2.5}$), CO, SO_2, and NO_x have the potential to affect aquatic, human, and terrestrial wildlife health. Particulates emissions, which are also referred to as fugitive dust, can be a nuisance issue of concern to the public. In addition to the indicator compounds noted above, hydrogen sulfide (H_2S), vinyl chloride (C_2H_3Cl), lead (Pb), mercury (Hg), and odour emissions have been considered as indicator compounds. Acrolein (C_3H_4O) was included to represent volatile organic compounds (VOCs) from combustion at the request of Canadian Nuclear Safety Commission (CNSC). Radiological indicator compounds are not included in this assessment and instead have been evaluated in Section 5.7 Ambient Radioactivity and Ecological Health.

The air quality assessment follows the overall environmental assessment approach and methods described in Section 5.1 Environmental Assessment Approach. The assessment was completed following the key steps listed below:

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries, and assessment cases** for the air quality assessment (refer to Sections 5.2.1.2 Valued Components and Section 5.2.1.3 Assessment Boundaries). The VCs, assessment endpoints, and measurement indicators used to assess Project-related changes to air quality are described, along with the spatial and temporal boundaries at which the assessment occurred; and the assessment cases considered.

[1] Consistent with *O. Reg. 419/05 Air Pollution – Local Air Quality,* the air quality assessment considers the following places as ‘sensitive receptors’: a health care facility; a senior citizens’ residence or long-term care facility; a child care facility; an educational facility; a dwelling; or a place specified by the Director in a notice under subsection (9) as a place where discharges of a contaminant may cause a risk to human health.

- **Step 2 – Describe the existing conditions** (refer to Section 5.2.1.4 Description of the Environment). Existing conditions in the local and regional areas are described, including the combined effects of previous and existing developments (Base Case). The existing environment represents the historical and current environmental pressures that have shaped the observed patterns in the environment (i.e., natural variation). The existing conditions provide a reference, to which the effects of the NSDF Project can be compared.
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 5.2.1.5 Project Interactions and Mitigation). Project components and/or activities with the potential to affect air quality are identified and mitigation developed to limit or avoid effects is presented. A pathways analysis is then used to focus further assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects are adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects to air quality after incorporating mitigation are carried forward to Steps 4 for further analysis and residual effects characterization.
- **Step 4 – Present the methods and results of the residual effects analysis** (refer to Section 5.2.1.6 Residual Effects Analysis). This section outlines the methods used to predict and characterize residual effects to air quality from primary effects pathways. The analysis results are also presented including the characterization of incremental effects from the NSDF Project, as well as cumulative effects of the Project in combination with other reasonably foreseeable developments (if applicable). A key outcome of this section is the predicted changes to emissions of indicator compounds that are passed on to other disciplines for their assessment.
- **Step 5 – Describe the level of certainty and management of uncertainty** (refer to Section 5.2.1.7 Prediction Confidence and Uncertainty). This purpose of this section is to evaluate the available literature, data, and models used for the assessment, and describe the level of certainty that can be placed on predicted residual effects. This section will also identify how the uncertainty has been managed so that the effects are not underestimated.
- **Step 6 – Classify and determine the significance of the predicted residual effects** (refer to Section 5.2.1.8 Residual Effects Classification and Determination of Significance). Residual effects predicted from primary pathways are classified using a common set of criteria: direction, magnitude, geographic extent, duration, reversibility, frequency, and likelihood. A determination of the significance of the predicted residual effects from NSDF Project for the air quality VC is made.
- **Step 7 – Identifying monitoring and follow-up** required to confirm effects predictions and address uncertainty (refer to Section 5.2.1.9 Monitoring and Follow-up).
- **Step 8 – Present a consolidated summary of conclusions and outcomes of the assessment** of residual effects on air quality (refer to Section 5.2.1.10 Conclusions).

Information and areas of interest raised by the public, communities of interest, and Indigenous communities or groups during engagement that influenced the scope of the air quality assessment are summarized in Table 5.2.1-1. Other general areas of interest and questions (if any) raised during the engagement that pertain to the air quality assessment are documented in CNL's Indigenous Engagement Report (CNL 2020a) and CNL's Stakeholder's Activity Reports (CNL 2017a,b, 2019a).

Table 5.2.1-1: Summary of Areas of Interest Raised During Engagement Activities that Influenced the Scope of the Air Quality Assessment

Areas of Interest	How the Area of Interest Was Included in the Assessment
Would like information on monitoring air contamination, including dust.	The monitoring program proposed for air quality includes monitoring of fugitive dust emissions and is described in Section 5.2.1.9. Fugitive Dust Monitoring is captured through the implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and air verification monitoring. In addition, the *Dust Management Plan* (AECOM 2018a) to be implemented for the NSDF Project will include information on dust mitigation and monitoring for the NSDF Project.

5.2.1.2 Valued Components

Valued Components (VCs) refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community or the public (The Agency 2018). Air quality was selected as a VC as there is a potential for the NSDF Project activities to release air emissions that could affect the air quality (Table 5.2.1-2). Meteorology is also important as it governs the transport, dispersion, and deposition of air emissions from the NSDF Project. An understanding of the meteorological processes is necessary to address and model potential air quality effects of the NSDF Project. Details on meteorology are provided in the Air Quality Assessment Technical Supporting Document (TSD; Golder 2019) Section 2 (Meteorology Assessment).

Table 5.2.1-2: Valued Components for Air Quality Assessment

Valued Component	Rationale for Selection
Air Quality	■ Air quality is selected as a VC as emissions from the NSDF Project activities have the potential to alter the existing air quality regime. ■ Changes in air quality can affect human health, aquatic and terrestrial biodiversity.

VC = valued component

Assessment endpoints are qualitative expressions used to assess the significance of residual effects on VCs and represent the key properties of the VC that should be protected for future generations. The assessment endpoint for air quality is performance against the criteria and thresholds for protection of human health and the environment.

Measurement indicators represent properties of the environment and VCs that, when changed, could result in or contribute to an effect on a VC. Measurement indicators also provide the primary factors for discussing the uncertainty of effects on VCs and, subsequently, are the key variables for study in follow-up and monitoring programs. The assessment of air quality focused on predicting changes in the concentrations of selected non-radiological indicator compounds. The measurement indicator considered in the air quality assessment includes changes to the concentrations of non-radiological indicator compounds listed in Table 5.2.1-3. Deposition rates for non-radiological indicator compounds were also predicted and provided to other disciplines to assess the indirect effects of air quality. In addition, the decomposition of waste can result in emissions due to the breakdown of waste material within the NSDF. Overall, these compounds are generally accepted as indicative in changing air quality, and for which relevant air quality criteria exist. The selected non-radiological indicator compounds fall into the following four categories:

- **particulate matter**: SPM, PM_{10}, and $PM_{2.5}$;
- **combustion gases**: NO_X represented by NO_2, SO_2, CO, and C_3H_4O;

- **decomposition of waste**: H_2S, C_2H_3Cl, and odour; and
- **metals**: Pb and Hg.

Table 5.2.1-3: Assessment Endpoints and Measurement Indicators for the Air Quality Assessment

Valued Component	Assessment Endpoints	Measurement Indicators	Discipline Assessments where Effects on Air Quality are Considered
Air Quality	Performance against criteria and thresholds for protection of human health and the environment	Changes to ambient concentrations of indicator compounds (SPM, PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, C_3H_4O, H_2S, C_2H_3Cl, Pb, Hg, and odour).	■ Section 5.4.2 Surface Water Quality ■ Section 5.5 Aquatic Environment ■ Section 5.6 Terrestrial Environment ■ Section 5.8 Human Health ■ Section 5.9 Land and Resource Use

SPM = suspended particulate matter; $PM_{2.5}$ = particulate matter less than 2.5 µm (microns) in diameter; PM_{10} = particulate matter less than 10 µm (microns) in diameter; CO = carbon monoxide; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; C_3H_4O = acrolein; H_2S; = hydrogen sulfide; C_2H_3Cl = vinyl chloride; Pb = lead; Hg = mercury.

These compounds are associated with various NSDF Project activities, as well as activities at the Chalk River Laboratories (CRL) main campus. Particulate matter in the form of fugitive dust is typically associated with airborne dust from vehicles travelling on unpaved roads/haul routes on site, as well as material loading, stockpiling and unloading activities. Products of combustion (e.g., particulate matter, NO_2, SO_2, CO, and Pb) are associated with the exhaust from on-site vehicles and stationary combustion from the Wastewater Treatment Plant (WWTP) process and comfort heating equipment. In addition, C_3H_4O was included to represent VOCs from combustion. Emissions from the decomposition of waste (e.g., H_2S, C_2H_3Cl, and odour) were not included in *Effluent Verification Monitoring at Chalk River Laboratories in 2018* (CNL 2019b), but are the result of the breakdown of waste material within the NSDF Project; and therefore, included as indicator compounds.

Ozone (O_3) was also included in the air quality assessment as it will be used to calculate the NO_2 in the effects assessment. Ozone is not emitted directly into atmosphere but is associated with the reaction of NO_X and VOCs (MECP 2018).

Other contaminants identified as indicator compounds that occur from the decomposition of the waste in the engineered containment mound (ECM), such as CO and Hg were also included. Odour emissions from the WWTP processes were also included. Metals are associated with number 6 fuel oil consumption at the CRL main campus (CNL 2019b), and have decreased since the conversion to natural gas at the powerhouse as part of the completed facility improvements.

Total VOCs and halocarbon refrigerants identified as emissions from the CRL main campus (CNL 2019b) are not considered indicator compounds for the NSDF Project; and therefore, were not retained for the air quality assessment.

The measurement indicators used for assessing the effects of the NSDF Project on the air quality VC are a combination of indicator compound and averaging period for which federal and provincial air quality objectives and criteria are available. A single measure is used when evaluating effects, namely the maximum predicted concentration resulting from the NSDF Project activities. To evaluate the effect of Project-related changes to air quality on other VCs, the results of the air quality assessment were provided for the disciplines listed in Table 5.2.1-3.

5.2.1.3 Assessment Boundaries

5.2.1.3.1 Spatial Boundaries

The spatial boundaries selected for the air quality assessment are presented on Figure 5.2.1-1 and are described below:

- **Site Study Area (SSA):** the SSA is the NSDF Project footprint (i.e., the NSDF Project site, where Project activities would be undertaken including proposed facilities, buildings and infrastructure).
- **Local Study Area (LSA):** The LSA is defined to encompass activities and sources of emissions associated with the Project. The LSA includes the SSA and corresponds to the CRL site boundary.
- **Regional Study Area (RSA):** The RSA is defined as the area within which the potential effects of the NSDF Project may interact with the effects of other existing or reasonably foreseeable developments. The RSA is equivalent to a circle surrounding the LSA with an approximate 7.4 km radius (Figure 5.2.1-1).

For the purposes of this assessment, results at the LSA boundary will be presented in the air quality assessment as it represents the highest ground-level concentrations of contaminants expected outside the CRL site.

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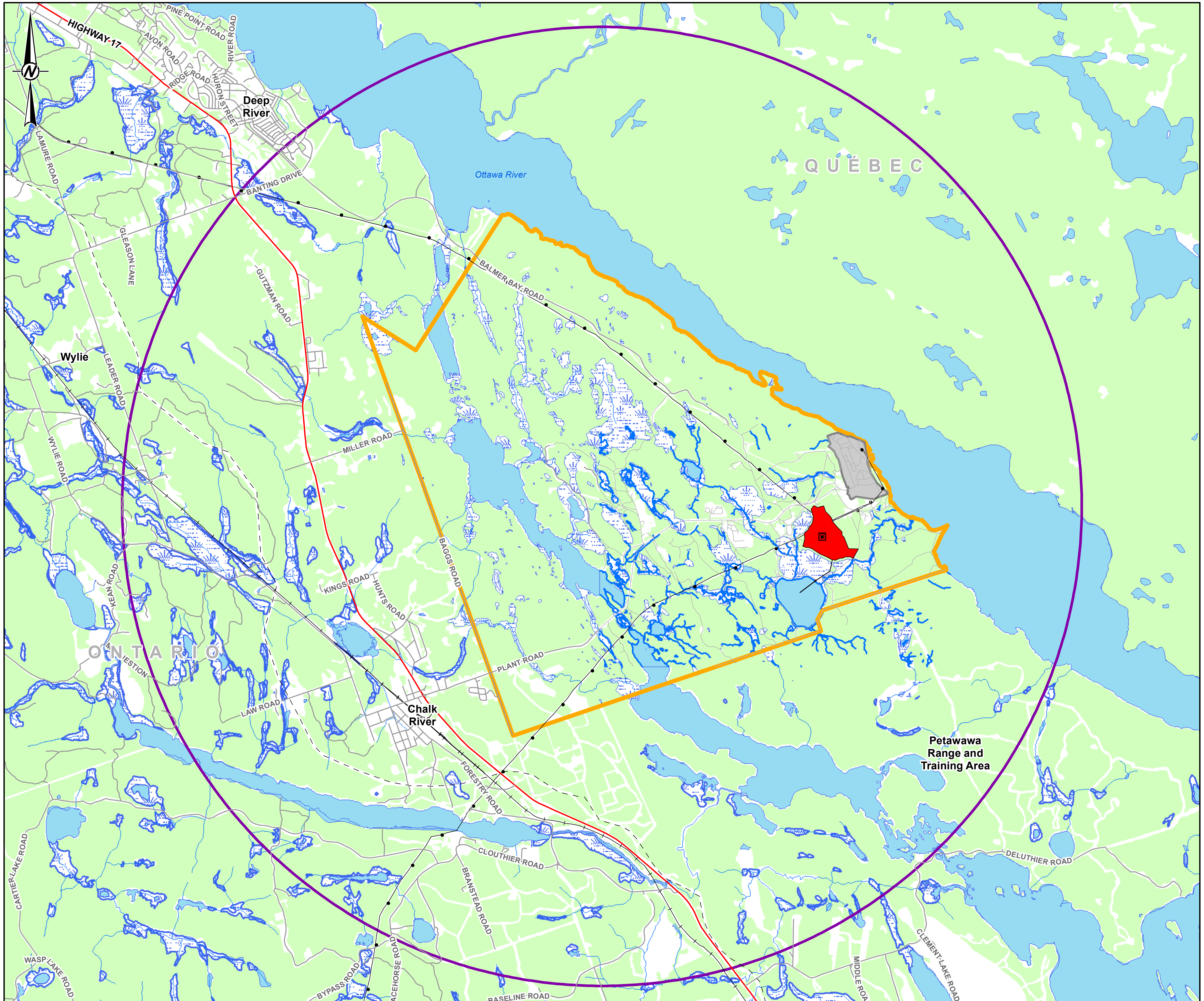

LEGEND

- HIGHWAY
- ROAD
- RAILWAY
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- NEAR SURFACE DISPOSAL FACILITY (NSDF) PROJECT CENTROID
- CRL MAIN CAMPUS
- SITE STUDY AREA (NSDF PROJECT SITE)
- LOCAL STUDY AREA (CRL SITE)
- REGIONAL STUDY AREA

2.5 0 2.5

1:60,000 KILOMETRES

REFERENCE(S)

1. BASEMAP:SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. HIGHWAYS AND FIRST NATION RESERVES MNRF 2016
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT CHALK RIVER, ONTARIO

TITLE

SPATIAL BOUNDARIES SELECTED FOR THE ATMOSPHERIC ENVIRONMENT ASSESSMENT

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO/PR
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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5.2.1.3.2 Temporal Boundaries

Temporal boundaries (i.e., project phases) establish the timeframe during which NSDF Project effects are assessed. The temporal boundary represents the timeframe during which project activities are actively occurring, and considers the duration of predicted residual effects. The duration of an effect is defined as the amount of time between the start and end of a project activity or stressor (which is related to the project phases) plus the time required for the residual effect to be reversed. In some cases, a residual effect may be irreversible within the temporal boundaries of the project or if the effects were predicted to last so far into the future that the level of uncertainty (e.g., residual effect lasts for thousands of years). The following phases were identified for the NSDF Project:

- **Construction phase**: This phase includes site preparation and all activities associated with the construction of the NSDF Project. This phase includes activities such as installing the necessary supporting and/or ancillary facilities and infrastructure to facilitate NSDF Project operations, inactive commissioning and systems testing, and transportation of construction materials. Construction activities are expected take place from 2021 to 2023.
- **Operations phase**: This phase includes all activities associated with waste placement, water management, WWTP operations, vehicle movements into and from the NSDF Project site, and maintenance activities. Operations activities are expected to last approximately 50 years (i.e., 2024 to 2070).
- **Closure phase:** This phase includes activities necessary to complete the installation of the ECM final cover and implementation of long-term monitoring. Closure activities are expected to last approximately 30 years starting in 2070 and continue through to 2100, after which the NSDF Project will transfer into the post-closure phase.
- **Post-closure phase:** This phase has two discrete periods: institutional control and post-institutional control. The institutional control period includes implementation of controls throughout 2100 to 2400 (i.e., 300 years). During the institutional control period, environmental monitoring will continue to demonstrate compliance with the environmental assessment predictions. The post-institutional control period occurs after year 2400 and continues indefinitely.

The temporal boundaries for the air quality assessment include consideration of the effects of the NSDF Project during the construction and operation phases, as the emissions from these phases will be higher than those during the closure and post-closure phases. Emissions from the construction phase are expected to be representative of those during closure as they will be similar in nature. The emissions from the closure phase are expected to be considerably less than those during the construction and operation phases, as most of the NSDF Project site will have been decommissioned. Effects to air quality would immediately cease following decommissioning of the WWTP and associated water management systems at the end of the closure phase.

5.2.1.3.3 Assessment Cases

The assessment cases considered in the air quality assessment include the Base Case, Application Case and the Reasonably Foreseeable Development Case:

- **Base Case:** This scenario represents existing conditions and characterizes effects from previous and existing developments and activities. The Base Case reflects the effects of existing disturbances, such as forestry, transportation, agricultural, mining, and residential and recreational development. Current effects from the existing operations and activities on the CRL site are considered part of the Base Case.
- **Application Case:** This scenario represents predictions of the effects of the Base Case combined with the effects that may result from the NSDF Project. The Application Case considers potential effects from the NSDF Project during construction and operations phases.
- **Reasonably Foreseeable Development (RFD) Case**: This scenario represents predictions of the cumulative effects of the Application Case, which includes the Base Case, plus projects that are currently under application review or that have officially entered a regulatory application process, and are therefore considered reasonably foreseeable. Reasonably foreseeable developments in the RSA that are anticipated to overlap with potential effects of the NSDF Project include new/upgrades to research and development facilities, construction and operation of a Small Modular Reactor (SMR), new support infrastructure, on-going decommissioning and environmental remediation activities on the CRL site. As well, there may be overlap of the construction period with limited construction at neighbouring Garrison Petawawa.

5.2.1.4 Description of the Environment

5.2.1.4.1 Climate and Meteorology for the NSDF Project

Climate normals are usually long-term averages of observed climate data used to summarize or describe the average climatic conditions of a particular location. Climate normals from Environment and Climate Change Canada (ECCC) stations located near the NSDF Project are used to describe the long-term record of general meteorological conditions in the region and are used to validate the Ontario Ministry of the Environment, Conservation and Parks (MECP) dispersion meteorological dataset.

The nearest 30-year (1981 to 2010) climate station is located on the CRL site, and is less than 1 km north of the centroid of the SSA. For meteorological parameters not monitored at the Chalk River AECL station, the next closest climate normals station with the required parameters, Ottawa MacDonald-Cartier International Airport (Ottawa), was used for the assessment (ECCC 2016).

The 30-year climate normal from the Chalk River AECL station calculates an average daily temperature of approximately 5.6°C while the daily average temperature in the winter season is approximately -9.3°C and the daily average temperature in the summer season is approximately 19.1°C. Annual precipitation of approximately 859 millimetres equivalent (mm[eq]) is calculated for the region, with the highest precipitation typically occurring in the summer at 252 mm[eq].

A more detailed breakdown of the climate and meteorology for the NSDF Project can be found in Section 2.2 of the Air Quality Assessment TSD (Golder 2019).

5.2.1.4.2 Methods

This section documents the methods, data and assumptions that were used to assess the non-radiological background air quality at the NSDF Project and in the LSA and RSA. The assessment was carried out by:

- identifying the non-radiological indicator compounds expected to be emitted from the NSDF Project;
- identifying and comparing non-radiological air quality guidelines in Ontario and Canada for the indicator compounds;
- identifying existing emission sources located within 25 km of the LSA with shared indicator compounds;
- assessing air quality data sources for use in the background air quality assessment; and
- comparing air quality monitoring data to the applicable air quality guidelines.

These steps are detailed in the following sections.

5.2.1.4.2.1 Applicable Criteria

The relevant air quality criteria used for screening air quality in the region include the Ontario criteria, and federal standards and objectives where provincial guidelines are not available. The MECP has set guidelines related to ambient air concentrations and are summarized in Ontario's Ambient Air Quality Criteria (AAQC) document (MOE 2012). The Ontario AAQCs are characterized as desirable ambient air concentrations and have been set at levels that are protective of human health and the environment. The Ontario AAQCs are not regulatory limits, and therefore, exceedances are permitted. The Ontario AAQCs are used for screening the air quality effects in environmental assessments, in studies using ambient air monitoring data, and as an assessment of general air quality in a community or across the province (MOE 2012).

Where provincial criteria were not available, the National Ambient Air Quality Objectives (NAAQOs) and the Canadian Ambient Air Quality Standards (CAAQSs; formerly National Ambient Air Quality Standards) were used. Similar to the Ontario AAQCs, the NAAQOs are benchmarks that can be used to facilitate air quality management on a regional scale, and provide goals for outdoor air quality that protect public health, the environment, or aesthetic properties of the environment (CCME 1999). The federal government has established the following levels of NAAQOs (Hopper et al. 1994):

- the maximum ***Desirable*** level defines the long-term goal for air quality and provides a basis for an anti-degradation policy for unpolluted parts of the country and for the continuing development of control technology; and
- the maximum ***Acceptable*** level is intended to provide adequate protection against adverse effects on soil, water, vegetation, materials, animals, visibility, personal comfort, and well-being.

The CAAQSs have been developed under the *Canadian Environmental Protection Act, 1999*, and include standards for $PM_{2.5}$, NO_2, SO_2 and ozone that must be achieved by 2020. In 2015 the standard was phased in, with the final standard phase in date in 2020 (Government of Canada 2013). Like the Ontario AAQCs, the CAAQSs are not regulatory limits and are used as national targets for $PM_{2.5}$, NO_2, SO_2 and ozone, excluding Quebec (CCME 2014). These more stringent standards were adopted because, as stated by the CCME (emphasis added):

> *Canadians living in heavily populated and industrialized areas of the country may be exposed to potentially harmful levels of outdoor air pollutants, at concentrations that exceeded established standards. (CCME 2014)*

However, the key aspect of "CAAQS Achievement" (i.e., compliance), as stated by the CCME, is (emphasis added):

> *Achievement of the CAAQS means that the measured air pollutant concentration in an air zone does not exceed the CAAQS numerical value. (CCME 2014)*

These values are reported based on a series of monitoring stations located in airsheds across Canada and in this context, an "air zone" refers to a local or regional sub-region of the established provincial or territorial airsheds. Currently, Southern Ontario and Southern Quebec are treated as a single Airshed (East Central) and Southern Ontario, excluding Hamilton and Sarnia, is designated as a single air zone.

For conservatism in this assessment, the lower of the Ontario AAQCs and the CAAQS, where applicable, were used for comparison to the maximum modelled concentrations. However, comparing the maximum predicted concentrations to the CAAQS standards is not appropriate for the following reasons:

- The NSDF Project boundary does not, nor does the 7.4 km radius circular regional study area (RSA), represent an "air zone", the region over which the CCME states that achievement of the CAAQS is to be evaluated/compared.
- There are not heavily populated or industrialized areas located within the 7.4 km radius circular air quality RSA. Therefore, there is no exposure pathway by which:
  - *Canadians living in heavily populated and industrialized areas of the country may be exposed to potentially harmful levels of outdoor air pollutants, at concentrations that exceeded established standards.* (CCME 2014)

A summary of the applicable Ontario, Quebec and federal objectives and criteria are listed in Table 5.2.1-4.

Table 5.2.1-4: Provincial and Federal Regulatory Air Quality Criteria[1]

Substance	Averaging Period	Ontario Ambient Air Quality Guidelines[a] (µg/m³)	Canadian Ambient Air Quality Standards[b] (µg/m³)	National Ambient Air Quality Objectives and Canadian Ambient Air Quality Standards[c] (µg/m³)		Quebec Atmospheric Quality Standards and Criteria (µg/m³)[p]
				Desirable	Acceptable	
SPM[d]	24-Hour	**120**	—	—	120	120
	Annual	**60[e]**	—	60	70	—
PM_{10}	24-Hour	**50[f]**	—	—	—	—
$PM_{2.5}$	24-Hour	30[g]	**27**	—	—	30
	Annual	—	**8.8**	—	—	
NO_2	1-Hour	400[h]	**113** (60 ppb)[i]	—	400	414
	24-Hour	**200[h]**	—	—	—	207
	Annual	—	**32** (17 ppb)	60	100	103
SO_2	4-minute	—	—	—	—	1050
	1-Hour	690	**183** (70 ppb)[j]	450	900	—
	24-Hour	**275**	—	150	300	288
	Annual	55	**13** (5 ppb)	30	60	52
CO	1-Hour	**36,200**	—	15,000	35,000	34,000
	8-Hour	**15,700**	—	6,000	15,000	12,700
C_3H_4O	4-minute	—	—	—	—	8.3
	1-Hour	**4.5**	—	—	—	—
	24-Hour	**0.4**	—	—	—	—
	Annual	—	—	—	—	0.02
O_3	1-Hour	165	—	100	160	160
	8-Hour	—	122 (62 ppb)[k]	—	—	125
Pb	24-Hour	**0.5**	—	—	—	—
	30-Day	**0.2[l]**	—	—	—	—
	Annual	—	—	—	—	0.1
Hg	24-Hour	**2**	—	—	—	—
	Annual	—	—	—	—	0.005

Table 5.2.1-4: Provincial and Federal Regulatory Air Quality Criteria[1]

Substance	Averaging Period	Ontario Ambient Air Quality Guidelines[a] (µg/m³)	Canadian Ambient Air Quality Standards[b] (µg/m³)	National Ambient Air Quality Objectives and Canadian Ambient Air Quality Standards[c] (µg/m³)		Quebec Atmospheric Quality Standards and Criteria (µg/m³)[p]
				Desirable	Acceptable	
H_2S	4-minute	—	—	—	—	6
	10-Minute	**13**	—	—	—	—
	24-Hour	**7**	—	—	—	—
	Annual	—	—	—	—	2
C_2H_3Cl	24-Hour	**1**	—	—	—	—
	Annual	**0.2**	—	—	—	0.05
Odour[m] (OU/m³)	4-minute	—	—	—	—	1 (5)[o]
	10-minute	**1[n]**	—	—	—	

Note: **Bold** = ambient air criteria retained for use in the assessment.

(1) The lowest values in the table were used in the assessment of significance although the monitoring-based CAAQS numbers are not intended to be used in this manner.

a) Ontario's Ambient Air Quality Criteria (MOE 2012).

b) Canadian Ambient Air Quality Standards (Government of Canada 2013). Final standard phase in date of 2020 used. For SO_2, NO_2 and O_3, the reference is ppb and was converted using a pressure of 1 atmosphere and a temperature of 25ºC.

c) Canadian National Ambient Air Quality Objectives: Process and Status (CCME 1999).

d) SPM in Ontario is defined as <44 µm diameter.

e) Geometric mean.

f) Interim Ambient Air Quality Criteria and is provided as a guide for decision making (MOE 2012).

g) Compliance is based on the 98th percentile of the annual monitored data averaged over three years of measurements.

h) Standard is for nitrogen oxides (NO_X), but is based on the health effects of NO_2.

i) As described by the CCME, 3-year average of the annual 98th percentile of the NO_2 daily maximum 1-hour average concentrations.

j) As described by the CCME, 3-year average of the annual 99th percentile of the SO_2 daily maximum 1-hour average concentrations.

k) Ozone is not emitted directly into the atmosphere but is associated with the reaction of NO_X to calculate NO_2 in the effects assessment.

l) Arithmetic mean.

m) Odour unit per cubic metre (OU/m³).

n) The Ontario Guideline is based on the 99.5th percentile on a 10-minute averaging period, in OU/m³.

o) Odour concentration must be 1 odour unit or less 98% of the time and 5 units or less 99.5 % of the time. Predicted concentrations above the 1 odour unit criteria are permitted up to 175 hours per year and predicted concentrations above the 5 odour unit criteria are permitted up to 44 hours per year.

p) MELCC 2018.

— = No guideline available; SPM = suspended particulate matter; $PM_{2.5}$ = particulate matter less than 2.5 µm (microns) in diameter; PM_{10} = particulate matter less than 10 µm (microns) in diameter; CO = carbon monoxide; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; H_2S; = hydrogen sulfide; C_2H_3Cl = vinyl chloride; Pb = lead; Hg = mercury; µg/m³ = microgram per cubic metre; C_3H_4O = acrolein; O_3 = Ozone; ppb = parts per billion; OU/m³ = odour unit per cubic metre.

Existing Emissions Sources

There are two industrial facilities, the CRL main campus and the Department of National Defence, that report indicator compounds and pollutant releases, disposals, and transfers for recycling under Part 1A to the National Pollutant Release Inventory (NPRI) within 25 km of the LSA (ECCC 2018a). The only facility within the LSA is the CRL main campus. These emissions contribute to the local air quality and the consideration of effects from the NSDF Project. The reporting facilities and emission totals are summarized in Table 5.2.1-5. In general, these sources are minor contributors of the non-radiological indicator compounds, with the exception of the lead emissions from the Department of National Defence.

CNL baseline emissions of indicator compounds (NOx, SO_2, SPM, PM_{10}, $PM_{2.5}$, Pb and Hg) have decreased appreciably starting in 2017. The reduction of these emissions and greenhouse gas emissions are the direct result of the full switch over to Natural Gas from #6 fuel oil for the CRL Powerhouse, the facility providing most of the heating for buildings on the Chalk River Laboratory Site. The switchover was a CNL initiative to reduce emissions from the CRL site.

Table 5.2.1-5: Air Emission Totals for Industries within 25 km of the Local Study Area

Company Name	Distance to the NSDF Project[a] (km)	Direction from the NSDF Project	Emissions						
			Contaminant	Units	2014	2015	2016	2017	2018[b]
Canadian Nuclear Laboratories	1	North	NOx	tonnes	65.124	62.421	58.478	67.955	52.350
			SO_2	tonnes	223.901	200.373	240.393	182.076	10.000
			CO[c]	tonnes	8.463	8.386	8.250	11.048	9.920
			SPM	tonnes	33.098	29.067	49.148	38.980	14.760
			PM_{10}	tonnes	19.220	17.248	23.684	19.268	5.300
			$PM_{2.5}$	tonnes	10.523	9.627	11.260	9.736	2.220
			Hg	kg	0.145	0.132	0.122	0.104[d]	0.053
			Pb	kg	2.042	1.963	1.778	1.222	0.148
Department of National Defence	16	Southeast	NOx	tonnes	37.537	37.983	24.020	24.463	—
			SO_2	tonnes	—	—	—	—	—
			CO	tonnes	35.391	34.523	35.869	38.701	—
			SPM	tonnes	—	—	—	—	—
			PM_{10}	tonnes	2.200	4.374	3.610	9.972	—
			$PM_{2.5}$	tonnes	1.459	2.579	2.350	5.806	—
			Hg	kg	—	—	—	—	—
			Pb	kg	20.404	19.517	21.200	24.500	—

Note: All emissions taken from ECCC 2018a unless otherwise noted.

a) Distance from the SSA centroid.

b) NPRI database is current up to 2017 reporting year. CNL Emissions for 2018 taken from CNL 2019b. No available data for DND emissions in 2018.

c) CO emissions provided by CNL.

d) CNL did not report Hg emissions to NPRI in 2017. Emissions taken from CNL 2019b.

— = Data Not available; SPM = suspended particulate matter; PM2.5 = particulate matter less than 2.5 µm (microns) in diameter; PM10 = particulate matter less than 10 µm (microns) in diameter; CO = carbon monoxide; NO2 = nitrogen dioxide; SO2 = sulphur dioxide; Pb = lead; Hg = mercury.

Baseline Air Quality Data

Although air quality data are provided in the report *Effluent Verification Monitoring at Chalk River Laboratories in 2018* (CNL 2019b), the data are based on emission estimates (emission factors), rather than measured data, and represents emissions solely from the CRL main campus. Other industries outside the LSA are not considered in the baseline and, therefore, data from monitored data sources was used and is considered to be more representative of background air quality. Site-specific air quality monitoring was not carried out as part of this assessment.

The background air quality was assessed using observations from the ECCC National Air Pollution Surveillance Network (NAPS) air quality monitoring stations (ECCC 2013) at locations outside the RSA (See Section 3 [Air Quality Baseline] of the Air Quality Assessment TSD [Golder 2019]). The monitoring data considered ranged from 2009 through 2013 which was the latest data available at the time of the baseline assessment in 2015 and is still considered representative of the baseline air quality for the NSDF Project site. Data from the Canadian Air and Precipitation Monitoring Network was received from ECCC for the station located at the CRL site (CAPMCAON1CHA); however due to limited data availability at the time of the assessment (only 2009 to 2011 and only certain indicator compounds) the data were not considered for the air quality assessment. The closest air quality monitoring station otherwise is located in Petawawa, however not all indicator compounds are monitored at the Petawawa station. The next closest air quality monitoring station with additional indicator compounds is the Ottawa Downtown monitoring station. Some indicator compounds (C_3H_4O, Hg, H_2S, C_2H_3Cl, and odour) were not monitored at either monitoring station. The specific stations selected to describe the existing air quality regime are presented in Table 5.2-1-6, and are illustrated on Figure 5.2.1-2.

Table 5.2.1-6: Location of Air Monitoring Station

City	NAPS Station Identification	Location	Latitude and Longitude	Distance to the NSDF Project[a] (km)	Location with Respect to the NSDF Project
Petawawa	66201	Outside Regional Study Area	45.996722, -77.441194	7	Southwest, generally downwind
Ottawa Downtown	60104	Outside Regional Study Area	45.43433, -75.676	148	Southeast, generally upwind

a) Distance from the SSA centroid.

NAPS = National Air Pollution Surveillance Network.

The wind direction into the Chalk River area is predominantly from the southeast along the Ottawa River (see Section 2 [Meteorology Assessment]) of the Air Quality Assessment TSD [Golder 2019]). The air quality monitoring station in Ottawa Downtown (NAPS ID 60104) captures this air flow into Chalk River; however, the station is located approximately 150 km from the NSDF Project site. The results can be considered to provide conservative air quality estimates (likely to be greater than the existing conditions in the RSA) given its urban location. The Petawawa station (NAPS ID 66201), located approximately 2 km south of the Village of Chalk River, is generally downwind of the NSDF Project and is considered to be the most representative station of the RSA, due to proximity and similarity in geographic siting (rural location and distance from the Ottawa River).
The majority of the stations located outside the 100 km radius only monitor $PM_{2.5}$ and O_3.

There is no monitoring data available for SPM or PM_{10} at the Petawawa station, however, background SPM and PM_{10} concentrations can be estimated from the available $PM_{2.5}$ monitoring results. $PM_{2.5}$ is a subset of PM_{10}, and PM_{10} is a subset of SPM. Therefore, it is reasonable to assume that the ambient concentrations of SPM will be greater than corresponding PM_{10} levels, and PM_{10} concentrations will be greater than the corresponding levels of $PM_{2.5}$. The mean levels of $PM_{2.5}$ in Canadian locations are found to be about 50% of the PM_{10} concentrations and about 25% of the SPM concentrations (Brook et al. 2011). By applying this ratio, it is possible to estimate the background SPM and PM_{10} concentrations for the RSA.

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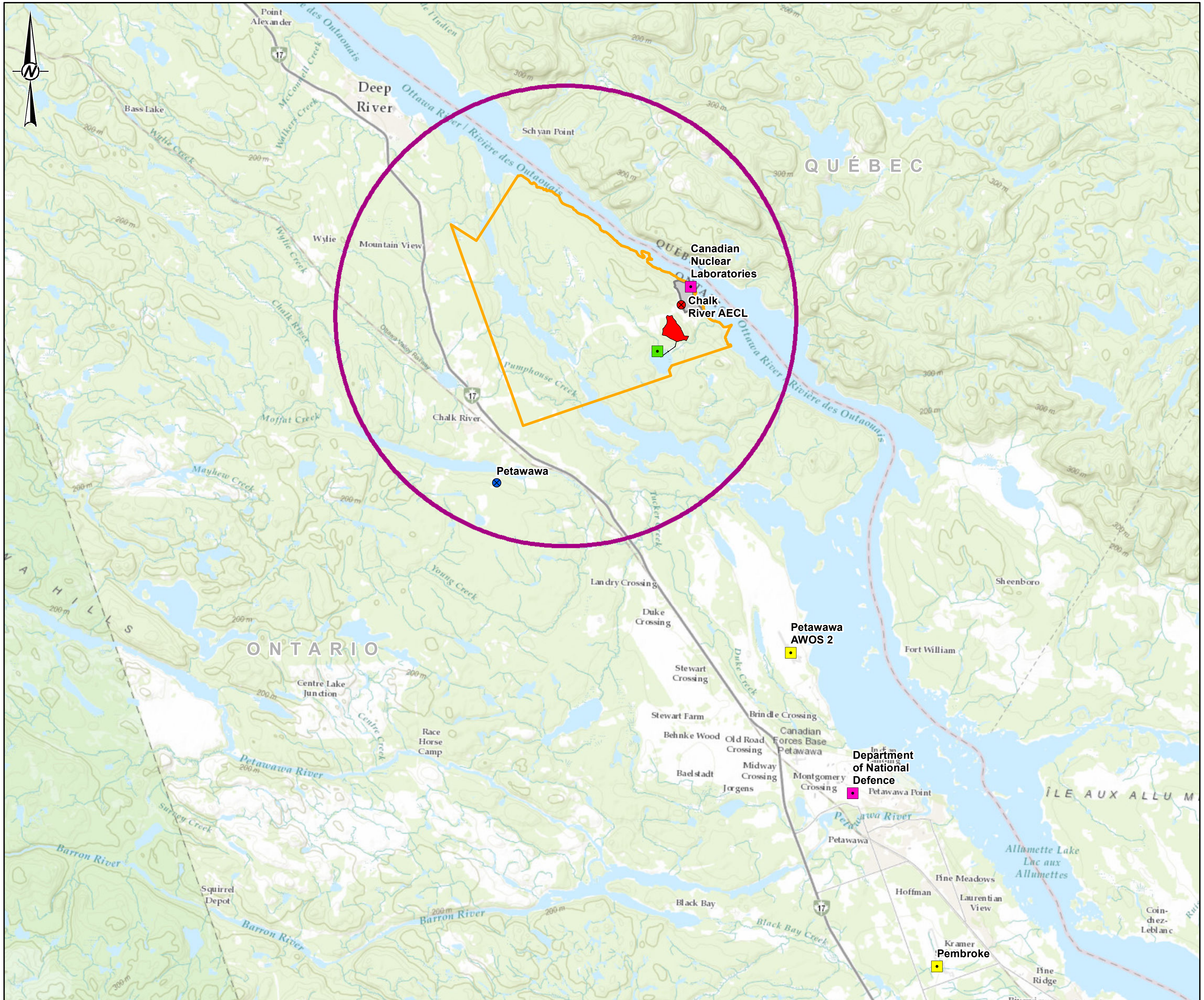
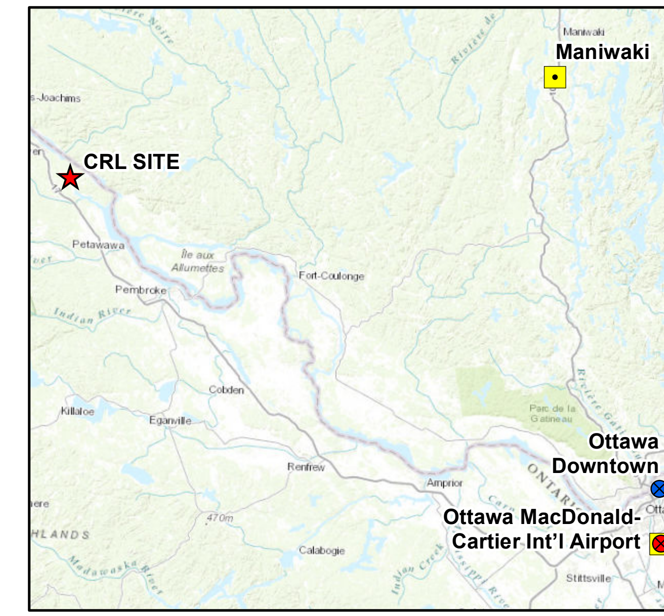


LEGEND

- CRL ENVIRONMENTAL MONITORING STATION
- AMBIENT AIR QUALITY MONITORING STATION
- NPRI REPORTING FACILITY
- CLIMATE NORMALS STATION
- METEOROLOGICAL STATION
- CHALK RIVER LABORATORIES (CRL) MAIN CAMPUS
- SITE STUDY AREA (NSDF PROJECT SITE)
- LOCAL STUDY AREA (CRL SITE)
- REGIONAL STUDY AREA

REGIONAL AMBIANT AIR MONITORING STATION



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REFERENCE(S)
1. BASEMAP:SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
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CLIENT
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PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
AMBIENT AIR QUALITY MONITORING STATIONS AND NATIONAL POLLUTANT RELEASE INVENTORY REPORTING FACILITIES

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO/PR
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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5.2.1.4.3 Results

Table 5.2.1-7 provides a summary of the existing air quality data based on Petawawa station and the Ottawa Downtown stations, for consideration in the Base Case. Due to proximity and similarity in geographic siting (rural location and distance from the Ottawa River), the Petawawa station is considered to be the most representative station of the RSA, and therefore represents the background for indicator compounds monitored at that station. For some of the remaining indicator compounds, monitored data from the Ottawa Downtown have been used in the background although the station is located approximately 150 km from the NSDF Project site. The results from the Ottawa Downtown station can be considered to provide conservative air quality estimates (likely to be greater than the existing conditions in the RSA) given its urban location.

The data presented in Table 5.2.1-7 represent the 90th percentile of the 1-hour, 8-hour, and 24-hour monitored data; a value usually considered to be an appropriate representation of background concentrations from measured data (AESRD 2013). The annual average is used for the annual background concentrations. The existing concentrations are below the respective provincial and federal criteria for each indicator compound, suggesting that the region has generally good air quality (Table 5.2.1-7).

Table 5.2.1-7: Background Air Quality Values (90th Percentile, Average for Annual Only)

Indicator	Averaging Period	Background [µg/m³]	Petawawa (7 km SSW) [µg/m³]	Ottawa Downtown (148 km SE) [µg/m³]
SPM	24-hour	**30.95**	**30.95**	41.50
	Annual	**14.53**	**14.53**	20.68
PM_{10}	24-hour	**15.48**	**15.48**	20.75
$PM_{2.5}$	24-hour	**7.74**	**7.74**	10.38
	Annual	**3.63**	**3.63**	5.17
NO_2	1-Hour	**31.98**	—	**31.98**
	24-Hour	**28.61**	—	**28.61**
	Annual	**14.86**	—	**14.86**
SO_2	1-Hour	**2.62**	—	**2.62**
	24-Hour	**2.62**	—	**2.62**
	Annual	**1.05**	—	**1.05**
CO	1-Hour	**458.10**	—	**458.10**
	8-Hour	**486.73**	—	**486.73**
C_3H_4O	1-Hour	—	—	—
	24-Hour	—	—	—
O_3	1-Hour	**84.39**	**84.39**	78.50
	8-Hour	**93.93**	**93.93**	89.95
Pb	24-Hour	**0.0046**	—	**0.0046**
	30-Day	—	—	—
Hg	24-Hour	—	—	—
H_2S	10-Minute	—	—	—
	1-Hour	—	—	—
C_2H_3Cl	24-Hour	—	—	—
	Annual	—	—	—
Odour (OU/m³)	10-Minute	—	—	—

Note: **Bolded** values represent the background air quality.

SSW = south-southwest; SE = southeast; — = No monitored data available; µg/m³ = micrograms per cubic metre; SPM = suspended particulate matter; $PM_{2.5}$ = particulate matter less than 2.5 µm (microns) in diameter; PM_{10} = particulate matter less than 10 µm (microns) in diameter; CO = carbon monoxide; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; H_2S; = hydrogen sulfide; C_2H_3Cl = vinyl chloride; Pb = lead; Hg = mercury; O_3 = Ozone; C_2H_3O = acrolein.

5.2.1.5 Project Interactions and Mitigation

5.2.1.5.1 Methods

This section describes the process by which interactions between NSDF Project components and activities and air quality were identified and evaluated. Potential effects pathways are identified and mitigation developed to eliminate and/or reduce effects is presented. A pathways analysis is then used to focus the assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects will be adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects after incorporation of mitigation are further characterized in subsequent subsections of the assessment (i.e., Section 5.2.1.6). As such, the Project Interactions and Mitigation section helps to focus the remainder of the assessment on those interactions (effects pathways) likely to result in residual adverse effects.

The first part of the analysis was to identify the potential effects pathways for all stages of the NSDF Project. The next step in the analysis was the development of environmental design features and mitigation practices that could be incorporated into the NSDF Project to eliminate and/or reduce effects to air quality. Environmental design features included design elements, environmental best practices, and management policies and procedures. Environmental design features and mitigation were developed through an iterative process between the engineering and environmental teams, combined with input from project-specific or regional engagement with other interested parties. The design features and/or mitigation were selected considering their effectiveness for implementation and maintenance, and their appropriateness within the context of the identified effects pathways.

After incorporation of mitigation, potential pathways were evaluated into the following categories using scientific knowledge, logic, experience with similar developments, and the effectiveness of environmental design features and mitigation:

- **No linkage:** The pathway is removed by environmental design features or mitigation such that the NSDF Project would not be expected to result in a measurable environmental change to concentrations of indicator compounds relative to Base Case values, and therefore would have no residual effects to air quality.
- **Secondary pathway:** The pathway could result in a measurable minor change to concentrations of indicator compounds, but would have a negligible residual effect on air quality relative to Base Case and/or guideline values and is not expected to contribute cumulatively to other Project effects or to the effects of other previous, existing or reasonably foreseeable developments to cause a significant effect.
- **Primary pathway:** The pathway is likely to result in an environmental change relative to the Base Case and/or guideline values that could contribute to residual effects on air quality.

Environmental design features and mitigation that have been or could be incorporated into the NSDF Project to eliminate and/or reduce adverse effects to air quality were considered. Potential pathways that were completely removed due to implementation of environmental design or mitigation were not assessed further. Pathways that were assessed to be secondary and demonstrated to have a negligible residual effect to air quality through simple qualitative or semi-quantitative evaluation of the pathway were also not advanced for further assessment. Primary pathways were carried forward for more detailed quantitative and qualitative effects analysis to characterize the residual effects of the NSDF Project on air quality.

5.2.1.5.2 Results

The potential pathways from sources of air emissions to air quality are dependent on the presence and relative intensity of the activity over the various NSDF Project phases. Each activity or source would have a different level of intensity or use a different amount of equipment depending on the phase in which the activity occurred. Pathways through which all stages of the NSDF Project may interact with and result in changes to concentrations of indicator compounds are provided in Table 5.2.1-8. Operational exposures related to workers were assessed as part of the NSDF *Safety Analysis Report* (CNL 2020b) and are summarized in Section 5.8.

Table 5.2.1-8: Pathways Analysis for Air Quality Valued Component

	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Construction ■ Site preparation ■ Construction of the ECM ■ Development of surface water management structures ■ Construction of the WWTP and other support facilities ■ On-site road and access development ■ Soil spoils haulage to a soil storage area	Construction activities use vehicles and equipment that combust fuel and emit indicator compounds. These activities involve material handling, vehicles travelling on unpaved roads, and wind erosion of stockpiles that will result in fugitive dust emissions.	■ Implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and air verification monitoring. ■ The *Dust Management Plan* (AECOM 2018a) to be implemented for the NSDF Project will provide information on dust mitigation, including: ▪ Use of water spraying or misting techniques (e.g., water trucks) as the primary dust control method. ▪ Use of fixatives (e.g., chemical suppressant) for dust control. ▪ Covering stockpiles and exposed areas prior to high wind or dry conditions where standard dust suppressants may be inadequate in preventing dust generation caused by wind erosion. ▪ Minimizing the size of the exposed working areas containing contaminated materials to the extent practicable using a phased excavation approach. ▪ Revegetating affected areas or adding mulch to completed cells and excavated areas as soon as practicable. ▪ Dampening soil in dry areas prior to commencing truck/machinery activities in the area. ▪ Reducing activities to avoid unnecessary dust generation; ▪ Using wind fencing around work areas. ▪ Postponing work activities likely to cause dust if sustained wind speeds are predicted to exceed 40 km/hr, unless it can be shown that the work site is sufficiently protected that wind will not generate unacceptable amounts of dust. ■ On-site vehicles and equipment engines will meet Tier 2 emission standards and be maintained in good working order. ■ Limit idling of vehicles on-site.	Primary

Table 5.2.1-8: Pathways Analysis for Air Quality Valued Component

	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment

Operations
■ Phased development of ECM disposal cells
■ On-site transportation of waste and placement of waste in the ECM
■ Progressive closure of disposal cells and installation of final cover
■ Operation of the WWTP
	Most activity and material handling occurs during the operations phase, and pathways include:
	■ vehicles and equipment combust fuel and emit indicator compounds.
	■ material handling, vehicles travelling on unpaved roads, and wind erosion of stockpiles emit fugitive dust.
	■ Release of emissions from the disposal cell cover and passive vents.
	■ emissions from the decomposition of waste.
	■ release of emissions from the operation of the WWTP.
		■ Implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and air verification monitoring.
		■ The *Dust Management Plan* (AECOM 2018a) to be implemented for the NSDF Project will provide information on dust mitigation, including:
		  ■ Use of water spraying or misting techniques (e.g., water trucks) as the primary dust control method.
		  ■ Use of fixatives (e.g., chemical suppressant) for dust control
		  ■ Dampening soil in dry areas prior to commencing truck/machinery activities in the area.
		  ■ Reducing activities to avoid unnecessary dust generation;
		  ■ Using wind fencing around work areas.
		  ■ Postponing work activities likely to cause dust if sustained wind speeds are predicted to exceed 40 km/hr, unless it can be shown that the work site is sufficiently protected that wind will not generate unacceptable amounts of dust.
		■ On-site vehicles and equipment engines will meet Tier 2 emission standards and be maintained in good working order.
		■ Limit idling of vehicles on-site.
		■ Processed wastewater will not be heated within the WWTP (raising the temperature increases potential release rates).
		■ There is active ventilation within the WWTP building and all active ventilation exhaust will be filtered through HEPA prior to release.
			Primary

Operations and Post-closure ■ Placement of waste in the ECM	Air emissions from the decomposition of waste.	■ Installation of the interim and final covers will reduce release of emissions from the ECM.	Primary

ECM = engineered containment mound; WWTP = Wastewater Treatment Plant.

5.2.1.5.2.1 No Linkage Pathways

No pathways are identified as having no linkage to air quality as part of this assessment.

5.2.1.5.2.2 Secondary Pathways

No secondary pathways are identified to air quality as part of this assessment.

5.2.1.5.2.3 Primary Pathways

The following primary pathways were identified as having the potential to result in residual effects to air quality, and therefore, have been carried forward to the residual effects analysis.

- Project construction activities use vehicles and equipment that combust fuel and emit indicator compounds. These activities involve material handling, vehicles travelling on unpaved roads, and wind erosion of stockpiles that will result in fugitive dust emissions.
- Most activity and material handling occurs during the operations phase, and pathways include:
  - vehicles and equipment combust fuel and emit indicator compounds;
  - material handling, vehicles travelling on unpaved roads, and wind erosion of stockpiles emit fugitive dust; and
  - the release of emissions from the disposal cell cover and passive vents and the WWTP.
- Air emissions from the decomposition of waste.

5.2.1.6 Residual Effects Analysis

5.2.1.6.1 Methods

Residual effects of the NSDF Project are those effects that remain after implementation of all mitigation.
The assessment of effects of the NSDF Project on the air quality involves two steps, namely the calculation of emission rates and use of dispersion modelling to predict the resulting concentrations of indicator compounds.

Emissions Quantification

The method used for calculating and quantifying air emissions resulting from the NSDF Project involved the following steps.

- **Identifying emissions sources:** Emission sources were identified based on the NSDF Project conceptual design and the project information provided in the Project Description (Section 3.0).
- **Calculating emission rates:** Air emission rates were calculated using accepted methods, such as emission factors, and were based on activity data provided in the Project Description (Section 3.0), as well as LandGEM and MOBILE6.2.C modelling results provided in Section 4 (Emissions Estimate) of the Air Quality Assessment TSD (Golder 2019). Emission rates were calculated for the Application Case scenario for both the construction and operations phases.
- **Summarizing overall emissions:** The calculated emissions were summarized by activity type.

The emission estimation methods used in the air quality assessment follow generally accepted practices for conducting environmental assessments and, where appropriate, guidance *Procedure for Preparing an Emission Summary and Dispersion Modelling Report* Version 4.1 (MOECC 2018). Details of the specific emission calculation methods and resulting emissions are provided in Section 4 (Emissions Estimate) of the Air Quality Assessment TSD (Golder 2019).

Dispersion Modelling

Models were used to predict ground-level concentrations of non-radiological indicator compounds. The AERMOD dispersion model (Version 16216r) was used to predict concentrations and deposition rates associated with NSDF Project emissions. The AERMOD dispersion modelling system was developed by the United States Environmental Protection Agency (US EPA) as a replacement to the long-standing Industrial Source Complex model (US EPA 2004), and is the model recommended by the US EPA for regulatory applications in the United States (US EPA 2005). This model has also been adopted in Ontario as the regulatory model recommended for permitting and regulatory applications (MOECC 2018).

The AERMOD modelling system was selected as the dispersion model for the NSDF Project due to its following capabilities:

- has a technical basis that is scientifically sound, and is in keeping with the current understanding of dispersion in the atmosphere;
- applies formulations that are clearly delineated and are subjected to rigorous independent scrutiny;
- makes predictions that are consistent with observations;
- is recognized by federal and provincial regulators as one suitable for use;
- evaluates the various source configurations and indicator compounds associated with the NSDF Project;
- the terrain surrounding the NSDF Project site is relatively simple and can be addressed by the terrain features of the model;
- allows for the use of localised meteorological data;
- incorporates building downwash effects; and
- long-range transport of compounds is not anticipated.

The AERMOD modelling system consists of the AERMOD dispersion model, the AERMET meteorological pre-processor and the AERMAP terrain pre-processor. The following approved dispersion model and pre-processors were used in the assessment:

- AERMOD dispersion model (v. 16216r);
- AERMAP surface pre-processor (v. 11103); and
- Building Profile Input Program building downwash pre-processor (v.42104).

Building heights are required inputs to assess building downwash using the Building Profile Input Program pre-processor. However, for conservatism and because most sources in this assessment would not be subject to building downwash, building downwash has not been included in this assessment. The AERMET meteorological pre-processor was used by the MECP to prepare a 5-year meteorological dataset for the NSDF Project from 2011 to 2015. The meteorological dataset incorporated data from the CNL on-site station. Additional information on the meteorology is presented in Section 2 (Meteorology Assessment) of the Air Quality Assessment TSD (Golder 2019). Details regarding the dispersion modelling, including receptor grids and source input parameters are provided in Section 5 (Dispersion Modelling) of the Air Quality Assessment TSD (Golder 2019).

5.2.1.6.2 Application Case Results

Average and Maximum Emission Rates

In accordance with the CNSC's *REGDOC-2.9.1 Environmental Protection: Environmental Principles, Assessments and Protection Measures* (CNSC 2017), average and maximum emission rates have been provided for the construction and operations phases. Table 5.2.1-9 and Table 5.2.1-10 summarize the average and maximum emission rates in kilograms per day for each activity during construction, respectively. Table 5.2.1-11 and Table 5.2.1-12 summarize the average and maximum emission rates in kilograms per day for each activity during the operations phase, respectively. Maximum emission rates assume the source emits continuously for 24 hrs per day. Average emission rates are scaled from the maximum emission rates based on the source's hours of operation. Sources that emit 24 hrs per day will have identical maximum and average emission rates. Vehicle exhaust and fugitive dust from unpaved roads is the largest contributor to SPM and PM_{10} during both construction and operations. Vehicle exhaust during the construction and operation of the ECM is the largest contributor of $PM_{2.5}$, NOx/NO_2, SO_2, CO, and C_3H_4O. Emissions from the WWTP activities and natural gas combustion for comfort heating include SPM, PM_{10}, $PM_{2.5}$, NOx/NO_2, SO_2, CO, and Pb; however, the only indicator compound that was retained from natural gas combustion emissions is Pb. Indicator compounds from natural gas combustion, other than NOx/NO_2 and Pb, were not retained as they are not required to be assessed per the *Procedure for Preparing an Emission Summary and Dispersion Modelling Report,* Version 4.1 (MOECC 2018). The NOx/NO_2 from combustion was deemed negligible as it contributed to less than 1% of the total emissions and was therefore excluded from the dispersion modelling. Details of the specific emission calculation methods and resulting emissions estimates used for dispersion modelling are provided in Section 4 (Emissions Estimate) of the Air Quality Assessment TSD (Golder 2019).

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Table 5.2.1-9: Summary of Average Emission Rates during the Construction Phase

NSDF Project Activity[a]	Source	Source Description	Average Emission Rates (kg/day)											
			SPM	PM_{10}	$PM_{2.5}$	NO_x/NO_2	SO_2	CO	C_3H_4O	Hg	Pb	H_2S	C_2H_3Cl	Odour
—	Engineered Containment Mound (ECM)	ECM cap[c]	—	—	—	—	—	—	—	—	—	—	—	—
—		ECM passive vents[c]	—	—	—	—	—	—	—	—	—	—	—	—
All construction activities[b]		ECM construction (material handling)	2.26E-02	1.07E-02	1.62E-03	—	—	—	—	—	—	—	—	—
All construction activities[b]		ECM construction (vehicle exhaust)	1.24E+01	1.24E+01	1.24E+01	3.98E+02	4.61E-01	7.75E+01	1.05E-02	—[d]	—[d]	—	—	—
All construction activities[b]	Unpaved Roads	Vehicle exhaust and fugitive road dust	5.61E+02	1.52E+02	1.52E+01	1.49E+00	1.12E-02	8.08E-01	2.50E-04	—[d]	—[d]	—	—	—
All construction activities[b]	Storage Piles	Stockpile	3.11E+00	1.56E+00	2.33E-01	—	—	—	—	—	—	—	—	—
—	Wastewater Treatment Plant (WWTP)	Wastewater treatment activities[c]	—	—	—	—	—	—	—	—	—	—	—	—
—		WWTP natural gas combustion[c]	—	—	—	—	—	—	—	—	—	—	—	—
—	Support Activities	Vehicle Decontamination Facility natural gas combustion[c]	—	—	—	—	—	—	—	—	—	—	—	—
—		Administration Office natural gas combustion[c]	—	—	—	—	—	—	—	—	—	—	—	—
—		Operations Support Centre natural gas combustion[c]	—	—	—	—	—	—	—	—	—	—	—	—

a) As described in the air quality pathway analysis in Section 5.2.1.5.2.

b) Construction activities include site preparation, construction of the ECM, development of the surface water management structures, construction of the WWTP and other support facilities, and on-site road access development.

c) These sources are not operational while they are constructed resulting in no emissions during the construction phase

d) Hg and Pb occur as trace elements from the combustion of diesel fuel and are excluded from the diesel combustion sources emissions.

ECM = engineered containment mound; WWTP = Wastewater Treatment Plant; SPM = suspended particulate matter; $PM_{2.5}$ = particulate matter less than 2.5 µm (microns) in diameter; PM_{10} = particulate matter less than 10 µm (microns) in diameter; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; CO = carbon monoxide; H_2S; = hydrogen sulfide; C_2H_3Cl = vinyl chloride; Pb = lead; Hg = mercury; C_3H_4O = Acrolein; OU/day = Odour Unit per day.

Table 5.2.1-10: Summary of Maximum Emission Rates during the Construction Phase

NSDF Project Activity[a]	Source	Source Description	Maximum Emission Rates (kg/day)											
			SPM	PM_{10}	$PM_{2.5}$	NO_x/NO_2	SO_2	CO	C_3H_4O	Hg	Pb	H_2S	C_2H_3Cl	Odour
—	Engineered Containment Mound (ECM)	ECM cap[c]	—	—	—	—	—	—	—	—	—	—	—	—
—		ECM passive vents[c]	—	—	—	—	—	—	—	—	—	—	—	—
All construction activities[b]		ECM construction (material handling)	2.26E-02	1.07E-02	1.62E-03	—	—	—	—	—	—	—	—	—
All construction activities[b]		ECM construction (vehicle exhaust)	2.47E+01	2.47E+01	2.47E+01	7.96E+02	9.22E-01	1.55E+02	2.10E-02	—[d]	—[d]	—	—	—
All construction activities[b]	Unpaved Roads	Vehicle exhaust and fugitive road dust	8.42E+02	2.27E+02	2.28E+01	2.23E+00	1.67E-02	1.21E+00	3.75E-04	—[d]	—[d]	—	—	—
All construction activities[b]	Storage Piles	Stockpile	3.11E+00	1.56E+00	2.33E-01	—	—	—	—	—	—	—	—	—
—	Wastewater Treatment Plant (WWTP)	Wastewater treatment activities[c]	—	—	—	—	—	—	—	—	—	—	—	—
—		WWTP natural gas combustion[c]	—	—	—	—	—	—	—	—	—	—	—	—
—	Support Activities	Vehicle Decontamination Facility natural gas combustion[c]	—	—	—	—	—	—	—	—	—	—	—	—
—		Administration Office natural gas combustion[c]	—	—	—	—	—	—	—	—	—	—	—	—
—		Operations Support Centre natural gas combustion[c]	—	—	—	—	—	—	—	—	—	—	—	—

a) As described in the air quality pathway analysis in Section 5.2.1.5.2.

b) Construction activities include site preparation, construction of the ECM, development of the surface water management structures, construction of the WWTP and other support facilities, and on-site road access development.

c) These sources are not operational while they are constructed resulting in no emissions during the construction phase

d) Hg and Pb occur as trace elements from the combustion of diesel fuel and are excluded from the diesel combustion sources emissions.

ECM = engineered containment mound; WWTP = Wastewater Treatment Plant; SPM = suspended particulate matter; $PM_{2.5}$ = particulate matter less than 2.5 µm (microns) in diameter; PM_{10} = particulate matter less than 10 µm (microns) in diameter; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; CO = carbon monoxide; H_2S; = hydrogen sulfide; C_2H_3Cl = vinyl chloride; Pb = lead; Hg = mercury; C_3H_4O = Acrolein; OU/day = Odour Unit per day.

Table 5.2.1-11: Summary of Average Emission Rates during the Operation Phase

NSDF Project Activity(a)	Source	Source Description	Average Emission Rates (kg/day)											
			SPM	PM_{10}	$PM_{2.5}$	NO_x/NO_2	SO_2	CO	C_3H_4O	Hg	Pb	H_2S	C_2H_3Cl	Odour (OU/day)
—	Engineered Containment Mound (ECM)	ECM cap	—	—	—	—	—	1.93E-03	—	6.91E-08	—	3.08E-03	2.50E-04	6.90E+02
—		ECM passive vents	—	—	—	—	—	1.74E-02	—	6.22E-07	—	2.77E-02	2.25E-03	6.21E+03
Phased development of the ECM disposal cells, placement of waste in the ECM, and progressive closure of disposal cells and installation of cover		ECM operation (material handling)	2.52E-02	1.19E-02	1.80E-03	—	—	—	—	—	—	—	—	—
Phased development of the ECM disposal cells, placement of waste in the ECM, and progressive closure of disposal cells and installation of cover		ECM operation (vehicle exhaust)	3.60E+00	3.60E+00	3.60E+00	1.13E+02	1.31E-01	2.25E+01	3.14E-03	—(b)	—(b)	—	—	—
On-site transportation of waste	Unpaved Roads	Vehicle exhaust and fugitive road dust	5.48E+01	1.48E+01	1.48E+00	1.66E-01	1.25E-03	9.01E-02	2.79E-05	—(b)	—(b)	—	—	—
Phased development of the ECM disposal cells	Storage Piles	Stockpile	3.11E+00	1.56E+00	2.33E-01	—	—	—	—	—	—	—	—	—
Operation of WWTP	Wastewater Treatment Plant (WWTP)	Wastewater treatment activities	—	—	—	—	—	—	—	—	—	—	—	3.19E+04
Operation of WWTP		WWTP natural gas combustion	6.01E-03(c)	6.01E-03(c)	6.01E-03(c)	2.00E+00(c)	1.20E-02(c)	1.68E+00(c)	—	—(d)	1.00E-05	—	—	—
—	Support Activities	Vehicle Decontamination Facility natural gas combustion	1.08E-03(c)	1.08E-03(c)	1.08E-03(c)	3.59E-01(c)	2.16E-03(c)	3.02E-01(c)	—	—(d)	1.80E-06	—	—	—
—		Administration Office natural gas combustion	1.10E-04(c)	1.10E-04(c)	1.10E-04(c)	3.68E-02(c)	2.21E-04(c)	3.09E-02(c)	—	—(d)	1.84E-07	—	—	—
—		Operations Support Centre natural gas combustion	3.66E-04(c)	3.66E-04(c)	3.66E-04(c)	1.22E-01(c)	7.31E-04(c)	1.02E-01(c)	—	—(d)	6.09E-07	—	—	—

a) As described in the air quality pathway analysis in Section 5.2.1.5.2

b) Hg and Pb occur as trace elements from the combustion of diesel fuel and are excluded from the diesel combustion sources emissions.

c) Contaminants are presented for completeness however they have not been carried through for the dispersion modelling assessment as they were identified as negligible as identified in Table 5.2.1-13.

d) Hg occurs as trace element from the combustion of natural gas and is excluded from the natural gas combustion sources emissions.

ECM = engineered containment mound; WWTP = Wastewater Treatment Plant; SPM = suspended particulate matter; $PM_{2.5}$ = particulate matter less than 2.5 µm (microns) in diameter; PM_{10} = particulate matter less than 10 µm (microns) in diameter; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; CO = carbon monoxide; H_2S = hydrogen sulfide; C_2H_3Cl = vinyl chloride; Pb = lead; Hg = mercury; C_3H_4O = Acrolein; OU/day = Odour Unit per day.

Table 5.2.1-12: Summary of Maximum Emission Rates during the Operation Phase

NSDF Project Activity[a]	Source	Source Description	Maximum Emission Rates (kg/day)											
			SPM	PM_{10}	$PM_{2.5}$	NO_x/NO_2	SO_2	CO	C_3H_4O	Hg	Pb	H_2S	C_2H_3Cl	Odour (OU/day)
—	Engineered Containment Mound (ECM)	ECM cap	—	—	—	—	—	1.93E-03	—	6.91E-08	—	3.08E-03	2.50E-04	6.90E+02
—		ECM passive vents	—	—	—	—	—	1.74E-02	—	6.22E-07	—	2.77E-02	2.25E-03	
Phased development of the ECM disposal cells, placement of waste in the ECM, and progressive closure of disposal cells and installation of cover		ECM operation (material handling)	2.52E-02	1.19E-02	1.80E-03	—	—	—	—	—	—	—	—	—
Phased development of the ECM disposal cells, placement of waste in the ECM, and progressive closure of disposal cells and installation of cover		ECM operation (vehicle exhaust)	7.20E+00	7.20E+00	7.20E+00	2.26E+02	2.63E-01	4.50E+01	6.29E-03	—[b]	—[b]	—	—	—
On-site transportation of waste	Unpaved Roads	Vehicle exhaust and fugitive road dust	1.10E+02	2.96E+01	2.96E+00	3.32E-01	2.49E-03	1.80E-01	5.59E-05	—[b]	—[b]	—	—	—
Phased development of the ECM disposal cells	Storage Piles	Stockpile	3.11E+00	1.56E+00	2.33E-01	—	—	—	—	—	—	—	—	—
Operation of WWTP	Wastewater Treatment Plant (WWTP)	Wastewater treatment activities	—	—	—	—	—	—	—	—	—	—	—	3.19E+04
Operation of WWTP		WWTP natural gas combustion	6.01E-03[c]	6.01E-03[c]	6.01E-03[c]	2.00E+00[c]	1.20E-02[c]	1.68E+00[c]	—	—[d]	1.00E-05	—	—	—
—	Support Activities	Vehicle Decontamination Facility natural gas combustion	1.08E-03[c]	1.08E-03[c]	1.08E-03[c]	3.59E-01[c]	2.16E-03[c]	3.02E-01[c]	—	—[d]	1.80E-06	—	—	—
—		Administration Office natural gas combustion	1.10E-04[c]	1.10E-04[c]	1.10E-04[c]	3.68E-02[c]	2.21E-04[c]	3.09E-02[c]	—	—[d]	1.84E-07	—	—	—
—		Operations Support Centre natural gas combustion	3.66E-04[c]	3.66E-04[c]	3.66E-04[c]	1.22E-01[c]	7.31E-04[c]	1.02E-01[c]	—	—[d]	6.09E-07	—	—	—

a) As described in the air quality pathway analysis in Section 5.2.1.5.2

b) Hg and Pb occur as trace elements from the combustion of diesel fuel and are excluded from the diesel combustion sources emissions.

c) Contaminants are presented for completeness however they have not been carried through for the dispersion modelling assessment as they were identified as negligible as identified in Table 5.2.1-13.

d) Hg occurs as trace element from the combustion of natural gas and is excluded from the natural gas combustion sources emissions.

ECM = engineered containment mound; WWTP = Wastewater Treatment Plant; SPM = suspended particulate matter; $PM_{2.5}$ = particulate matter less than 2.5 µm (microns) in diameter; PM_{10} = particulate matter less than 10 µm (microns) in diameter; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; CO = carbon monoxide; H_2S = hydrogen sulfide; C_2H_3Cl = vinyl chloride; Pb = lead; Hg = mercury; C_3H_4O = Acrolein; OU/day = Odour Unit per day.

Negligible Emissions from the Project

Not all activities associated with the NSDF Project produce emissions for compounds that are relevant to the overall emissions assessment. All activities that potentially produce emissions are evaluated to identify their relevance; however, only activities that are considered to be relevant are included in the assessment.

The following provides rationale as to why certain activities and/or emissions of certain compounds are excluded from the assessment:

- the emission rates of certain compounds are minor relative to the overall emissions at the NSDF Project;
- the emissions of certain sources are known to not be relevant due to the type of operations in the assessment; and
- the location of the source relative to the rest of the sources on site (i.e., the source is located far away from any potential receptors).

Table 5.2.1-13 lists the activities that are not assessed and the accompanying rationale.

Table 5.2.1-13: Emission Sources and Contaminants not included in the Assessment

Activity/Compound	Rationale for Excluding from the Assessment
Natural gas combustion for WWTP process, Vehicle Decontamination Facility, Administration Office and Operations Support Centre	CO, SO_2, SPM, PM_{10}, and $PM_{2.5}$ emissions from these sources are not required to be assessed (MOECC 2018) and NOx/NO_2 are negligible (<1%) compared to emissions from the mobile combustion sources. Only Pb emissions were included in the dispersion modelling in response to regulator feedback received during the review process.
WWTP and associated equipment (i.e., equalization tanks)	The treatment of wastewater may result in the release of H_2S, mercaptans, chlorine and various other chemicals, to a lesser extent. With the exception of odour, the emissions from the WWTP have been excluded from the assessment as they are expected to have a negligible effect on the overall air quality.
Contact water ponds	Water from precipitation that has not infiltrated into the waste but is treated as suspect of contamination is collected in contact water ponds or equivalent structures on a lined portion of the cell floor. The contact ponds are temporary, and therefore, potential odorous emissions have been excluded from the assessment as they are expected to have a negligible effect on the overall air quality.
Natural gas emergency power generator	The emergency power equipment only operates periodically during monthly routine maintenance testing and for very short duration (20 minutes; rather than continuously). Additionally, the emergency power generator will only be used to supply electricity during power outage when other equipment is not operational; and therefore, is not included in the representative scenario as the modelling is meant to represent normal operations for the NSDF Project.
Diesel pumps, air compressors, and lighting equipment at all NSDF buildings	This equipment is part of miscellaneous equipment and only operates periodically and for short durations. Emissions rates from these sources are minor compared to emissions from the other diesel equipment on-site, and therefore, are not included in the representative scenarios.
Snow removal equipment	Emissions from this equipment occur seasonally and are infrequent (i.e., only during the winter following a snowfall), and therefore, are not included in the representative scenario.
Operational support activities, such as maintenance activities	Emissions from these sources are infrequent, relatively minor, and do not occur at all times compared to the other activities that are occurring regularly and/or continuously. For example, these activities may include minor emissions such as particulates and metals (e.g., welding).

WWTP = Wastewater Treatment Plant; CO = carbon monoxide; SO_2 = sulphur dioxide; SPM = suspended particulate matter; PM_{10}, = particulate matter less than 10 microns in diameter; NOx/NO_2 = nitrogen oxides/nitrogen dioxide; H_2S = hydrogen sulphide; $PM_{2.5}$ = particulate matter less than 2.5 microns in diameter; Pb = lead; < = less than.

Halocarbon emissions are not considered a source of emissions for the NSDF Project. However, if a spill or lead occurs from equipment (e.g., air conditioners) it is reported to the CNL Environmental Protection Program and included in the annual report.

Predicted Modelling Concentrations

Concentrations resulting from the construction and operations phases of the NSDF Project for the air quality indicator compounds were predicted with the aid of the AERMOD dispersion model (Tables 5.2.1-9 to 5.2.1-12). The predicted concentrations at the LSA boundary for the construction and operations phases are presented in Table 5.2.1-14. The maximum predicted incremental concentration represents the incremental effect of the NSDF Project, without taking into consideration existing Base Case concentrations. The predicted concentrations for the Application Case represent the combined concentrations of the Base Case plus the incremental concentrations from the NSDF Project. Predicted concentrations for the Application Case during both construction and operations phases are below applicable air quality guidelines and/or standards, with the exception of NO_2 and the 2020 1-hour CAAQS. The contributing factor to maximum predicted NO_2 concentration being above the 2020 CAAQS is the heavy-duty construction equipment and the conservative assumption that all equipment will run simultaneously and continuously during working hours. In reality, individual equipment will be idling or off for varying parts of the workday that cannot be predicted but will result in lower emissions than currently estimated.

Table 5.2.1-14: Concentrations at the Local Study Area Boundary for the Base Case and Application Case

Indicator	Averaging Period	Air Quality Guideline/ Standard[a] (µg/m³)	Base Case (Existing Conditions)[b] (µg/m³)	Maximum Predicted Incremental Concentration – Construction Phase (µg/m³)	Maximum Predicted Incremental Concentration – Operation Phase (µg/m³)	Application Case - Construction Phase (µg/m³)	Application Case - Operation Phase (µg/m³)
SPM	24-hour	120	30.95	54.56	7.24	85.51	38.19
SPM	Annual	60	14.53	4.59	0.45	19.12	14.98
PM_{10}	24-hour	50	15.48	15.65	2.35	31.13	17.83
$PM_{2.5}$	24-hour	27	7.74	2.56	0.66	10.30	8.40
$PM_{2.5}$	Annual	8.8	3.63	0.18	0.03	3.81	3.66
NO_2[d]	1-hour	113	31.98	149.84	98.87	181.82	130.85
NO_2	24-hour	200	28.61	48.72	14.56	77.33	43.17
NO_2	Annual	32	14.86	1.76	0.62	16.62	15.48
SO_2	1-hour	183	2.62	0.76	0.17	3.38	2.79
SO_2	24-hour	275	2.62	0.06	0.02	2.68	2.64
SO_2	Annual	13	1.05	2.05E-03	7.20E-04	1.05	1.05
CO	1-hour	36,200	458.10	127.21	28.79	585.31	486.89
CO	8-hour	15,700	486.73	18.46	5.02	505.19	491.75
C_3H_4O	1-hour	4.5	—	1.73E-02	4.02E-03	1.73E-02	4.02E-03
C_3H_4O	24-hour	0.4	—	1.29E-03	4.00E-04	1.29E-03	4.00E-04
Pb	24-hour	0.5	0.0046	—[c]	3.05E-06	—[c]	4.60E-03
Pb	30-day	0.2	—	—[c]	5.00E-07	—[c]	5.00E-07
Hg	24-hour	2	—	—[c]	4.44E-08	—[c]	4.44E-08
H_2S	10-min	13	—	—[c]	3.25E-02	—[c]	3.25E-02
H_2S	24-hour	7	—	—[c]	1.98E-03	—[c]	1.98E-03

Table 5.2.1-14: Concentrations at the Local Study Area Boundary for the Base Case and Application Case

Indicator	Averaging Period	Air Quality Guideline/ Standard[(a)] (µg/m³)	Base Case (Existing Conditions)[(b)] (µg/m³)	Maximum Predicted Incremental Concentration – Construction Phase (µg/m³)	Maximum Predicted Incremental Concentration – Operation Phase (µg/m³)	Application Case - Construction Phase (µg/m³)	Application Case - Operation Phase (µg/m³)
C_2H_3Cl	24-hour	1	—	—[(c)]	1.61E-04	—[(c)]	1.61E-04
C_2H_3Cl	Annual	0.2	—	—[(c)]	6.84E-06	—[(c)]	6.84E-06
Odour[(e)]	10-min	1	—	—[(c)]	3.98E-02	—[(c)]	3.98E-02

a) Table 5.2.1-4 identifies which guideline or standard was used in the screening of effects to air quality.

b) The 90th percentile predicted existing concentrations; values for SPM and PM_{10} are calculated from the $PM_{2.5}$ as described in Section 5.2.1.

c) "—" indicates there are no predicted concentrations because there are no emissions.

d) Calculated using the Ozone Limiting Method. Refer to Section 5.2 of the Air Quality Assessment TSD (Golder 2019).

e) 99.5th percentile on a 10-minute averaging period, in OU/m^3.

µg/m³ = micrograms per cubic metre; SPM = suspended particulate matter; $PM_{2.5}$ = particulate matter less than 2.5 µm (microns) in diameter; PM_{10} = particulate matter less than 10 µm (microns) in diameter; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; CO = carbon monoxide; C_3H_4O = acrolein H_2S; = hydrogen sulfide; C_2H_3Cl = vinyl chloride; Pb = lead; Hg = mercury; µg/m³ = microgram per cubic metre; OU/m^3 = odour unit per cubic metre.

5.2.1.6.3 Reasonably Foreseeable Development Case Results

Reasonably foreseeable developments in the RSA with potential to overlap with the residual effects of the NSDF Project include revitalization activities (i.e., new/upgrades to research and development facilities, new support infrastructure), on-going decommissioning and environmental remediation activities on the CRL site. These revitalization and decommissioning activities involve renovation of some current buildings, construction of new buildings, and removal of more than 100 existing buildings on the CRL site over the 10-year period from 2016 to 2026. A specific new research and development project announced in 2019 is the planned construction and 20-year operation of a SMR at the CRL site. As well, there may be overlap of the construction period with limited construction at neighbouring Garrison Petawawa.

Site revitalization, SMR construction, construction at Garrison Petawawa and on-going decommissioning activities on the CRL site will generate air and dust emissions such as CO, oxides of sulphur (SO_x includes SO_2), oxides of nitrogen (NO_x includes NO_2), particulate matter ($PM_{2.5}$, PM_{10}), and suspended particulate matter (SPM). Air emissions, such as SO_x and NO_x, can result from the use of fossil fuels in generators, vehicles, and machinery. Vehicle exhaust and fugitive dust from unpaved and paved roads is expected to be the largest contributor to particulate matter (SPM, PM_{10}, and $PM_{2.5}$). The waste from the decommissioning of the CRL structures will be placed in the NSDF and the Application Case assessed for the operations phase considers the transport of this waste for disposal in the ECM.

Decommissioning of eight buildings, renovation of three and construction of a new 9,900 m^2 facility for the Royal Dragoons planned within the built-up area at Garrison Petawawa (approximately 10 km south of the SSA) in 2020-2021 are also expected to follow best practice construction techniques. As a result, emissions to air are expected to be short term and limited. Given the distance of these activities from the SSA and limited potential overlap in time of the construction periods, no potential for cumulative effects is identified.

The airborne emissions from new facility construction and decommissioning projects on the CRL site will be assessed as part of the approval process for these projects. Examples of mitigation expected to be implemented by site revitalization, SMR construction and on-going decommissioning activities on the CRL site to limit potential effects to air quality include:

- limiting the construction activities required on-site through the use of modular structures for construction of the SMR (Global First Power 2019);
- staging site revitalization and decommissioning activities over a ten-year period to reduce periods of simultaneous construction at the CRL site;
- implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and verification monitoring;
- implementation of best practice dust management techniques such as water spraying or misting techniques (e.g., water trucks);
- using on-site vehicles and equipment engines that meet Tier 2 emission standards and maintaining them in good working order; and
- limiting idling of vehicles on site.

Site revitalization and decommissioning activities include several small projects staged over a ten-year period where best practices, mitigation and monitoring for management of emissions will to be followed. Accordingly, the incremental additional equipment use and emissions at any one time are expected to be small, distributed across the CRL site and removed from the more intensive activities within the SSA. The conclusions of the NSDF Project assessment in Section 5.2.1.6.2 for the Assessment Case indicate that the predicted concentrations of indicator compounds for air quality are below the relevant guideline/standard during the construction and operations phases, except for 1-hour NO2. These predictions are based on conservative assumptions around number of heavy-duty vehicles and intensity of use, as well as meteorological conditions. When compared with current CRL site operations and NSDF Project activities, it is anticipated that the small incremental effect to indicator compounds from site revitalization and decommissioning activities in progress at any one time would be negligible to air quality outside of the CRL site. Similarly, the scale and modular construction technique for the SMR limits the length of its construction period, as well as associated equipment use. The locations for placement of the SMR under consideration are removed from the SSA within the CRL site. During operation of the SMR, dry cooling towers may be used to dissipate excess heat from steam condensation in operation of the steam turbine generator. No additional activities or new sources for release of indicator compounds are planned (Global First Power 2019). With effective implementation of mitigation measures and monitoring programs, no cumulative residual effect is identified to air quality.

5.2.1.7 Prediction Confidence and Uncertainty

Potential sources of uncertainty in the assessment of air quality include:

- potential modifications associated with the location, physical footprint and activity level of the NSDF Project;
- the accuracy and representativeness of the activity data and emission factors used to estimate emissions;
- the accuracy and representativeness of the waste inventory;
- the accuracy and representativeness of the meteorological data used in the AERMOD model;
- the accuracy of formulations within the AERMOD dispersion modelling system;
- the representativeness of the ambient data used to represent background concentrations; and
- the potential error associated with omitting some emission sources.

Dispersion models employ assumptions that simplify the random processes associated with atmospheric motions and turbulence. While this simplification limits the model's ability to replicate individual events, the strength of the model lies in the ability to predict overall values for a given set of meteorological conditions. The process undertaken by the US EPA ensured that the model predictions can be relied on as reasonable estimate of the likely concentrations. AERMOD is based on known theory and proven to reliably produce repeatable results (Section 5.2.1.6.1). Uncertainties were managed using the following conservative assumptions in the emission estimation and dispersion modelling.

- Waste receipt for the maximum capacity of 1,000,000 m^3 was used in determining emission rates for dispersion modelling. All emission rate calculations were completed for the maximum amount of waste received during the entire life of the NSDF Project.

- The ECM was modelled as an area source that summed emissions from the ECM cap, the passive vents, material handling and vehicle exhaust. Modelling the ECM emissions as an area source assumes that emissions are being released from the entire area, however in reality emissions will only be emitted from discrete areas on the source.
- The modelling assessment includes all operations occurring simultaneously and continuous for each individual source's modelling period.
- The influence of natural mitigation from events such as rainfall, snowfall, residual moisture, or snow cover was not considered in determining fugitive dust emission rates for all sources, except unpaved roads and grading. The modelling will likely yield higher concentrations since contaminants will be deposited from the air by dry or wet depletion and deposition processes.
- The 90th percentile observed concentration was added to maximum predicted concentrations for short-term averaging periods to account for existing background emission sources. The use of 90th percentile background concentrations is conservative in that it assumes that the maximum predicted concentration and the 90th percentile background concentration will occur at the same time, even though background concentrations greater than or equal to the 90th percentile occur only 10% of the time.
- Five years of meteorological data are used as an input to the model to provide that a full range of possible meteorological conditions is evaluated.

The parameters that were required for fugitive dust modelling from unpaved roads include the locations of the roadway segments, base elevations, effective heights of the emissions, and the initial plume size in the lateral and vertical directions. It is recognized that this modelling approach will result in higher predicted concentrations close to the roadways than actual values for the following reasons.

- There has been extensive research on the estimation of the "transportable fraction" of fugitive dust from roadways. Studies completed by the Desert Research Institute in Nevada and in the San Joaquin Valley, California (Watson et al. 1996) showed a large (i.e., greater than 90%) decrease in dust concentration within 100 m of an unpaved road (Watson et al. 1996; Watson et al. 2000). A value of 75% reduction has been suggested beyond 50 m for unpaved roadway emissions. This value would increase at greater distances. This adjustment was not made to the dispersion modelling concentration results.
- When the roads are wet or snow-covered, the emissions will be reduced or eliminated. AERMOD has the capacity to have a variable emission rate that could account for actual meteorological emissions.
- The best management practices will further reduce emissions; specifically, speed limits and watering were assumed to be used on unpaved roads to decrease emissions from roads and a truck-wheel wash station will be used to reduce track out. A conservative control efficiency of 85% was selected to represent the implementation of the best management practices.

It is assumed that the conservative emission rates, when combined with the conservative operating conditions and conservative dispersion modelling assumptions description herein, are not likely to under predict the modelled concentrations at each of the identified receptors.

5.2.1.8 Residual Effects Classification and Determination of Significance

This section classifies the residual effects from changes to measurement indicators for the Application Case and presents a determination of significance for the air quality VC.

5.2.1.8.1 Residual Effects Classification

Effects from adverse residual changes to measurement indicators were classified using a categorical scale and common words to facilitate the determination of significance. The purpose of categorical classification is to provide definitions that permit a clear, thorough and unambiguous classification of residual effects such that reviewers and readers can follow and apply the logic used in the assessment and reach the same classification for a given residual effect.

Magnitude, geographic extent and duration are the principal factors considered to predict significance. The magnitude of a residual environmental effect is determined by the change in a measurement indicator from a project interaction. Geographic extent refers to the area affected, and duration is defined as the amount of time for a residual effect to be reversed. For air quality, residual effects stop almost immediately when the NSDF Project activity stops. It should be noted that reversibility refers to effects to air quality only; how effects to air quality affect other VCs are assessed in their discipline-specific sections. Other criteria, such as frequency and likelihood are used as modifiers, where applicable. Residual adverse effects were classified using the criteria and definitions outlined in Table 5.2.1-15.

Table 5.2.1-15: Assessment Criteria for Classifying Predicted Residual Adverse Effects to Air Quality

Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
Positive: Maximum concentration for an indicator compound represents a decrease from Base Case. **Negative:** Maximum concentration for an indicator compound represents an increase from Base Case. **Neutral:** No change in concentrations of an indicator compound relative to Base Case.	**Negligible:** Maximum concentration for an indicator compound is less than 5% of the corresponding criteria **Low:** Maximum concentration for an indicator compound is less than 50% of the corresponding criteria **Moderate:** Maximum concentration for an indicator compound is between 50% and 100% of the corresponding criteria **High:** Maximum concentration for an indicator compound is above the corresponding criteria	**Local:** Effect is limited to within the LSA **Regional:** Effect extends beyond the LSA, but is contained within the RSA **Beyond Regional:** Effect extends beyond the RSA	**Short-term:** Effects are not evident beyond the construction phase **Medium-term:** Effects are not evident beyond the operations phase **Long-term:** Effects are not evident beyond the closure and post-closure phases **Permanent**: Effects are not reversible	**Infrequent:** Effects are confined to a specific discrete period **Frequent:** Effects occur intermittently, but repeatedly, or continuous over the assessment period	**Reversible:** Change of state in environment is not permanent **Irreversible:** Change of state in the environment is permanent	**Low:** Effect is unlikely to occur **Medium:** Effect is likely to occur **High:** Effect is highly likely to occur

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

5.2.1.8.2 Determination of Significance

The residual effects classification of primary pathways and the associated predicted changes in measurement indicators provide the foundation for determining the significance of residual effects from the NSDF Project on air quality. Where possible and appropriate, established guidelines, thresholds and screening values were used to support the classification of the predicted amount of change in measurement indicators and associated effects on air quality. For an effect to be deemed significant the effect must be negative in direction, high in magnitude, regional in geographic extent and long-term in duration. As part of the determination of significance, confidence in the assessment identified in Section 5.2.1.7 was considered for the air quality VC. Where uncertainty was high, and the cumulative effect might be either significant or not significant, the assessment conservatively identified the effect as significant and provided additional follow-up actions to reduce uncertainty (Section 5.2.1.9).

The duration, frequency, reversibility and likelihood of effects are the same for all indicator compounds for each of the Application Cases (i.e., construction and operations phases), and only the direction, magnitude and geographic extent varies by indicator compound (Table 5.2.1-16). The magnitude of changes for SPM, PM_{10}, $PM_{2.5}$, NO_2 and SO_2 (annual only) for the Base Case are classified as low before considering effects from the NSDF Project. Emissions of indicator compounds will stop at the end of the construction and operations phase; therefore, the duration of effect is short-term and medium-term, respectively, and they are reversible. Criteria air contaminants will be emitted continuously or near-continuously during the construction and operations phases, and therefore the effect is considered frequent. The likelihood of emissions from the NSDF Project changing indicator compound concentrations for the Application Case during construction and operations is medium (Table 5.2.1-16).

Construction Phase

For the Application Case construction phase, the direction is neutral for some indicator compounds as there are no emissions of these compound during this phase of the NSDF Project (i.e., H_2S, C_2H_3Cl, and odour). The magnitude of changes to indicator compound emissions are predicted to be negligible to moderate, as the predicted concentrations are below the relevant guideline/standard with the exception of 1-hour NO_2 when compared to the CAAQS. However, comparison to the CAAQS is not appropriate and the maximum predicted 1-hour NO_2 concentrations above the CAAQS standard is not significant because the Project boundary does not, nor does the 7.4 km radius circular regional study area (RSA), represent an “air zone”, the region over which the CCME states that achievement of the CAAQS is to be evaluated/compared (Section 5.2.1.4.2).

The predicted 1-hr CAAQS for NO_2 can be calculated within the RSA using the model output, however, such a comparison is inherently biased by model input assumptions and is not suitable for comparison to a monitoring based values such as the CAAQS that use a 3-year averaging period. The NO_2 emissions inventory for the Project are designed to be conservative and represent a ‘worst-case’ scenario. Project emissions assume all heavy-duty construction equipment combustion sources operate at their peak intensity/load/capacity for each hour for 1-hr simulations. In reality, individual equipment will be idling or off for varying parts of the workday, which cannot be predicted but will result in lower emissions than currently estimated. The likelihood that all equipment operates simultaneously for an hour or more along with unfavourable weather conditions to produce the maximum concentrations modelled is very low. A less conservative but more appropriate comparison to the Ontario AAQS of 400 µg/m^3 for 1-hr NO_2 would result in a Low magnitude.

The predicted effects at the highest magnitude modelled are beyond regional for all indicator compounds except for SPM and PM_{10}. The moderate magnitude results of SPM and PM_{10} do not extend beyond the RSA and are therefore classified as regional. For an effect to be deemed significant the effect must be negative in direction, high in magnitude, regional in geographic extent and long-term in duration. No indicator compounds meet all of these requirements; therefore, the overall residual adverse effect of the Application Case during construction on air quality is determined to be not significant.

Operations Phase

For the Application Case operations phase, the direction is negative for all indicator compounds as concentrations of emissions are predicted to increase during this phase of the NSDF Project. However, the magnitude of changes to indicator compound emissions are predicted to be negligible to moderate as the predicted concentrations are below the relevant guideline/standard with the exception of 1-hour NO_2 when compared to the CAAQS. However, on the same grounds described in the construction phase, comparison to the CAAQS is not appropriate and the maximum predicted 1-hour NO_2 concentrations above the CAAQS standard is not significant. A less conservative but more appropriate comparison to the Ontario AAQS of 400 $\mu g/m^3$ for 1-hr NO_2 would result in a Low magnitude.

The predicted effects at the highest magnitude modelled are beyond regional for all indicator compounds except for NO_2. The high magnitude result for NO_2 when compared to the CAAQS does not extend beyond the RSA and is therefore classified as Regional. For an effect to be deemed significant the effect must be negative in direction, high in magnitude, regional in geographic extent and long-term in duration and zero indicator compounds meet all of these requirements, therefore, the overall residual adverse effect of the Application Case during operations on air quality is determined to be not significant.

Table 5.2.1-16: Classification of Predicted Residual Adverse Effects on Air Quality for the Application Case

Indicator Compound	Direction	Magnitude[(a)]	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
Application Case – Construction Phase							
SPM	Negative	Moderate (24hr)	Regional	Short-term	Frequent	Reversible	Medium
PM_{10}	Negative	Moderate (24hr)	Regional	Short-term	Frequent	Reversible	Medium
$PM_{2.5}$	Negative	Low (All)	Beyond Regional	Short-term	Frequent	Reversible	Medium
NO_2	Negative	High (1hr)	Beyond Regional	Short-term	Frequent	Reversible	Medium
SO_2	Negative	Low (Annual)	Beyond Regional	Short-term	Frequent	Reversible	Medium
CO	Negative	Negligible (All)	Beyond Regional	Short-term	Frequent	Reversible	Medium
C_3H_4O	Negative	Negligible (All)	Beyond Regional	Short-term	Frequent	Reversible	Medium
Hg	Negative	Negligible (All)	Beyond Regional	Short-term	Frequent	Reversible	Medium
Pb	Negative	Negligible (All)	Beyond Regional	Short-term	Frequent	Reversible	Medium
H_2S	Neutral	n/a	n/a	n/a	n/a	n/a	n/a
C_2H_3Cl	Neutral	n/a	n/a	n/a	n/a	n/a	n/a
Odour	Neutral	n/a	n/a	n/a	n/a	n/a	n/a
Application Case – Operations Phase							
SPM	Negative	Low (All)	Beyond Regional	Medium-term	Frequent	Reversible	Medium
PM_{10}	Negative	Low (All)	Beyond Regional	Medium-term	Frequent	Reversible	Medium
$PM_{2.5}$	Negative	Low (All)	Beyond Regional	Medium-term	Frequent	Reversible	Medium
NO_2	Negative	High (1hr)	Regional	Medium-term	Frequent	Reversible	Medium
SO_2	Negative	Low (Annual)	Beyond Regional	Medium-term	Frequent	Reversible	Medium
CO	Negative	Negligible (All)	Beyond Regional	Medium-term	Frequent	Reversible	Medium
C_3H_4O	Negative	Negligible (All)	Beyond Regional	Medium-term	Frequent	Reversible	Medium
Hg	Negative	Negligible (All)	Beyond Regional	Medium-term	Frequent	Reversible	Medium
Pb	Negative	Negligible (All)	Beyond Regional	Medium-term	Frequent	Reversible	Medium
H_2S	Negative	Negligible (All)	Beyond Regional	Medium-term	Frequent	Reversible	Medium

Table 5.2.1-16: Classification of Predicted Residual Adverse Effects on Air Quality for the Application Case

Indicator Compound	Direction	Magnitude[(a)]	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
C_2H_3Cl	Negative	Negligible (All)	Beyond Regional	Medium-term	Frequent	Reversible	Medium
Odour	Negative	Negligible (All)	Beyond Regional	Medium-term	Frequent	Reversible	Medium

a) Averaging period with the highest magnitude in brackets ( )

n/a = neutral effects are not classified; SPM = suspended particulate matter; $PM_{2.5}$ = particulate matter less than 2.5 µm (microns) in diameter; PM_{10} = particulate matter less than 10 µm (microns) in diameter; CO = carbon monoxide; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; C_3H_4O = acrolein; H_2S; = hydrogen sulfide; C_2H_3Cl = vinyl chloride; Pb = lead; Hg = mercury.

5.2.1.9 Monitoring and Follow-up

Implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and air verification monitoring, will continue for the NSDF Project as it outlines the key management practices to limit effects to air quality. The CRL Radioactive Effluent Verification Monitoring Program includes airborne effluents verification monitoring that comprises 56 monitoring points and will also continue for the NSDF Project. In addition, air quality monitoring activities for the NSDF Project will be implemented (Table 5.2.1-17) and the purpose it to:

- verify effects predictions, and compare actual with predicted effects;
- confirm effectiveness of mitigation, and in doing so evaluate if alternate mitigation is required;
- provide information for use in adaptive management to address potential unforeseen effects; and
- demonstrate compliance with regulatory requirements.

Table 5.2.1-17: Environmental Monitoring and Follow up Programs for Air Quality

Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Air Quality	Construction activities will result in fugitive dust emissions.	■ Verify that mitigation is being implemented effectively. ■ Verify predictions in the assessment are reasonable and conservative. ■ Verify predictions are within air quality criteria (SPM monitoring).	■ Application of aggregate to unpaved roads – a record will be kept of the date of each application of aggregate to unpaved roads. ■ Road misting and fixative application – a record will be maintained of dust suppression applications. ■ Site inspection – during periods of high dust susceptibility, regular inspections will be carried out to monitor the efficacy of dust mitigation and any potential concerns with regards to fugitive dust and, if required, implementation of mitigation will be recommended. Environmental conditions will be recorded. ■ Particulate monitoring –SPM using a high volume sampler.	Through the construction phase.	*Dust Management Plan* (AECOM 2018a) to be implemented for the NSDF Project.
Air Quality	Operations activities will result in fugitive dust emissions.	■ Verify that the mitigation is being incorporated as planned, and are effective. ■ Verify predictions in the assessment are reasonable and conservative. ■ Verify predictions are within air quality criteria.	■ Application of aggregate to unpaved roads – a record will be kept of the date of each application of aggregate to unpaved roads. ■ Road misting and fixative application – a record will be maintained of dust suppression applications. ■ Site inspection – during periods of high dust susceptibility, regular inspections will be carried out to monitor the efficacy of dust mitigation and any potential concerns with regards to fugitive dust, and if required implementation of mitigation will be recommended. Environmental conditions will be recorded. ■ Particulate monitoring – SPM using a high volume sampler.	Based on observations and monitoring data during first year of operation, the frequency of monitoring will be determined	Captured through the implementation of the *Dust Management Plan* (AECOM 2018a) and CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and air verification monitoring.

SPM = suspended particulate matter.

5.2.1.10 Conclusions

Valued components refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous peoples, the scientific community, or the public (The Agency 2018). Air quality was selected as a VC as emissions from the NSDF Project activities have the potential to alter the existing air quality regime. The assessment endpoints for the air quality assessment are comparison against criteria and thresholds for protection of human health and the environment.
The measurement indicators for air quality include changes in ambient concentrations of indicator compounds and dustfall deposition rates in comparison to the provincial or federal ambient air quality criteria.

Residual effects from activities that occur during the construction and operations phases have been identified as the primary linkage to potentially affect ambient air quality. During the construction and operations phases, NSDF Project activities will result in emissions associated with the operation of vehicles and equipment, as well as emissions from the decomposition of waste in the ECM. A summary of the predicted residual adverse effects for air quality, including associated mitigation, are provide in Table 5.2.1-18. Examples of mitigation practices implemented to limit predicted residual effects to air quality include:

- implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring, air verification monitoring and environmental monitoring;
- implementation of the *Dust Management Plan* (AECOM 2018a) for the NSDF Project;
- use of water spraying or misting techniques (e.g., water trucks) as the primary dust control method;
- vehicles that have come into contact with contamination will need to pass through the vehicle decontamination facility; and
- compliance of on-site vehicles and equipment engines with Tier 2 emission standards and their maintenance in good working order.

The predicted residual effects on air quality are estimated to increase because of the NSDF Project.
Vehicle exhaust and fugitive dust from unpaved roads is the largest contributor to SPM and PM_{10} during both the construction and operations phases. Vehicle exhaust during the construction of the ECM is the largest contributor of $PM_{2.5}$, SO_2, NO_x/NO_2, CO and C_3H_4O. Predicted concentrations for the Application Case during both construction and operations phases are below applicable air quality guidelines and/or standards, except for NO_2 that will not meet the 2020 1-hour CAAQS. However, as described in Section 5.2.1.4.2.1, in reviewing the criteria used for the assessment of magnitude, a less conservative but still applicable comparison for 1-hour NO_2 concentrations to the Ontario AAQS would result in a low magnitude at less than 50% of the criteria.

For an effect to be deemed significant the effect must be negative in direction, high in magnitude, regional in geographic extent and long-term in duration. None of the indicator compounds meet all of these requirements and consequently, the residual effects from the NSDF Project on air quality was predicted to be not significant. CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018) outlines the key management practices that limit air quality emissions effects, as well as the current monitoring requirements.

Table 5.2.1-18: Summary of Predicted Residual Adverse Effects for Air Quality Valued Components

Valued Components	Assessment Endpoint	Residual Adverse Effects	Project Effect Occurs in	Contributing Project Activity	Proposed Mitigation	Significance
Air Quality	Performance against criteria and thresholds for protection of human health and the environment	■ Construction and operation activities use vehicles and equipment that combust fuel and emit indicator compounds. These activities involve material handling, vehicles travelling on unpaved roads, and wind erosion of stockpiles that will result in fugitive dust emissions. ■ Decomposition of waste during the operations and post-closure phases will emit indicator compounds.	Construction, Operations and Post-Closure	**Construction** ■ Site preparation ■ Construction of the ECM ■ Development of surface water management structures ■ Construction of the WWTP and other support facilities ■ On-site road and access development **Operations** ■ Phased development of disposal cells ■ On-site transportation of waste and placement of waste in the ECM ■ Progressive closure of disposal cells and installation of final cover ■ Operation of the WWTP **Operations and Post-Closure** ■ Decomposition of waste from the ECM	■ Implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring, air verification monitoring and environmental monitoring. ■ The *Dust Management Plan* (AECOM 2018a) to be implemented for the NSDF Project will provide information on dust mitigation, including: ▪ Use of water spraying or misting techniques (e.g., water trucks) as the primary dust control method. ▪ Use of fixatives (e.g., chemical suppressant) for dust control. ▪ Covering stockpiles and exposed areas prior to high wind or dry conditions where standard dust suppressants may be inadequate in preventing dust generation caused by wind erosion. ▪ Minimizing the size of the exposed working areas containing contaminated materials to the extent practicable using a phased excavation approach. ▪ Revegetating affected areas or adding mulch to completed cells and excavated areas as soon as practicable. ▪ Dampening soil in dry areas prior to commencing truck/machinery activities in the area. ▪ Reducing activities to avoid unnecessary dust generation; ▪ Using wind fencing around work areas. ▪ Postponing work activities likely to cause dust if sustained wind speeds are predicted to exceed 40 km/hr, unless it can be shown that the work site is sufficiently protected that wind will not generate unacceptable amounts of dust. ■ On-site vehicles and equipment engines will meet Tier 2 emission standards and be maintained in good working order. ■ Limit idling of vehicles on-site. ■ Processed wastewater will not be heated within the WWTP (raising the temperature increases potential release rates). ■ There is active ventilation within the WWTP building and all active ventilation exhaust will be filtered through HEPA prior to release. ■ Installation of the interim and final covers will reduce release of emissions from the ECM.	Not Significant

ECM = engineered containment mound; WWTP = Wastewater Treatment Plant.

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5.2.2 Greenhouse Gases

5.2.2.1 Scope of the Assessment

Greenhouse gases have the potential to affect future climate as they contribute to the greenhouse effect by absorbing infrared radiation in the atmosphere, increasing temperature and changing weather patterns. The GHG assessment follows the overall approach and methods described in Section 5.1 Environmental Assessment Approach. The assessment is completed in the following eight primary steps:

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries, and assessment cases** for the GHG assessment (refer to Sections 5.2.2.2 Valued Components and Section 5.2.2.3 Assessment Boundaries). The VCs, assessment endpoints, and measurement indicators used to assess project-related changes to GHG; the spatial and temporal boundaries at which the assessment occurred; and the assessment cases considered.
- **Step 2 – Describe the existing conditions** (refer to Section 5.2.2.4 Description of the Environment). Existing conditions in the local and regional areas are described, including the combined effects of previous and existing developments (Base Case). The existing environment represents the historical and current environmental pressures that have shaped the observed patterns in the environment (i.e., natural variation).
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 5.2.2.5 Project Interactions and Mitigation). Project components and/or activities with the potential to affect GHG are identified and mitigation developed to limit or avoid effects is presented. A pathways analysis is then used to focus further assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects are adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects to GHG after incorporating mitigation are carried forward to Steps 4 for further analysis and residual effects characterization.
- **Step 4 - Present the methods and results of the residual effects analysis** (refer to Section 5.2.2.6 Residual Effects Analysis). This section outlines the methods used to predict and characterize residual effects to GHG from primary effects pathways. The analysis results are also presented including the characterization of incremental effects from the NSDF Project, as well as cumulative effects of the project in combination with other reasonably foreseeable developments (if applicable).
- **Step 5 – Describe the level of certainty and management of uncertainty** (refer to Section 5.2.2.7 Prediction Confidence and Uncertainty). This purpose of this section is to evaluate the available literature, data, and models used for the assessment, and describe the level of certainty that can be placed on predicted residual effects. This section will also identify how the uncertainty has been managed so that the effects are not underestimated.
- **Step 6 – Classify and determine the significance of the predicted residual effects** (refer to Section 5.2.2.8 Residual Effects Classification and Determination of Significance). Residual effects predicted from primary pathways are classified using a common set of criteria: direction, magnitude, geographic extent, duration, reversibility, frequency, and likelihood. A determination of the significance of the predicted residual effects from NSDF Project for the GHG VC is made.

- **Step 7 - Identify monitoring and follow-up** required to confirm effects predictions and address uncertainty (refer to Section 5.2.2.9 Monitoring and Follow-up).
- **Step 8 - Present a consolidated summary of conclusions and outcomes of the assessment** of residual effects on air quality (refer to Section 5.2.2.10 Conclusions).

Information and areas of interest raised by the public, communities of interest, regulators, and Indigenous communities or groups during engagement that influenced the scope of the GHG assessment are summarized in Table 5.2.2-1. Other general areas of interest and questions (if any) raised during the engagement that pertain to the GHG assessment are documented in CNL's Indigenous Engagement Report (CNL 2020a) and CNL's Stakeholder's Activity Reports (CNL 2017a,b, 2019a).

Table 5.2.2-1: Summary of Areas of Interest Raised During Engagement Activities that Influenced the Scope of the Greenhouse Gases Assessment

Area of Interest	How the Area of Interest Was Included in the Assessment
Will the Near Surface Disposal Facility produce methane gas?	The release of methane gas from the engineered containment mound is evaluated in the greenhouse gas assessment. Mitigation to limit the release of methane gas are discussed in Section 5.2.2.5 and predictions of methane gas release from the engineered containment mound are found in Section 5.2.2.6.2. The monitoring program to be implemented to verify that the measures for controlling landfill gas generated from wasted deposited in the engineered containment mound during operations and following final closure are adequate is described in Section 5.2.2.9.
Would like information on monitoring air contamination, including greenhouse gases.	The monitoring program proposed for greenhouse gas emissions is described in Section 5.2.2.9. Greenhouse gas monitoring is also captured through the implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and verification monitoring.

5.2.2.2 Valued Components

Valued Components (VCs) refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community or the public (The Agency 2018). Greenhouse gases was selected as a VC as there is a potential for the NSDF Project activities to release GHG emissions that could contribute incrementally to climate change (Table 5.2.2-2). The mechanism by which the NSDF Project has the potential to contribute to global climate change is by the addition of GHG emissions. Greenhouse gases refer to a group of gases that build up in the atmosphere and have the potential to contribute incrementally to climate change.

Table 5.2.2-2: Valued Components for the Greenhouse Gases Assessment

Valued Component	Rationale for Selection
Greenhouse Gases	This VC, assessed through incremental changes in emissions of a group of gases, considers the potential of the NSDF Project to contribute to climate change.

Assessment endpoints are qualitative expressions used to assess the significance of residual effects on VCs and represent the key properties of the VC that should be protected for future generations. The assessment endpoint for GHG is comparison to provincial and national totals (Table 5.2.2-3). Measurement indicators represent properties of the environment and VCs that, when changed, could result in, or contribute to, an effect on an assessment endpoint. Measurement indicators also provide the primary factors for discussing the uncertainty of effects on VCs and, subsequently, are the key variables for study in follow-up and monitoring programs. The measurement indicators considered in the GHG assessment include changes in concentrations of the following indicator compounds:

- CO_2;
- CH_4; and
- N_2O.

There are no NSDF Project activities that are expected to emit sulphur hexafluoride (SF_6), perfluorocarbons (PFCs) or hydrofluorocarbons (HFCs); therefore, these compounds are not included in the GHG assessment. Greenhouse gas emissions are expressed as tonnes of carbon dioxide equivalent (CO_2e), calculated by multiplying the annual emissions of each indicator compound by its 100-year global warming potential (GWP). A single measure is used when evaluating effects, namely the maximum annual GHG emissions resulting from the NSDF Project activities in tonnes of carbon dioxide equivalent. The assessment endpoints and measurement indicators used in the GHG assessment are listed in Table 5.2.2-3.

Table 5.2.2-3: Assessment Endpoints and Measurement Indicators for the Greenhouse Gas Assessment

Valued Component	Assessment Endpoints	Measurement Indicators
Greenhouse gases	Comparison of GHG emissions to provincial and national totals	Changes in greenhouse gas emissions (CO_2, CH_4 and N_2O) compared to provincial and national GHG totals

CO_2 = carbon dioxide; CH_4 = methane; N_2O = nitrous oxide; GHG = greenhouse gas.

5.2.2.3 Assessment Boundaries

5.2.2.3.1 Spatial Boundaries

The spatial boundaries for the GHG assessment are considered to be beyond regional as the predicted residual adverse effect of GHG emissions is considered global in nature.

5.2.2.3.2 Temporal Boundaries

Temporal boundaries (i.e., project phases) establish the timeframe during which NSDF Project effects are assessed. Four phases were identified for the NSDF Project including the construction phase, operations phase, closure phase, and post-closure phase (refer to Section 5.2.1.1 for more details on each phase). For the purposes of the GHG assessment, only the construction and operation phases have been considered. The GHG emissions from operations include the first year after closure, which represents the year where emissions from the decomposition of the waste within the ECM are expected to be at their highest as demonstrated in *Radon and Other Landfill Gas Modelling and Evaluation* (AECOM 2018b). Therefore, GHG emissions during operations phase are expected to be greater than the GHG emissions from the closure phase and the emissions from the post-closure phase are expected to be considerably less than the operations phase.

5.2.2.3.3 Assessment Cases

The assessment cases considered in the GHG assessment include the Base Case and the Application Case:

- **Base Case –** This scenario represents existing conditions and characterizes effects from previous and existing developments and activities. The Base Case reflects the effects of existing disturbances in the area, such as forestry, transportation, agricultural, mining, and residential and recreational development. For example, current effects from the existing operations and activities on the CRL site are considered part of the Base Case.
- **Application Case –** This scenario represents the effects of the Base Case combined with the predicted effects that from the NSDF Project. The Application Case was divided into the construction phase and the operations phase, and therefore, the emissions and associated effects during the construction and operations phases of the NSDF Project represent the bounding cases. Only direct GHG emissions within the LSA have been considered in this assessment (i.e., emissions outside of the Local Study Area, for example from off-site transportation of construction materials, are not included in the assessment). Direct emissions include emissions that are owned or controlled by CNL, such as fuel use and GHG emitted from the decomposition of the waste within the ECM. Indirect GHG emissions, such as electricity, are emissions that are a consequence of the CNL activities, but occur at sources owned or controlled by another entity; and therefore, are excluded from the assessment.
- **Reasonably Foreseeable Development (RFD) Case** – Reasonably foreseeable developments in the RSA that are anticipated to overlap with the potential effects of the NSDF Project include new/upgrades to research and development facilities, construction and operation of an SMR, new support infrastructure, on-going decommissioning and environmental remediation activities on the CRL site. The waste from the decommissioning of the CRL structures will be placed in the NSDF Project and the Application Case for the operations phase considers the transport of this waste for disposal in the ECM. As well, there may be overlap of the construction period with limited construction at neighbouring Garrison Petawawa. These RFD Case projects will involve smaller amounts of similar equipment used during the construction phase of the NSDF Project, and are expected to implement similar mitigation to limit release the same GHG emissions (vehicle and equipment exhaust).

5.2.2.4 Description of the Environment

5.2.2.4.1 Methods

Applicable Criteria

The relevant GHG emissions criteria include the provincial and federal emission levels. These emission levels are calculated using the assessment frameworks summarized below, followed by the baseline GHG emissions levels considered for the Base Case.

Federal Guidance on Reporting Greenhouse Gas Emissions

The *Technical Guidance on Reporting Greenhouse Gas Emissions* (ECCC 2019a) provides direction in determining if facilities are required to submit a GHG report to ECCC under the Greenhouse Gas Reporting Program (GHGRP), an overview of the reporting process, as well as technical information related to GHG emissions estimations, including identifying GHG emission sources subject to reporting (ECCC 2018b). The GHGRP falls under the *Canadian Environmental Protection Act, 1999*. The GHGRP Guideline references GHG estimation methodologies from the United Nations Framework Convention on Climate Change (UNFCCC) and was developed by the Intergovernmental Panel on Climate Change. The GHGRP Guideline states that "no specific estimation methods are prescribed" and that facilities should choose estimation methods that are most appropriate for their particular industry, but are consistent with the guidelines adopted by the UNFCCC for preparing GHG inventories. The reporting threshold for the GHGRP is 10,000 tonnes of carbon dioxide equivalent (CO_2e).

Provincial Guideline for Quantification, Reporting and Verification of Greenhouse Gas Emissions

The documenting and reporting of GHG emissions in Ontario are governed by *Ontario Regulation (O. Reg.) 390/18 Greenhouse Gas Emissions: Quantification, Reporting and Verification.* The *Guideline for Quantification, Reporting and Verification of Greenhouse Gas Emissions* (MEPC 2018) (i.e., O. Reg. 390/18 Guideline) provides the emission estimation methods that are required to be used under this reporting regulation. The emissions generated at the NSDF Project are defined by the O. Reg. 390/18 Guideline GHG emission estimation method ON.20 (General Stationary Combustion) for natural gas and diesel combustion and ON.280 (Mobile Equipment Operation) for the mobile equipment. The emissions generated from the ECM final cover are not covered under O. Reg. 390/18. The reporting threshold for O. Reg. 390/18 is 10,000 tonnes of CO_2e.

Baseline GHG Emissions Data

Existing GHG emissions are not measured; however, they are routinely estimated. For the purposes of this GHG assessment, federal and provincial reported GHG data, as well as CNL data, is used to describe the GHG emissions. The following sources of information were used to characterize the existing GHG emissions:

- ECCC National Inventory Report 1990-2017: Greenhouse Gas Sources and Sinks in Canada (ECCC 2019b);
- ECCC Greenhouse Gas Reporting Program (GHGRP) – Facility Greenhouse Gas (GHG) Data (ECCC 2018b); and
- Annual Compliance Monitoring Report *Effluent Verification Monitoring at Chalk River Laboratories in 2018* (CNL 2019b).

5.2.2.4.2 Base Case Results

The latest available federal and provincial reported GHG data were used to describe the background GHG emissions. The latest available federal and provincial data are from the 2017 reporting year (ECCC 2019b). There are no large GHG emitters within 100 km of the NSDF Project, with the exception of the CRL main campus and the Department of National Defense, located in Petawawa, that reported 31,655 tonnes of CO_2e in 2017. (ECCC 2019b). The latest data provided by CNL, indicated that the CNL main campus contributed 30,608 tonnes of CO_2e in 2018 (CNL 2019b). Total federal, provincial, and CRL main campus GHG emissions are provided in Table 5.2.2-4.

Table 5.2.2-4: Baseline Greenhouse Gas Emissions

Source	GHG Emissions (tonnes CO_2e)
Canada-wide 2017 Greenhouse Gas Emissions Total[a]	716,000,000
Ontario-wide 2017 Greenhouse Gas Emissions Total[a]	159,000,000
CRL Main Campus 2018 Greenhouse Gas Emissions[b]	30,608
Department of National Defense 2017 Greenhouse Gas Emissions[a]	31,655

a) ECCC 2019b
b) CNL 2019b
CO_2e = carbon dioxide equivalent.

5.2.2.5 Project Interactions and Mitigation

5.2.2.5.1 Methods

This section describes the process by which interactions between NSDF Project components and activities and GHG were identified and evaluated. Potential effects pathways are identified and mitigation developed to eliminate and/or reduce effects is presented. A pathways analysis is then used to focus the assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects will be adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects after incorporation of mitigation are further characterized in subsequent subsections of the assessment (i.e., Section 5.2.2.6). As such the 'Project Interactions and Mitigations' section helps to focus the remainder of the assessment on those interactions (effects pathways) likely to result in residual adverse effects.

The first part of the analysis was to identify the potential effects pathways for all stages of the NSDF Project. The next step in the analysis was the development of environmental design features and mitigation practices that could be incorporated into the NSDF Project to eliminate and/or reduce changes to GHG emissions. Environmental design features included design elements, environmental best practices, and management policies and procedures. Environmental design features and mitigation were developed through an iterative process between the engineering and environmental teams, combined with input from project-specific or regional engagement with other interested parties. The design features and/or mitigation were considered for their effectiveness for implementation and maintenance, and their appropriateness within the context of the identified effects pathways.

After incorporation of mitigation, potential pathways were evaluated into the following categories using scientific knowledge, logic, experience with similar developments, and the effectiveness of environmental design features and mitigation:

- **No linkage:** This pathway is removed by environmental design features or mitigation such that the NSDF Project would not be expected to result in a measurable environmental change to concentrations of indicator compounds relative to Base Case values, and therefore would have no residual effects to GHG.
- **Secondary pathway:** The pathway could result in a measurable minor change to concentrations of indicator compounds, but would have a negligible residual effect on GHG relative to Base Case and/or guideline values and is not expected to contribute cumulatively to other NSDF Project effects or to the effects of other previous, existing or reasonably foreseeable developments to cause a significant effect.
- **Primary pathway:** The pathway is likely to result in an environmental change to concentrations of indicator compounds relative to the Base Case and/or guideline values that could contribute to residual effects to GHG.

Environmental design features and mitigation that have been or could be incorporated into the NSDF Project to eliminate and/or reduce adverse effects to GHG were considered. Potential pathways that were completely removed due to implementation of environmental design or mitigation were not assessed further. Pathways that were assessed to be secondary and demonstrated to have a negligible residual effect to GHG through simple qualitative or semi-quantitative evaluation of the pathway were also not advanced for further assessment. Primary pathways were carried forward for more detailed quantitative and qualitative effects analysis to characterize the residual effects of the NSDF Project on GHG (see Section 5.2.2.6).

5.2.2.5.2 Results

Pathways through which all stages of the NSDF Project may interact with and result in changes to GHG emissions are provided in Table 5.2.2-5. The GHG emissions were estimated using information provided in the NSDF *Landfill Gas Management Plan* (AECOM 2018c) and by taking into consideration the mitigation that were considered to be integral to the design and implementation of the NSDF Project activities. These mitigation, which are considered to be typical and consistent with best practices, are presented in Table 5.2.2-5.

Table 5.2.2-5: Pathways Analysis for Greenhouse Gas Emissions Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Construction ▪ Site preparation ▪ Construction of the ECM ▪ Development of surface water management structures ▪ Construction of the WWTP and other support facilities ▪ On-site road and access development ▪ Soil spoils haulage to 'a soil storage area'	▪ Construction activities use vehicles that combust fuel and emit GHGs. These vehicles travel on roads on CRL site and are used for material handling. ▪ Additionally, there are GHG emissions associated with land clearing for the NSDF project. One-time emissions will be presented over the life-time of the NSDF Project.	▪ Implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and verification monitoring. ▪ On-site vehicles and equipment engines will be maintained in good working order. ▪ Limit idling of vehicles on site.	Primary

Operations
▪ Phased development of disposal cells
▪ On-site transportation of waste and placement of waste in the ECM
▪ Progressive closure of disposal cells and installation of final cover
▪ Operation of the WWTP
	▪ Most activity and material handling occurs during the operations phase.
	  ▪ Vehicles and equipment combust fuel and emit GHGs. These activities involve material handling with vehicles travelling on roads.
	  ▪ The disposal cell emits GHG emissions from the decomposition of waste.
	  ▪ The WWTP will be fuelled by Natural Gas.
	  ▪ Additionally, there is a loss of carbon sink as a result of the cleared land for the NSDF Project.
		▪ Implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and verification monitoring.
		▪ On-site vehicles and equipment engines will be maintained in good working order.
		▪ Limit idling of vehicles on-site.
			Primary

Operations and Post-closure ▪ Placement of waste in the ECM	▪ GHG emissions from the decomposition of waste.	▪ Installation of the interim and final covers will reduce release of emissions from the ECM.	Primary

ECM = engineered containment mound; GHG = greenhouse gas; WWTP = Wastewater Treatment Plant.

5.2.2.5.2.1 No Linkage Pathways

No pathways are identified as having no linkage to climate change as part of this assessment.

5.2.2.5.2.2 Secondary Pathways

No secondary pathways are identified to climate change as part of this assessment.

5.2.2.5.2.3 Primary Pathways

The following primary pathways were identified as having the potential to result in residual effects to climate change, and therefore, have been carried forward to the residual effects analysis.

- Construction activities use vehicles and equipment that combust fuel and emit GHGs. These activities involve material handling and vehicles travelling on roads.
- Additionally, there are GHG emissions associated with land clearing for the NSDF Project. One-time emissions will be presented over the lifetime of the NSDF Project.
- Most activity and material handling occurs during this stage. Vehicles and equipment combust fuel and emit GHGs. These activities involve material handling with vehicles travelling on roads. The disposal cell emits GHG emissions from the decomposition of waste. The WWTP will be fuelled by natural gas. Additionally, there is a loss of carbon sink as a result of the cleared land for the NSDF Project.
- GHG emissions from the decomposition of waste.

5.2.2.6 Residual Effects Analysis

5.2.2.6.1 Methods

Residual effects of a project are those effects that remain after implementation of all mitigation measures. The assessment of effects of the NSDF Project on the GHG involves two steps, namely the calculation of emission rates and use of dispersion modelling to predict the resulting concentrations of GHG emissions. These steps are described below.

Identification of emission sources was completed by defining an inventory boundary, which frames the GHG emission sources that are included in the assessment for the NSDF Project. The inventory boundary is based on the GHGRP; and therefore, stationary fuel combustion emissions, on-site mobile emissions, and emissions from waste have been included in this GHG assessment of effects. Additionally, there is a loss of carbon sink as a result of the cleared land for the NSDF Project. Table 5.2.2-6 outlines the GHG inventory boundaries of the provincial and federal programs and presents the source categories included in the GHG assessment.

Table 5.2.2-6: Sources Categories included in the Greenhouse Gas Assessment

Source Category	O. Reg.390/18	GHGRP	GHG Assessment
On-site stationary fuel combustion sources	Yes	Yes	Yes
On-site stationary fuel combustion for generator	No[(a)]	Yes	Yes
On-site mobile fuel combustion sources	Yes[(b)]	Yes	Yes
Final cover (emissions from waste)	No	Yes	Yes
Land clearing	No	No	Yes
WWTP and associated equipment (i.e., equalization tanks)	No	Yes	Yes

a) On-site generators are used for emergency purposes and are less than 10 megawatts, therefore are exempt from GHG reporting under O. Reg.390/18.

b) Reporting mobile fuel combustion sources is currently optional under O. Reg.390/18.

ECM = engineered containment mound; GHG = greenhouse gases; GHGRP = Greenhouse Gas Reporting Guideline.

The emission estimation methods follow guidance in *Guideline for Quantification, Reporting and Verification of Greenhouse Gas Emissions* (MECP 2018), as set out under O. Reg. 390/18 under the Ontario *Environmental Protection Act*, as well as the ISO 14064-1 standard entitled *Specification with Guidance at the Organizational Level for Quantification and Reporting of Greenhouse Gas Emissions and Removals* (ISO 2006). Additional alternative methods, such as LandGEM (US EPA 2005) were also used in the assessment to estimate emissions from the decomposition of waste within the landfill and Intergovernmental Panel on Climate Change guidelines were used to calculate greenhouse gas emissions from land clearing. Details of the specific GHG emission source identification, calculation methods, and sample calculations are provided in Section 4 (Emissions Estimate) of the Air Quality Assessment TSD (Golder 2019).

5.2.2.6.2 Application Case Results

Emission Rates

Table 5.2.2-7 and Table 5.2.2-8 summarizes the annual emission rates in tonnes per year for each activity at the NSDF Project for the construction and operations phases, respectively. The GWP used to calculate GHG emission in CO_2e correspond to the Ontario O. Reg. 390/18 GWPs. Details of the specific emission calculation methods, GWPs, and resulting emissions are provided in Section 4 (Emissions Estimate) of the Air Quality Assessment TSD (Golder 2019).

Table 5.2.2-7: Summary of Annual Greenhouse Gas Emissions during the Construction Phase

Project Activity	Source	Source Description	Annual GHG Emissions (tonnes/yr)			Annual Total (tonnes/ yr)[(a)]
			CO_2	CH_4	N_2O	CO_2e
Construction of the ECM, development of surface water management structures, construction of the WWTP and other support facilities, and on-site road and access development	Mobile Fuel Combustion (road and non-road vehicles)	Vehicle exhaust	26,986	1.3	4.1	28,271
Site Preparation	Land Clearing	One-time loss of carbon stored in biomass	160	—	—	160
		Loss of carbon sink potential	337	—	—	337

a) Calculated using provincial global warming potentials

"–"Not included in this assessment in the construction phase; CO_2 = carbon dioxide; CH_4 = methane; N_2O = nitrous oxide; CO_2e = carbon dioxide equivalent; GHG = greenhouse gas; ECM = engineered containment mound; WWTP = Wastewater Treatment Plant.

Table 5.2.2-8: Summary of Annual Greenhouse Gas Emissions during the Operation Phase

Project Activity	Source	Source Description	Annual GHG Emissions (tonnes/yr)			Annual Total (tonnes/ yr)[(a)]
			CO2	CH4	N2O	CO2e
ECM (decomposition of waste)	Engineered Containment Mound	Final cover (decomposition of waste emissions)	228	83	—	1,964
Operation of the WWTP	Stationary Fuel Combustion	Natural Gas comfort heating	1,071	0.02	0.02	1,078
Phased development of disposal cells, on-site transportation of waste and placement of the waste in the ECM, progressive closure of disposal cells and installation of final cover	Mobile Combustion (road & non-road vehicles)	Vehicle exhaust	5,589	0.3	0.8	5,855
Operations	Cleared Land	Loss of carbon sink potential	337	—	—	337

a) Calculated using provincial global warming potentials

"—" not included in the assessment; = CO_2 = carbon dioxide; CH_4 = methane; N_2O = nitrous oxide; CO_2e = carbon dioxide equivalent; GHG = greenhouse gas; ECM = engineered containment mound; WWTP = Wastewater Treatment Plant.

Negligible Emissions from the NSDF Project

There are many activities associated with the NSDF Project that produce GHG emissions; however, not all activities produce emissions for any or all compounds that are relevant to the overall emissions assessment. All activities that potentially produce emissions were evaluated to assess their relevance; however, only activities that were considered to be relevant were included in the assessment. The following lists rationale as to why certain activities and/or emissions of certain compounds are excluded from the assessment:

- the emission rates of certain compounds are minor relative to the overall emissions at the NSDF Project; and
- the emissions of certain sources are known to not be relevant due to the type of operations in the assessment.

Table 5.2.2-9 lists the activities that were not assessed and the accompanying rationale.

Table 5.2.2-9: GHG Emission Sources and Contaminants Not Included in the Assessment

Activity/Compound	Rationale for Excluding from the Assessment
WWTP and associated equipment (i.e., equalization tanks)	The process of treatment of wastewater may result in a minor release of greenhouse gases. These emissions have been excluded from the assessment as they are negligible in comparison to the other GHG emissions from the NSDF Project. At approximately, 29 tonnes CO_2e per year, GHG emissions from the WWTP process are less than 1% of the total GHG emissions and therefore have not been carried through the assessment.
Natural gas emergency power generator	The emergency natural gas generator only operates periodically during monthly routine maintenance testing and for very short duration (20 minutes) (rather than continuously). Additionally, the emergency power generator will only be used to supply electricity during power outage when other equipment is not operation, and therefore, is not included in the representative scenario. These emissions have been excluded from the assessment as they are expected to be negligible in comparison to the other GHG emissions from the NSDF Project relative to other present sources.
Diesel pumps, air compressors, and lighting equipment at all NSDF buildings	This equipment is part of miscellaneous equipment and only operates periodically and for short durations. Emissions rates from these sources are minor compared to emissions from the other diesel equipment on-site, and therefore, are not included in the representative scenarios.
Snow removal equipment	Emissions from this equipment occur seasonally and are infrequent (i.e., only during the winter following a snowfall), and therefore, are not included in the representative scenario. These emissions have been excluded from the assessment as they are expected to be negligible in comparison to the other GHG emissions from the NSDF Project relative to other present sources.
Upstream GHG emissions	A March 19, 2016 Notice in the Canada Gazette presented ECCC's proposed methodology for estimating the upstream GHG emissions associated with projects undergoing federal environmental assessments. Upstream GHG emissions are those resulting from all industrial activities from the point of resource extraction to the NSDF Project. The specific processes will vary by resource but generally include extraction, processing, handling, and transportation. The NSDF Project is not planned to enable new soil or clay extraction or cement production facilities. Rather, the NSDF Project will be a customer for existing soil or clay supply and cement facilities and is unlikely to impact the Provincial supply and demand for these materials. While grouting will occur during waste placement, it is expected to be minor as it will primarily be used to reduce void space in packages and is not anticipated to require a mobile cement facility. Therefore, these emissions have been excluded from the assessment as they are expected to be negligible in comparison to the other GHG emissions from the NSDF Project.

GHG = greenhouse gas; WWTP = Wastewater Treatment Plant; CO_2e = carbon dioxide equivalent.

GHG Results

Table 5.2.2-10 summarizes the annual overall emissions in tonnes of CO_2e for the NSDF Project construction and operations phase, respectively. It also summarizes the NSDF Project combined with the 30,608 tonnes of CO_2e the CRL main campus emitted in 2018 to show a projected annual total for the entire CRL site for both the construction and operations phases. Construction phase GHG emissions are approximately 6% less than the 2018 CRL main campus emissions while operations phase GHG emissions are approximately 70% less. Greenhouse gas emissions by source is presented in Tables 5.2.2-7 and 5.2.2-8. Since both construction and operations phase GHG emissions represent less than 0.02% of the provincial total and less than 0.005% of the Canada-wide total, a comparison to the global GHG emissions total was not completed as GHG emissions from the NSDF Project represent a negligible fraction of global GHG emissions.

Table 5.2.2-10: Comparison of Greenhouse Gas Emissions from the NSDF Project to Ontario and Canadian Emission Totals

Source	Construction GHG Emissions (CO_2e tonnes/yr)	Operation GHG Emissions (CO_2e tonnes/yr)
NSDF Project		
GHG Emissions	28,768	9,233
Comparison to Canada-wide Total	0.0040%	0.0013%
Comparison to Ontario Total	0.018%	0.0058%
NSDF Project + CRL main campus		
GHG Emissions[(a)]	59,376	39,841
Comparison to Canada-wide Total	0.0083%	0.0056%
Comparison to Ontario Total	0.037%	0.025%
Canada-wide GHG Emissions (2017)	**716,000,000**	
Ontario-wide GHG Emissions (2017)	**159,000,000**	

a) CRL main campus GHG Emissions for 2018 were 30,608 tonnes CO_2e (CNL 2019b)

GHG = greenhouse gases; NSDF = Near Surface Disposal Facility; CO_2e = carbon dioxide equivalent.

5.2.2.6.3 Reasonably Foreseeable Development Case Results

Consistent with the consideration of the RFD Case for air quality, revitalization activities (i.e., new/upgrades to research and development facilities, new support infrastructure), on-going decommissioning and environmental remediation activities on the CRL site, as well as construction and operations of a SMR at the CRL site will generate GHG emissions that may overlap with residual effects of the Project. As Project contributions within the LSA represent a negligible change to GHG emissions to provincial and national totals, contribution by the limited construction at neighbouring Garrison Petawawa would be anticipated to be similarly negligible and the areas of effect would not be anticipated to overlap.

The airborne emissions from new facility construction and decommissioning projects on the CRL site will be assessed as part of the approval process for these projects. Examples of mitigation to limit effects from GHG emissions applicable to all projects on the CRL site include:

- implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and verification monitoring;
- on-site vehicles and equipment engines will meet Tier 2 emission standards and be maintained in good working order; and
- limiting idling of vehicles on-site.

Revitalization and decommissioning activities at the CRL site are planned to be staggered over the ten- year period (2016 to 2026), and the required activities to be completed at any one time are anticipated to be less than that required for the larger scale construction of the NSDF Project. Similarly, the equipment requirements for construction and operations of the SMR are expected to be less than that assessed for the NSDF Project. Consistent with the conclusions in Section 5.2.2.6.2 for the Application Case, GHG emissions as a result of RFD Case projects are anticipated to result in a negligible change relative to provincial and national totals. With effective implementation of mitigation measures and monitoring programs, no cumulative residual effect is identified to GHGs.

5.2.2.7 Prediction Confidence and Uncertainty

For the assessment of GHGs, the main sources of error are the accuracy of the activity data and hours of operation used to estimate emissions to the NSDF and the omission of some emission sources. These uncertainties were managed using conservative assumptions in the emission estimation, including:

- maximum handling and operating capacities were used in determining emission rates;
- all equipment on-site was assumed to operate concurrently; and
- with respect to the GHG emissions and production levels used to calculate emission intensity factors, the information was derived either from the federal and provincial GHG reporting websites or from recent environmental assessments.

Sources not included in the assessment contribute less than 1% each to the total GHG emissions and the Ontario regulation dictates that materiality threshold is set to 5%. Therefore, the emissions from these sources do not constitute a material error and are within the conservatism assumed in the assessment.

5.2.2.8 Residual Effects Classification and Determination of Significance

This section classifies the residual effects from changes to measurement indicators for the Application Case and presents a determination of significance for the GHG VC. The results from the GHG assessment were compared to the relevant residual effects assessment criteria to evaluate the significance of the residual adverse effects.

5.2.2.8.1 Residual Effects Classification

Effects from adverse residual changes to measurement indicators were classified using a categorical scale and common words to facilitate the determination of significance. The purpose of categorical classification is to provide definitions that permit a clear, thorough and unambiguous classification of residual effects such that reviewers and readers can follow and apply the logic used in the assessment and reach the same classification for a given residual effect.

Magnitude, geographic extent and duration are the principal factors considered to predict significance. The magnitude of a residual environmental effect is determined by the change in a measurement indicator from a project interaction. Geographic extent refers to the area affected and duration is defined as the amount of time for a residual effect to be reversed. For GHG, residual effects are not evident beyond the closure and post closure phases. Other criteria, such as frequency and likelihood are used as modifiers, where applicable. Residual adverse effects were classified using the criteria and definitions outlined in Table 5.2.2-11.

Table 5.2.2-11: Assessment Criteria for Classifying Predicted Residual Adverse Effects to Greenhouse Gases

Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
Positive: Predicted GHG emissions represents a decrease from Base Case. **Negative:** Predicted GHG emissions represents an increase from Base Case. **Neutral:** No change predicted GHG emissions relative to Base Case.	**Negligible:** <0.1% of the provincial emission levels, or by <0.01% of the federal emission level **Low:** >0.1% but <1% of the provincial emission levels, or by <0.01% of the federal emission levels **Moderate:** >1% compared to provincial totals, or by >0.1% compared to national totals. **High:** >5% compared to provincial totals, or by >1% compared to national totals	Beyond Regional: Effects extends beyond the RSA	**Short-term:** Effects are not evident beyond the construction phase **Medium-term:** Effects are not evident beyond the operations phase **Long-term:** Effects are not evident beyond the closure and post-closure phases **Permanent**: Effects are not reversible	**Infrequent:** Effects are confined to a specific discrete period **Frequent:** Effects occur intermittently, but repeatedly, or continuous over the assessment period	**Reversible:** Change of state in environment is not permanent **Irreversible:** Change of state in the environment is permanent	**Low:** Effect is unlikely to occur **Medium:** Effect is likely to occur **High:** Effect is highly likely to occur

GHG = greenhouse gas; < = less than; > = greater than

5.2.2.8.2 Determination of Significance

The residual effects classification of primary pathways and the associated predicted changes in measurement indicators provide the foundation for determining the significance of residual effects from the NSDF Project on GHG. Where possible and appropriate, established guidelines, thresholds and screening values were used to support the classification of the predicted amount of change in measurement indicators and associated effects on GHG. For an effect to be deemed significant the effect must be negative in direction, high in magnitude, beyond regional in geographic extent and long term in duration. As part of the determination of significance, confidence in the assessment identified in Section 5.2.2.7 was considered for the GHG VC. Where uncertainty was high and the cumulative effect might be either significant or not significant, the assessment conservatively identified the effect as significant and provided additional follow-up actions to reduce uncertainty (Section 5.2.2.9).

The predicted residual adverse effect of GHG emissions is considered global in nature, and therefore the geographic extent was rated as beyond regional. Predicted effects of GHG emissions from the NSDF Project are anticipated to be reversible within the temporal boundary of the assessment and would occur continuously during operations (Table 5.2.2-12). The magnitude of the effects is rated negligible, as the change in GHG emissions due to the NSDF Project are estimated to be less than a 0.02% increase in total provincial GHG emissions and less than a 0.005% increase in total national GHG emissions. Consequently, the overall residual adverse effect of the Application Case during the construction and operations phases on GHG are determined to be not significant. Only the construction and operation phases have been considered as the emissions from these phases will be higher than those during the closure and post-closure phases.

Table 5.2.2-12: Classification of Predicted Residual Adverse Effects on Greenhouse Gases for the Application Case

Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
Application Case – Construction Phase						
Negative	Negligible	Beyond regional	Short-term	Frequent	Reversible	High
Application Case – Operations Phase						
Negative	Negligible	Beyond regional	Medium-term	Frequent	Reversible	High

5.2.2.9 Monitoring and Follow-up

Implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and air verification monitoring, will continue for the NSDF Project as it outlines the key management practices to limit effects to air quality. The CRL Radiological Air Effluent Verification Monitoring Program comprises 56 monitoring points and will also continue for the NSDF Project. In addition, GHG emissions monitoring activities for the NSDF Project will be implemented (Table 5.2.2-13) and the purpose is to:

- verify effects predictions, and compare actual with predicted effects;
- confirm effectiveness of mitigation, and in doing so evaluate if alternate mitigation is required;
- provide information for use in adaptive management to address potential unforeseen effects; and
- demonstrate compliance with regulatory requirements.

Table 5.2.2-13: Monitoring and Follow up Programs for Greenhouse Gas Emissions

Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Greenhouse gases	GHG emissions from the decomposition of waste during operations and closure.	■ Verify that the measures for controlling landfill gas generated from wasted deposited in the ECM during operations and following final closure are adequate ■ Verify that methane emission rates used in the assessment are reasonable and conservative. ■ Verify that there is no combustion hazard from methane gas generation	■ Monitoring for methane will be performed using handheld portable combustible gas meter detectors. ■ A passive landfill gas venting system will be constructed contemporaneously with installation of the ECM final cover system which will provide measured concentrations and emission rates. ■ The landfill gas monitoring probes will also be installed around the perimeter of the ECM to detect evidence of potential landfill gas migration away from the ECM.	Periodic monitoring during operations and for a specific period of time during closure phase (during which the frequency may be progressively reduced and possibly ultimately eliminated if no evidence of landfill gas migration from the ECM is detected)	*Landfill Gas Management Plan* (AECOM 2018c) to be implemented for the NSDF Project.
	Construction and operations activities will result in increased GHG emissions.	Verify that GHG emission rates used in the assessment are reasonable, but conservative. Monitoring results will be used for GHG reporting requirements.	Fuel Usage – a record will be kept of the fuel usage related to the NSDF Project.	Annual estimations and GHG reporting as required	Captured through the implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and verification monitoring.

GHG = greenhouse gas; ECM = engineered containment mound;

5.2.2.10 Conclusions

Valued components refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, scientists, government agencies, Indigenous peoples, the scientific community or the public (The Agency 2018). Greenhouse gases was selected as a VC as there is a potential for the NSDF Project activities to release GHG emissions that could contribute incrementally to climate change. The assessment endpoint for the GHG assessment is comparison to provincial and national totals. The measurement indicator for GHG include changes in emissions of CO_2e to provincial and national GHG totals.

Residual effects from activities that occur during the construction and operations phase have been identified as the primary linkage to potentially affect GHG emissions. During the construction and operations phases, NSDF Project activities will result in GHG emissions associated with the land clearing, operation of vehicles and equipment, as well as emissions from the decomposition of waste in the ECM. A summary of the predicted residual adverse effects for GHGs, including associated mitigation, are provide in Table 5.2.2-14. Examples of mitigation practices implemented to limit predicted residual effects to GHGs include:

- Implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and verification monitoring;
- on-site vehicles and equipment engines will be maintained in good working order; and
- limit idling of vehicles and equipment on-site.

The predicted residual effects to GHG emissions were estimated to increase because of the NSDF Project. Emissions of GHGs from the CRL site are estimated to increase approximately 94% during the construction phase and approximately 30% during the operations phase. However, the change is estimated to be less than a 0.02% increase in total provincial GHG emissions and less than a 0.005% increase in total national GHG emissions. Consequently, the residual effects from the NSDF Project on GHGs was determined to be not significant. CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018) outlines the key management practices that limit GHG emissions effects, as well as the current monitoring requirements.

Table 5.2.2-14: Summary of Predicted Residual Adverse Effects for Greenhouse Gas Emissions Valued Component

Valued Component	Assessment Endpoint	Residual Adverse Effects	Project Effect Occurs in	Contributing Project Activity	Proposed Mitigation	Significance
Greenhouse gases	Comparison to provincial and national totals	GHG emissions from the decomposition of waste.	Operations and Post-closure	■ Placement of waste in the ECM ■ Progressive closure of disposal cells and installation of final cover	Installation of the interim and final covers will reduce release of emissions from the ECM.	Not Significant
Greenhouse gases	Comparison to provincial and national totals	Construction and Operations activities will result in increased greenhouse gas emissions.	Construction and Operations	**Construction** ■ Site preparation ■ Construction of the ECM ■ Development of surface water management structures ■ Construction of the WWTP and other support facilities ■ On-site road and access development **Operations** ■ Phased development of disposal cells ■ On-site transportation of waste and placement of waste in the ECM ■ Progressive closure of disposal cells and installation of final cover ■ Operation of the WWTP	■ Implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and verification monitoring. ■ On-site vehicles and equipment engines will be maintained in good working order. ■ Limit idling of vehicles on-site.	Not Significant

ECM = engineered containment mound; WWTP = Wastewater Treatment Plant

5.3 Geological and Hydrogeological Environment

Section 5.3 of the Environmental Impact Statement for the Canadian Nuclear Laboratories (CNL) Near Surface Disposal Facility (NSDF) Project seeks to understand and characterize potential residual effects of the NSDF Project and other past, present and reasonably foreseeable developments on the physical aspects of the environment. Section 5.3.1 focuses on geology and Section 5.3.2 focuses on hydrogeology (groundwater).

5.3.1 Geology

5.3.1.1 Scope of the Assessment

This section focuses on geology, which includes bedrock, soils and geomorphology (i.e., the study of physical features on the earth and their relation to underlying geological structures). The geology assessment follows the overall environmental assessment approach and methods described in Section 5.1. The assessment was completed following the key steps listed below:

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries and assessment cases** for the geology assessment (refer to Section 5.3.1.2 Valued Components and Section 5.3.1.3 Assessment Boundaries). The VCs and measurement indicators used to assess Project-related changes to geology are described, along with the spatial and temporal boundaries at which the assessment occurred and the assessment cases considered.
- **Step 2 – Describe the existing conditions** (refer to Section 5.3.1.4 Description of the Environment). Existing conditions in the local and regional areas are described, including the combined effects of previous and existing developments (Base Case). The existing environment represents the historical and current environmental pressures that have shaped the observed patterns in the environment (i.e., natural variation). The existing conditions provide a reference to which the effects of the NSDF Project can be compared.
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 5.3.1.5 Project Interactions and Mitigation). Project components and/or activities with the potential to affect geology are identified, and mitigation developed to limit or avoid effects is presented. A pathways analysis is then used to focus further assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects are adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways were not identified for geology; therefore, no residual effects are carried forward for further analysis and characterization.
- **Step 4 - Present the methods and results of the residual effects analysis**. This step was not required as no primary pathways were identified in the geology assessment.
- **Step 5 - Describe the level of certainty and management of uncertainty.** This step was not required as no primary pathways were identified in the geology assessment.
- **Step 6 - Classify and determine the significance of the predicted residual effects**. This step was not required as the geology VC is an intermediate component which does not include an assessment endpoint to determine significance.
- **Step 7 – Identify monitoring and follow-up** required to confirm effects predictions and address uncertainty (refer to Section 5.3.1.6 Monitoring and Follow-up).

- **Step 8 – Present a consolidated summary of conclusions and outcomes of the assessment** of residual effects on geology (refer to Section 5.3.1.7 Conclusions).

This section also describes how the input from engagement influenced the scope of the geology assessment. To date, no areas of interest have been raised by the public, communities of interest, and Indigenous peoples during engagement activities specific to geology.

5.3.1.2 Valued Components

VCs refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community, or the public (The Agency 2018). Geology, which includes bedrock, soils and geomorphology, is recognized as an important component of the environment that may be affected by the NSDF Project, and changes to geology could, in turn, lead to effects on other VCs selected for assessment. For example, changes to the characteristics of geology, such as soil quality and quantity, have an influence on the local and regional diversity, contributing to the abundance and distribution of plants and animals on the landscape. Subsequently, changes to these characteristics by NSDF Project activities could affect terrestrial and aquatic ecosystem structure and function (Table 5.3.1-1). In addition, soil quality can potentially affect soil organisms. Consequently, soil quality is considered as a measurement indicator for geology. The effects of changes to soil quality on the aquatic and terrestrial environments are discussed in Sections 5.5 and 5.6, respectively, and effects on soil invertebrates are discussed in Section 5.7.

Acknowledging that changes to geology are important aspects of the natural and human environment, geology is referred to as an intermediate component (i.e., it does not have an assessment endpoint). Changes to intermediate component VCs must be understood to facilitate assessment of project interactions. The geology assessment, therefore, is analyzed for incremental and cumulative (if applicable) changes in the relevant measurement indicators associated with geology (Table 5.3.1-2). The assessment of geology focused on predicting changes in the concentrations of selected non-radiological substances; radiological parameters are considered in Section 5.7 Ambient Radioactivity and Ecological Health. The changes are characterized in terms of magnitude, duration and geographic extent, but are not classified using rankings for effects criteria. The geology assessment also does not include the assessment of the significance of these changes; rather, results of the analysis of changes in measurement indicators for geology are provided to other disciplines for inclusion in their assessment (Table 5.3.1-2).

Table 5.3.1-1: Valued Components for Geology Assessment

Valued Component	Rationale for Selection
Geology	Characteristics of geology, such as soil quality and quantity, bedrock and geomorphology, are important components that interact with other VCs (e.g., hydrogeology, hydrology and surface water quality) and if changed by NSDF Project activities, these characteristics could affect terrestrial and aquatic biodiversity.

VC = valued component

Table 5.3.1-2: Measurement Indicators for the Geology Assessment

Valued Component	Measurement Indicators	Discipline Assessments where Effects on Geology are Considered
Geology	■ Bedrock ■ Soil quality, quantity and distribution ■ Geomorphology	■ Section 5.3.2 Hydrogeology ■ Section 5.4.2 Surface Water Quality ■ Section 5.5 Aquatic Environment ■ Section 5.6 Terrestrial Environment ■ Section 5.9 Land and Resource Use

5.3.1.3 Assessment Boundaries

5.3.1.3.1 Spatial Boundaries

The spatial boundaries selected for the geology assessment were chosen because they permit description of existing conditions in sufficient detail to enable potential project-VC interactions and effects to be identified, understood and assessed, including understanding and assessing the contribution of the NSDF Project to cumulative effects. The spatial boundaries selected for the geology assessment are the same as those identified for hydrogeology and are presented on Figure 5.3.1-1 and described below:

- **Site Study Area (SSA):** The SSA is the NSDF Project footprint (i.e., where Project activities would be undertaken, including the NSDF Project's proposed facilities, buildings and infrastructure).
- **Local Study Area (LSA):** The LSA is selected in consideration of the NSDF Project footprint and the spatial extent of potential direct effects of the Project on the VCs. The LSA includes the SSA and is bounded by Perch Lake and Perch Creek and adjacent wetlands to be consistent with the LSA of the aquatic disciplines (e.g., hydrology, surface water quality).
- **Regional Study Area (RSA):** The RSA is defined as the area within which the potential effects of the NSDF Project may interact with the effects of other existing or reasonably foreseeable developments. The RSA for geology is determined by the spatial extent of the Perch Creek and Perch Lake Watershed, and includes the Perch Lake and Perch Creek basins, as well as a portion of the Ottawa River (i.e., roughly 8 km downstream in the Ottawa River to Harrington Bay), to be consistent with the aquatic disciplines.

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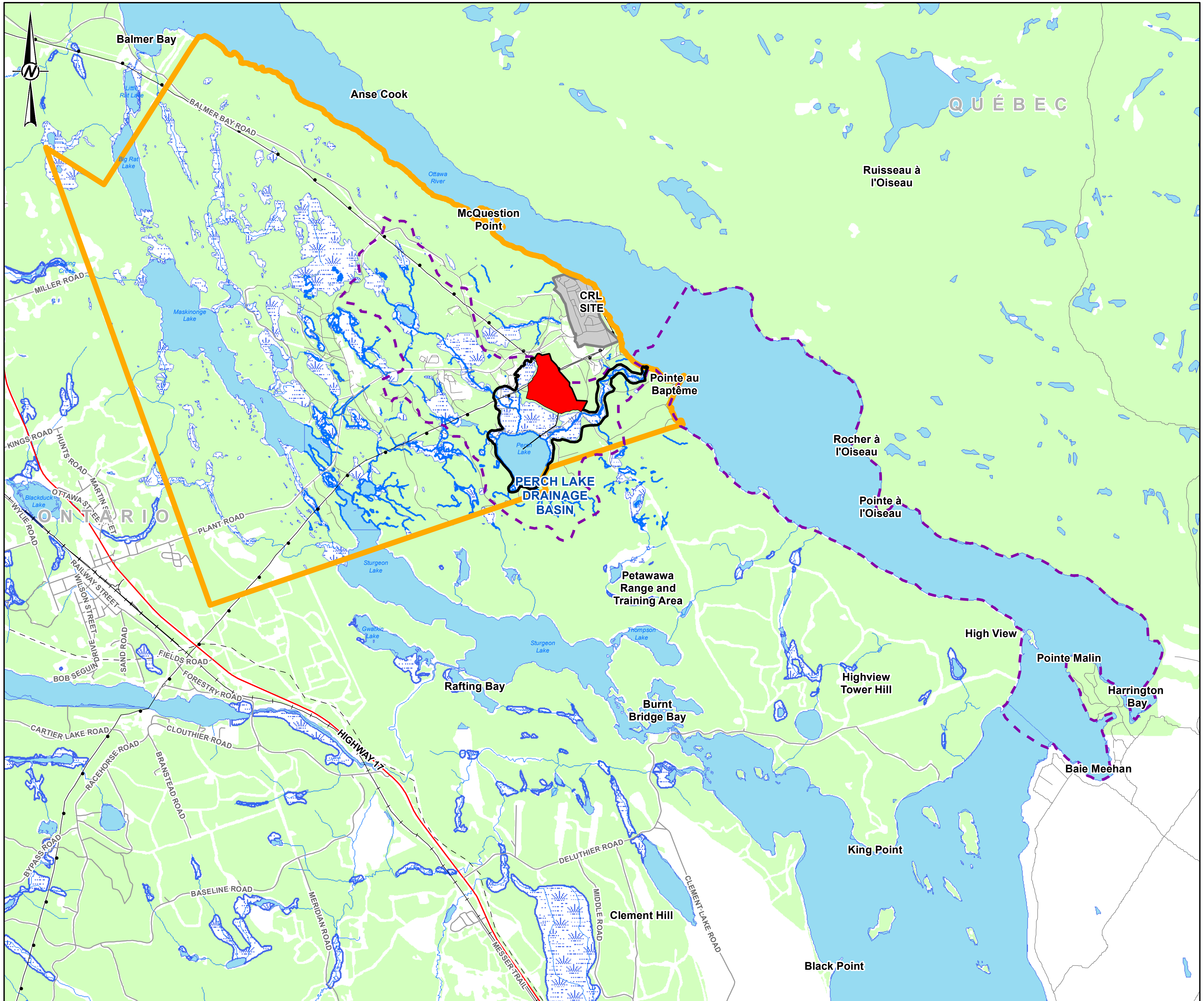

LEGEND

- HIGHWAY
- ROAD
- RAILWAY
- HYDRO LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- CRL MAIN CAMPUS
- CRL PROPERTY
- NSDF PROJECT
- LOCAL STUDY AREA
- REGIONAL STUDY AREA

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NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
SPATIAL BOUNDARIES SELECTED FOR THE GEOLOGY AND HYDROGEOLOGY ASSESSMENT

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0018	FINAL 2	5.3.1-1

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5.3.1.3.2 Temporal Boundaries

Temporal boundaries (i.e., project phases) establish the timeframe during which NSDF Project effects are assessed. The temporal boundary represents the timeframe during which project activities are actively occurring, and considers the duration of predicted residual effects. The duration of an effect is defined as the amount of time between the start and end of a project activity or stressor (which is related to the project phases) plus the time required for the residual effect to be reversed. In some cases, a residual effect may be irreversible within the temporal boundaries of the project or if the effects were predicted to last so far into the future that they could not be predicted with any level of certainty (e.g., a residual effect that lasts for thousands of years). The following phases were identified for the NSDF Project:

- **Construction phase**: This phase includes site preparation and all activities associated with the construction of the NSDF Project. This phase includes activities such as installing the necessary supporting and/or ancillary facilities and infrastructure to facilitate NSDF Project operations, inactive commissioning and systems testing, and transportation of construction materials. Construction activities are expected to take place from 2021 to 2023.
- **Operations phase**: This phase includes all activities associated with waste placement, water management, Wastewater Treatment Plant (WWTP) operations, vehicle movements into and from the SSA, and maintenance activities. Operations activities are expected to last approximately 50 years (i.e., 2024 to 2070).
- **Closure phase:** This phase includes activities necessary to complete the installation of the final cover and implementation of long-term monitoring. Closure activities are expected to start in 2070 and continue through to 2100, after which the NSDF Project will transfer into the post-closure phase.
- **Post-closure phase:** This phase has two discrete periods: institutional control and post-institutional control. The institutional control period includes implementation of controls throughout 2100 to 2400 (i.e., 300 years). During institutional control, environmental monitoring will continue to demonstrate compliance with the environmental assessment predictions. Post-institutional control occurs after year 2400 and continues indefinitely.

The temporal boundaries for the geology assessment consider all NSDF Project phases, from the construction phase through to the post-closure phase.

5.3.1.3.3 Assessment Cases

The assessment cases considered in the geology assessment are the Base Case and Application Case (the Reasonably Foreseeable Developments Case has not been considered for the reasons outlined below):

- **Base Case:** This scenario represents existing conditions and characterizes combined effects from previous and existing developments and activities. The Base Case reflects the effects of existing disturbances, such as forestry, transportation, agricultural, mining, and residential and recreational development. Current effects from the existing Chalk River Laboratories (CRL) facilities and operations are considered part of the Base Case.
- **Application Case:** This scenario represents predictions of the effects of the Base Case combined with the effects that may result from the NSDF Project. The Application Case considers potential effects from the NSDF Project from the construction phase through the post-closure phase.

- **Reasonably Foreseeable Developments (RFD) Case:** This scenario represents predictions of the cumulative effects of the Application Case, which includes the Base Case, plus projects that are currently under application review or that have officially entered a regulatory application process, and are therefore considered reasonably foreseeable. An RFD Case is not presented as part of this assessment because RFDs will either have no spatial overlap with Project effects or are likely to positively affect the geology. New support infrastructure, research and development facilities and the proposed small modular reactor (SMR) are planned within areas of the CRL site outside of the NSDF Project site and generally within existing disturbed areas. As such, potential effects from these activities are not expected to spatially overlap with potential effects to geology from the NSDF Project. The end-state plan for the CRL site will be to return lands disturbed by site activities to a condition that is physically stable and safe in keeping with the land use and landscape of the day. Therefore, decommissioning and environmental remediation activities are anticipated to positively affect measurement indicators for geology including soil quality and distribution, and geomorphology.

5.3.1.4 Description of the Environment

5.3.1.4.1 Methods

CNL completed previous studies in support of proposed geological waste management facilities (GWMFs) within the RSA in which data on the geological environment were compiled and used to develop a descriptive geosphere model of the site. These studies are documented in CNL's *Geologic Waste Management Facility Descriptive Geosphere Site Model Report: Phase 1* (CNL 2016a) and *Geologic Waste Management Facility Integrated Geosynthesis Report: Phase 1* (CNL 2016d). Data presented in these reports forms the basis of the current geological and hydrostratigraphic interpretations within the RSA, including characterization of the bedrock geology (lithology, mineralogy and structural geology), geomechanics, seismicity, overburden geology (soil characteristics and geotechnical properties), hydrogeology (hydraulic response testing of the overburden and shallow bedrock), and provides context on the anticipated evolution of the geological conditions at the CRL site over the assessment timeframe (10,000 years).

The geology of the SSA was characterized through a multidisciplinary site characterization consisting of intrusive and non-intrusive investigation completed under several phases, as summarized in the following reports:

- *Subsurface Geotechnical Survey of the Proposed Near Surface Disposal Facility at Chalk River Laboratories, Chalk River, Ontario* (Golder 2016)
- *Multidisciplinary Subsurface Investigation, Phase 1* (AMEC 2017a)
- *Multidisciplinary Subsurface Investigation, Phase 2* (AMEC 2017b)
- *Multidisciplinary Subsurface Investigation, Phase 3* (AMEC 2017c)
- *Multidisciplinary Subsurface Investigation, Phase 4* (AMEC 2018a)
- *Hydraulic Conductivity (Slug Test) Results for PH17-001 to PH17-010, Canadian Nuclear Laboratories, Chalk River, ON* (Wood 2018)
- *Wood Geotechnical Investigation (Ring Road for Effluent to Perch Lake)* (Wood 2019)
- *Proposed Initial (Baseline) Operational Control Monitoring for the Near Surface Disposal Facility (NSDF) Site* (CNL 2018a)

The multidisciplinary site characterization included the following intrusive components: 25 test pits to a maximum depth to 4 metres below ground surface (mbgs); 70 boreholes, drilled to a maximum depth of 30.3 mbgs; and 50 groundwater monitoring wells used to measure groundwater elevation and sample for groundwater quality. Eleven of the monitoring wells are located outside of the ECM footprint and were developed for operational control monitoring. Non-intrusive investigations included two rounds of ground penetrating radar surveys (Golder 2016; AMEC 2017c).

In consideration of the relatively shallow extents of the Near Surface Disposal Facility (NSDF) and its predicted impacts, site characterization focused on shallow depths to approximately 30 mbgs at the project site. At this depth, the characteristics of overburden, upper bedrock and shallow groundwater have the most significant impact on the development of the design and numerical models of the Engineered Containment Mound (ECM).

Field and laboratory tests were conducted for the NSDF to characterize “intact rock” and “rock mass” properties relevant to develop the design and numerical models. “Intact rock” represents ‘small’ samples of unfractured rock tested in a laboratory setting, while the term “rock mass” represents large volume of rock tested in situ and takes into account the bulk properties of the rock mass, including discontinuities and fractures features. The scope of rock characterization for NSDF included:

- Determination of elastic modulus and rock strength;
- Petrographic analysis to determine the quantitative distribution of constituent minerals, and characteristics and physical features of the bulk rock and fractures;
- X-ray diffraction (XRD) analyses;
- Rock Quality Designation (RQD);
- Downhole seismic survey;
- Geophysics survey, including photographic and acoustic televiewer;
- Field testing of hydraulic conductivity or permeability; and
- Installation and development of wells to monitor groundwater level and quality (e.g., chemical characteristics).

Considering the focus of the GWMF was different (i.e., deeper, e.g., 500 to 1,200 mbgs) from the NSDF, the results (e.g., CNL 2016a, d) were considered as supplementary information for the NSDF Project.

The information contained in the reports cited above was supplemented for the SSA and LSA by stratigraphic boundary points (i.e., elevations of contact between geological surfaces), overburden (i.e., the soil or unconsolidated material that overlies the bedrock surface) thickness data and light detection and ranging (LiDAR) topographic data provided by CNL to develop isopach maps (i.e., a map illustrating the thickness variations for a geological unit) for the SSA. The stratigraphic boundary points were screened to remove duplicate points, and elevations were corrected using LiDAR data, where necessary. The data were then contoured using Golden Software’s Surfer package to generate isopach maps of the thickness of each stratigraphic unit. Where surfaces were found to spatially overlap, they were corrected by shifting the underlying layers downward, with ground surface topography and total overburden thickness maintained. These isopach maps are described in greater detail in Section 5.3.1.4.2.

Data collected within the SSA and LSA were also supplemented by baseline geology data collected from the review of selected geological literature (Catto et al. 1982, Chapman and Putman 1984, Raven Beck 1994, King and Killey 1994, CNL 2016a) along with geological mapping produced by the Ontario Geological Survey.

A desktop study was completed to identify the soils baseline conditions in the LSA. Information for the characterization of soils baseline conditions obtained from *The Canadian System of Soil Classification* (SCWG 1998), *The Ecosystems of Ontario, Part 1: Ecozones and Ecoregions* (Crins et al. 2009) and the *Soil Survey of Renfrew County* (Gillespie et al. 1964). Soil mapping involved the correlation of vegetation mapping to soil substrate units (i.e., the type of soil that underlies the vegetation (e.g., organic, disturbed, or coarse textured)). The primary soil characteristics used to group soil substrates into map units included parent material (i.e., the underlying geological material (e.g., bedrock) from which soils form) and terrain (slope and surface expression). Map units (soil polygons) were created after considering relationships between map resources, vegetation mapping and Google Earth satellite imagery.

5.3.1.4.2 Results

5.3.1.4.2.1 Regional Geological Conditions

Bedrock

The CRL site is located within the Central Gneiss belt of the Grenville Structural Province of the Canadian Shield. Structurally, the CRL site is located within the Ottawa-Bonnechere Graben, a rift valley which trends from northwest to southeast from Lake Nipissing to the St. Lawrence River, occupying a 60 km-wide by 700 km-long area. The Ottawa River occupies the eastern bounding fault of the rift valley, with the CRL site located on the western edge of the river. Secondary faulting (also oriented northwest to southeast) has a considerable effect on surface drainage and bedrock topography (CNL 2016a,b) in the vicinity of the SSA. Historical glaciations have generated a knobby bedrock surface (CNL 2016a,b), which outcrops in several locations in the region.

Bedrock in the area consists of highly altered gneissic rock (coarse grained metamorphic rock) and felsic igneous rock of late Precambrian-early Paleozoic age. Bedrock at the CRL site has been grouped into three main assemblages as shown on Figure 5.3.1-2. The bedrock within the Perch Lake basin and the SSA has been mapped as quartz monzonitic, monzonitic and monzodioritic gneisses of Assemblage B. Assemblage C (mainly composed of granitic, granodioritic and leucodioritic gneisses) has been mapped at the bedrock surface under the eastern portion of the SSA.

Two east-west trending post-orogenic Neoproterozoic diabase dykes are mapped at CRL site: the northern dyke mapped approximately 400 m north of the SSA, and the southern dyke identified in the LSA in close proximity to the western boundary of the SSA. These dykes are part of the Grenville dyke swarm that extends from the Georgian Bay-Lake Timiskaming region to at least north of Montreal. The dykes are proven at the CRL site by borehole intersections from CR-, FS- and CRG-series boreholes, strong magnetic geophysical signature and dispersed outcrop exposures and in floats/boulders (mainly near Maskinonge Lake). The northern and southern dykes dip steeply north (~70°), range in true width between about 15 and 40 m and appear to be relatively continuous across the property. They have lower permeabilities (*c.* 10^{-21} m^2 and 10^{-18} m^2 in borehole intersections in boreholes CRG-3 and CRG-6, respectively) as compared to the host rock mass and thus have potential to act as relatively impermeable flow barriers (aquitards). The decreased permeability is attributed to the ubiquitous distribution of fracture fillings in most fractures. This earlier observation is confirmed by tests done for the GWMF project and its predecessors. Transitions between these relatively low permeability rock types are not expected to be significant to this assessment.

Lineament studies for the CRL site and surrounding area were completed as a part of previous studies (Canadian Nuclear Fuel Waste Management Program [CNFWMP] from 1977 to 1983, Raven Beck 1994, and the Geological Waste Management Facility [GWMF] Project in 2015). The lineament studies performed by the CNFWMP (1977-1983) focused on the area around Maskinonge Lake, and due to its distance from NSDF SSA therefore not relevant for the NSDF. Based on analysis of air photo and linear geophysical anomalies, the lineament study by Raven Beck (1994) provided the basis for major fracture and fault zones interpretation, though this survey did not cover the NSDF SSA. Fracture and fault zones were categorized based on their level of confidence i.e., zones were ranked as “confirmed or very high probability”, “high probability”, “moderate probability” and “possible”). The “confirmed or very high probability” and “high probability” were adapted by the GWMF project and further site investigation was done to develop the conceptual 3D geological model for CRL site and surrounding area.

In conclusion, the lineament analyses performed by the GWMF project and its predecessors provides an indication for the general orientation and location of potential fracture zones as well as the confidence level associated to these geological features. However, they do not include detailed information regarding spatial location, attitude and characteristics to be applied for the NSDF footprint. Consequently, an alternative approach was adopted to take into account the fracture features for the NDSF as discussed below.

One feature identified in the previous work (i.e., Feature #17, a possible fracture zone) is located in the southern section of the NSDF SSA and on the edge of the southwestern boundary of the ECM. The degree of confidence corresponding to this feature was categorized as a “high-probability” fracture zone by the Siting Task Force (STF; Natural Resources Canada 1994), but later it was re-categorized as “possible” by the GWMF (CNL 2016d). The Feature # 17 was assigned an ESE-WNW (105/285°azimuth) trend, a length of 1,100 m and width of 10 m. A clearly defined structural control parallel to this feature was observed in the LiDAR image and in air photos. A dip direction of 70° towards the NE is assumed based on the field mapping data. This feature has potential to exhibit permeability values several orders of magnitude greater than bulk rock mass and is considered potential groundwater flow pathway. However, considering that the interpreted orientation is perpendicular to the direction of groundwater flow, this feature is considered to have limited potential as a preferential groundwater flowpath. The implications of potential fracture zones are further assessed through numerical groundwater flow modelling (as detailed in Section 5.3.2 of the EIS and Golder 2019b, 2020).

While there may be potential to accelerate groundwater transport through fracture zone, it is important to recognize that bedrock fractures have been indirectly incorporated in the model through the use of field measurements of bulk rock properties as input to the groundwater flow model. Additional scenarios have been developed that take into account the hypothetical existence of bedrock fracture zones within the NSDF SSA (Golder 2020). The results show that the presence of the geological features have negligible effect on the groundwater travel times between the ECM and downgradient receptors (i.e., Perch Creek) for post closure scenarios where the liner and/or cover of the ECM were compromised. This is reflective of the fact that the primary groundwater flow pathway is situated in the overburden.

Overburden

The regional topography of the CRL site is shown on Figure 5.3.1-3 and regional surficial geology of the CRL site is shown on Figure 5.3.1-4 (from King and Killey 1994). A widespread but thin deposit of glacial till overlies the bedrock in most areas where overburden is present (Catto et al. 1982). The more recent post-glacial sediments (above the till) formed following the last glacial retreat, which began approximately 11,000 years before present in the area east of Mattawa (Barry 1975). At this time, drainage from the western Great Lakes occurred through the Ottawa River valley. This resulted in the development of the Petawawa sand plain, a delta-like deposit that formed on the westernmost portion of the Champlain Sea. River terraces formed as the Champlain Sea retreated, and the Ottawa River down-cut and eroded the local surficial deposits. This occurred between approximately 9,900 and 7,000 years before present (Barry 1975). The early post-glacial Ottawa River covered most of the CRL site and deposited fluvial sands and silts throughout the region. These fluvial deposits filled the depressions in the bedrock and glacial till surfaces. A brief period of Aeolian reworking (i.e., shaped by wind) of the fluvial sands into dune and sheet deposits occurred as the Ottawa River dropped to its current level and location.

Recent sediment accumulation has been in the form of organic deposits in the low-lying and wetland areas of the region. The thickness of the unconsolidated sediments is variable as a result of the variable bedrock topography and the historical location of the Ottawa River. In general, the sediments are thickest towards the centre of the rift valley and thinnest to the west and east towards the bounding faults. Within the Perch Lake Basin, which came into existence during the early erosional phases of the Ottawa River (approximately 9,900 years before present), the sedimentation rate has been estimated to be 16.5 years per centimetre (Barry 1975). As shown on Figure 5.3.1-4, surficial geology within the low-lying areas of the Perch Lake Basin is predominately composed of recent organic soils. Sand and glacial till are present at surface near topographic highs, such as the SSA.

5.3.1.4.2.2 Future Evolution of Geological Environment

Previous studies completed by CNL in support of proposed geological waste management facilities at the CRL site include discussion on the long-term future evolution of geological conditions (CNL 2016a). Although the focus of these studies is on factors that influence the deep geological setting (as compared to the shallow geological setting of the NSDF) over timeframes on the order of 100,000 years (as compared to the shorter NSDF assessment timeframe of 10,000 years), the presented information is relevant to the current assessment. The natural processes identified as having potential to influence the geological conditions at the CRL site include glaciation (glacial erosion and deposition of surficial material, glacial loading, permafrost formation, changes in sea level, changes in topography, isostatic adjustment, post-glacial effects such as flooding); tectonism (fault rupture or reactivation); and volcanism. A summary of the findings for each of these factors is provided as follows:

- Long-term future climate predictions indicate that the next major glaciation will occur at least 60,000 years after the present time. Therefore, the effects of glacial erosion permafrost and associated changes to the groundwater flow system are expected to be minimal over the NSDF assessment timeframe (10,000 years).
- The potential for fault reactivation in the vicinity of the NSDF Project exists, but the effects are expected to be minimal on the existing fault system. Evidence from bedrock fractures that have been subjected to historical tectonic stresses and glacial loading and unloading indicates that the rock is inherently stable. No evidence of post-glacial structural disruption has been found. A detailed seismic analysis of the site was completed as a part of the design package (AECOM 2019), which discusses the potential for future seismic events in greater detail.
- Volcanic activity and orogenic (i.e., upward displacement of the earth’s crust) events are not considered to be factors that could potentially influence the geological setting over the assessment timeframe.

In consideration of the above findings, the primary factors influencing the future geological evolution in the vicinity of the CRL site over the 10,000-year assessment timeframe are erosion and deposition of the overburden and weathering of the shallow bedrock. The future climate will be the primary natural control on these factors. *Climate Change Assessment for the Near Surface Disposal Facility Project* (Golder 2019a) provides an assessment of long-term future climate for the CRL site, and concludes that the climate will be warmer (by up to 8°C) and wetter (by up to 20%) in the early portion (the first 1,000 years) of the assessment timeframe. Because of the uncertainty associated with estimating future climate in the long term, the predictions are limited to this early portion of the assessment timeframe.

Given the uncertainty associated with future climate predictions, one approach to evaluating future geological changes to the CRL site is to qualitatively extrapolate future conditions based on historical geological evolution. This assumes processes that have in the past (and at present) influenced the geological conditions will continue to do so in the future. The recent geological evolution has been primarily controlled through glacial activity; the last major deposition of sediment in Perch Lake basin occurred during the draining of Glacial Lake Agassiz via the early post-glacial Ottawa River, which ceased approximately 9,800 years before present (Teller 1988). Since that time the geological setting in the Perch Lake Basin has been stable, as indicated by the development of organic deposits in Perch Lake (Boyko-Diakonow and Terasmae 1975). Because glacial activity has been the primary factor influencing the near-surface geological evolution at the site, and glacial activity is not expected to occur within the assessment timeframe (CNL 2016a), it is inferred that the geological conditions will be relatively stable over the assessment timeframe.

5.3.1.4.2.3 Seismicity

Major seismic events (i.e., earthquakes) are related to movements at tectonic plate boundaries. The CRL property is located in the Ottawa-Bonnechere Graben geologic feature and adjacent to the Western Quebec Seismic Zone. This region of the country has continued to experience minor to moderate seismic activity, and several earthquakes have been documented within this zone. These include the following:

- Timiskaming, Quebec, earthquake of 1935 (6.2 on the Richter Scale and epicentre over 100 km away);
- Cornwall, Ontario, earthquake of 1944 (5.6 on the Richter Scale and epicentre over 200 km away); and
- Val-des-Bois, Quebec, earthquake of 2010 (5.0 on the Richter Scale and epicentre over 137 km away).

Most recently, an earthquake with a magnitude of 3.7 on the Richter Scale occurred on October 15, 2015, approximately 40 km from the SSA, and an earthquake with a magnitude of 3.5 occurred on May 14, 2016, approximately 10 km from the SSA, 6 km north of Petawawa, Ontario.

A site-specific *Probabilistic Seismic Hazard Analysis* (AECOM 2018a) was completed for the SSA to determine design ground motions for the NSDF. The analysis included a review of potential seismic sources in the surrounding region and it utilized the latest generation seismic hazard model for southeastern Canada developed by the Geological Survey of Canada, in agreement with the method used in the latest *National Building Code of Canada* (NRCC 2015). As noted above, the SSA is located within a region (within 500 km) that has historically experienced low- to moderate-magnitude historical seismicity. However, few recent (i.e., Quaternary) faults have been mapped within this region. This is in agreement with the findings of a recent paleoseismicity investigation completed at the CRL site (CNL 2015a). This investigation involved excavation of trenches through the overburden and a review of the trench faces for evidence of soil displacement related to seismic activity. Although displacement of the overburden was found in some locations, none of the displacements were attributed to seismic activity.

There are seismic monitoring stations located at CRL site which are operated by Natural Resources Canada (NRCan), as well as three microseismic monitoring stations operated by CNL (CNL 2015d). These monitoring stations have the capability to monitor lower magnitude of seismic events. The primary objective of the microseismic monitoring system (MMS) has been to provide an analysis of the natural seismic activity of the area associated with tectonic faulting and to detect any specific active geological structures. The current seismic array consists of three surface seismic stations monitoring an area of approximately 7 km x 7 km to the west of the CRL facilities.

5.3.1.4.2.4 Local and Site Study Area Geological Conditions

The local geological conditions in the subsections below describe the lower portion of the Perch Lake Basin and the SSA on the basis of previous investigations of the waste management areas and recent investigations within the SSA.

Topography

Ground surface elevations range from a low of approximately 156 metres above sea level (masl) within the low-lying and relatively flat terrain bordering the north side of Perch Lake to a high of 197 masl along the crest of the ridge to the east of East Mattawa Road that separates the Perch Lake and Ottawa River drainage basins. Topography and local drainage features are shown on Figure 5.3.1-5. The SSA is located in the central portion of the lower Perch Lake Basin. Topographic evidence suggests that a former branch of the Ottawa River followed a chain of lakes, the largest of which is Maskinonge Lake, that bisect the western part of the CRL site boundary.

Bedrock Topography and Geology

A bedrock topography map was generated for the SSA using stratigraphic data (Figure 5.3.1-6). The bedrock topography is dominated by the ridge that delineates the eastern boundary of the Perch Lake Basin and the depression or valley that runs from the northwest corner of Waste Management Area A, to the southeast towards Perch Creek. The bedrock ridge reaches an elevation of approximately 192 masl and dips to the northwest and southeast, to an elevation of 165 masl at Plant Road and 155 masl at Perch Creek. The bedrock valley is composed of a western portion that slopes irregularly from north to south and a southern portion that slopes irregularly from east to west. These two portions meet just north of where the Main Stream discharges to Perch Lake. Bedrock in that area is at an elevation of 120 masl. The northwestern portion of the SSA is underlain by a spur from the bedrock valley, at an elevation of 151 masl. The ridge that delineates the western boundary of the Perch Lake Basin is shown reaching an elevation of 175 masl at the limit of the map on Figure 5.3.1-6.

Bedrock within the Perch Lake Basin and surroundings is primarily composed of quartz monzonitic, monzonitic and monzodioritic gneisses with some occurrence of granitic-granodioritic and leucodioritic gneisses (CNL 2016a). As previously mentioned in Section 5.3.1.4.2.1 the east-west trending post-orogenic Neoproterozoic southern diabase dyke was identified in the LSA in close proximity to the western boundary of the SSA.

Two main fracture or faulting zones are present at the CRL site: the Mattawa Fault, which lies below the Ottawa River and consists of the northeast boundary of the property, and the Maskinonge Lake lineament in the southwest area of the property. As noted in Section 5.3.1.4.2.1, a possible fracture zone trending westnorthwest-eastsoutheast through the upper portion of Perch Lake Basin (Raven Beck 1994, CNL 2016a). This feature (Feature # 17), categorized as “possible” in the 3D sub-regional scale geological model, is a suspected structural feature. The absence of direct evidence prevents correlating this lineament with a proven discontinuity in the rock mass. The NSDF site specific borehole data provided by AMEC (2017a,b) do not show the presence of any major fracture zone. Further, the interpreted orientation of Feature #17 is perpendicular to the direction of groundwater flow, and is limited in spatial extent within the SSA, thus limiting its potential as a preferential groundwater flow pathway.

Investigations by AMEC (2017a,b) included the advancement of 32 boreholes to depths of up to 13.2 m below bedrock surface. Borehole logs included in AMEC (2017a,b) indicate that the upper several metres of bedrock generally consist of a pink gneiss, with the exception of boreholes W7, W8, BH2-1, BH2-6 and GH1-4, in which diorite was logged. This transition in rock types in the eastern portion of the SSA appears to be consistent with the mapping shown on Figure 5.3.1-2, with the exception of the presence of gabbro in borehole BH2-1 in the northwest corner of the SSA.

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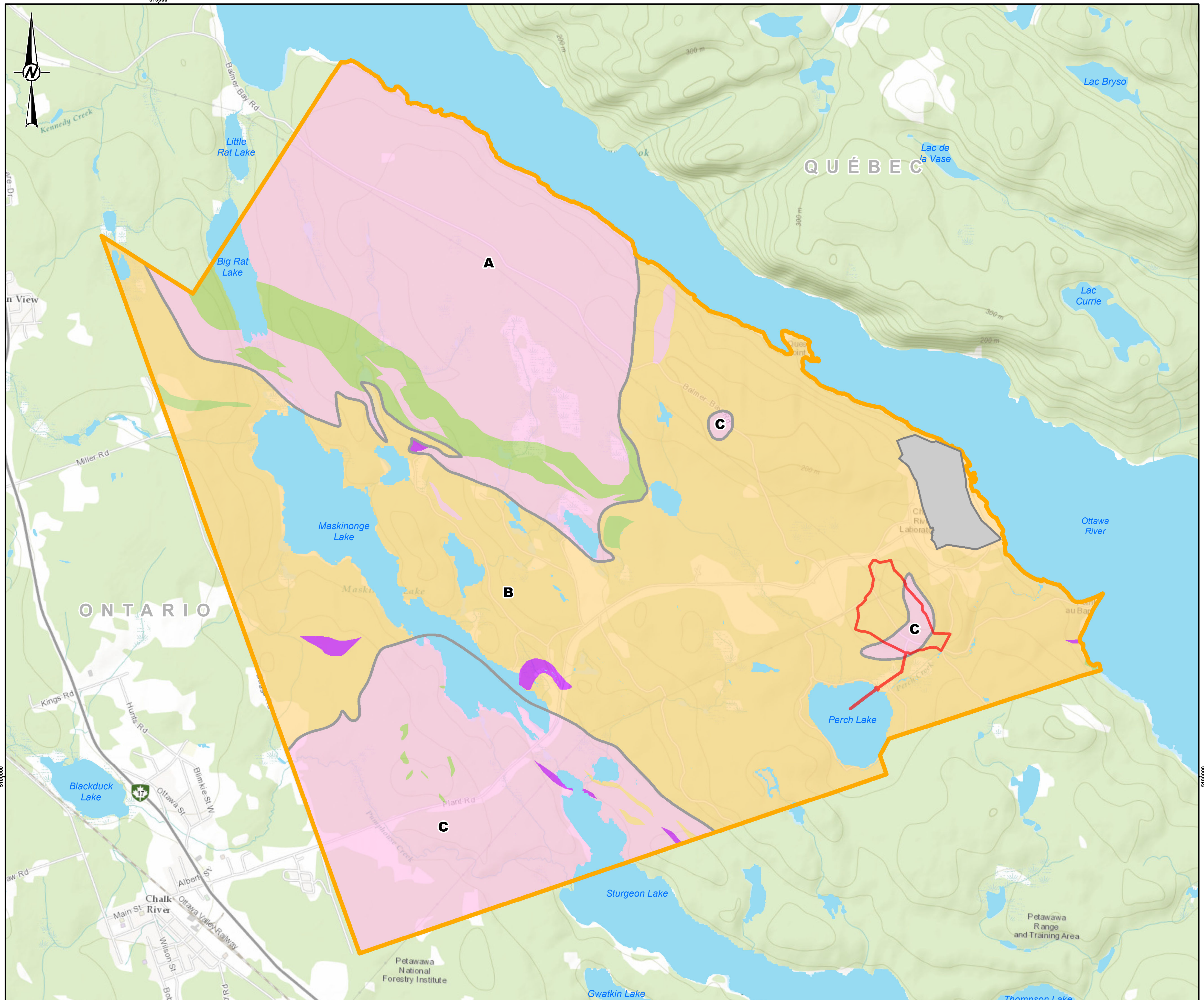

LEGEND

- WATERBODY
- SITE STUDY AREA (NSDF PROJECT SITE)
- CRL MAIN CAMPUS
- CRL SITE
- LITHOLOGICAL ASSEMBLAGES

PRE-GRENVILLE OROGENY

- DIORITIC AND AMPHIBOLITIC GNEISS
- GRANITIC, GRANODIORITIC AND LEUCODIORITIC GNEISS
- METAGABBRO AND METABASITE
- QUARTZ MONZONITIC, MONZONITIC AND MONZODIORITIC GNEISS

A, B and C LITHOLOGICAL ASSEMBLAGES AT CRL SITE

1 0 1
1:35,000 KILOMETRES

REFERENCE(S)

1. BASEMAP:SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY.
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. BEDROCK GEOLOGY: CNL. 2016A. GEOLOGIC WASTE MANAGEMENT FACILITY DESCRIPTIVE GEOSPHERE SITE MODEL REPORT: PHASE 1, 361101-10260-REPT-005, CANADIAN NUCLEAR LABORATORIES.
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
REGIONAL BEDROCK GEOLOGY

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.1-2

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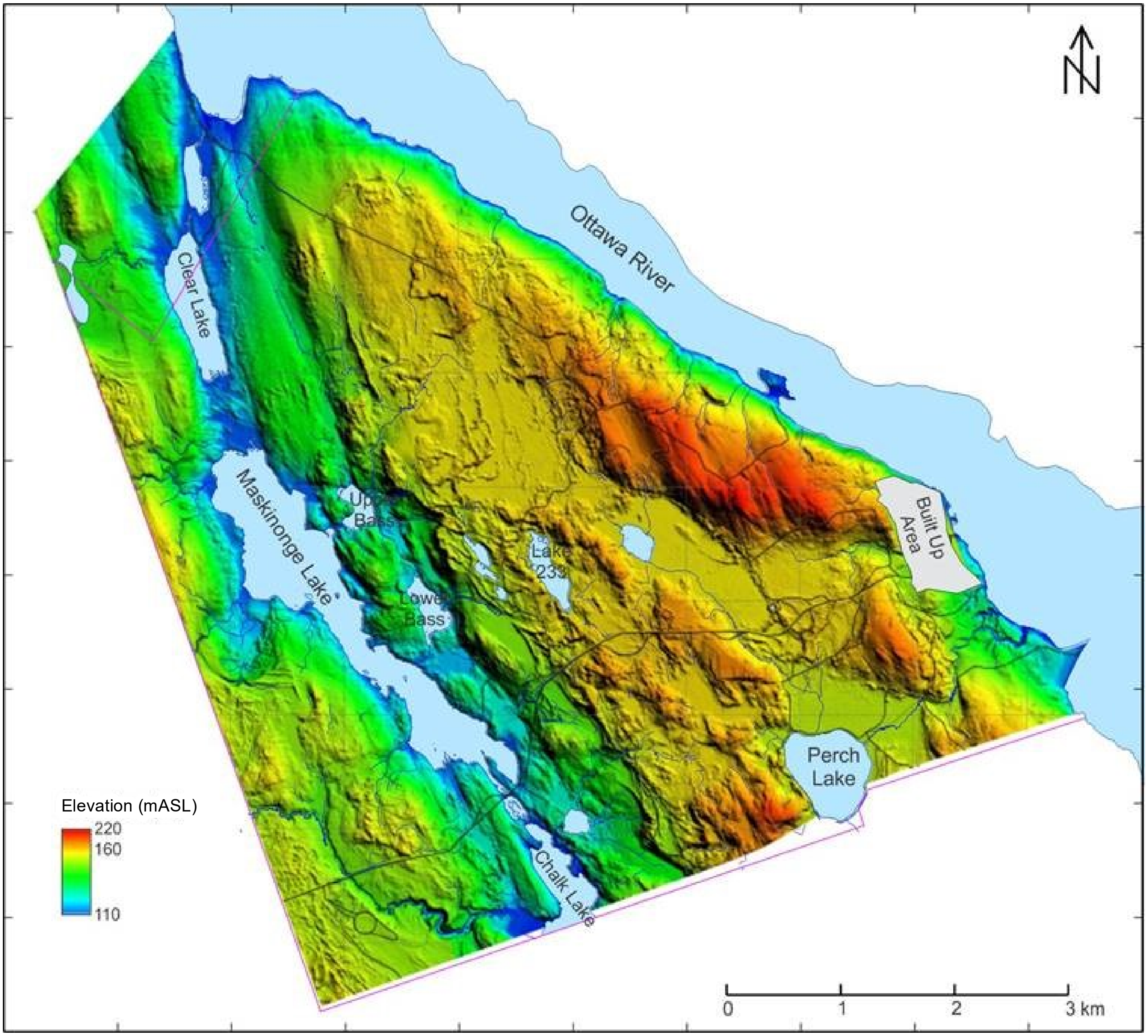

REFERENCE(S)
1. REGIONAL TOPOGRAPHY SOURCE CNL 2019

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CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
REGIONAL TOPOGRAPHY

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GOLDER

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REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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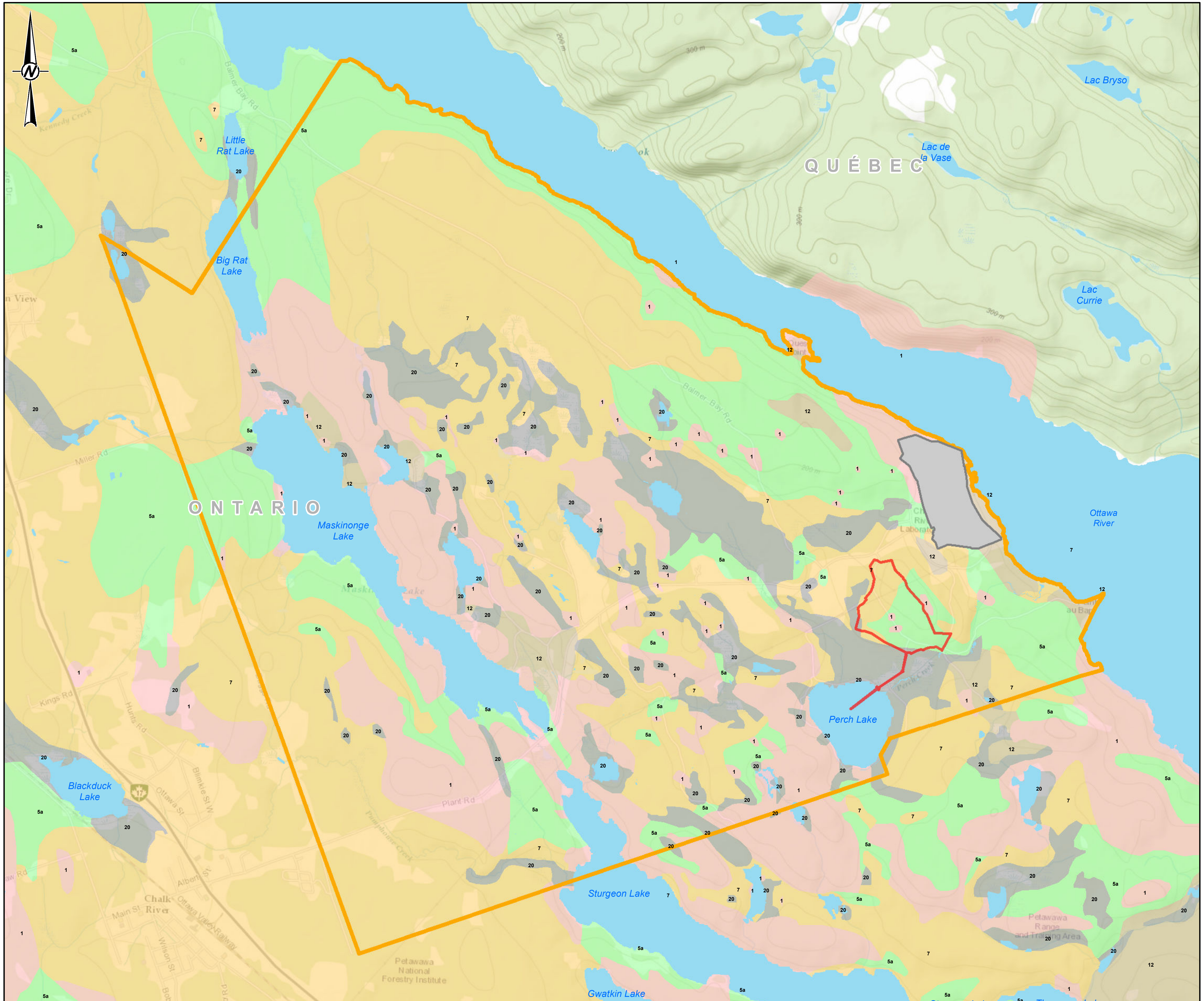

LEGEND

- WATERBODY
- SITE STUDY AREA (NSDF PROJECT SITE)
- CRL MAIN CAMPUS
- CRL SITE

SURFICIAL GEOLOGY

- 1: PRECAMBRIAN BEDROCK
- 5A: GLACIAL TILL
- 7: FLUVIAL AND AEOLIAN SANDS
- 12: SAND AND GRAVEL DEPOSITS
- 20: ORGANIC DEPOSITS

1 0 1
1:35,000 KILOMETRES

REFERENCE(S)

1. BASEMAP:SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. SURFICIAL GEOLOGY OF ONTARIO OBTAINED FROM ONTARIO GEOLOGICAL SURVEY (OGS) AND MINISTRY OF NORTHERN DEVELOPMENT MINES(MNDM), JUNE 2010
4. KING, K.J., AND R.W.D. KILLEY. 1994. QUATERNARY GEOLOGY OF THE AECL CHALK RIVER LABORATORIES PROPERTY: A REVIEW. STF TECH. BIB. NO. 345, SITTING TASK FORCE, LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT.
5. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

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CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
REGIONAL SURFICIAL GEOLOGY

CONSULTANT GOLDER

DATE	NOVEMBER 2020
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PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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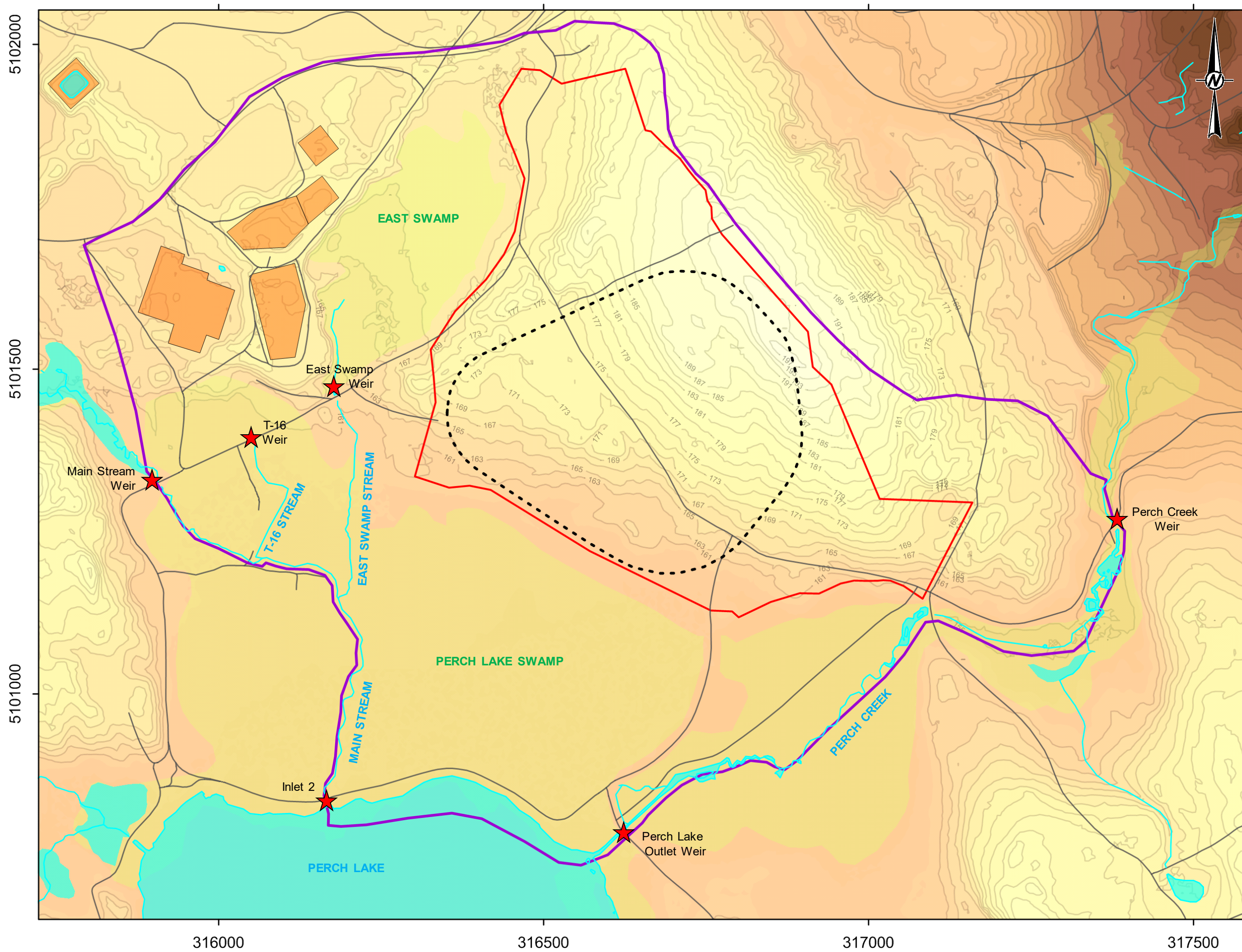

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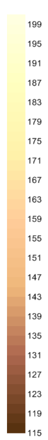


LEGEND

- Groundwater Model Boundary
- Roads
- ECM Location
- Site Study Area (NSDF Project Site)
- Stream
- Waterbody
- Wetland
- Waste Management Area
- Weir Location

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

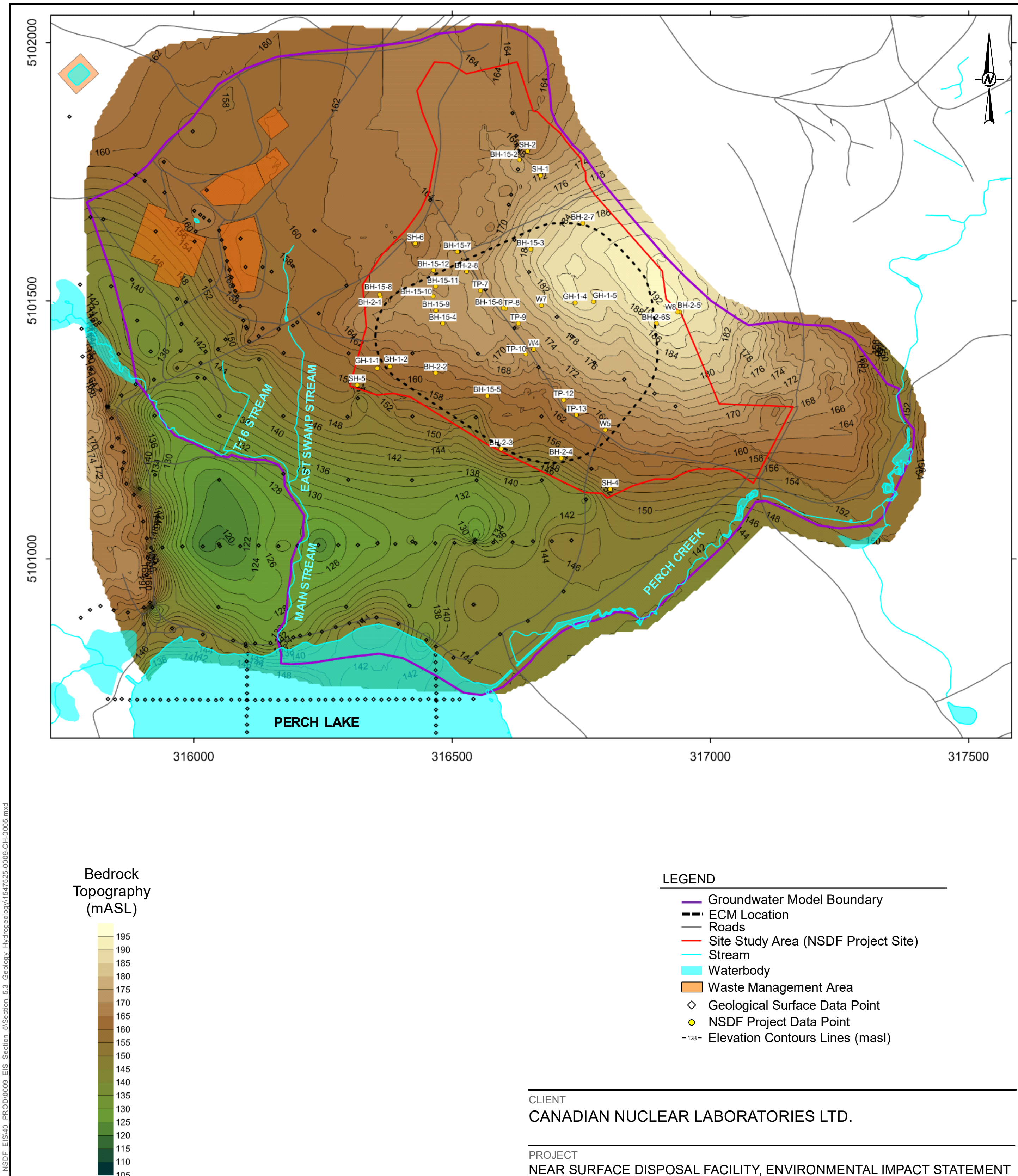
TITLE
TOPOGRAPHY AND DRAINAGE FOR THE NEAR SURFACE DISPOSAL FACILITY PROJECT SITE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.1-5

REFERENCE(S)
1. PERCH LAKE SUB-BASINS OBTAINED FROM E. ROBERTSON & P.J. BARRY (1985) THE WATER AND ENERGY BALANCES OF PERCH LAKE (1969–1980), ATMOSPHERE-OCEAN, 23:3, 238-253, DOI: 10.1080/07055900.1985.96492270)



REFERENCE(S)

1. PERCH LAKE SUB-BASINS OBTAINED FROM E. ROBERTSON & P.J. BARRY (1985) THE WATER AND ENERGY BALANCES OF PERCH LAKE (1969–1980), ATMOSPHERE-OCEAN, 23:3, 238-253, DOI: 10.1080/07055900.1985.96492270)

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
BEDROCK TOPOGRAPHY FOR THE NEAR SURFACE DISPOSAL FACILITY PROJECT SITE

CONSULTANT: GOLDER

DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.1-6

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Overburden Geology

The overburden geology at the SSA consists primarily of fine sands, underlain locally by glacial till. The sands are interpreted to be the result of Aeolian reworking of precursor fluvial sands and silts laid down in the late Pleistocene/early Holocene period by an early phase of the Ottawa River. Unconsolidated glacial and post-glacial deposits in the Perch Lake Basin (which includes the LSA and SSA) have been subdivided into six main units:

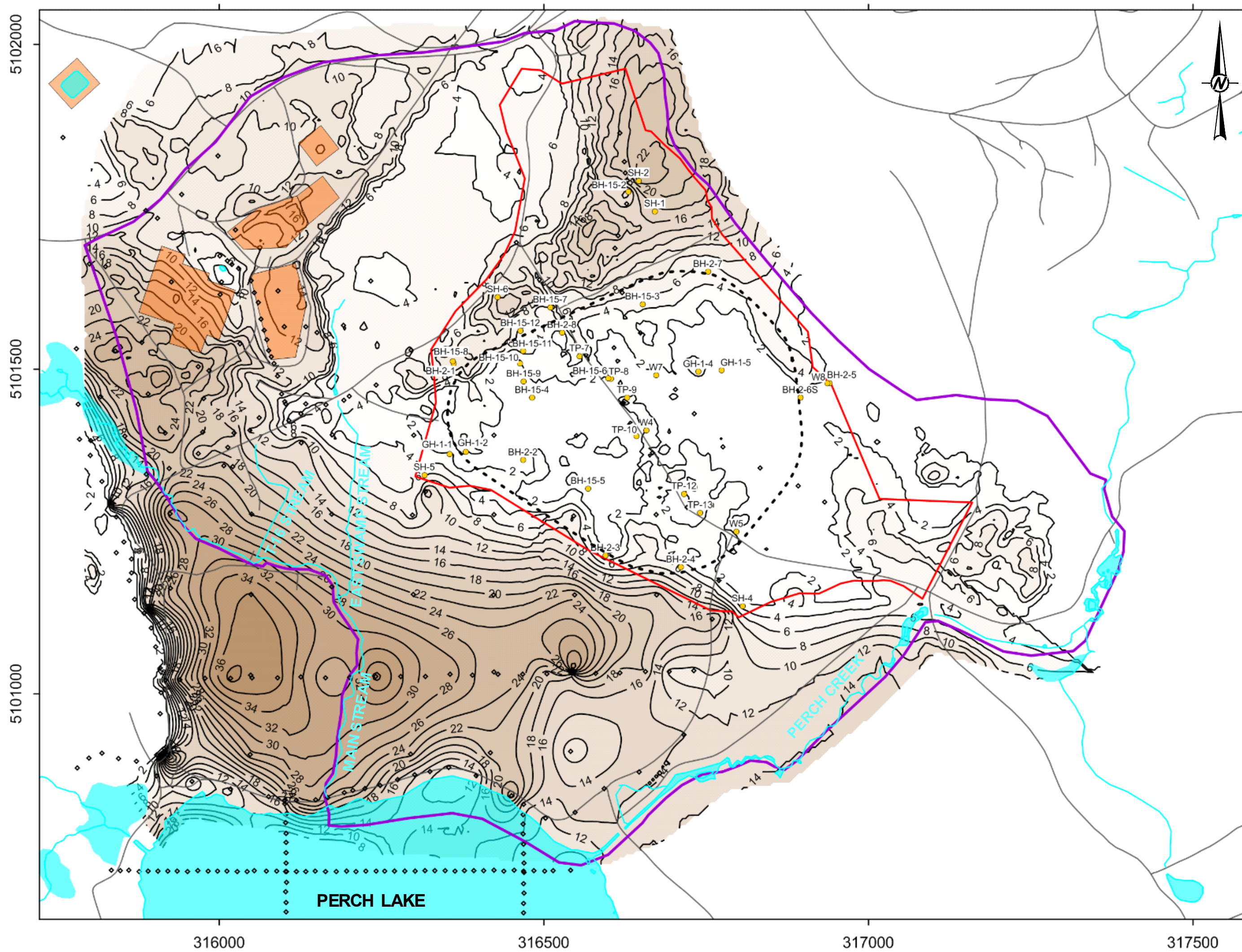
- glacial till;
- basal sand and gravel;
- clayey silt;
- middle sand;
- interstratified silt and sand; and
- upper sand.

More recent organic deposits are also present in the Perch Lake Basin, but are not considered substantial hydrostratigraphic units (i.e., geological formations with similar hydrological characteristics regarding groundwater flow). The total thickness of the unconsolidated deposits is shown by an isopach map on Figure 5.3.1-7. The thickness of the unconsolidated sediments is generally lowest on the eastern bedrock ridge (in the vicinity of the SSA). The thickness of these sediments increases to the west and is highest in the bedrock valley, reaching more than 36 m in the bedrock low. Within the area of the SSA, unconsolidated deposits are locally thicker in the area to the north and east, reaching more than 26 m thick at the northern terminus of the bedrock ridge (Figure 5.3.1-7). Elsewhere on the CRL site, overburden thickness ranges from 0 m (i.e., no overburden) to more than 25 m, being thickest in topographic lows (Raven Beck 1994). The sedimentary geology in the Perch Lake Basin is illustrated in cross-section on Figure 5.3.1-8. Logging of the overburden at the 2016 and 2017 boreholes was not sufficient to delineate the geological units listed above. Therefore, interpolation of the overburden surfaces in the area of the ECM was based on the assumption that the thickness of the Glacial Till was at least 1 m, with the remaining overburden thickness comprised of upper sand.

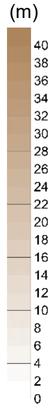
Glacial Till

The thickness of the glacial till unit within the SSA is shown by an isopach on Figure 5.3.1-9. Glacial till covers a large portion of the bedrock surface and is thickest in the areas of the bedrock lows. Glacial till thins to the east towards the bedrock ridge. Where present, glacial till is generally less than 12 m thick but reaches thicknesses of up to 15 m within the bedrock valley and 24 m in the area to the north of the eastern bedrock ridge. Glacial till is locally thicker along a line that extends from the northern edge of the eastern bedrock ridge to the south of the East Swamp, ending approximately 250 m northeast of where the East Stream meets the Main Stream. In this area, the glacial till ranges from 3 to 8 m in thickness. Within the southern portion of the SSA (where bedrock is close to ground surface) the till is generally less than 1 m thick.

Glacial till within the Perch Lake Basin consists of poorly sorted boulders, cobbles and gravel in a silty sand to sandy silt matrix (Golder 2016), with no visible stratification (CNL 2016b). Grain size analyses indicate a low silt content (less than 10%) and a negligible clay content (CNL 2016b).



Overburden Thickness (m)



LEGEND

- Groundwater Model Boundary
- ECM Location
- Roads
- Site Study Area (NSDF Project Site)
- Stream
- Waterbody
- Waste Management Area
- Geological Surface Data Point
- NSDF Project Data Point
- Overburden Thickness Contour Lines (m)

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

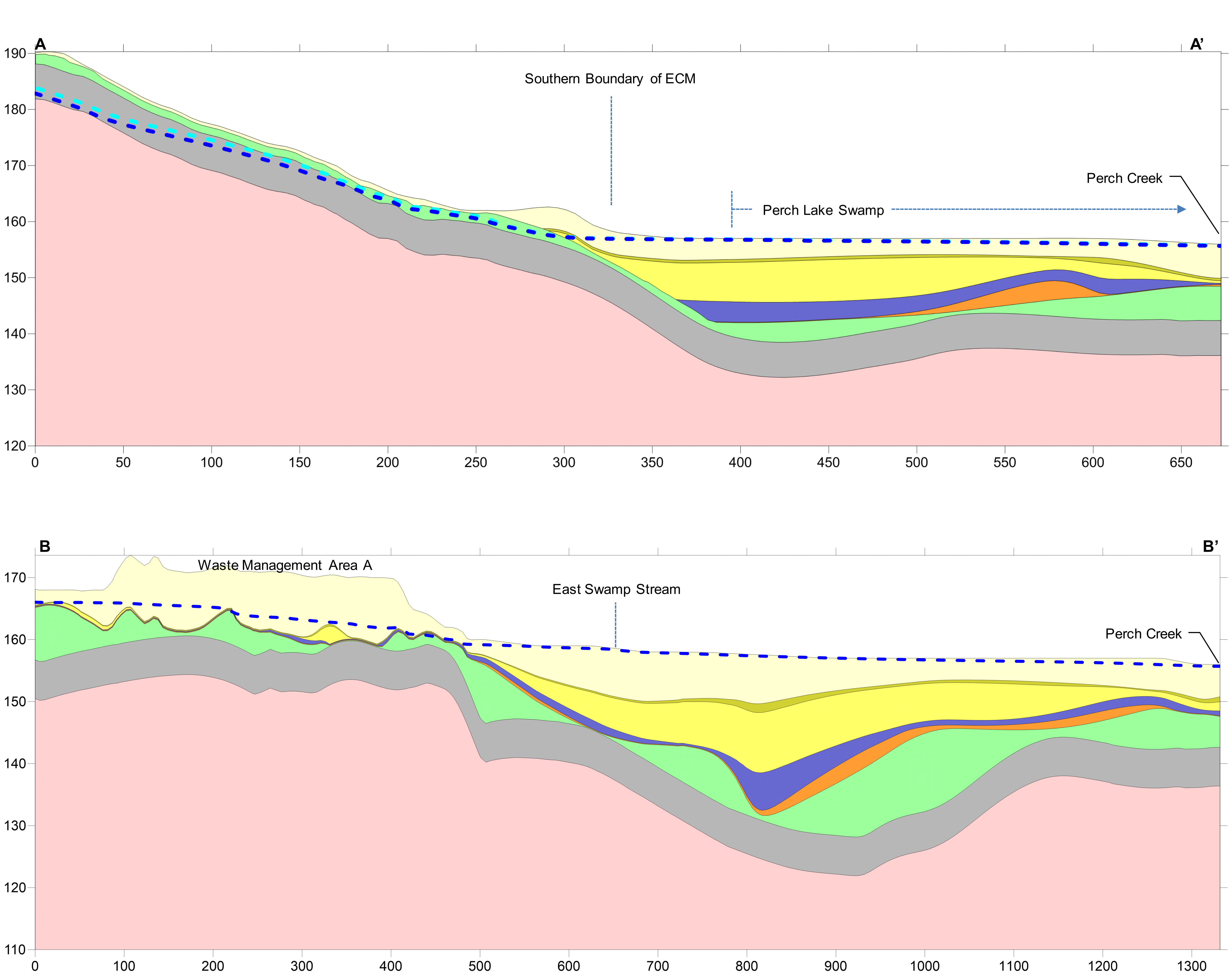
TITLE
ISOPACH MAP – AREAL EXTENT AND THICKNESS OF UNCONSOLIDATED DEPOSITS FOR THE NSDF PROJECT SITE

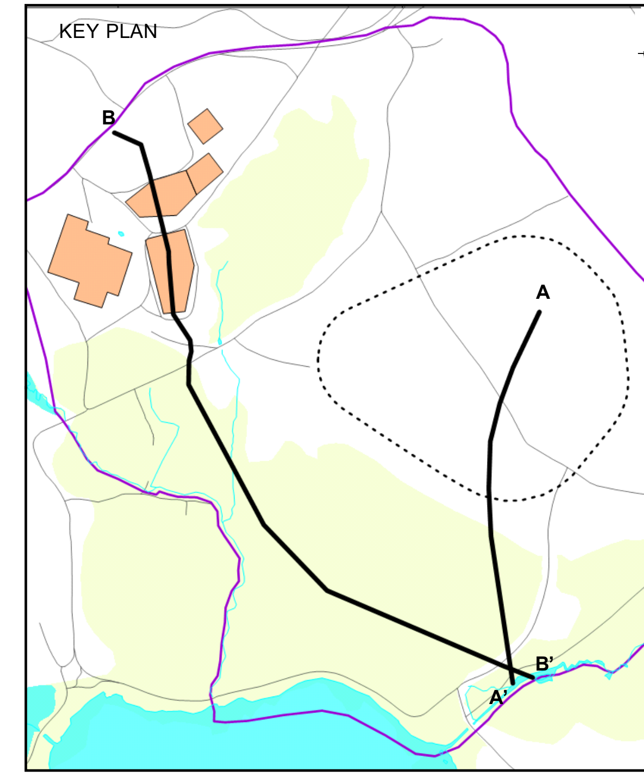
CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.1-7

REFERENCE(S)
1. PERCH LAKE SUB-BASINS OBTAINED FROM E. ROBERTSON & P.J. BARRY (1985) THE WATER AND ENERGY BALANCES OF PERCH LAKE (1969–1980), ATMOSPHERE-OCEAN, 23:3, 238-253, DOI: 10.1080/07055900.1985.96492270)





NOTE(S)
1. VERTICAL EXAGGERATION IS 3.0.

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PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
HYDROSTRATIGRAPHIC CROSS-SECTIONS WITH SIMULATED WATER TABLE ELEVATION

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.1-8

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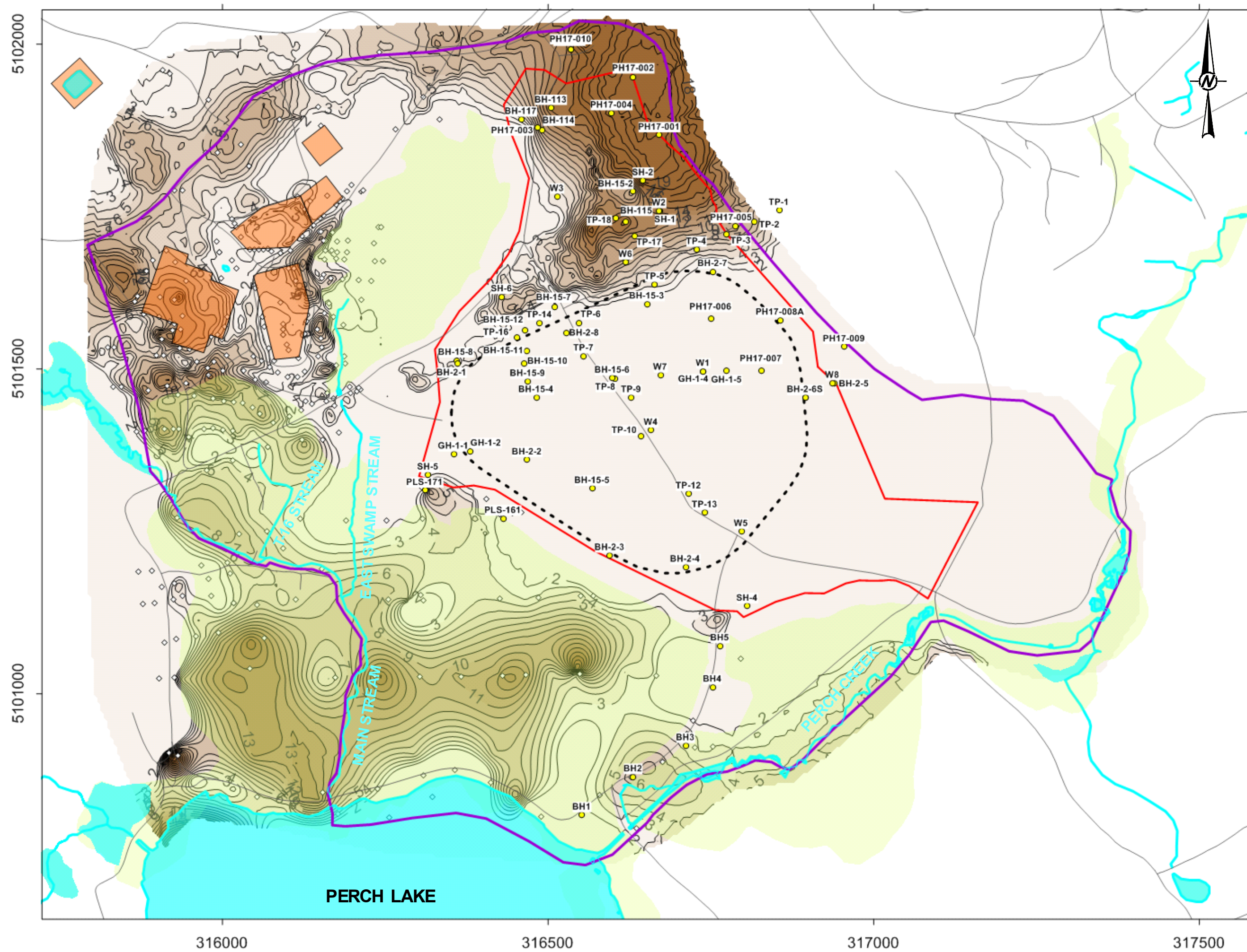


Till Thickness (m)

22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
0

LEGEND

- Model Boundary
- Roads
- ECM Location
- Site Study Area (NSDF Project Site)
- Stream
- Waterbody
- Waste Management Area
- ◇ Geological Surface Data Point
- ● Geological Surface Data Point (NSDF Area)

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
ISOPACH MAP – AREAL EXTENT AND THICKNESS OF GLACIAL TILL UNIT FOR THE NSDF PROJECT SITE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.1-9

REFERENCE(S)
1. PERCH LAKE SUB-BASINS OBTAINED FROM E. ROBERTSON & P.J. BARRY (1985) THE WATER AND ENERGY BALANCES OF PERCH LAKE (1969–1980), ATMOSPHERE-OCEAN, 23:3, 238-253, DOI: 10.1080/07055900.1985.96492270)

Basal Sand and Gravel

A basal sand and gravel unit overlies the glacial till in a limited area of the western portion of the Perch Lake Basin. The areal extent and thickness of this unit is shown by an isopach map on Figure 5.3.1-10. This unit ranges from 3.5 to 5.5 m in thickness within the bedrock valley to the north of Perch Lake and Perch Creek. The unit has also been found to underlie Waste Management Area A and the South Swamp, in thicknesses ranging from 1 to 4 m. This unit is not present in the SSA.

Clayey Silt

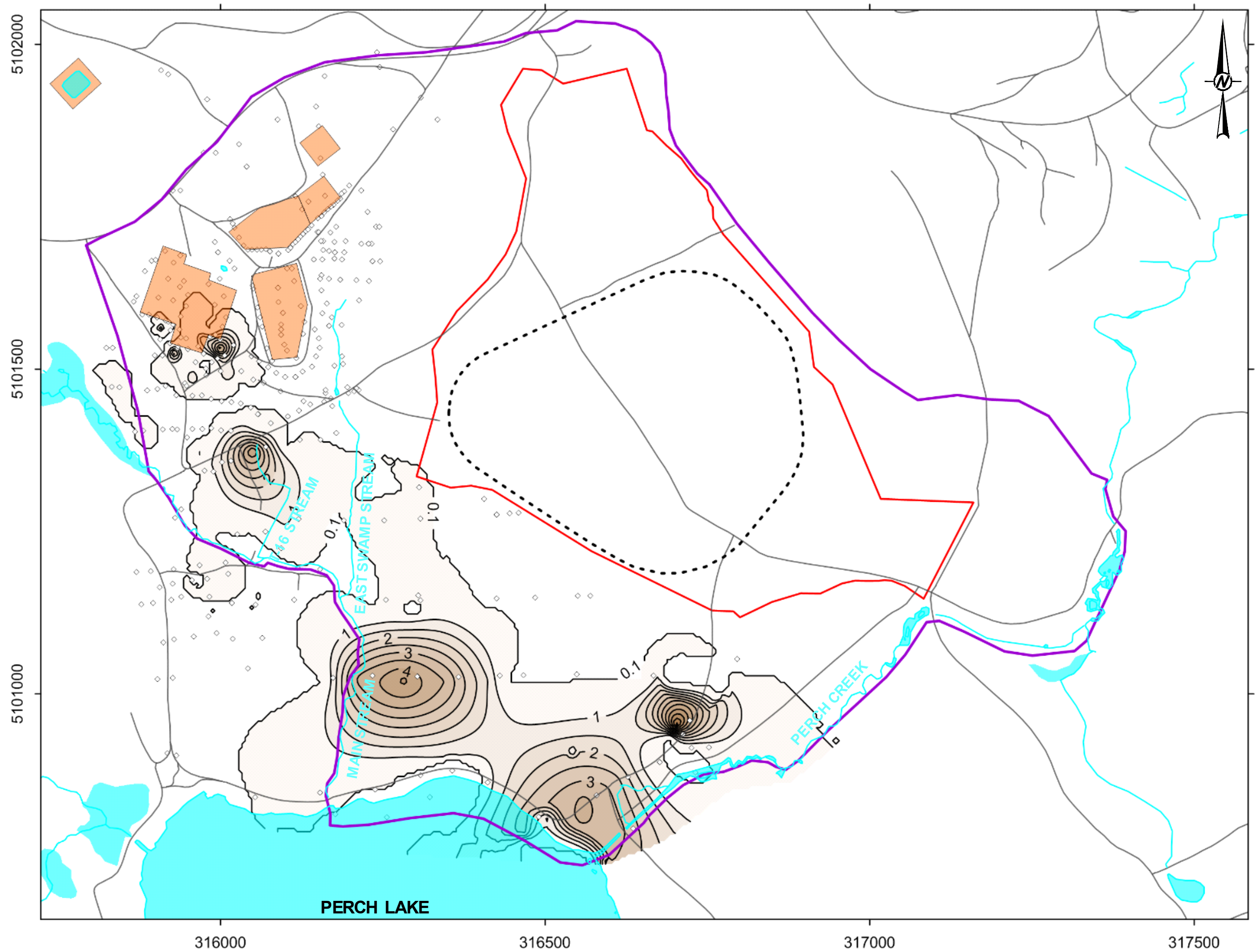
The thickness and areal extent of the clayey silt unit is shown as an isopach map on Figure 5.3.1-11. The clayey silt is generally present in the southwest portion of the Perch Lake Basin, where there are depressions in the surfaces of the till and the bedrock. Where present, the clayey silt is generally less than 2 m thick, but is more than 5 m thick in the bedrock depression approximately 200 m north of Perch Lake. North of the SSA, the clayey silt unit ranges in thickness from 0.5 to 1.5 m, being thickest to the east along East Mattawa Road. Clayey silt in the Perch Lake Basin is fluvial in origin and consists of laminations of coarser and finer fractions. The clay content of this unit, as determined through grain size analysis, is less than 20% by weight (CNL 2016b).

Middle Sand

The extent and thickness of the middle sand unit is shown by an isopach map on Figure 5.3.1-12. As with the other sedimentary units, the middle sand is thickest in the areas of the bedrock depressions. This unit generally fills the bedrock valley and ranges in thickness from 2 m to 9 m in this area. Middle sand is also present in the southern portion of Reactor Pit 2 (up to 4 m in thickness) and on the northern and southern flanks of the eastern bedrock ridge that delineates the Perch Lake Basin (up to 3 m in thickness in the south and 2 m thickness in the north). The middle sand has been classified as moderately well sorted fine sand through the results of grain size analyses.

Interstratified Silt and Sand

The extent and thickness of the interstratified sand and silt unit is shown by an isopach map on Figure 5.3.1-13. Where present, this unit is generally less than 0.4 m thick but can reach thicknesses of up to 2 m locally (i.e., near the point of discharge from Perch Lake to Perch Creek and to the south and west of Waste Management Area A). This unit has been encountered in the northern portion of the SSA at thicknesses of less than 0.4 m. The interstratified silt and sand consist of alternating layers of fine to very fine sand and sandy silts. Individual layers are on the order of several centimetres (CNL 2016b).



CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
ISOPACH MAP – AREAL EXTENT AND THICKNESS OF BASAL SAND AND GRAVEL UNIT FOR THE NSDF PROJECT SITE

CONSULTANT: GOLDER

DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.1-10

REFERENCE(S)
1. PERCH LAKE SUB-BASINS OBTAINED FROM E. ROBERTSON & P.J. BARRY (1985) THE WATER AND ENERGY BALANCES OF PERCH LAKE (1969–1980), ATMOSPHERE-OCEAN, 23:3, 238-253, DOI: 10.1080/07055900.1985.96492270)

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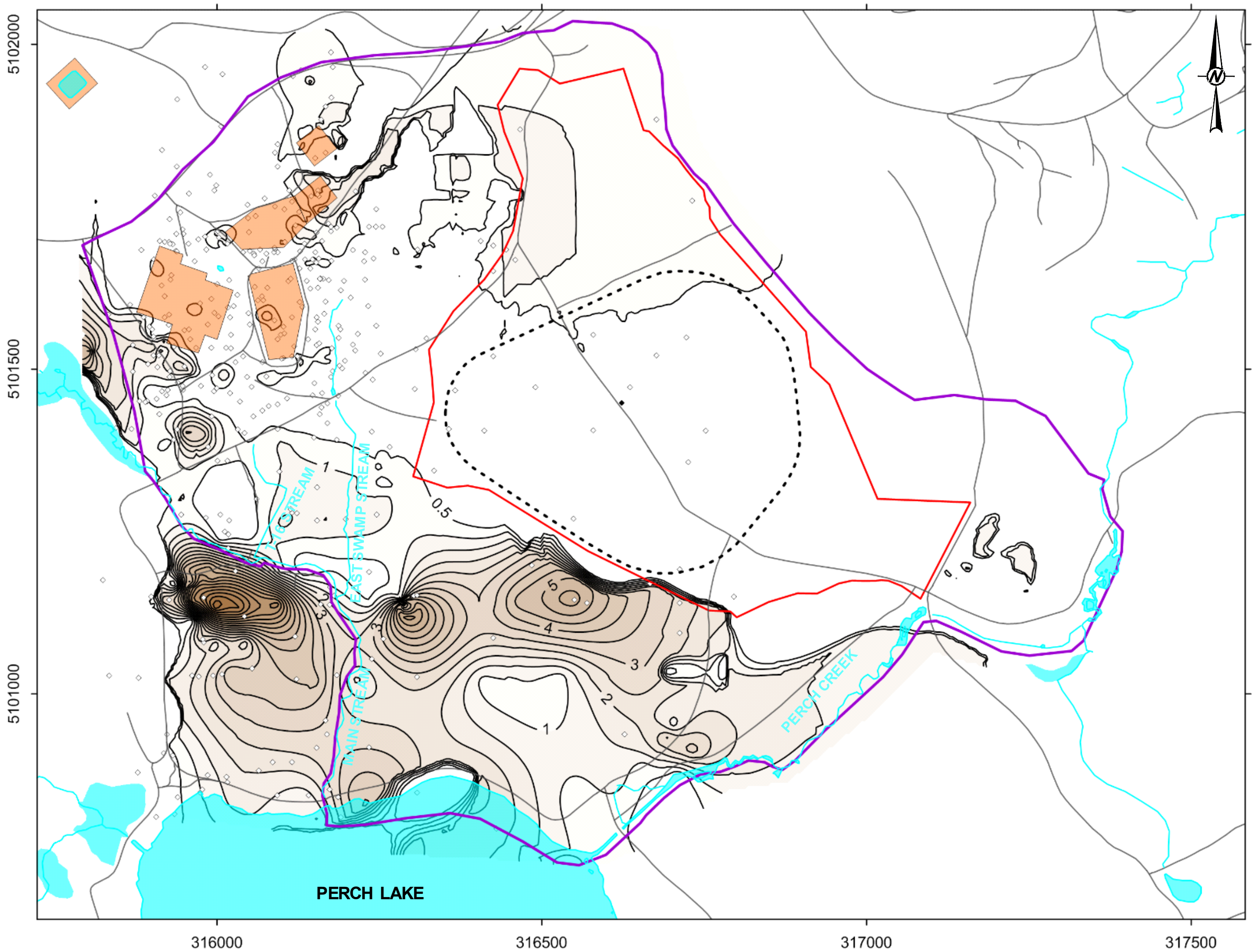
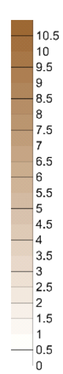


Clayey Silt Thickness (m)



LEGEND

- Groundwater Model Boundary
- ECM Location
- Roads
- Site Study Area (NSDF Project Site)
- Stream
- Waterbody
- Waste Management Area
- Geological Surface Data Point
- Thickness Contour Lines (m)

REFERENCE(S)

1. PERCH LAKE SUB-BASINS OBTAINED FROM E. ROBERTSON & P.J. BARRY (1985) THE WATER AND ENERGY BALANCES OF PERCH LAKE (1969–1980), ATMOSPHERE-OCEAN, 23:3, 238-253, DOI: 10.1080/07055900.1985.96492270)

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
ISOPACH MAP – AREAL EXTENT AND THICKNESS OF CLAYEY SILT UNIT FOR THE NSDF PROJECT SITE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.1-11

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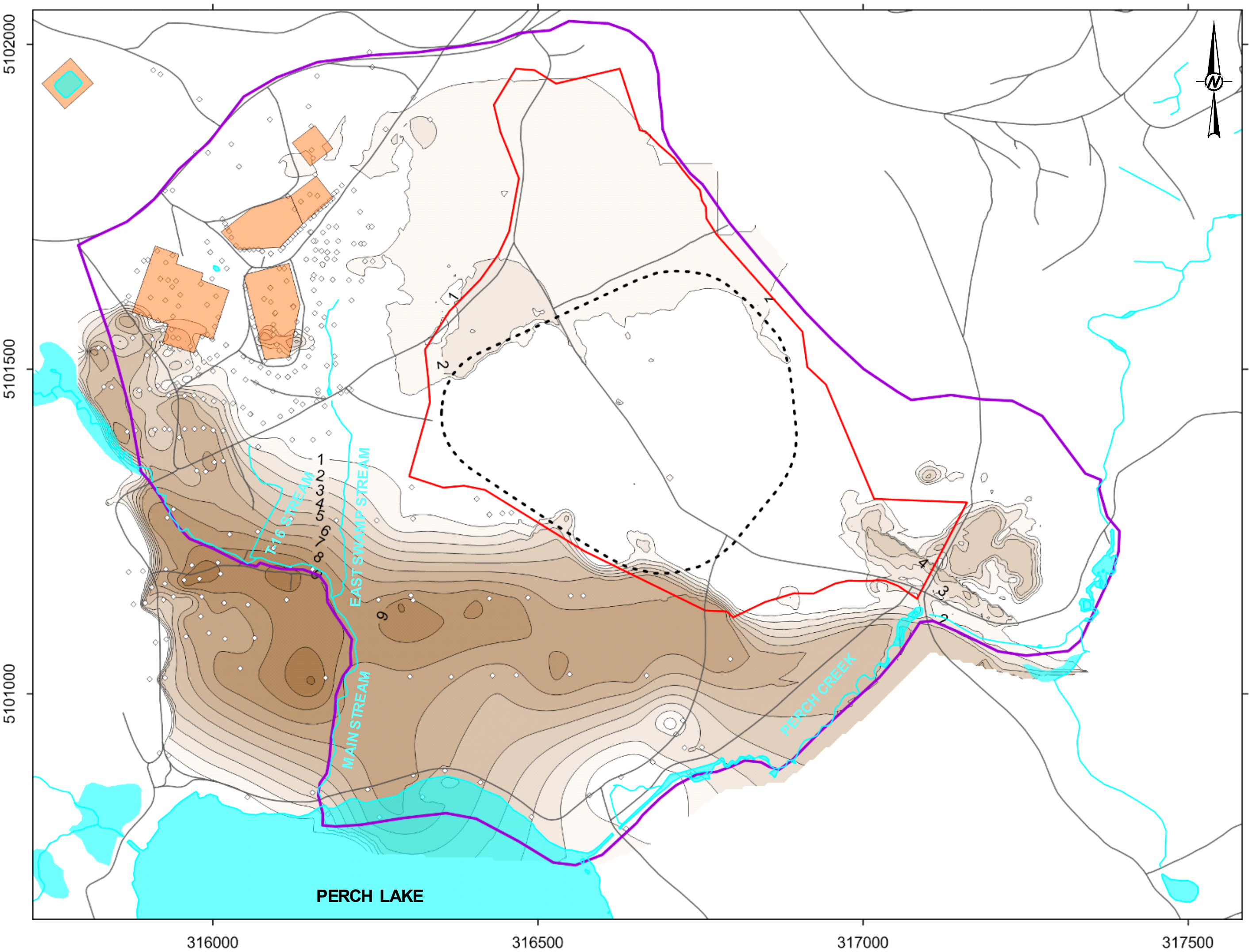
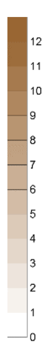




LEGEND

- Groundwater Model Boundary
- ECM Location
- Roads
- Site Study Area (NSDF Project Site)
- Stream
- Waterbody
- Waste Management Area
- Geological Surface Data Point
- Thickness Contour Lines (m)

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
ISOPACH MAP – AREAL EXTENT AND THICKNESS OF MIDDLE SAND UNIT FOR THE NSDF PROJECT SITE

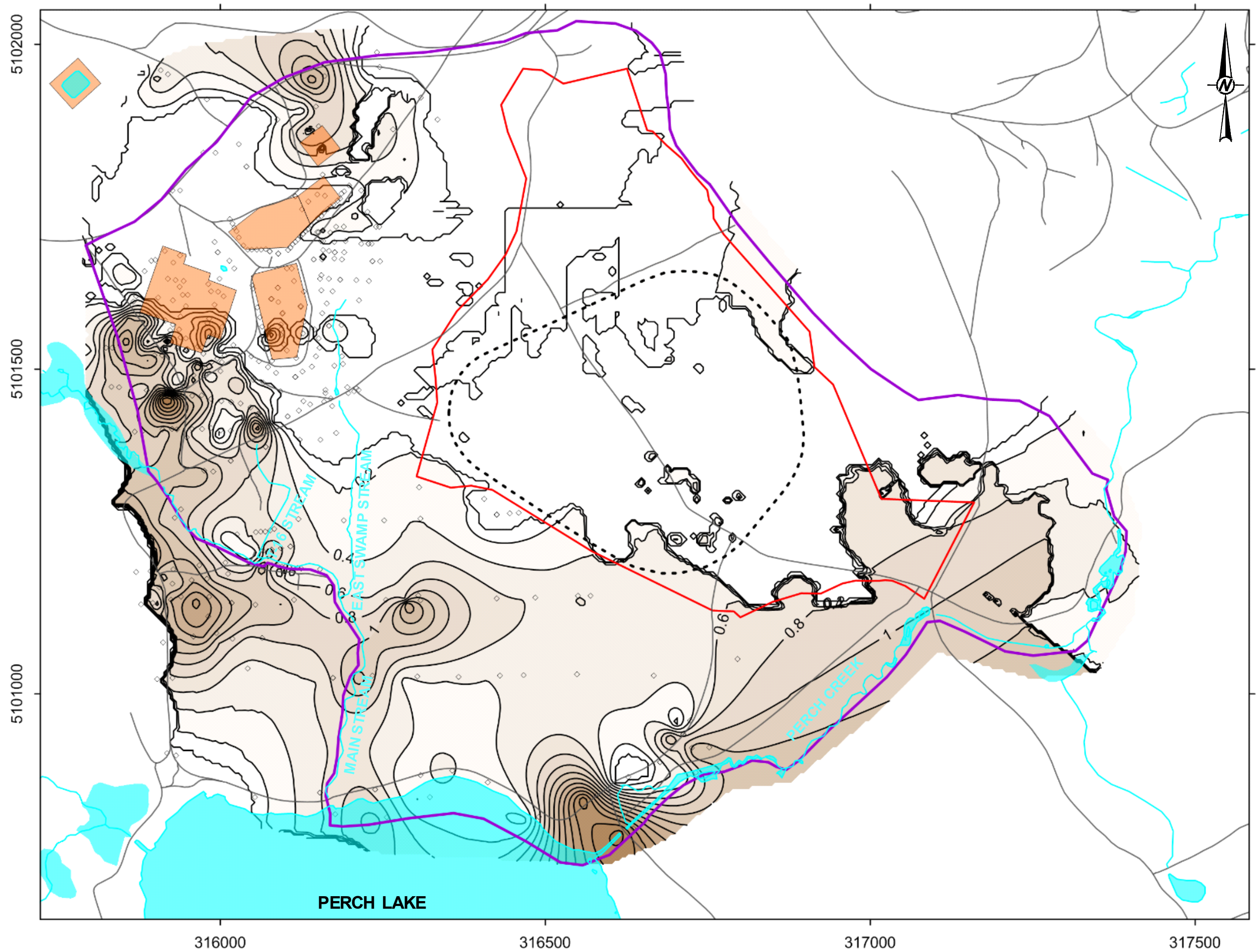
CONSULTANT

GOLDER

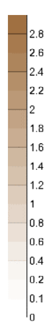
DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.1-12

REFERENCE(S)
1. PERCH LAKE SUB-BASINS OBTAINED FROM E. ROBERTSON & P.J. BARRY (1985) THE WATER AND ENERGY BALANCES OF PERCH LAKE (1969–1980), ATMOSPHERE-OCEAN, 23:3, 238-253, DOI: 10.1080/07055900.1985.96492270)



Interstratified Sand and Silt Thickness (m)



LEGEND

- Groundwater Model Boundary
- ECM Location
- Roads
- Site Study Area (NSDF Project Site)
- Stream
- Waterbody
- Waste Management Area
- Geological Surface Data Point
- Thickness Contour Lines (m)

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
ISOPACH MAP – AREAL EXTENT AND THICKNESS OF INTERSTRATIFIED SILT AND SAND UNIT FOR THE NSDF PROJECT SITE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.1-13

REFERENCE(S)
1. PERCH LAKE SUB-BASINS OBTAINED FROM E. ROBERTSON & P.J. BARRY (1985) THE WATER AND ENERGY BALANCES OF PERCH LAKE (1969–1980), ATMOSPHERE-OCEAN, 23:3, 238-253, DOI: 10.1080/07055900.1985.96492270)

Upper Sand

The upper sand unit is the uppermost sand unit in the Perch Lake Basin. The base of the upper sand unit is defined by either the top of the interstratified silt and sand unit, or by an inferred contact with the middle sand. The thickness of the upper sand unit is shown as an isopach map on Figure 5.3.1-14. The unit is thickest where the bedrock valley abuts the bedrock ridge that delineates the western boundary of the Perch Lake Basin. In this area, the unit can be up to 13 m thick. The upper sand unit is also locally thicker through an area extending from Plant Road, south through Reactor Pit 1 and Reactor Pit 2, then extending west through the southern portion of Waste Management Area A. In this area, the unit reaches thicknesses of up to 10 m. The upper sand unit is present in the SSA at a relatively uniform thickness of approximately 1 m. There is a localized area to the immediate southwest of the SSA where the upper sand thickness increases to approximately 5 m. In comparison to the middle sand, the upper sand is slightly coarser and better sorted (CNL 2016b).

Surficial Soils

The LSA is located in the Brent Ecodistrict in the Georgian Bay Ecoregion of the Ontario Shield Ecozone. Ecodistricts are subdivisions of the region that are based on patterns of relief, geology, geomorphology and substrate parent material (Crins et. al. 2009). A layer of leaf litter and organic silt (topsoil), 50 to 230 mm thick was encountered at the ground surface (Golder 2016). This material was generally a mixture of organic and mineral soil components. No purely organic soils were encountered during the 2016 geotechnical investigations (Golder 2016).

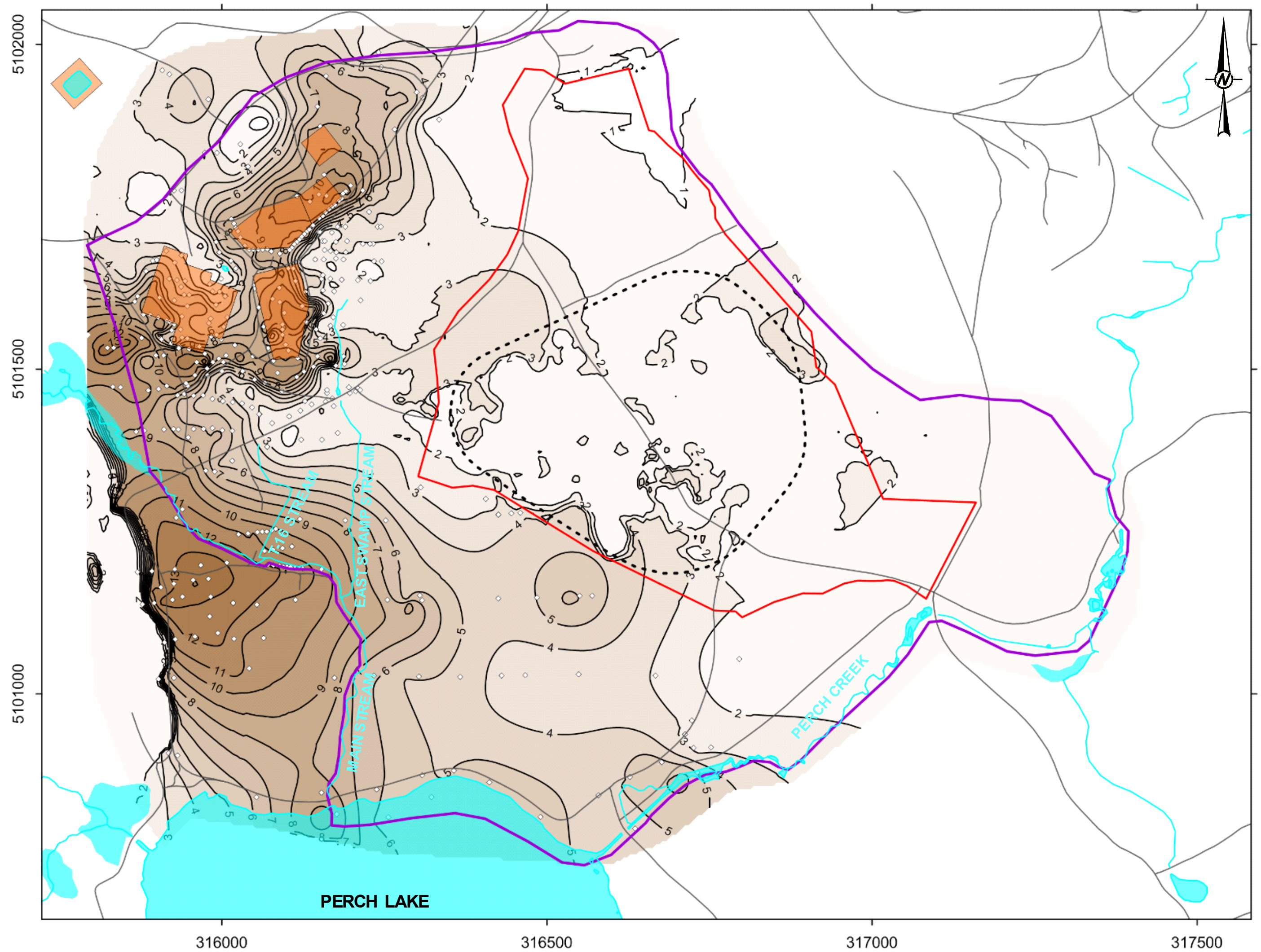
Soil substrates generally consist of well-drained sandy soils in the LSA. The coarse-grained parent materials have been derived from acidic gneissic and granitic rocks of the Precambrian shield and, as such, have aided in the development of Humo-ferric podzolic soils and to a lesser extent Melanic Brunisols (Gillespie et al. 1964). Organic peats and gleysols are found in poorly drained sites and depressions (Crins et al. 2009). The dominant soil substrates in the LSA are a thin layer of organic/gleysolic soils overlying well-drained sandy soils (Table 5.3.1-3 and Figure 5.3.1-15).

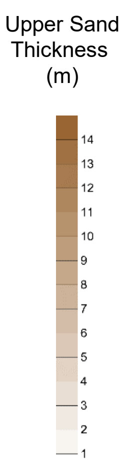
Table 5.3.1-3: Dominant Soil Orders in the Local Study Area

Dominant Soil Substrate	Area (ha)	Proportion (%)
Coarse Grained	54	31
Organic/Gleysolic	61	34
Water	41	23
Previously Disturbed	21	12
Total	**177**	**100**

Source: Gendron Resource Surveys Ltd. 1987; MNRF 2016.

Note: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values





LEGEND
- Groundwater Model Boundary
- ECM Location
- Roads
- Site Study Area (NSDF Project Site)
- Stream
- Waterbody
- Waste Management Area
- Geological Surface Data Point
- Thickness Contour Lines (m)

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
ISOPACH MAP – AREAL EXTENT AND THICKNESS OF UPPER SAND UNIT FOR THE NSDF PROJECT SITE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	**5.3.1-14**

REFERENCE(S)
1. PERCH LAKE SUB-BASINS OBTAINED FROM E. ROBERTSON & P.J. BARRY (1985) THE WATER AND ENERGY BALANCES OF PERCH LAKE (1969–1980), ATMOSPHERE-OCEAN, 23:3, 238-253, DOI: 10.1080/07055900.1985.96492270)

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- SITE STUDY AREA (NSDF PROJECT SITE)
- CRL SITE
- LOCAL STUDY AREA

DOMINANT SOIL ORDERS

- COARSE TEXTURED
- ORGANIC/GLEYSOL
- DISTURBED

250 0 250

1:10,000 METRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
DOMINANT SOIL ORDERS IN THE LOCAL STUDY AREA

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.1-15

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
25mm

S:\Clients\Canadian_Nuclear_Laboratories\NSDF\99_PROJ\1547525_NSDF_EIS\40_PROD\0009_EIS_Section_5\Section_5_3_Geology_Hydrogeology\1547525-0009-CH-0014.mxd

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Drainage ranges from well-drained, coarse-textured soils to poorly and very poorly drained organic soils in lower slope positions. Coarse-textured soils, with higher initial total porosity, are relatively resistant to compaction compared to finer textured soils found in other geographies (Carr et al. 1991); these soils are, however, prone to wind erosion. Sandy textured soils typically do not have a well-developed soil structure. The lack of soil structure is due to limited soil aggregation or adhesion of the soil particles and, therefore, does not form larger and more stable soil aggregates. Aggregated soil particles are less likely to be moved by wind. Soil erosion risk is a concern for disturbed soils because the sparse vegetation cover exposes soil materials to the elements (e.g., wind and water).

The NSDF Project site is an area of largely undeveloped land within the CRL site. Soil samples have been collected at 36 locations within the SSA and analyzed for radioactivity and metals. The soil analysis results concluded that the SSA does not contain radionuclide concentrations above local background levels (CNL 2017a). The analytical results for metals in surface soils at the SSA are below the provincial background values (Table 1, Residential / Parkland / Institutional / Commercial / Community Land Use [MECP 2019]) and are comparable to CRL site wide background values for soils (CNL 2018b).

Radiological contamination in the East Swamp wetland may be relevant to the NSDF Project, as this area is immediately west of the SSA. The East Swamp wetland has existing contamination associated with a shallow subsurface plume from the Chemical Pit, and a second plume from Reactor Pit 2. The surface contamination distribution in the East Swamp has been characterized with radiation field surveys, surface surveys and vegetation contamination surveys performed in 2002, 2007 and 2012. In 2002 and 2012, these surveys included wetland soil and vegetation sampling to determine the radionuclide concentrations in these media. These results are discussed in Section 5.7.4.7 Radioactivity in Soils.

5.3.1.5 Project Interactions and Mitigation

5.3.1.5.1 Methods

This section describes the process by which interactions between NSDF Project components and activities and geology were identified and evaluated. Potential effects pathways are identified, and mitigation developed to eliminate and/or reduce effects is presented. A pathways analysis is then used to focus the assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects will be adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects after incorporation of mitigation are further characterized in subsequent subsections of the assessment, as required. As such, the “Project Interactions and Mitigation” section helps to focus the remainder of the assessment on those interactions (effects pathways) likely to result in residual adverse effects.

The first part of the analysis was to identify the potential effects pathways for all phases of the NSDF Project. The next step in the analysis was the development of environmental design features and mitigation that could be incorporated into the NSDF Project to eliminate and/or reduce adverse effects to geology. Environmental design features included Project design elements, environmental best practices and management policies and procedures. Environmental design features and mitigation were developed through an iterative process between the Project’s engineering and environmental teams, combined with input from Project-specific or regional engagement with other interested parties. The environmental design features and/or mitigation were selected considering their effectiveness for implementation and maintenance and their appropriateness within the context of the identified effects pathways.

After incorporation of mitigation, potential pathways were evaluated into the following categories using scientific knowledge, logic, experience with similar developments and the effectiveness of environmental design features and mitigation:

- **No linkage:** The pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change relative to Base Case values and therefore would have no residual effects on geology.
- **Secondary pathway:** The pathway could result in a measurable minor environmental change, but would have a negligible residual effect on geology relative to Base Case and/or guideline values and is not expected to contribute cumulatively to other Project effects or to the effects of other previous, existing or reasonably foreseeable developments to cause a significant effect.
- **Primary pathway:** The pathway is likely to result in an environmental change relative to the Base Case and/or guideline values that could contribute to residual effects on geology.

Environmental design features and mitigation that have been or could be incorporated into the NSDF Project to eliminate and/or reduce adverse effects were considered. Potential pathways that were completely removed due to implementation of environmental design or mitigation were not assessed further. Pathways that were assessed to be secondary and demonstrated to have a negligible residual effect to geology through simple qualitative or semi-quantitative evaluation of the pathway were also not advanced for further assessment. Primary pathways were carried forward for more detailed quantitative and qualitative effects analysis to characterize the residual effects of the NSDF Project.

5.3.1.5.2 Results

Pathways through which all stages of the NSDF Project may interact with and result in changes to measurement indicators for geology are provided in Table 5.3.1-4.

Table 5.3.1-4: Pathways Analysis for Geology Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation	Pathway Assessment
■ Project activities during the construction phase: ▪ Site preparation ▪ Construction of the ECM ▪ Blasting (as required) ▪ Development of surface water management structures ▪ Construction of the WWTP and other support facilities ▪ On-site road and access development	■ Construction activities can alter soil quantity, quality and distribution. ■ Construction activities can alter geomorphology. ■ Construction activities (i.e., blasting) can locally alter physical properties of the bedrock	■ The SSA has been designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. ■ Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site (i.e., CNL's procedure for *Management of Land, Habitat and Wildlife* [CNL 2018c]) will be used during construction around disturbed areas, where appropriate. ■ Blasting activities will follow industry standard Best Management Practices and applicable federal regulations. Physical changes to the bedrock resulting from blasting (e.g., blast-induced fracturing) will be limited to the local area within the ECM footprint.	Secondary
	■ Blasting residuals and metals may be released during construction of the ECM, and surface water drainage features through the SSA may cause changes to soil quality.	■ Blasting activities will follow industry standard Best Management Practices and applicable federal regulations. ■ Additional guidance for the NSDF Project blasting limits will be obtained from *OPSS 120 – General Specification for the Use of Explosives* (OPSS 2014).	Secondary
	■ Storage and use of blasted rock in ECM berm construction may result in metal leaching and acid rock drainage	■ Blasting and use of excavated rock and ECM construction activities will follow industry standard Best Management Practices and applicable federal regulations. ■ ECM liner will extend to the berm crest thereby limiting infiltration through these materials. ■ Additional guidance for the NSDF Project blasting limits will be obtained from *OPSS 120 – General Specification for the Use of Explosives* (OPSS 2014).	Secondary

Table 5.3.1-4: Pathways Analysis for Geology Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation	Pathway Assessment

■ Project activities during the construction phase (as described above) and
  ■ Haulage of construction materials
■ Project activities during the operations phase:
  ■ On-site transportation of waste and placement in the ECM
  ■ Progressive closure of disposal cells and installation of final cover
  ■ Surface water management
  ■ Domestic waste (solid and liquid) management; and,
  ■ Routine operational management and monitoring activities.
	■ General activities that require the use of vehicles and equipment that combust fuel and emit criteria air contaminants. These activities involve material handling, vehicles travelling on paved and unpaved roads, and wind erosion of stockpiles that will result in fugitive dust emissions. Air and dust emissions and subsequent deposition may cause a change in soil quality.	■ Implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018d), which includes operational control monitoring, verification monitoring and environmental monitoring.
		■ The *Dust Management Plan* (AECOM 2018b) to be implemented for the NSDF Project includes measures for dust mitigation, such as:
		  ■ restricting or suspending activities if unacceptable amounts of dust are generated due to winds or other site conditions;
		  ■ use of water spraying or misting techniques (e.g., water trucks) as the primary dust control method;
		  ■ use of fixatives (e.g., chemical suppressant) for dust control and for use as daily ECM cover;
		  ■ suspension of excavating, loading, hauling and disposal operations when wind speeds exceed the specified criterion; and
		  ■ requirement that vehicles that have come into contact with contamination pass through the vehicle decontamination facility.
		■ On-site vehicles and equipment engines will meet Tier 2 emission standards and be maintained in good working order.
		■ Idling of vehicles on-site will be limited.
			Secondary

Table 5.3.1-4: Pathways Analysis for Geology Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation	Pathway Assessment
■ General Project activities during the construction and operations phases (as described above)	■ Surface water runoff from the CRL site can alter soil quantity, quality and distribution	■ Procedures for surface water management are being developed and implemented for the NSDF Project (CNL 2018e). ■ Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site (i.e., CNL's *Management of Land, Habitat and Wildlife* procedure [CNL 2018c] and NSDF *Environmental Protection Plan* [CNL 2018e]) will be used around disturbed areas, where appropriate. ■ The target surface water quality objective is provided in the *Stormwater Management Planning and Design Manual* (MOE 2003). ■ Surface water from all external areas will be conveyed by ditches, swales and culverts to surface water management ponds (SWMPs) to address water quality and water quantity criteria established for the wetland receiving waters and, ultimately, Perch Creek. ■ The SWMPs are designed to address erosion and sediment control concerns during construction by providing interim sediment control and by providing water quality/quantity controls during operations, closure and post-closure. ■ The current SWMP footprints reflect the overall storage required to control post-closure flows to predevelopment levels for the 2-year through to 100-year rainfall events at the site. This volume also contains the storage required for sediment control during construction and water quality control during operations.	No Linkage

Table 5.3.1-4: Pathways Analysis for Geology Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation	Pathway Assessment
■ Project activities during the operations and closure phases: ▪ Surface water management ▪ Operation of the WWTP	■ Leakage of leachate from the ECM during operations and closure may cause changes to groundwater quality, which can affect soil quality	■ Design of the ECM includes base contours that have been developed using a herringbone pattern with ridges and valleys to promote leachate transport to the leachate collection system for removal. ■ The base liner design includes both primary and secondary liner systems that are designed to have redundancy in case of premature failure and are a combination of natural and synthetic barrier systems. These include a compacted clay liner (CCL), two geosynthetic clay liners (GCL) and a high density polyethylene (HDPE) geomembrane. ■ Clay materials were selected for the CCL and GCL components of the liner system as these materials are anticipated to maintain their function as hydraulic barriers throughout and beyond the design life of the disposal facility (i.e., 550 years). ■ The HDPE geomembrane for the liner was selected as it is compatible with the leachate generated by the waste and achieves a long service life. ■ The base liner system includes an underlying compacted clay liner to supplement the primary and secondary liner systems. ■ The leachate collection and monitoring system design provides access points for monitoring, inspections, maintenance, repairs and replacements. ■ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water and groundwater quality.	No Linkage

Table 5.3.1-4: Pathways Analysis for Geology Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation	Pathway Assessment
■ Project activities during the closure and post-closure phases: ▪ Maintenance of fencing around perimeter of ECM ▪ Installation of final cover, restoration and grading of SSA ▪ On-going long-term performance monitoring, transfer of NSDF Project into Institutional Control	■ The installation of the final cover of the ECM and decommissioning and site grading of SSA can cause increased erosion and alter soil quality, quantity and distribution.	■ The final cover is designed to promote positive drainage from the SSA and reduce erosion or abrasion of the final cover. ■ Performance monitoring will be completed throughout the post-closure phase for the NSDF Project to confirm that the final cover is functioning as intended.	Secondary

ECM = engineered containment mound; WWTP = Wastewater Treatment lant; OPSS = Ontario Provincial Standard Specification; CNL = Canadian Nuclear Laboratories; CRL = Chalk River Laboratories; SWMP = surface water management pond; HDPE = high density polyethylene; SSA = site study area; MECP = Ministry of Environment, Conservation and Parks.

5.3.1.5.2.1 No Linkage Pathways

The following pathways were assessed as having no measurable environmental change and, hence, no linkage to residual effects on geology VCs.

- **Surface water runoff from the CRL site can alter soil quantity, quality and distribution.**

The surface water management ponds (SWMPs) are designed to address erosion and sediment control concerns during construction by providing interim sediment control and by providing water quality/quantity controls during operations, closure and post-closure. The current SWMP footprints reflect the overall storage required to control post-closure flows to predevelopment levels for the 2-year through 100-year rainfall events at the site. This volume also contains the storage required for sediment control during construction and water quality control during operations. The target surface water quality objective of 60% TSS removal that provides basic water quality treatment for discharge to the receiving wetland is provided in *Stormwater Management Planning and Design Manual* (MOE 2003). SWMP #1 will meet 80% TSS removal which will provide enhanced water quality treatment. SWMP #2 will provide 76% TSS removal and SWMP #3 will provide 60% TSS removal during operations, which will be sufficient because the receiving waterbody is a wetland and not a watercourse. The wetland functions as a sediment trap that will provide additional treatment prior to stormwater reaching any watercourses in wetlands.

During the construction phase, erosion and sediment control measures will be in place to mitigate the effects of soil erosion and sediment transport (CNL 2018e). The measures include the use of erosion control blankets, as needed, to control erosion on steep slopes, check dams in ditches and swales, and the three proposed SWMPs that will be constructed to serve as interim sediment control facilities during the construction phase and then as stormwater management facilities during the operations, closure and post-closure phase. Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site (i.e., CNL's *Management of Land, Habitat and Wildlife* procedure [CNL 2018c]) will be used around disturbed areas, where appropriate. An Environmental Management Plan will be developed as part of construction planning for the site to provide detailed erosion and sediment control measures and the SWMP construction schedule. The plan will include administrative protocols such as training, contractor document submissions and staffing required for effective surface water management throughout all phases of the NSDF Project.

Site operations include surface water management for the ECM and all external areas. Surface water from all external areas will be conveyed by ditches, swales and culverts to SWMPs that will address water quality and water quantity criteria established for the wetland receiving waters and, ultimately, Perch Creek. Contact water, which is exposed to waste within the ECM, will drain from the active cells of the ECM and be conveyed to the WWTP. Non-contact water drainage from completed cells and yet-to-be-completed cells will be directed either by gravity to the external surface water management system or to temporary holding ponds within the ECM, and then pumped to the three SWMPs.

Facility inspections will be completed twice annually and after major storm events to confirm that inlets and outlets are clear of debris and to confirm that there are no major erosion issues at the inlet or outlet. As well, the integrity of berms and outlet structures will be confirmed by visual inspections (e.g., to identify any animal burrowing activity or active soil erosion). Inspections will also include an annual sediment level monitoring component within each pond to identify sediment accumulation rates that may require clean-out requirements. If necessary, pond sediment will be extracted by excavation equipment and will be disposed of based on sediment sampling, testing and classification according to MECP standards, or stockpiled, dewatered and reused on site for the daily ECM cover operations. Sediment removal will follow procedures identified in the *Stormwater Management Planning and Design Manual* (MOE 2003).

Roadway, sidewalk and parking lot winter maintenance activities that may release road salt to the environment include snow plowing/shoveling and de-icing practices, salt and sand storage and snow stockpiling, removal and disposal. The current winter maintenance practices outlined in the *CRL Salt Management Plan* (AECL 2013) provide for effective management of salt use and will be applied to the NSDF Project, as necessary. As stated in the plan, the application of road salt on the CRL site will be limited as salt residual within contact water and/or leachate may compromise the treatment effectiveness of the WWTP systems. Instead, alternative products in winter road management, such as a sand-stone mixtures, are currently being considered.

Overall, the implementation of the above-mentioned mitigation will reduce the potential for changes to soil quality, quantity and distribution. As such, this pathway was determined to have no linkage to effects on geology.

- **Leakage of leachate from the ECM during the operations and closure phases may cause changes to groundwater quality, which can affect soil quality.**

Design of the ECM includes base contours that have been developed using a herringbone pattern with ridges and valleys to promote leachate transport to the leachate collection system for removal. The base liner design includes both primary and secondary liner systems that are designed to provide redundancy in case of premature failure and are a combination of natural and synthetic barrier systems. The primary liner includes a leachate collection system with the secondary liner housing a leak detection system. The primary and secondary liner systems each include a high density polyethylene (HDPE) geomembrane that is compatible with the leachate generated by the waste and is expected to perform as an effective hydraulic and diffusion barrier over the 550-year design life (see Section 3.4.1.4). The base liner system includes an underlying compacted clay liner to supplement the primary and secondary liner systems. The leachate collection system design provides access points for inspections, maintenance, repairs and replacements.

The primary liner system will contain the leachate collection system, and will convey leachate to a single collection point for removal from the mound, for transfer to the WWTP for treatment. The primary liner system serves as the primary source of protection for the natural environment below the mound from leachate migration. The secondary liner system will contain the leak detection system, which will be used to detect leaks in the unlikely event that the primary liner system fails. Leachate collected by the leachate collection system will be pumped to the on-site WWTP for treatment.

Perimeter berms consist of three main geotechnical elements, or layers, each contributing to the soundness and integrity of the berm itself and the whole ECM. A slope stability analysis was completed to provide the information needed to support the design of the base slopes, sidewalls and side slopes of the ECM. The slope stability analysis addresses the range of anticipated loading conditions, under both short-term and long-term scenarios, to confirm that the slope designs will satisfy minimum factor-of-safety requirements for stability. Size and shape of the berms and each of the elements and layers were determined using a seismic design basis, including the National Building Code of Canada (NBCC).

Overall, implementation of the above-mentioned mitigation will reduce the potential for changes to groundwater water quality from the SSA and thereby soil quality. As such, this pathway was determined to have no linkage to effects on geology.

5.3.1.5.2.2 Secondary Pathways

The following pathways were assessed as potentially having a measurable minor environmental change but resulting in a negligible residual effect on geology relative to the Base Case.

- **Construction activities can alter soil quantity, quality and distribution.**
- **Construction activities can alter geomorphology.**
- **The installation of the final cover of the ECM and closure and site grading of the SSA can cause increased erosion and alter soil quality, quantity and distribution.**

Changes to surface flows, water levels and water quality from NSDF Project construction and closure are expected to be limited using environmental design features and mitigation. The NSDF Project site was designed to be as small as possible to limit disturbance to the natural environment to the extent feasible and will avoid stream and wetland habitats. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. Excavation for the ECM, drainage ditches and the SWMPs will be completed once the SSA has been cleared and topsoil removed.

During the construction phase, erosion and sediment control measures will be in place to mitigate the effects of soil erosion and sediment transport. The measures include the use of erosion control blankets, as needed, to control erosion on steep slopes, check dams in ditches and swales, and the three SWMPs that will be constructed to serve as interim sediment control facilities during construction, and then as stormwater management facilities during the operations, closure and post-closure phases. Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site (i.e., CNL's *Management of Land, Habitat and Wildlife* procedure [CNL 2018c]) will be used around disturbed areas, where appropriate. Closure activities include the installation of a final cover over the ECM to limit ponding and water infiltration into the waste. Modification to the drainage ditches and conveyance channels will be made to promote positive drainage from the site and limit erosion or abrasion of the final cover. Runoff control for the final cover is designed to limit ponding and infiltration of water into the ECM, erosion of the final cover and waste material, and destabilization of the structure. The ECM design approach is to control the direction and velocity of the runoff to prevent erosion and abrasion of the final cover. Any surface water infiltrating the final cover will be collected by the leachate collection system and sent to the WWTP. The three SWMPs will remain to promote infiltration and settlement of suspended solids and restrict discharge rates to the nearby wetland. Decommissioning of the WWTP and all associated surface water management structures will be completed after the leachate quantity and quality no longer requires treatment. In the event that the WWTP is required beyond its design life, the unit would be refurbished to enable continued treatment of leachate or other treatment options investigated.

Environmental monitoring will be completed as required during the institutional control period for the NSDF Project to confirm that the final cover is functioning as intended. Overall, changes to soil quantity and quality from the NSDF CRL site, and changes to geomorphology from the closure activities was determined to have no residual effect on geology.

- **Construction activities (i.e., blasting) can locally alter physical properties of the bedrock.**

Blasting activities related to excavation of bedrock for construction of the ECM will result in localized physical changes to the bedrock (e.g., blast-induced fracturing), which will be limited to the local area within the ECM footprint. These have been considered as a part of the overall hydrogeological assessment (see Section 5.3.2).

- **Blasting residuals and metals may be released during construction of the ECM and surface water drainage features through the SSA may cause changes to soil quality.**

Use of explosives during the construction phase of the NSDF Project could cause changes in soil quality. Explosives have the potential to release nitrogen residual substances (e.g., ammonium nitrate/fuel oil). Blasting activities and the removal of waste rock could increase dust deposition and could increase trace metal (e.g., aluminum, cadmium, chromium, copper, iron, mercury and silver) concentrations and nitrogen residual substances.

The Blasting Plan will provide mitigation to limit the potential for effects on soil quality from fugitive dust generation through excavation and material transport. Additional guidance will be obtained from *OPSS 120 – General Specification for the Use of Explosives* (OPSS 2014). The anticipated quantities of blasted rock are approximately 170,000 m^3. An allowance will also be made for additional trench blasting that may be required to facilitate utility runs. It is anticipated that the majority of blasted rock will be recycled for use within the construction of the ECM. Rock that cannot be recycled for reuse will either be stored at the CRL site or cleared for off-site use. Any runoff in contact with blasting residues at the SSA will be managed where appropriate (e.g., SWMPs) during the construction phase to avoid adverse environmental effects off site. Consequently, change to soil quality from the use of explosives was determined to have a negligible residual effect on geology.

- **Storage and use of blasted rock may result in metal leaching and acid rock drainage**

Due to the stable nature of the bedrock constituent minerals it is anticipated that the potential generation of metal leaching, acid rock drainage and any potential adverse effects on water quality are negligible.

Bedrock in the vicinity of the NSDF is primarily comprised of quartzofeldspathic and dioritic gneiss. Mineralogically, the rocks are comprised of quartz, potassium and plagioclase feldspars, hornblende, clinopyroxene, biotite and garnet as major minerals (CNL 2016d). These minerals are generally considered to have low potential for acid rock drainage and leachability (Jambor et al. 2003, Jambor et al. 2002).

Iron sulphide minerals (e.g., pyrite, pyrrhotite), which would indicate potential for acid rock drainage, have been identified through previous studies as alteration minerals formed through low-temperature fracture infilling in deep bedrock boreholes at the CRL site. One occurrence of pyrite was noted in the logs of boreholes at the NSDF site (PH17-008) at a depth of approximately 14m, which is approximately 2 m deeper than the excavation horizon (CNL 2016d).

Given the relatively low occurrence of the sulphide minerals and the relative stability of the constituent minerals of the rock the potential for metal leaching and acid rock drainage is anticipated to be low.

The excavated rock is intended to be used as construction material for the berm around the perimeter of the ECM, situated above the water table. The interior portion of the berm (from the berm crest inwards) will be covered with a base liner and cover system that will limit infiltration through the material.

A Blasting Plan will be developed by the Construction Contractor after that contract has been awarded since it is required to be prepared by qualified individuals. The Blasting Plan will follow 'DFO Guidelines for the Use of

Explosives In or Near Canadian Fisheries Waters' (Wright and Hopky 1998) and Ontario Provincial Standard Specification (OPSS) in the document *OPSS 120 – General Specification for Use of Explosives* (OPS 2014), as well as standard best management practices to minimizing the transport of blasting residuals into downstream waterbodies. Although the Blasting Plan is not available at this phase of the NSDF Project, CNL has specified requirements in technical specifications to the Construction Contractor.

Therefore, based on the discussion above, this pathway was determined to have negligible residual effects on geology.

- **General activities that require the use of vehicles and equipment that combust fuel and emit criteria air contaminants (CACs). These activities involve material handling, vehicles travelling on paved and unpaved roads, and wind erosion of stockpiles that will result in fugitive dust emissions. Air and dust emissions and subsequent deposition may cause a change in soil quality.**

The construction and operations phases of the NSDF Project will generate air and dust emissions such as carbon monoxide, oxides of sulphur (includes sulphur dioxide), oxides of nitrogen (includes nitrogen dioxide), particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) and suspended particulate matter (SPM). Air emissions such as oxides of sulphur and oxides of nitrogen can result from the use of fossil fuels in generators, vehicles and machinery. Vehicle exhaust and fugitive dust from unpaved and paved roads is the largest contributor to particulate matter (SPM, PM_{10} and $PM_{2.5}$) during both the construction and operations phases (Section 5.2.1.6.2).

Implementation of mitigation measures are anticipated to limit predicted residual effects from NSDF Project emissions to air quality (and subsequently to aquatic biodiversity VCs) include: meeting Tier 2 emission standards for on-site vehicles and equipment engines, use of vehicles that are maintained in good working order and idling of vehicles on site will be limited consistent with CNL's Environmental Protection Program. Dust control will be conducted to support waste placement operations in accordance with the *Dust Management Plan* (AECOM 2018b) during loading, transportation, placement and compaction operations. Work areas that have the potential for generating dust will require implementation of dust suppression techniques. The primary dust control method will include water spraying or misting techniques (e.g., water trucks). Water application is controlled to avoid generation of free liquids. Fixatives (e.g., chemical suppressant) may also be used for dust control and for use as daily ECM cover. The use of fixatives is reviewed prior to application for potential effects on leachate and surface water runoff generated by the ECM.

Predicted concentrations for the Application Case during both construction and operations phases are below applicable air quality guidelines and/or standards with the exception of nitrogen dioxide, that will not meet the 2020 1-hour CAAQS (Section 5.2.1.6.2, Table 5.2.1-14). The contributing factor to the high magnitude nitrogen dioxide emissions is the heavy-duty construction equipment and the conservative assumption that all equipment will run simultaneously and continuously during working hours. In reality, individual equipment will be idling or off for varying parts of the workday that cannot be predicted but will result in lower emissions than currently estimated. The likelihood that all equipment operates simultaneously for an hour or more along with unfavourable weather conditions to produce the maximum concentrations modelled is very low. With the implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018d) and through the implementation of the *Dust Management Plan* (AECOM 2018b) for the NSDF Project, air and dust emissions and subsequent deposition are expected to result in minor and local changes to soil quality relative to Base Case conditions. Therefore, this pathway was determined to have negligible residual effects on geology.

5.3.1.5.2.3 Primary Pathways

No primary pathways were identified as having potential for residual effects on geology.

5.3.1.6 Monitoring and Follow-up

Monitoring and followup programs are not specifically identified for geology; rather, operational monitoring will be implemented to verify effects predictions for geology. For example, continued seismic and microseismic monitoring on the CRL site, and visual inspections of the SSA and surface water management systems will be completed to confirm erosion control measures are effective (AECOM 2018c).

5.3.1.7 Conclusions

VCs refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous peoples, the scientific community or the public (The Agency 2018). Geology, which includes bedrock, soils and geomorphology, is recognized as an important component of the environment that may be affected by the NSDF Project and changes to geology could, in turn, lead to effects on other VCs selected for assessment. Acknowledging that changes to geology are important aspects of the natural and human environment, geology is referred to as an intermediate component. Results of the analysis of changes in measurement indicators for geology are provided to other disciplines for inclusion in their assessment (Table 5.3.1-2).

Potential effects on geology are related to changes in soil quantity and quality and geomorphology as a result of construction of the NSDF Project, and changes to soil quality from blasting activities and air emissions. Mitigation and environmental design features implemented for the NSDF Project are well understood and include existing practices at the CRL site. For example, a Blasting Plan and the NSDF *Dust Management Plan* (AECOM 2018b) includes mitigation measures to limit the potential for effects on soil quality from fugitive dust generation through excavation and material transport. Consequently, residual effects on geology are predicted to be negligible as a result of the NSDF Project.

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5.3.2 Hydrogeology

5.3.2.1 Scope of the Assessment

This section focuses on hydrogeology and follows the overall environmental assessment approach and methods described in Section 5.1. The assessment was completed following the key steps listed below:

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries and assessment cases** for the hydrogeology assessment (refer to Sections 5.3.2.2 Valued Components and 5.3.2.3 Assessment Boundaries). The VCs and measurement indicators used to assess Project-related changes to hydrogeology are described, along with the spatial and temporal boundaries at which the assessment occurred and the assessment cases considered.
- **Step 2 – Describe the existing conditions** (refer to Section 5.3.2.4 Description of the Environment). Existing conditions in the local and regional areas are described, including the combined effects of previous and existing developments (Base Case). The existing environment represents the historical and current environmental pressures that have shaped the observed patterns in the environment (i.e., natural variation). The existing conditions provide a reference to which the effects of the NSDF Project can be compared.
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 5.3.2.5 Project Interactions and Mitigation). Project components and/or activities with the potential to affect hydrogeology are identified and mitigation developed to limit or avoid effects is presented. A pathways analysis is then used to focus further assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects are adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects to hydrogeology after incorporating mitigation are carried forward to Steps 4 for further analysis and residual effects characterization.
- **Step 4 – Present the methods and results of the residual effects analysis** (refer to Section 5.3.2.6 Residual Effects Analysis). This section outlines the methods used to predict and characterize residual effects to hydrogeology from primary effects pathways. The analysis results are also presented including the characterization of: (i) residual incremental effects of the NSDF Project and the effects of the Project in combination with previous and existing developments on hydrogeology (Application Case); and (ii) residual effects of the Project in combination with previous and existing developments, as well as other reasonably foreseeable developments (Reasonably Foreseeable Developments [RFD] Case). A key outcome of this section is the predicted effects to hydrogeology that are passed on to other VCs for inclusion in their assessment.
- **Step 5 – Describe the level of certainty and management of uncertainty** (refer to Section 5.3.2.7 Prediction Confidence and Uncertainty). Evaluate the available literature, data and models used for the assessment, and describe the level of certainty that can be placed on predicted residual effects. This section will also identify how the uncertainty has been managed so that the effects are not underestimated.
- **Step 6 – Classify and determine the significance of the predicted residual effects**. This step was not required as no primary pathways were identified in the hydrogeology assessment.

- **Step 7 – Identifying monitoring and follow-up** required to confirm effects predictions and address uncertainty (refer to Section 5.3.2.8 Monitoring and Follow-up).
- **Step 8 – Present a consolidated summary of conclusions and outcomes of the assessment** of residual effects on hydrogeology (refer to Section 5.3.2.9 Conclusions).

This section also describes how the input from engagement influenced the scope of the hydrogeology assessment. Information and areas of interest raised by the public, communities of interest, and Indigenous peoples during engagement are summarized in Table 5.3.2-1. Other general areas of interest and questions raised during the engagement that pertain to the hydrogeology assessment (if any) are documented in CNL's Indigenous Engagement Report (CNL 2020) and CNL's Stakeholder's Activity Reports (CNL 2017b,c, 2019a).

Table 5.3.2-1: Summary of Areas of Interest Raised During Engagement Activities that Influenced the Scope of the Hydrogeology Assessment

Area of Interest	How the Area of Interest Was Included in the Assessment
Potential for changes in groundwater quality to affect uses downstream of the ECM	Potential changes in groundwater quality from the NSDF Project were evaluated in the hydrogeology assessment and included potential changes from construction activities (e.g., erosion and blasting activities), changes from treated effluent discharge from the WWTP and leakage from the ECM during the post-closure phase following decommissioning of the WWTP.
Treatment of leachate and contaminated water	Leachate and contaminated water from the ECM will be collected and pumped to the WWTP for treatment prior to discharge.
Potential leakage of leachate from the ECM	Potential leakage of leachate from the ECM during operations will be mitigated through the design and implementation of a composite base liner system, a leachate detection system and a leak collection system. Potential leakage from the ECM during the operations and post-closure phases is considered in the hydrogeology assessment.
Long-term monitoring of groundwater	A conceptual long-term monitoring program for the NSDF Project as it relates to groundwater has been developed and is described in the hydrogeology assessment. A detailed groundwater monitoring program will be provided in the follow-up monitoring plan.

ECM = engineered containment mound; WWTP = Wastewater Treatment Plant.

5.3.2.2 Valued Components

Valued Components (VCs) refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous peoples, the scientific community or the public (The Agency 2018). Hydrogeology is recognized as an important component of the environment that may be affected by the NSDF Project and changes to hydrogeology could, in turn, lead to effects on other VCs selected for assessment. For example, changes to the characteristics of groundwater quality may have a large influence on surface water quality. Subsequently, changes to these characteristics by NSDF Project activities could affect the terrestrial and aquatic ecosystems structure and function, and human health including future use (e.g., human intrusion; Table 5.3.2-2).

Acknowledging that changes to groundwater quantity and quality are important aspects of the natural and human environment, hydrogeology is referred to as an intermediate component (i.e., it does not have an assessment endpoint). Changes to intermediate component VCs must be understood to facilitate assessment of project interactions. The hydrogeology assessment, therefore, is analyzed for incremental and cumulative (if applicable) changes in the relevant measurement indicators associated with hydrogeology (Table 5.3.2-3). The assessment of hydrogeology focused on predicting changes in the groundwater flow patterns, groundwater table elevations and concentrations of selected non-radiological substances. Radiological parameters are mainly considered in

Section 5.7 Ambient Radioactivity; however, some discussion of radiological parameters is provided in this section (i.e., Section 5.3.2). The changes are characterized in terms of magnitude, duration and geographic extent, but are not classified using rankings for effects criteria. The hydrogeology assessment does not include the assessment of the significance of these changes; rather, results of the analysis of changes in measurement indicators for hydrogeology are provided to other disciplines for inclusion in their assessment (Table 5.3.2-3).

Table 5.3.2-2: Valued Components for the Hydrogeology Assessment

Valued Component	Rationale for Selection
Groundwater quantity and quality	Characteristics of hydrogeology, such as groundwater quantity and quality are important components that interact with other VCs (e.g., hydrology and surface water quality) and if changed by NSDF Project activities, these characteristics could affect terrestrial and aquatic biodiversity, and human health including future use (e.g., human intrusion).

VC = valued component

Table 5.3.2-3: Assessment Endpoints and Measurement Indicators for the Hydrogeology Assessment

Valued Component	Measurement Indicators	Discipline Assessments where Effects on Hydrogeology are Considered
Groundwater quantity	■ Groundwater flow patterns and discharge rates ■ Groundwater table elevations	■ Section 5.4 Surface Water Environment ■ Section 5.5 Aquatic Environment ■ Section 5.6 Terrestrial Environment ■ Section 5.7 Ambient Radioactivity and Ecological Health ■ Section 5.8 Human Health
Groundwater quality	■ Groundwater quality with a focus on changes to the groundwater discharged to Perch Creek and Perch Lake Watershed	

5.3.2.3 Assessment Boundaries

5.3.2.3.1 Spatial Boundaries

The spatial boundaries selected for the hydrogeology assessment are the same as those defined for geology (see Section 5.3.1.3.1 and Figure 5.3.1-1).

5.3.2.3.2 Temporal Boundaries

Temporal boundaries (i.e., project phases) establish the timeframe during which NSDF Project effects are assessed. The phases identified for the NSDF Project are described in Section 5.3.1.3.2. The temporal boundary of the hydrogeology assessment considers all phases of the NSDF Project.

5.3.2.3.3 Assessment Cases

The assessment cases defined for the hydrogeology assessment are the same as those defined for geology (see Section 5.3.1.3.3). Similar to the geology assessment, the hydrogeology assessment includes the Base Case and Application Case.

An RFD Case is not presented as part of this assessment because RFDs will either have no spatial overlap or are likely to positively affect hydrogeology. New support infrastructure, research and development facilities and the proposed small modular reactor (SMR) are planned within areas of the CRL site outside of the SSA and generally within existing disturbed areas. Best practices, such as storm water management systems and waste management programs, are expected to be implemented to minimize any potential effects to hydrogeology during construction or operation of these facilities, including groundwater flow or quality. No process water intakes from or discharges to surface or groundwater are identified in the description of the planned SMR (Global First Power 2019). As such, potential effects from the construction and operation of the SMR or revitalization activities are not expected to spatially overlap with potential effects to hydrogeology from the NSDF Project. The end-state plan for the CRL site will be to return lands disturbed by site activities to a condition that is physically stable and safe in keeping with the land use and landscape of the day. Therefore, decommissioning and environmental remediation activities are anticipated to positively affect measurement indicators for hydrogeology such as groundwater quality.

There are no potable water wells anticipated to be installed within the Regional Study Area (RSA) during the time up to the end of the post-closure phase. However, a Human Intrusion Scenario assuming a borehole is drilled into the ECM during the post-closure phase has been evaluated in Section 5.8 Human Health.

5.3.2.4 Description of the Environment

5.3.2.4.1 Methods

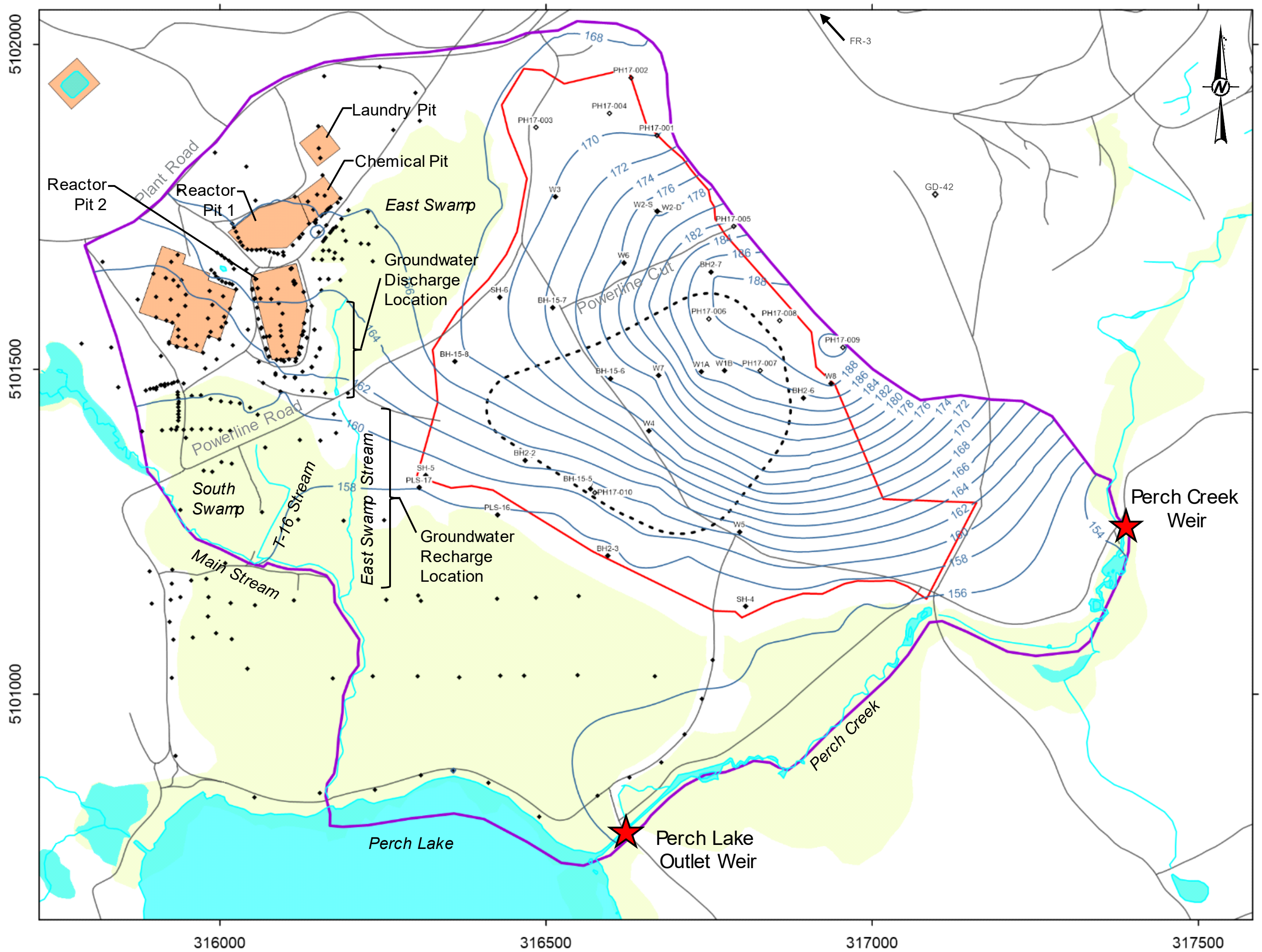
Base Case hydrogeological data were collected from the review of the following reports:

- *Subsurface Geotechnical Survey of the Proposed Near Surface Disposal Facility at Chalk River Laboratories* (Golder 2016);
- *Multidisciplinary Subsurface Investigation, Phase 1*, (AMEC 2017a);
- *Multidisciplinary Subsurface Investigation, Phase 2* (AMEC 2017b);
- *Multidisciplinary Subsurface Investigation, Phase 4* (AMEC 2018a);
- *Hydraulic Conductivity (Slug Test) Results for PH17-001 to PH17-010, Canadian Nuclear Laboratories, Chalk River* (Wood 2018)
- *Wood Geotechnical Investigation (Ring Road for Effluent to Perch Lake* (Wood 2019)
- *Radiological Contamination in the South Swamp, 1997 to 2011* (CNL 2015b);
- *Radiological Contamination in the East Swamp, 2002 to 2012* (CNL 2015c);
- *Subsurface Radionuclide Migration from the Chemical Pit* (AECL 2014);
- *Chalk River Laboratories Groundwater Monitoring Program Annual Report for 2017* (CNL 2019b);
- *Contaminant Migration from Reactor Pit 2* (CNL 2016b);
- *Baseline Groundwater Quality in the Vicinity of the Proposed NSDF Project site* (CNL 2017d); and
- *Hydrographs – October 2016 to June 2018* (AMEC 2018b).

The Groundwater Monitoring Program (GWMP) at the CRL site includes annual and semi-annual water level measurements, and sampling and analysis from 180 monitoring wells or boreholes at 32 sites. These wells or boreholes are referred to by borehole ID, which typically includes a study location (e.g., PLS = Perch Lake Series) and borehole number. All locations referred to in the text are indicated on Figure 5.3.2-1A. Many of the GWMP monitoring locations are at the perimeters of various operating areas, and the objective of the program is to monitor the behavior and condition of the facilities. The data from this monitoring program is reported annually (CNL 2019b). These data provide operational feedback on the conditions and behaviour of facilities, including the performance of existing remedial measures (e.g., infiltration barriers). The GWMP includes wells that are upgradient of the monitored areas, in order to provide reference values. Where groundwater contamination is present downgradient of these facilities, this routine monitoring is augmented by periodic detailed evaluations of subsurface contaminants. Contaminant migration (i.e., plume) reports such as AECL (2014) and CNL (2016a) are updated on 5- and 10-year cycles based on data collected as part of the annual program and supplementary investigations.

Hydrogeological investigations to support the NSDF Project by Golder (2016) and AMEC (2017a,b, 2018a) have included in-situ permeability/hydraulic conductivity testing, groundwater sampling and groundwater elevation measurements at the wells noted in Section 5.3.1.4.1.

A water table elevation map throughout the lower Perch Lake Basin, which includes the SSA, is shown on Figure 5.3.2-1A for average water table conditions. For monitoring wells within the SSA, groundwater levels observed in January 2017 were used to infer the water table elevation. For monitoring wells outside of the SSA the average of historical groundwater elevation (from 1982 to 2017) at each monitoring well was calculated and used to infer a water table elevation.



LEGEND

- Groundwater Model Boundary
- Roads
- ECM Location
- Site Study Area (NSDF Project Site)
- Stream
- Waste Management Area
- Groundwater Table Data Point
- Swamp

REFERENCE(S)
1. PERCH LAKE SUB-BASINS OBTAINED FROM E. ROBERTSON & P.J. BARRY (1985) THE WATER AND ENERGY BALANCES OF PERCH LAKE (1969–1980), ATMOSPHERE-OCEAN, 23:3, 238-253, DOI: 10.1080/07055900.1985.96492270)

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
AVERAGE GROUNDWATER TABLE ELEVATION MAP

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.2-1A

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Path: S:\Clients\Canadian_Nuclear_Laboratories\NSDF\99_PROJ\1547525_NSDF_EIS\40_PROD\0009_EIS_Section_5\Section_5.3_Geology_Hydrogeology\1547525-0009-CH-0029.mxd

5.3.2.4.2 Results

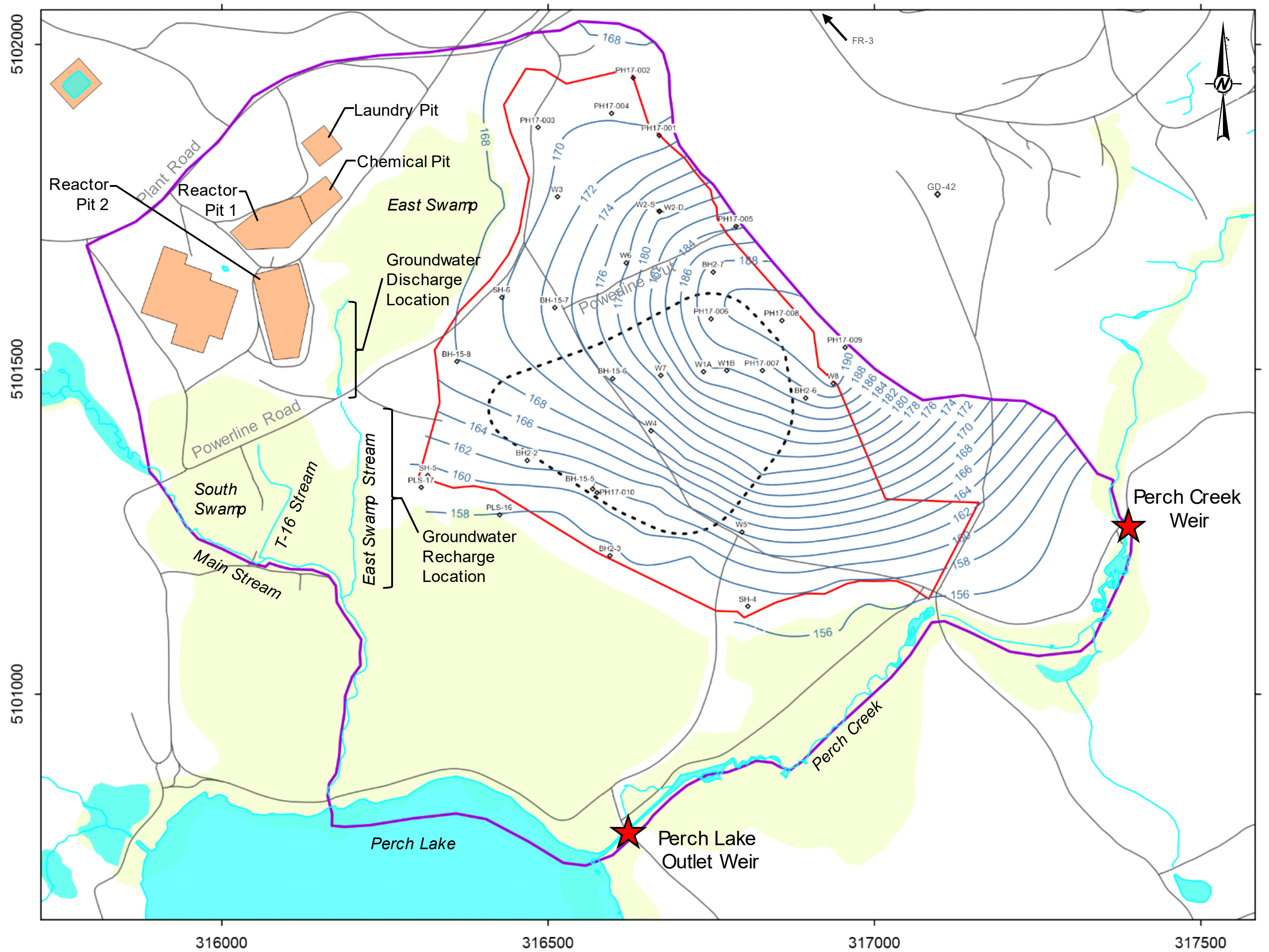
5.3.2.4.2.1 Groundwater Flow

The average water table elevation within the SSA, and throughout the lower Perch Lake Basin (the domain of the groundwater model) is shown on Figure 5.3.2-1A. Elevation contours were generated based on historical information and from data collections between October 2016 and June 2018 at the SSA (AMEC 2017b, 2018a). The seasonal high water table elevation within the SSA is shown on Figure 5.3.2-1B. The high water table elevation contours were generated based on the maximum groundwater elevation from the transducer records collected by AMEC between October 2016 and June 2018. On average, the maximum value from the transducer record was 1.2 m above the average values and approximately 3 m above the minimum value. The high water table position occurred in April or May at most locations. Elsewhere within the Perch Lake Basin the water table elevation is expected to vary seasonally by 1 to 2 m (depending on location), with the high water table position occurring in April and May (CNL 2016b). The length of transducer records varies at individual wells, depending on the date of installation. For the most recent installations the transducer records span a period of approximately 6 months. Figure 5.3.2-1C provides a “snapshot” of the seasonal high water table elevation from April 26, 2018 when the most recent seasonal high elevation was measured for most wells. A comparison of Figures 5.3.2-1B and 5.3.2-1C shows that the groundwater elevations and flow directions are similar for the absolute maximum and snapshot readings (April 26, 2018). Hydrographs of the transducer data are included in Appendix 5.3-1.

Within the lower Perch Lake Basin, groundwater flow within the overburden is influenced by local topography (and bedrock topography) and is interpreted to be primarily horizontal (CNL 2016b). In the overburden deposits, groundwater flow occurs mainly within the basal sand and gravel, middle sand and upper sand units, where present (CNL 2016b). As the silty clay and interstratified silt and sand units that separate these aquifers are not continuous throughout the valley, groundwater elevations, groundwater flow directions and horizontal hydraulic gradients are not differentiated between units. The available data includes monitoring wells located at the peak of the bedrock ridge to the northeast (e.g., W8, PH17-005, PH17-008, PH17-009, BH2-6). Data from these locations indicate the presence of a northeast to southwest groundwater divide corresponding to the topographic high along the ridge. Hydrogeological mapping of the CRL site completed by Raven Beck (1994) also infers the presence of a groundwater divide along this ridge.

The water table depth within the SSA was calculated based on average groundwater elevation data collected by transducer between October 2016 and June 2018 (AMEC 2018a). Average groundwater depths ranged from 0.06 metres below ground surface (mbgs; at monitoring well SH-4) to 15.95 mbgs (at monitoring well PH17-001). The seasonal high water table elevations range from 0.26 meters above ground surface (at W-4) to 15.43 mbgs (at PH17-001). The average water table depth across the SSA was 4.81 mbgs under average conditions and 3.61 mbgs under seasonal high water table conditions. Depth to the water table is generally greatest near the top of the bedrock ridge, and decreases to the south, west and north, towards the low-lying wetland areas. Cross-sections through the ECM (AECOM 2017) were used to compare the interpreted water table surface (based on January 2017 and May 2017 water level measurements) against ground surface and bedrock topography (see Figures 5.3.2-2A through 5.3.2-2C). Figure 5.3.2-2D provides a simulated water table for post-closure. The water table elevation generally follows topography. The water table elevation was higher in May 2017 compared to January 2017 in the upper portions of the ECM (to the east of East Mattawa Road), with increases of up to 6 m occurring in bedrock monitoring wells located in areas of high elevation (e.g., W-8, W-7). Increases in groundwater elevation at these monitoring wells occurred during thaw and precipitation events in the spring. Variability in groundwater elevations in monitoring wells located near the low-lying areas (i.e., in close proximity to East Swamp and Perch Lake Swamp) was generally within 1 m to 2 m. It should be noted that installation of the ECM will limit local recharge to the water table, resulting in a lowering of the water table elevation beneath the facility. The reduction in water table elevation was assessed as a part of numerical modelling (Golder 2019b). Additionally, the bedrock beneath the ECM will undergo blasting as a part of ECM construction activities, which is anticipated to result in localized increases to hydraulic conductivity of the bedrock (Golder 2019b).

Within the SSA, groundwater flow to the northwest of the ECM footprint is generally to the northwest towards the East Swamp (see Figure 5.3.2-1A). In this area hydraulic gradients are low, and minor variations in groundwater elevations can result in a component of groundwater flow towards the northeast for the northernmost portion of the NSDF study area. Based on the transducer records from the PH-series monitoring wells, these reversals in groundwater flow direction are sustained for a period of less than a month. Groundwater flow within the ECM footprint is generally to the southwest and south towards the Perch Lake Swamp and Perch Creek. In the operations areas adjacent to the SSA, groundwater flow from Waste Management Area A and Reactor Pit 2 is generally to the south and southwest towards the South Swamp, while groundwater flow from the Chemical Pit is generally to the southeast towards the East Swamp. Within the southern portion of the Perch Lake Basin, groundwater flow is generally towards Perch Lake and Perch Creek.



LEGEND

- Groundwater Model Boundary
- Roads
- ECM Location
- Site Study Area (NSDF Project Site)
- Stream
- Waste Management Area
- Groundwater Table Data Point
- Swamp

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PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
HIGH GROUNDWATER TABLE ELEVATION MAP

CONSULTANT
GOLDER

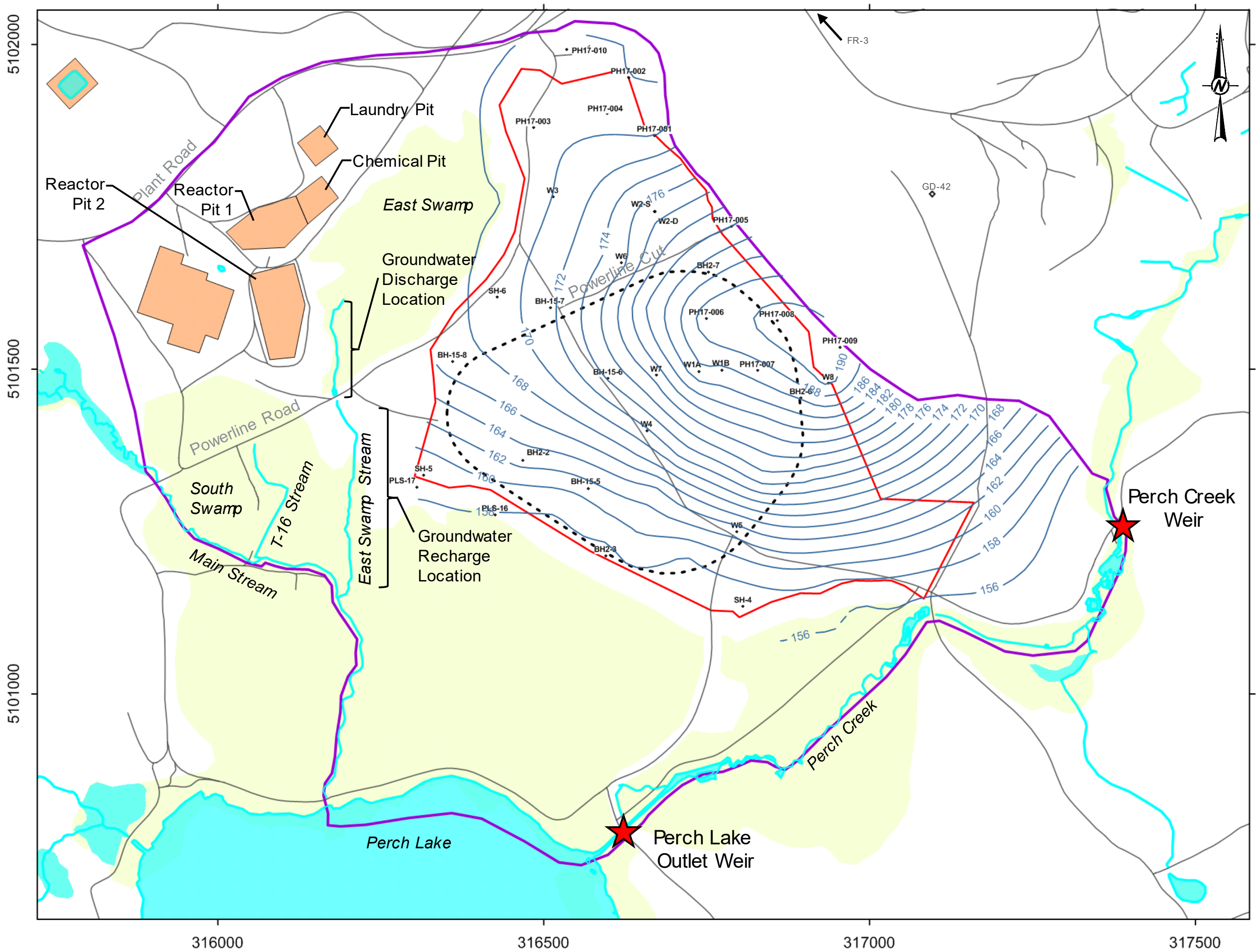
DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.2-1B

NOTE(S)
1. FOR THE NSDF-AREA WELLS MAXIMUM GROUNDWATER ELEVATIONS WERE CALCULATED FOR THE PERIOD OF RECORD OF THE AVAILABLE TRANSDUCER DATA, INCLUDING DATA TO JUNE 2018. PERIODS OF RECORD VARIED BETWEEN TRANSDUCERS.

REFERENCE(S)

1. PERCH LAKE SUB-BASINS OBTAINED FROM E. ROBERTSON & P.J. BARRY (1985) THE WATER AND ENERGY BALANCES OF PERCH LAKE (1969–1980), ATMOSPHERE-OCEAN, 23:3, 238-253, DOI: 10.1080/07055900.1985.96492270)



LEGEND

- Groundwater Model Boundary
- Roads
- ECM Location
- Site Study Area (NSDF Project Site)
- Stream
- Waste Management Area
- Groundwater Table Data Point
- Swamp

NOTE(S)

1. FOR THE NSDF-AREA WELLS GROUNDWATER ELEVATIONS WERE BASED OFF OF THE CLOSEST TRANSDUCER READING TO APRIL 26, 2018 AT 12:00 PM FOR EACH MONITORING WELL, WHICH GENERALLY CORRESPONDS TO THE MOST RECENT GROUNDWATER ELEVATION MAXIMUM.

REFERENCE(S)

1. PERCH LAKE SUB-BASINS OBTAINED FROM E. ROBERTSON & P.J. BARRY (1985) THE WATER AND ENERGY BALANCES OF PERCH LAKE (1969–1980), ATMOSPHERE-OCEAN, 23:3, 238-253, DOI: 10.1080/07055900.1985.96492270)

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PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
GROUNDWATER TABLE ELEVATION MAP
APRIL 26, 2018

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
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REVIEWED	CS
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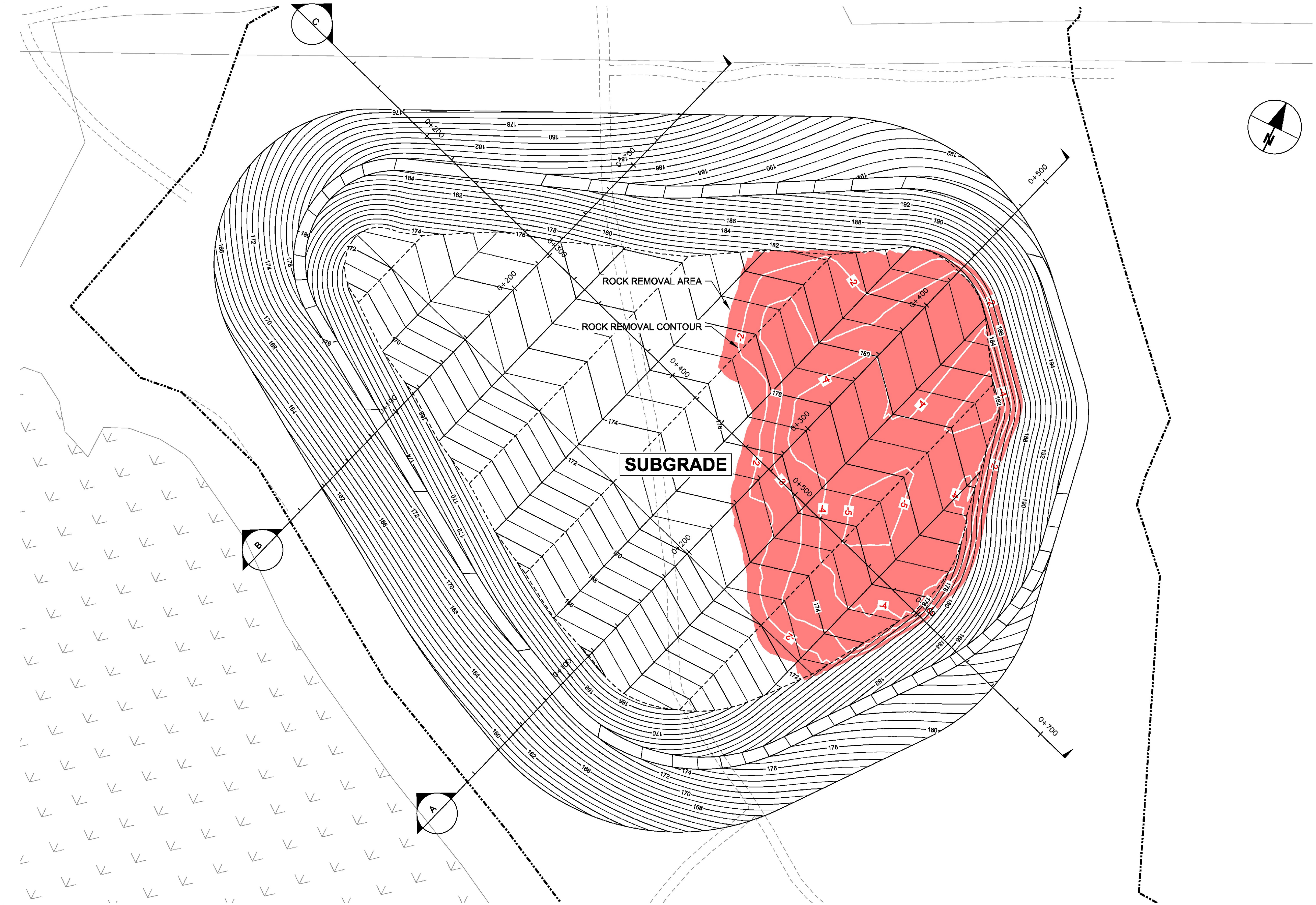
PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.2-1C



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NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

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REVIEW	CS
APPROVED	AB

TITLE
ECM PLAN AND CROSS-SECTIONS

PROJECT NO.	PHASE	REV.	FIGURE
1547525	0009	FINAL 2	**5.3.2-2A**

REFERENCES
AECOM, 2017.

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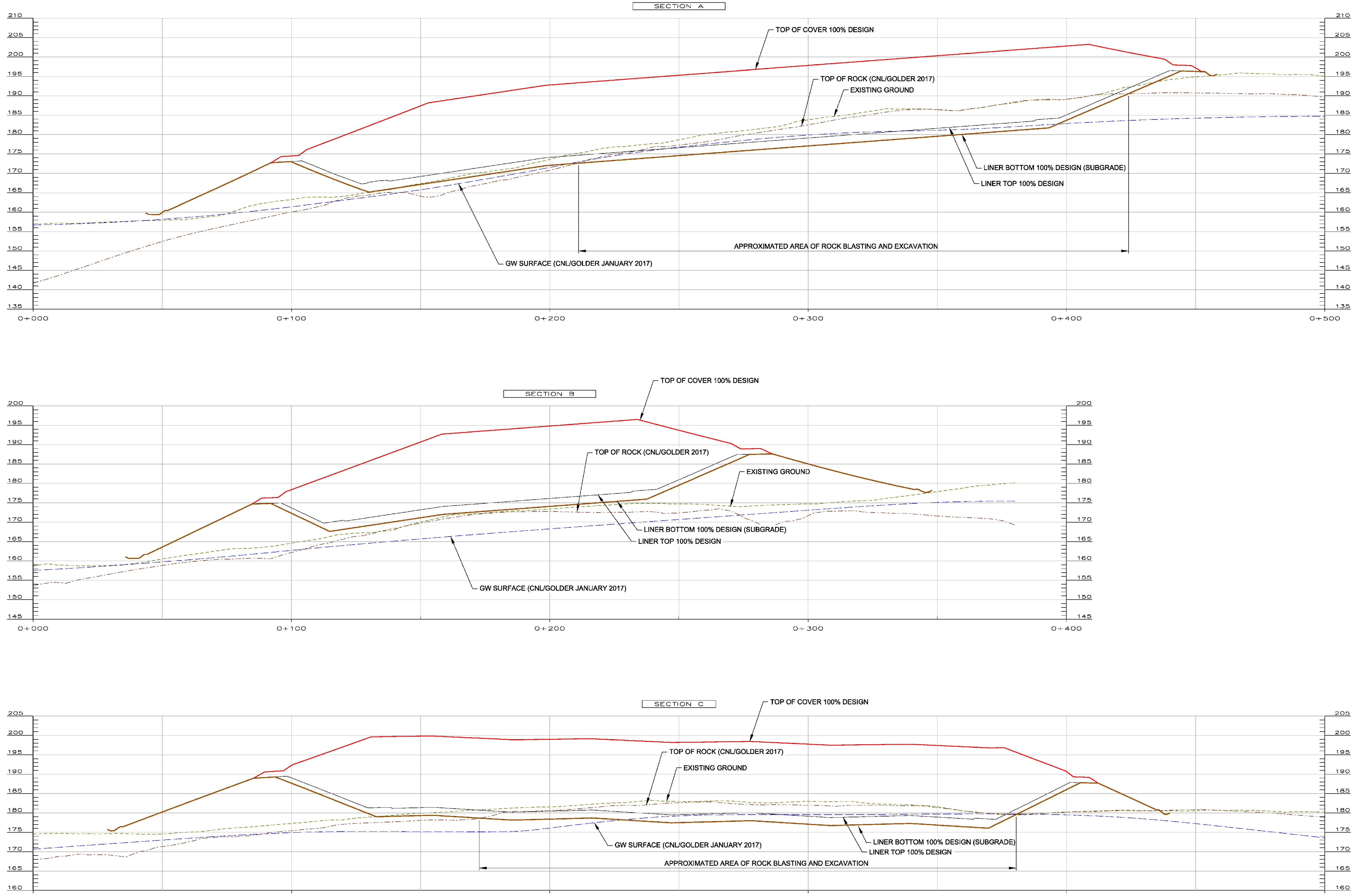

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PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
ECM PLAN AND CROSS-SECTIONS

PROJECT NO.	PHASE	REV.	FIGURE
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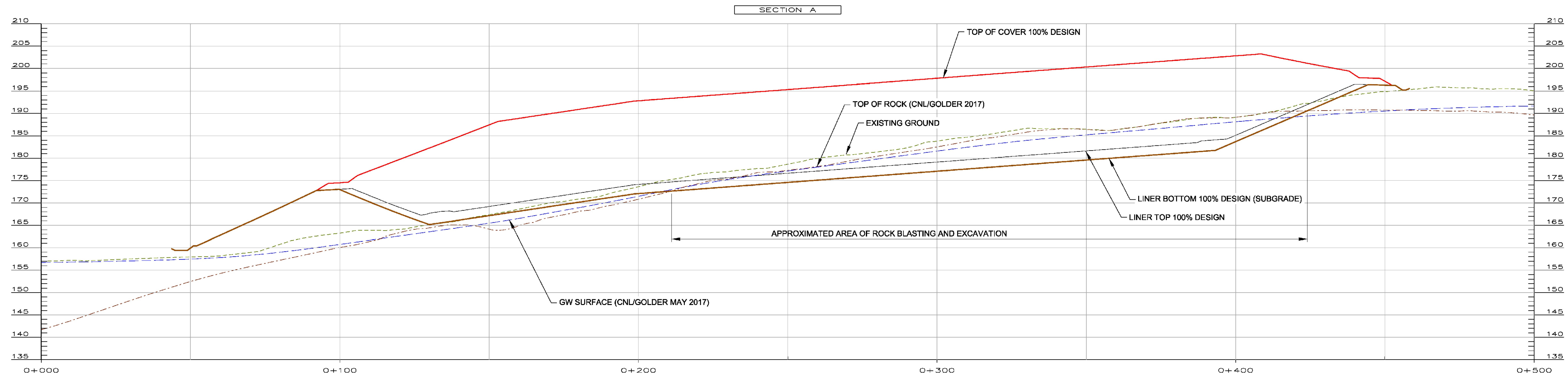

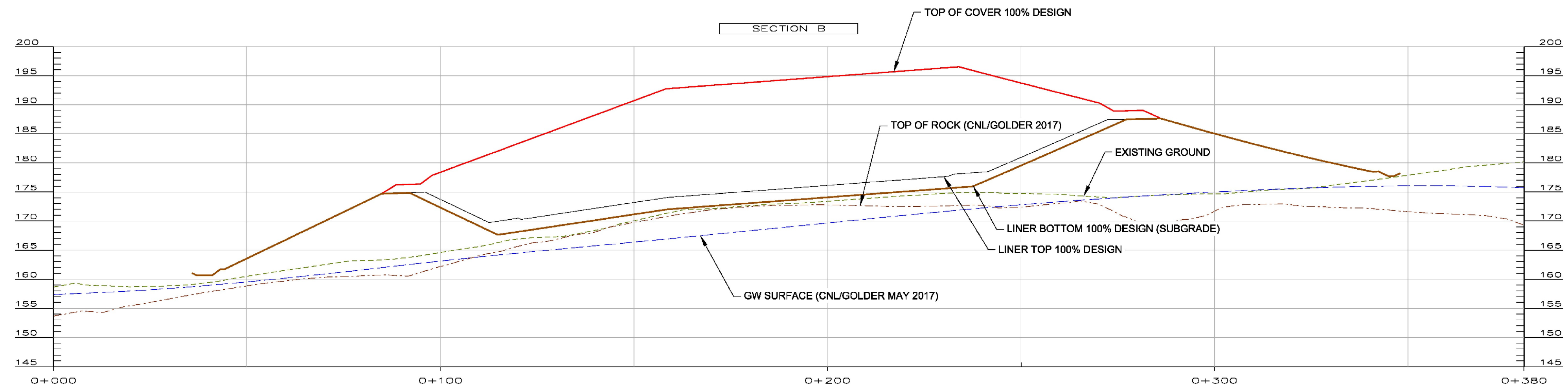

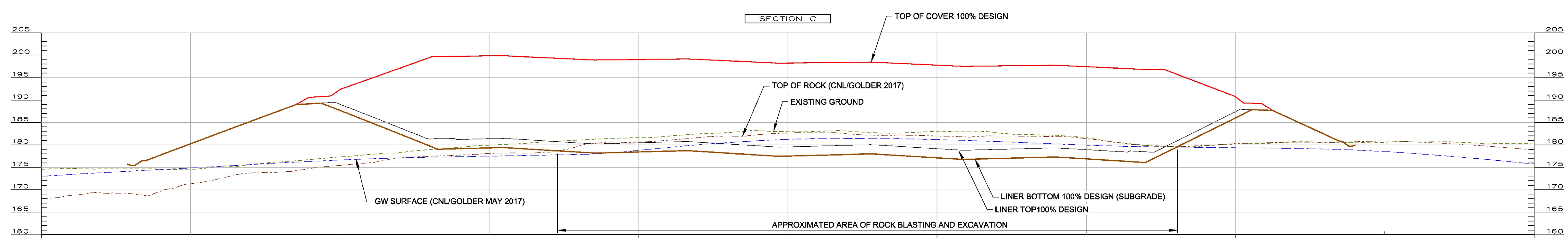

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PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
ECM PLAN AND CROSS-SECTIONS

PROJECT NO.	PHASE	REV.	FIGURE
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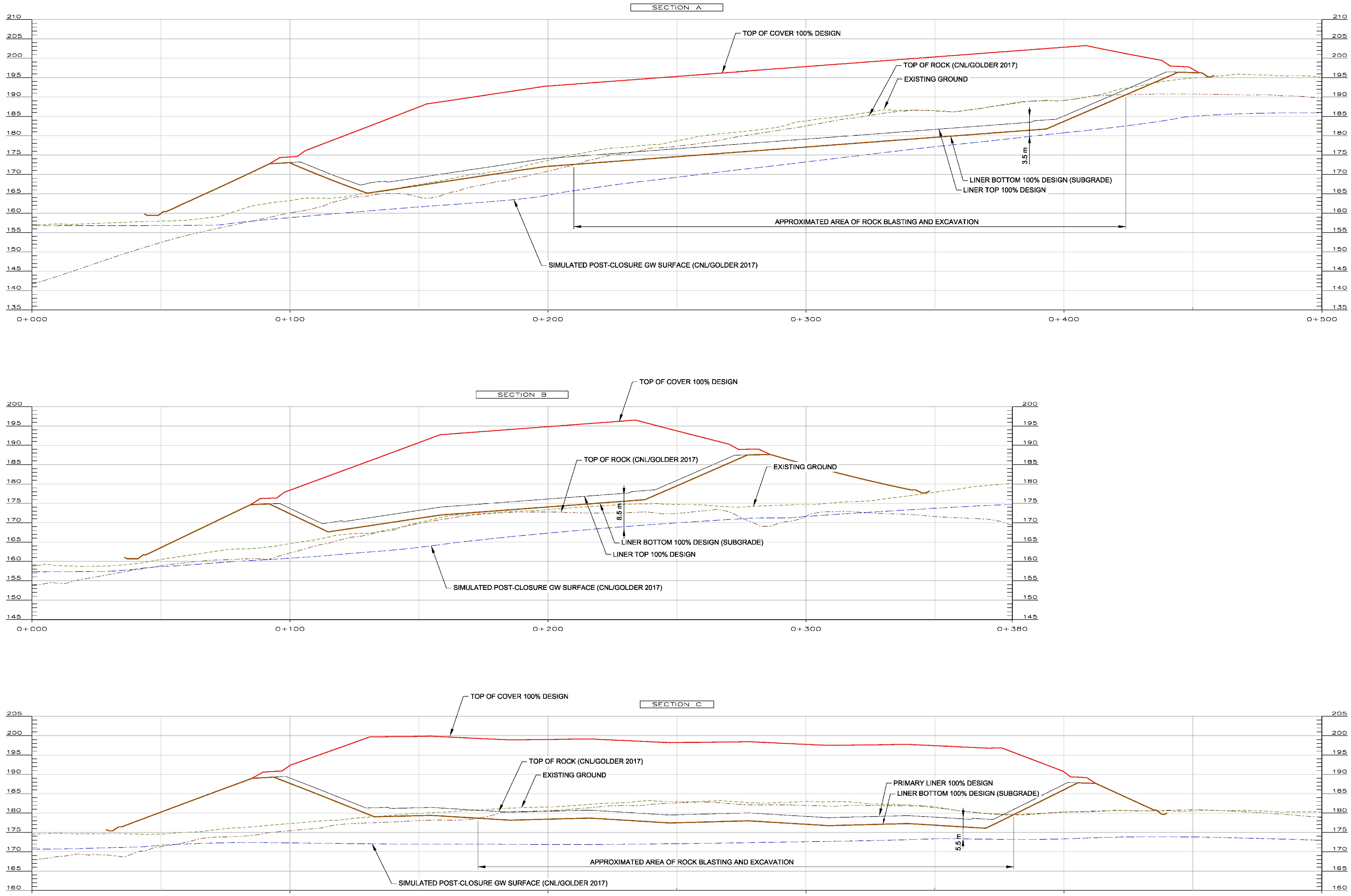

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REFERENCES
AECOM, 2017.

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REVIEW	CS
APPROVED	AB

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
ECM PLAN AND CROSS-SECTIONS

PROJECT NO.	PHASE	REV.	FIGURE
1547525	0009	FINAL 2	5.3.2-2D

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Hydraulic Gradients

Horizontal hydraulic gradients within the SSA were calculated based on average groundwater levels collected by AMEC between October 2016 and June 2018 (AMEC 2018a,b) and the groundwater elevation mapping shown on Figure 5.3.2-1A. The horizontal hydraulic gradient within the overburden in the northern portion the SSA was approximately 0.04 metres per metre (m/m) to the northwest (between monitoring wells W2-S and PH17-003). In the southern portion of the SSA the horizontal hydraulic gradient is approximately 0.05 m/m to the southwest in the overburden between monitoring wells BH-15-8 and SH-5 and approximately 0.07 m/m to the southwest in the bedrock between monitoring wells W4 and BH2-3.

Under high water table conditions (as shown on Figure 5.3.2-1B) the horizontal hydraulic gradient within the overburden in the northern portion of the SSA is increased to approximately 0.05 m/m to the northwest (between W2-S and PH17-003). In the southern portion of the SSA the horizontal hydraulic gradient to the southwest in the overburden (between BH15-8 and SH-5) is 0.05 m/m (unchanged from average conditions), while the horizontal hydraulic gradient to the southwest in the bedrock (between W4 and BH2-3) is increased to 0.09 m/m.

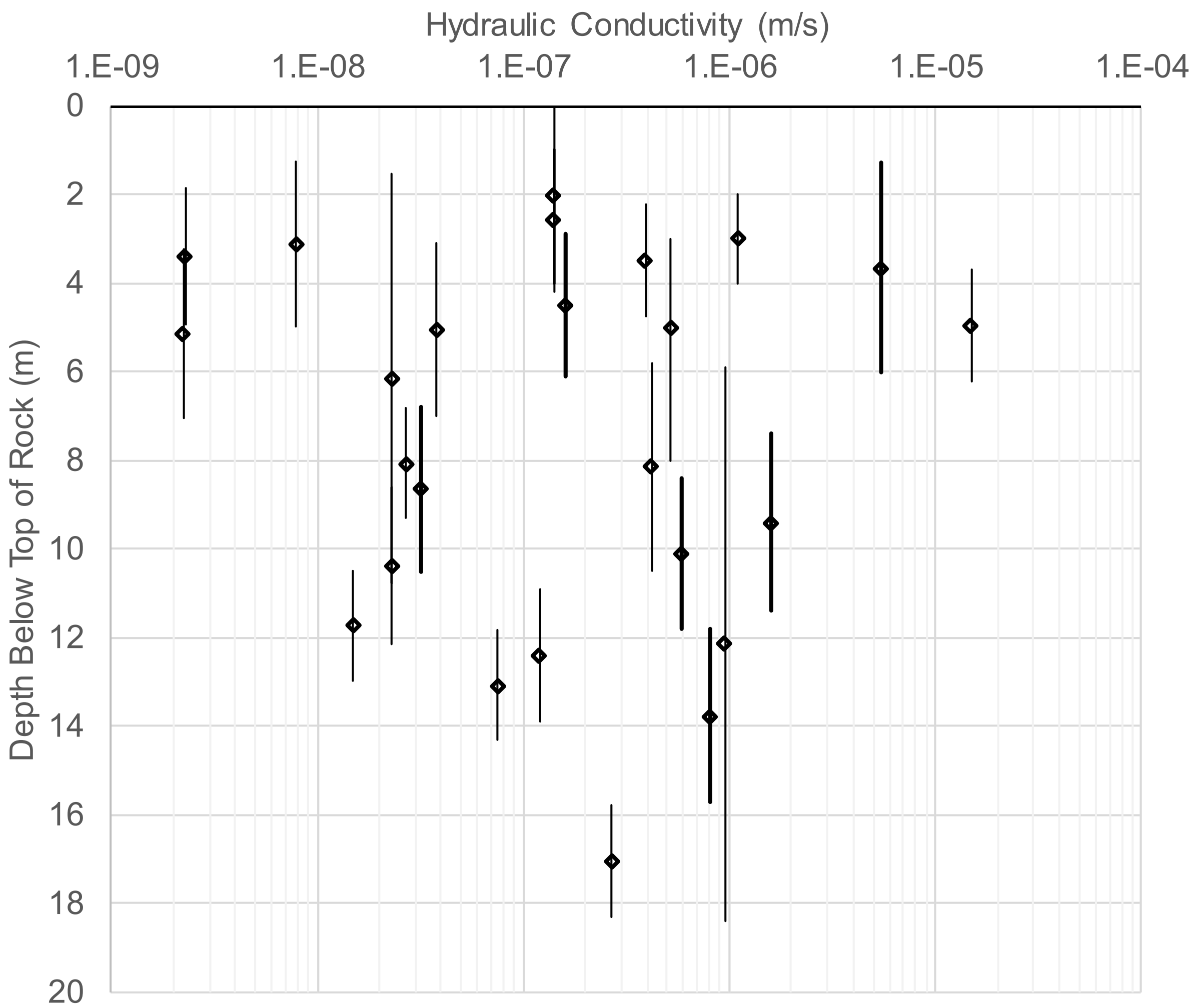
Vertical hydraulic gradients between the overburden and the bedrock were calculated for monitoring well pairs W2-S/D and BH2-2S/D based on groundwater elevation data collected in between December 2017 and June 2018 (AMEC 2017b, 2018a). At W2-S/D downward vertical gradients of 0.13 m/m and 0.16 m/m under average and high water table conditions respectively, from the overburden to the bedrock was calculated, indicating recharging conditions at the topographic high. At BH2-2S/D a downward gradient of 0.03 m/m was calculated under average water table conditions. A very slight upward gradient of 0.006 m/m was calculated at this location under high water table conditions. From June 2017 to December 2017, vertical gradients at BH2-S/D were predominately downwards, while vertical gradients at this location were predominately upwards between December 2017 and June 2018.

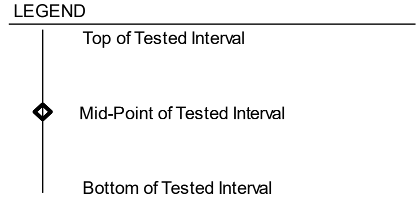
Average horizontal hydraulic gradients measured in low-lying portions of the Perch Lake Basin range from 0.006 to 0.03 m/m in the area between Reactor Pit 2 and the South Swamp (CNL 2016b). The average horizontal hydraulic gradient is slightly higher, 0.05 m/m, between the South Swamp and Perch Lake Swamp. In the aquifers underlying the Perch Lake swamp, the average horizontal hydraulic gradients decrease in a southerly direction, from 0.009 m/m) to 0.002 m/m. Average horizontal hydraulic gradients were found to increase slightly (to 0.006 m/m) towards the zone of groundwater discharge at Perch Creek. In general, the horizontal hydraulic gradients observed in the low-lying areas of the Basin are lower than those observed at the SSA.

Hydraulic Conductivity

Interpretation of hydraulic response testing of the till completed at the SSA by AMEC and Golder has been summarized in AMEC (2017a,b). Till hydraulic conductivity was found to range from 0.00000057 to 0.000016 m/s with a geometric mean of 0.0000016 m/s based on the results of hydraulic response tests completed at 14 locations. Two additional tests were completed at the bedrock overburden interface, resulting in a slightly higher range of hydraulic conductivity (from 0.0000072 to 0.000031 m/s).

A total of 41 hydraulic response tests were completed in the bedrock at 24 borehole locations within the SSA. Of these tests, 26 were suitable for analysis and interpretation and the remainder were not analyzable due to slow recovery or instrument malfunction. Hydraulic conductivity was found to range from 0.0000000023 to 0.000015 m/s with a geometric mean of 0.00000014 m/s. As shown on Figure 5.3.2-3, no significant trend in hydraulic conductivity with depth is observed through the tested interval; however, at depths greater than 6 mbgs the hydraulic conductivity did not exceed 0.000002 m/s. Overburden porosity was found to range from 0.25 to 0.5 in sand and silty sand intervals, and from 0.25 to 0.3 in sand and gravel intervals (porosity of the bedrock core samples was not reported) (AMEC 2017b).





CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
BEDROCK HYDROLIC CONDUCTIVITY DISTRIBUTION FOR THE NSDF PROJECT SITE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	**5.3.2-3**

A significant amount of additional hydraulic property information is available based on studies throughout the CRL site in units similar to those encountered at the SSA. This information is summarized as follows:

- A total of approximately 66 historical measurements of hydraulic conductivity have been made the upper 50 m of bedrock throughout the CRL site (including within the Perch Lake Basin). The geometric mean hydraulic conductivity from these tests was 0.000000052 m/s, with a range of 0.00000000002 m/s to 0.0008 m/s (CNL 2016b). The fracture porosity of the bedrock is estimated to range from 0.0002 to 0.005 (CNL 2016b,c). A total of 42 single well response tests have been completed in the glacial till and the resulting mean hydraulic conductivity is 0.0000015 m/s with a one log standard deviation of 0.0000004 m/s to 0.0000058 m/s. The results of permeameter tests (to measure permeability) indicate that vertical hydraulic conductivity may be almost five times lower than these values. However, as only five permeameter tests have been completed and no visible layering is present in the till, this unit is not considered anisotropic (CNL 2016b). Porosity of the glacial till unit ranged from 0.19 to 0.33 (CNL 2016b).
- Testing of the basal sand and gravel has been limited due to the limited extent of the unit (see Section 5.3.1.4.2.4). Sand within this unit is characterized as a moderately to poorly sorted medium sand (CNL 2016b). The mean vertical hydraulic conductivity of the basal sand and gravel is 0.00011 m/s based on the results of two permeameter tests. The porosity of this unit has not been measured, but is assumed to be 0.38 (CNL 2016b).
- The laminated nature of the clayey silts in the Perch Lake Basin results in a degree of hydraulic conductivity anisotropy as expected. The vertical mean hydraulic conductivity of this unit, based on the results of 12 permeameter tests, is 0.0000000055 m/s, with a one log standard deviation ranging from 0.00000000046 m/s to 0.000000065 m/s. The horizontal hydraulic conductivity of this unit has been inferred from the results of six single well response tests. The mean horizontal hydraulic conductivity is 0.00000013 m/s, with a one log standard deviation ranging from 0.000000037 m/s to 0.00000043m/s. The average porosity of the clayey silt unit is 0.48 (CNL 2016b).
- The vertical mean hydraulic conductivity of the middle sand unit, based on the results of 53 permeameter tests, is 0.0000087 m/s, with a one log standard deviation ranging from 0.0000036 m/s to 0.000021 m/s. The horizontal hydraulic conductivity of this unit is 0.000078 m/s, based on the geometric mean of the results of 13 borehole dilution tests (CNL 2016b). The porosity of this unit is 0.38 (CNL 2016b).
- The vertical mean hydraulic conductivity of the interstratified silt and sand unit, based on the results of 14 permeameter tests, is 0.000000036 m/s, with a one log standard deviation ranging from 0.00000000176 m/s to 0.00000075 m/s. Due to the limited thickness of this unit, only one single well response test was completed and the mean horizontal hydraulic conductivity of 0.000018 m/s is estimated from the results of grain size analyses (CNL 2016b). The one log standard deviation of horizontal hydraulic conductivity based on the grain size analyses ranges from 0.0000055 to 0.000086 m/s. The measured porosity of this unit is 0.39 (CNL 2016b).
- The vertical mean hydraulic conductivity of the upper sand unit, based on the results of 103 permeameter tests, is 0.000014 m/s, with a one log standard deviation ranging from 0.0000053 m/s to 0.000038 m/s. The horizontal hydraulic conductivity of this unit is 0.000048 m/s, based on the geometric mean of the results of 38 borehole dilution tests (CNL 2016b). The porosity of this unit is 0.38 (CNL 2016b).

The hydraulic conductivity of the bedrock at the SSA is at the higher end of the range observed throughout the CRL site. Testing at the SSA was limited to the upper 20 m of the bedrock unit, while the range observed throughout the CRL site includes tests up to 50 m below the top of the bedrock unit. These results indicate a likely decrease in hydraulic conductivity with depth in bedrock. Overburden hydraulic conductivity at the SSA is consistent with the range in glacial till and sand units observed elsewhere on the CRL site.

Groundwater Recharge and Discharge

The bedrock ridges and topographic highs at the eastern and western boundaries of the Perch Lake Basin act as groundwater (and surface water) divides. A groundwater divide is also present to the north, along Plant Road (CNL 2016b). The shallow groundwater flow system is expected to be recharged through precipitation at these topographic highs. Groundwater discharge generally occurs at the surface water features within the low-lying portions of the Perch Lake Basin. Groundwater springs are observed in the East Swamp Stream to the north of Powerline Road and in Perch Creek, downstream of the Perch Lake Outlet. Groundwater discharge to the East Swamp Stream to the north of Powerline Road was observed to range from 25 to 770 (m^3/day) during low-flow periods (Golder 2019b). Groundwater discharge to Perch Creek during low-flow periods is estimated to be approximately 790 m^3/day based on the difference in average flow measurements between the Perch Lake Outlet and the Perch Creek weir (shown on Figure 5.3.2-1A). It is noted that the East Swamp Stream south of Powerline Road and the T-16 Stream act as sources of groundwater recharge to the upper sand unit; however, no quantitative estimates are available for these areas.

Within the SSA, groundwater to the north of the powerline cut likely discharges to surface water within the East Swamp, while groundwater to the south of the powerline cut likely discharges to the surface water within Perch Lake Swamp (or to Perch Creek for the southern portion of the SSA). No areas of groundwater discharge (i.e., seeps or springs) were noted within the observable portions of the SSA by AMEC (2017b).

Surface water within the East Swamp receives groundwater discharge from the Chemical Pit (AECL 2014) and to a lesser degree from Reactor Pit 2 (CNL 2015c). Groundwater flow from the Chemical Pit to the East Swamp follows a relatively short groundwater flow-path, with a travel time of approximately four months (CNL 2015c). Surface water within the South Swamp receives groundwater discharge from Waste Management Area A and Reactor Pit 2.

5.3.2.4.2.2 Groundwater Quality

Long-term Groundwater Quality Data

Bedrock groundwater quality throughout the CRL site was previously characterized through the sampling of a series of deep bedrock boreholes (as documented in AECL 2011 and King-Sharpe et al. 2016). It was found that variations in bedrock groundwater quality with depth are generally consistent throughout the CRL site. Shallow groundwater, to depths of up to 100 m, is dominated by sodium and bicarbonate, with pH values generally between 7 and 8. Deeper groundwater (between depths of 100 and 900 m) is consistently alkaline with a pH value of about 9. Concentrations of sodium and chloride were found to increase with depth; however, concentrations of these parameters are relatively low (total dissolved solids concentrations generally below 200 mg/L) in comparison to deep groundwater in other parts of the Canadian Shield (King-Sharpe et al. 2016). A profile of chloride concentrations in borehole CR9 indicated three distinct zones: a shallow zone (in the upper 300 m) with chloride concentrations ranging from 10 to 60 mg/L, a middle zone (from 300 to 500 m) with chloride concentrations ranging from 150 to 200 mg/L and a deep zone (from 500 to 700 m) with chloride concentrations ranging from 1,000 to 1,600 mg/L indicating slightly saline conditions (AECL 2011). It was concluded that these relatively dilute waters are likely related to recharge of meteoric waters at the end of the last glaciation (King-Sharpe et al. 2016).

As discussed in Section 5.3.2.4.1, the GWMP at the CRL site includes annual and semi-annual water level measurements, sampling and analysis from 180 monitoring wells or boreholes at 32 sites. The proposed SSA is in a portion of the Perch Lake/Perch Creek basin that has not previously been used for the storage of waste or other materials. As a result, there is no longer-term groundwater quality data that specifically applies to the SSA; however, monitoring wells included in the GWMP are present to the east and west of the SSA.

Monitoring wells FR-3 and GD-42 are located to the east of the SSA and to the east of the bedrock-controlled ridge where the rock surface slopes towards the Ottawa River. The screened interval of well FR-3 straddles the contact between the till and the silty very fine sand, and the screen of well GD-42 is located in the fluvial silty sand. These monitoring locations are in a hydrogeological setting that is not entirely analogous to that of the SSA, but they do represent the closest conditions for which longer-term data are available. It should also be noted that well FR-3 is downgradient of the Foundation Road Landfill, making it not entirely a background monitoring location, but the data from it do not show any inorganic water quality anomalies. Well GD-42 is upgradient of a historic non-radiological waste landfill and the current non-radiological landfill (CNL 2017d).

The overall water quality at FR-3 and GD-42 is classified as diluted calcium/sodium bicarbonate, with sulphate and chloride as the other dominant anions. There is little to no reduced nitrogen in these groundwaters, and iron and manganese concentrations are also low, all showing the oxidizing character of the groundwater. Average concentrations of trace metals are all below the Ontario background groundwater quality criteria (MECP 2019). No temporal trends are evident in the data from FR-3, which consists of twice-yearly samples spanning the period from 2005 to the present. The annual samples from GD-42 extend only from 2011, although an earlier background well (GD-22, adjacent to the current non-radiological landfill) was monitored annually from 1996 to 2013 and provided data similar to GD-42, and no temporal trends are noted (CNL 2017d). Water quality from these two monitoring wells is summarized in Table 5.3.2-4; only the parameters monitored at these locations are included.

Table 5.3.2-4: Background Inorganic Water Quality Data for GWMP Wells East of the Ridge of the Site Study Area

Parameter	Units	Average Detection Limits	FR-3					GD-42					Ontario Groundwater Quality Criteria[a]
			Average	Std Dev	Max	Min	# Values	Average	Std Dev	Max	Min	# Values	
pH (field)		—	6.63	0.26	7.01	6.10	25	6.95	0.13	7.18	6.84	5	—
Conductivity	(µS/cm)	—	124	21	150	57	25	461	61	546	398	5	—
Temperature	˚C	—	10.2	1.4	13.9	8.3	25	9.5	1.1	11.0	8.6	5	—
Dissolved Inorganic Carbon (DIC)	(mg/L)	—	10.5	1.1	13.1	8.5	25	28.4	1.6	31.0	27.0	5	—
Dissolved Organic Carbon (DOC)	(mg/L)	—	1.3	0.9	4.8	0.6	25	3.4	1.8	6.6	2.5	5	—
Alkalinity	(mg/L)	—	58	9	79	46	15	142	--	--	--	1	—
Bicarbonate (HCO3-)	(mg/L)	—	53	5	66	43	25	144	8	157	137	5	—
Fluoride (F-)	(mg/L)	0.04	0.07	0.04	0.20	0.04	13	0.05	0.02	0.07	0.03	4	—
Chloride (Cl-)	(mg/L)	0.06	2.1	1.1	5.1	1.4	25	42.7	29.7	95.5	25.7	5	790
Nitrate (NO3-)	(mg/L)	0.08	1.4	4.1	20.5	0.3	24	6.2	2.7	10.5	3.7	5	—
Ammonia (NH3 + NH4+)	(mg/L)	0.05	0.4	—	—	—	1	0.1	—	—	—	1	—
Total Kjeldahl Nitrogen (TKN)	(mg/L)	0.25	0.8	0.6	1.4	0.3	4	0.9	0.1	1.0	0.8	2	—
Sulphate (SO42-)	(mg/L)	0.05	20.4	3.0	26.1	13.4	25	51.3	27.8	96.7	26.4	5	—
Phosphate (PO43-)	(mg/L)	0.13	0.05	—	—	—	1	—	—	—	—	0	
Sodium (Na)	(mg/L)	0.02	4.5	0.4	6.0	4.1	22	40.0	6.1	47.0	33.0	5	490
Potassium (K)	(mg/L)	0.24	2.6	0.4	3.6	2.1	22	2.9	0.2	3.1	2.5	5	—
Calcium (Ca)	(mg/L)	0.01	13.6	0.7	14.6	12.5	22	31.9	4.8	40.0	27.0	5	—
Magnesium (Mg)	(mg/L)	0.01	4.5	0.2	4.9	4.3	22	9.8	1.5	12.3	8.2	5	—
Strontium (Sr)	(µg/L)	0.56	73	5	81	65	22	166	35	218	126	5	—
Iron (Fe)	(µg/L)	4.72	48	63	170	4	11	7	3	10	4	5	—
Manganese (Mn)	(µg/L)	2.04	9	12	41	1	15	2	2	4	1	2	—
Aluminum (Al)	(µg/L)	0.32	17.1	32.8	110	0.2	21	5.6	5.6	12	1.3	3	—
Antimony (Sb)	(µg/L)	0.08	0.02	0.01	0.04	0.01	5	0.02	0.01	0.03	0.01	4	1.5

Table 5.3.2-4: Background Inorganic Water Quality Data for GWMP Wells East of the Ridge of the Site Study Area

Parameter	Units	Average Detection Limits	FR-3					GD-42					Ontario Groundwater Quality Criteria[a]
			Average	Std Dev	Max	Min	# Values	Average	Std Dev	Max	Min	# Values	
Arsenic (As)	(µg/L)	0.53	0.09	0.07	0.20	0.03	5	0.05	--	--	--	2	13
Barium (Ba)	(µg/L)	1.10	10	1	12	8	22	63	12	81	51	5	610
Beryllium (Be)	(µg/L)	0.43	0.17	0.05	0.20	0.13	2	—	—	—	—	0	0.5
Boron (B)	(µg/L)	1.11	6	2	9	1	21	7	1	8	5	5	1700
Cadmium (Cd)	(µg/L)	0.20	0.02	0.01	0.03	0.02	2	0.03	—	—	—	2	0.5
Chromium (Cr)	(µg/L)	0.53	0.9	0.5	2.7	0.4	21	1.3	0.1	1.4	1.2	5	11
Cobalt (Co)	(µg/L)	0.04	0.2	0.2	0.7	0.0	19	0.1	0.0	0.1	0.1	3	3.8
Copper (Cu)	(µg/L)	0.10	1.4	1.7	8.4	0.2	22	0.8	0.6	1.7	0.3	5	5
Lead (Pb)	(µg/L)	0.06	0.12	0.19	0.70	0.02	12	0.05	—	—	—	3	1.9
Lithium (Li)	(µg/L)	1.79	2	2	9	1	13	3	0	4	3	5	—
Molybdenum (Mo)	(µg/L)	0.13	1.5	0.4	2.4	0.8	22	0.0	—	—	—	1	23
Nickel (Ni)	(µg/L)	0.39	1.07	0.74	3.70	0.41	18	1.06	0.40	1.60	0.62	4	14
Rubidium (Rb)	(µg/L)	0.03	0.3	0.1	0.5	0.2	22	0.7	0.1	0.8	0.6	5	—
Selenium (Se)	(µg/L)	3.20	0.2	0.0	0.2	0.2	2	0.4	—	—	—	2	5
Thallium (Tl)	(µg/L)	0.24	0.03	0.00	0.03	0.03	2	0.02	—	—	—	2	0.5
Tin (Sn)	(µg/L)	0.10	0.09	0.04	0.14	0.04	5	0.05	—	—	—	1	—
Uranium (U)	(µg/L)	0.07	0.07	0.02	0.12	0.03	13	0.07	0.02	0.10	0.04	4	8.9
Vanadium (V)	(µg/L)	0.27	0.89	0.26	1.30	0.26	22	0.23	—	—	—	3	3.9
Zinc (Zn)	(µg/L)	0.46	4.8	2.9	12.0	1.7	18	2.1	1.2	3.7	0.6	5	160

Source: CNL 2017d.

a) Table 1: Full Depth Background Site Conditions (MECP 2019).

Std Dev = standard deviation; µS/cm = microSiemens per centimetre; µg/L = micrograms per litre; — = no value

Groundwater samples collected by the GWMP at locations FR-3 and GD-42 are also analysed for a variety of volatile organic compounds (CNL 2017d). None of these compounds have been detected in groundwaters from FR-3 or GD-42.

Radiological data from the groundwater samples collected from FR-3 and GD-42 are summarized in Tables 5.3.2-5 and 5.3.2-6, respectively. The consistent presence of tritium in samples from FR-3 and GD-42 reflects the presence of elevated concentrations of tritium in local precipitation from routine emissions through the National Research Universal reactor stack and from roof vents on facilities in the CRL main campus. Over the 12-year record for FR-3, the tritium concentration has averaged 140 becquerels per litre (Bq/L), while over the shorter record at GD-42, the average tritium concentration has been 270 Bq/L. Gross alpha activity has always been below detection limits (averaging 0.17 Bq/L) at both of these monitoring locations. Gross beta activity has always been below detection (averaging 0.36 Bq/L) in samples from GD-42; a few of the early samples from FR-3 yielded detectable quantities of beta activity (to a maximum of 1.35 Bq/L), but since 2007 gross beta activity has either been below the detection limit or less than 1 counting standard deviation above it (CNL 2017d).

Table 5.3.2-5: Groundwater Monitoring Program Data for Well FR 3 (Bq/L), 2005 to 2016

Location	Monitor	Date	Tritium	Gross Beta	Gross Alpha
FR- 3	I	2005 May 04	84	<0.72	<0.19
FR- 3	I	2005 Oct 05	98	0.55	<0.11
FR- 3	I	2006 May 03	137	0.60	<0.12
FR- 3	I	2006 May 04	100	0.76	<0.11
FR- 3	I	2006 Oct 10	99	—	<0.10
FR- 3	I	2007 May 02	121	1.35	<0.11
FR- 3	I	2007 Oct 03	148	<0.44	<0.12
FR- 3	I	2007 Oct 04	116	<0.42	<0.11
FR- 3	I	2008 Apr 24	135	<0.38	<0.10
FR- 3	I	2008 Oct 09	359	<0.38	<0.11
FR- 3	I	2009 May 08	119	<0.41	<0.11
FR- 3	I	2009 Oct 08	96	<0.39	<0.12
FR- 3	I	2009 Oct 09	135	<0.38	<0.12
FR- 3	I	2010 May 06	103	<0.39	<0.11
FR- 3	I	2010 Oct 14	338	0.43	<0.13
FR- 3	I	2011 May 10	135	<0.53	<0.15
FR- 3	I	2011 Oct 11	125	<0.38	<0.13
FR- 3	I	2012 May 08	111	<0.47	<0.13
FR- 3	I	2012 Oct 12	97	<0.41	<0.15
FR- 3	I	2013 May 13	129	0.39	<0.17
FR- 3	I	2013 Oct 21	116	<0.30	<0.20
FR- 3	I	2014 May 20	134	<0.30	<0.20
FR- 3	I	2014 Oct 23	48	<0.33	<0.18
FR- 3	I	2015 May 06	79	<0.26	<0.18
FR- 3	I	2015 Oct 19	68	<0.26	<0.16

Table 5.3.2-5: Groundwater Monitoring Program Data for Well FR 3 (Bq/L), 2005 to 2016

Location	Monitor	Date	Tritium	Gross Beta	Gross Alpha
FR- 3	I	2016 May 06	340	<0.23	<0.17
FR- 3	I	2016 Oct 19	126	<0.25	<0.15

Source: CNL 2017d.
Bq/L = becquerels per litre.

Table 5.3.2-6: Groundwater Monitoring Program Data for Well GD 42 (Bq/L) , 2011 to 2016

Location	Monitor	Date	Tritium	Gross Beta	Gross Alpha
GD- 42	II	2011 May 10	178	<0.57	<0.18
GD- 42	II	2012 May 15	195	<0.45	<0.15
GD- 42	II	2013 May 24	399	<0.26	<0.24
GD- 42	II	2014 May 22	398	<0.32	<0.26
GD- 42	II	2015 May 14	275	<0.31	<0.23
GD- 42	II	2016 May 11	164	<0.22	<0.21

Source: CNL 2017d.
Bq/L = becquerels per litre.

Long-term groundwater quality to the west of the SSA has been characterized through both the GWMP and a series of detailed evaluations of subsurface contaminant distributions for facilities such as the Chemical Pit, Waste Management Area A and Reactor Pit 2. It should be noted that groundwater treatment systems are in place at Waste Management Area A (passive treatment) and Chemical Pit (pump-and-treat) to facilitate the removal of strontium-90.

Downgradient of the Chemical Pit, elevated concentrations of mercury (generally less than 2 micrograms per litre [µg/L]), lead (generally less than 10 µg/L) and uranium (between 10 and 20 µg/L) have been observed in groundwater (AECL 2014). No elevated concentrations of mercury or other heavy metals have been detected downgradient of Waste Management Area A or Reactor Pit 2. Elevated chloride concentrations attributed to road salt effects have been observed in groundwater downgradient of Waste Management Area A and Reactor Pit 2. Downgradient of these facilities chloride concentrations are on the order of 500 to 1,000 mg/L (CNL 2016b). Based on results of routine monitoring conducted since 1997 for the GWMP (CNL 2018f), as well as detailed plume monitoring downgradient of the Liquid Dispersal Areas (LDAs) including Chemical Pit (AECL 2014), Reactor Pit 2, Reactor Pit 1 and Laundry Pit, it can be concluded that these facilities do not make a considerable contribution to inorganic parameter concentrations in the groundwater (CNL 2018f).

Volatile organic compounds have been detected downgradient of Waste Management Area A at concentrations generally below 10 µg/L; however, the most prevalent volatile organic compound 1,1,2,2-Tetrachloroethane has been detected at concentrations as high as 50 µg/L. With the exception of chloroform (and only for a brief period), no volatile organic compounds or extractable organic compounds were detected in groundwater downgradient of Reactor Pit 2 between 1997 and 2012 (CNL 2016b). No polycyclic aromatic hydrocarbons (PAHs), dioxins, or furans were present in the groundwater plumes from Waste Management Area A or Reactor Pit 2 (CNL 2018g). PCBs were detected at downgradient of the Chemical Pit at concentrations up to 0.7 µg/L (AECL 2014). Trace detections of dioxins and furans were also noted downgradient of the Chemical Pit in 2014 (CNL 2016c).

Downgradient of the SSA, the highest concentrations and widest variety of radioactive constituents in groundwater on the CRL site are located downgradient of the Chemical Pit in East Swamp (CNL 2018f). Total beta activity associated with strontium-90 in groundwater between the Chemical Pit and the East Swamp is on the order of 10,000 to 70,000 Bq/L. Total beta activity in the groundwater plume downgradient of the Chemical Pit (as reported in 2012) is shown on Figure 5.3.2-4. The Chemical Pit plume consists of two partially distinct plumes extending from the two chemical pits. Extension of the plumes to the northwest, northeast and southwest (upgradient and cross-gradient of the current groundwater flow direction) is likely the result of a period of groundwater mounding during the early period of operation of the pits (AECL 2014). The groundwater plume shown on Figure 5.3.2-4 is similar to the plume measure in 2002; however, total beta concentrations in the shallow groundwater in the East Swamp were two to six times higher in 2012 in comparison to 2002 (AECL 2014). Gross alpha, caesium-137 and cobalt-60 in groundwater downgradient of the chemical pit are also elevated (AECL 2014).

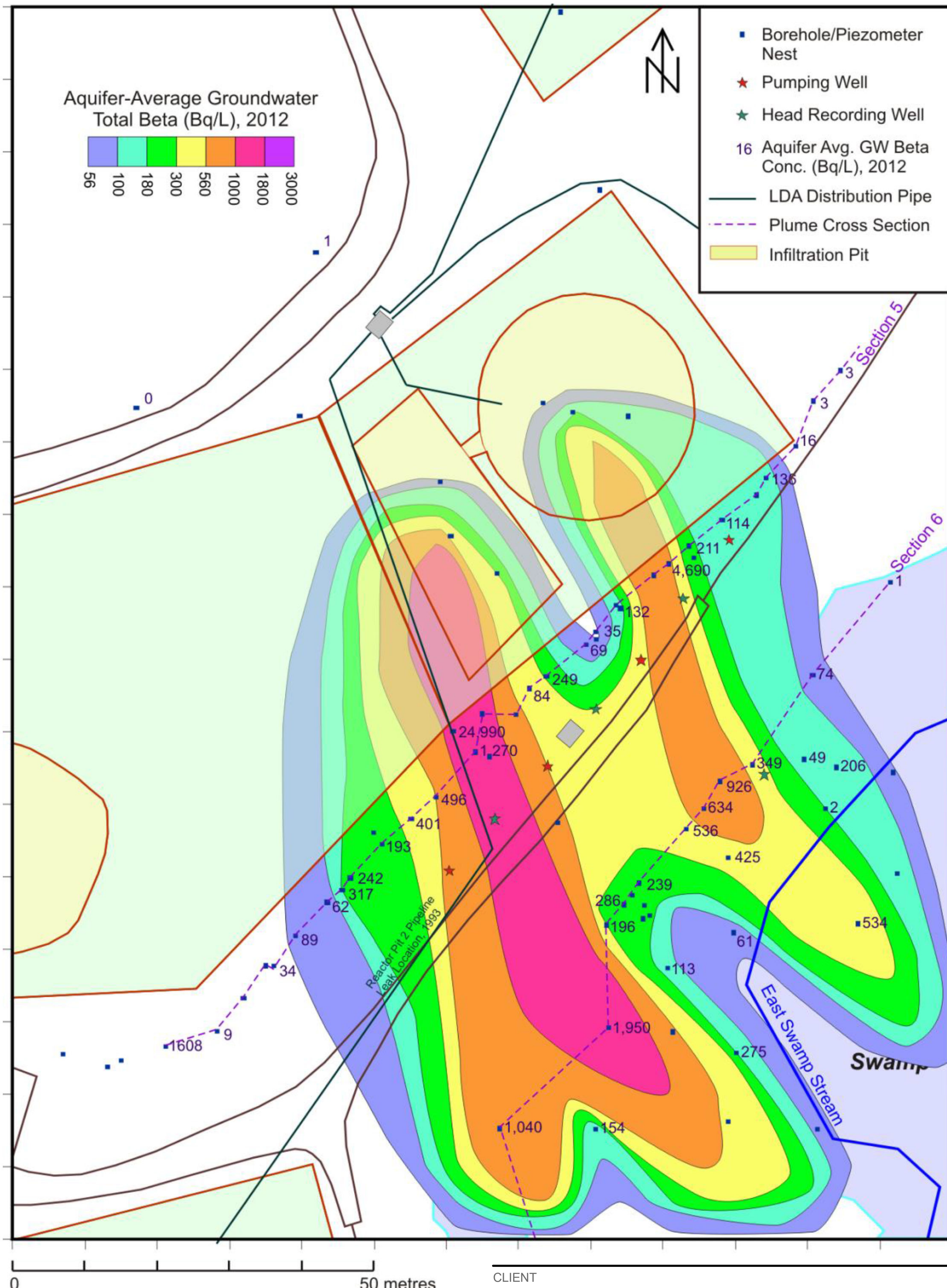
Downgradient of Waste Management Area A, total beta activity in groundwater was generally between 3,000 and 10,000 Bq/L with a peak of 30,000 Bq/L (CNL 2018g). Downgradient of Reactor Pit 2, total beta activity in groundwater was generally between 2,000 and 15,000 Bq/L with a peak of 22,100 Bq/L based on data from 2001, 2006, and 2011 (CNL 2016b). Total beta activity in the groundwater plume downgradient of Reactor Pit 2 (as reported in 2011) is shown on Figure 5.3.2-5. The groundwater plume downgradient of Reactor Pit 2 consists of two lobes. One lobe extends towards the south-southeast, terminating in the East Swamp Stream near Powerline Road. The second lobe extends to the south-southwest towards Perch Lake. As the groundwater plume mapping completed in 2011 was based on data from an expanded network of piezometers in comparison to mapping completed in 2001 and 2006, differences in plume extent and geometry in 2011 may be related to the increased monitoring density. Total beta activities downgradient of Reactor Pit 2 are consistently highest along the eastern perimeter; however, concentrations in this area have shown a consistently decreasing trend based on plume mapping completed in 2001, 2006 and 2011 (CNL 2016b). Ecological risk associated with radioactivity in the East Swamp is assessed every five years. Further details are provided in Section 5.7.

Investigations of contamination in East Swamp have included measurements of radioactivity in pore water (indicative of groundwater discharging to the surface water (CNL 2015c). The East Swamp has existing contamination due to groundwater plumes from the Chemical Pit and Reactor Pit 2. Since it is immediately west of the SSA, this contamination is relevant to the Base Case radioactivity characterization for the SSA. Surveying conducted in 2012 included collection and analysis of pore water at seven locations. All gross alpha concentrations in these pore water samples were less than detection limits (less than 8 Bq/L). Total beta ranged from 180 Bq/L to a maximum of 4,900 Bq/L. Strontium-90 concentrations ranged from 120 Bq/L to a maximum of 2,960 Bq/L. Ambient radiological contaminant concentrations upgradient of the waste management areas are summarized in Section 5.7.4.6.

Eight surveys of tritium concentration in groundwater have been completed within the lower Perch Lake since 1962 (1962, 1969, 1982, 1986, 1992, 2001, 2006, and 2011), with a focus on the areas downgradient of the Chemical Pit and Reactor Pit 2 (CNL, 2016b). Data collected in the surveys was used to calculate inventories of tritium within the sand aquifers, and to estimate groundwater travel times between the source areas and downgradient receptors.

Early conclusions of the tritium surveys were that tritium (and hence groundwater) transit time in the Upper Sand Aquifer between Reactor Pit 2 and Perch Lake was 5.7 years. It was also found that groundwater from Reactor Pit 2 that discharges to East Swamp Stream and then recharged to the Upper Aquifer downstream of the East Swamp Stream weir would have a 4-year transit time from RP 2 to Perch Lake. The projected groundwater transit time between Reactor Pit 2 and Perch Lake in the Middle Sand Aquifer was seven years.

The estimated total tritium mass inventory in the Lower Perch Lake Basin aquifers in 2011 (96 tera becquerels [TBq] to 112 TBq) has decreased (through decay and loss to Perch Lake) from the peak value (412 to 515 TBq), which was estimated following the 1992 survey.



CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
DEPTH AVERAGED TOTAL BETA ACTIVITY DOWNGRADIENT OF THE CHEMICAL PIT IN 2012

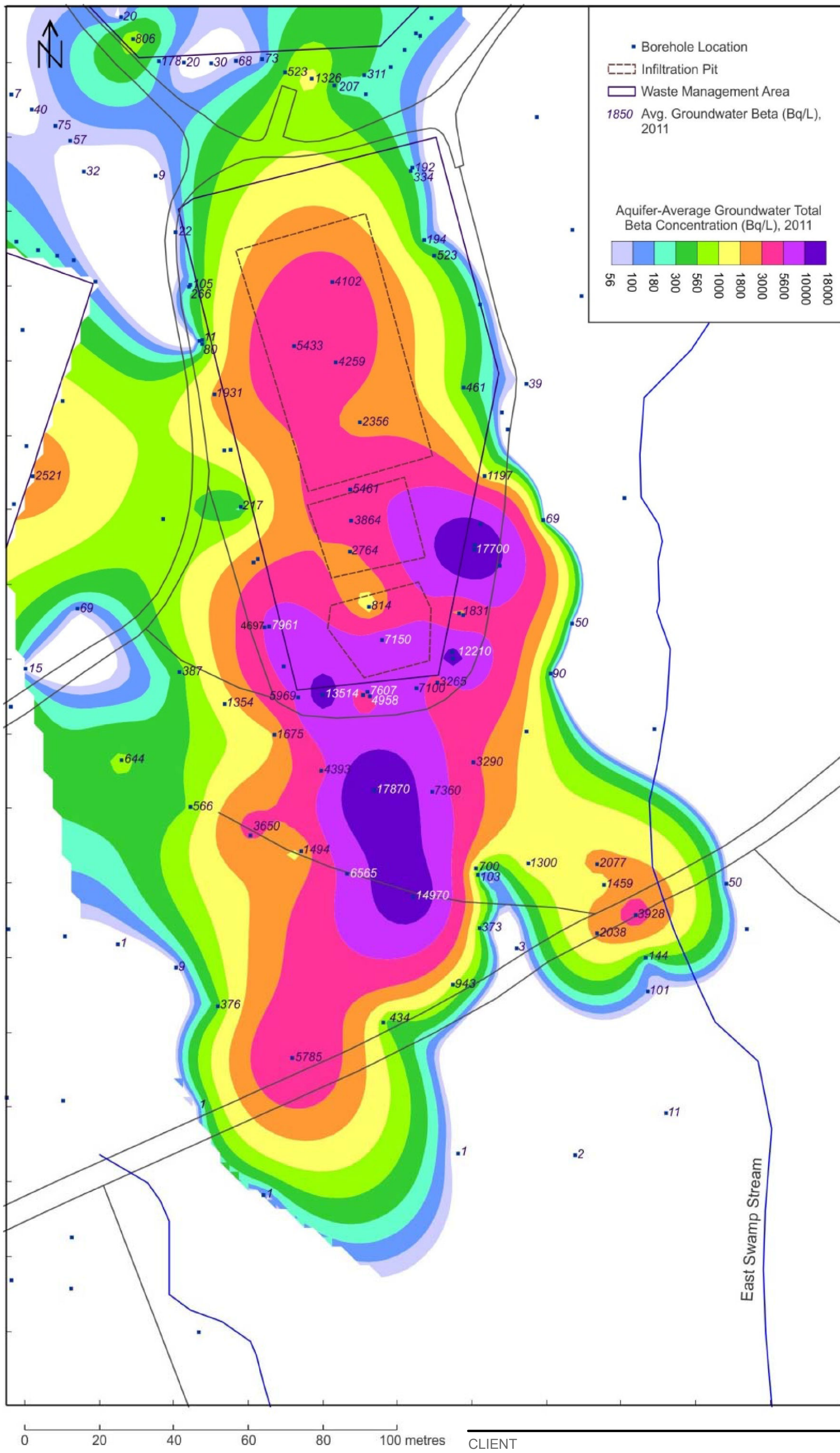
CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.2-4

REFERENCE(S)
1. SUBSURFACE RADIONUCLIDE MIGRATION FROM THE CHEMICAL PIT, CRL LEGACY WASTE AREAS, 3613-121250-REPT-008 REVISION 0, 2014, ATOMIC ENERGY OF CANADA LIMITED.

S:\Clients\Canadian_Nuclear_Laboratories\NSDF\99_PROJ\1547525_NSDF_EIS\40_PROD\0009_EIS_Section_5\Section_5.3_Geology_Hydrogeology\1547525-0009-CH-0017.mxd



CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
AQUIFER AVERAGED TOTAL BETA ACTIVITY DOWNGRADIENT OF REACTOR PIT 2 IN 2011

CONSULTANT		
GOLDER	DATE	NOVEMBER 2020
	DESIGNED	MIB
	PREPARED	SO
	REVIEWED	CS
	APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.2-5

REFERENCE(S)
1. CONTAMINANT MIGRATION FROM REACTOR PIT 2, CRL LEGACY WASTE AREAS, 3613-121221-REPT-003 REVISION 0, 2016, CANADIAN NUCLEAR LABORATORIES.

Groundwater Quality Data Specific to the Site Study Area

To date, 21 wells in and adjacent to the proposed SSA have been sampled for inorganic water quality parameters and for a number of radiological parameters. The sampling locations are shown on Figure 5.3.2-1A. Nine locations were sampled in 2016 October and the results are provided in AMEC (2017a). An additional 12 samples were collected in December 2016 from a series of newly installed (Phase 2) wells (shown on Figure 5.3.2-6) and the data for those samples are presented in (AMEC 2017b). Although the wells were purged repeatedly to remove drilling water prior to sampling, at some locations drilling water may still have been present. This interpretation is based on the presence of chloroform (indicative of residual drilling water) in a number of the October 2016 samples (CNL 2017d). As such, additional sampling of all 21 wells was completed in August and September 2017 (CNL 2018f). Analysis of the 2017 sample data indicates that the effects of drilling water remain in some of the monitoring wells (particularly those that have low capacity to produce water), though in general the groundwater quality is consistent with expectations of background conditions. As discussed in CNL's *Baseline Groundwater Chemistry Evaluation of the Proposed NSDF Site (*CNL 2018f), the results of the 2017 sampling (neglecting the potential influence of drilling water) indicates the following:

- Groundwater collected from wells screened in rock had pH levels of between 5.9 and 8.0, and in groundwaters from well screened in overburden (or straddling the overburden/bedrock contact) pH levels were between 5.4 and 7.2.
- Total dissolved solids concentrations ranged from 43 to 370 mg/L. Bedrock groundwater was either dominated by sodium and bicarbonate or by calcium-magnesium bicarbonate with sulphate at concentrations between 4 and 22 mg/L as the next most abundant anion. The one exception was water from bedrock well W-7, which contained 115 mg/L of sulphate and 15 mg/L of chloride.
- Overburden groundwater chemistry is characterized as dilute calcium-magnesium bicarbonate-sulphate, although most of the wells located downgradient (west) of the East Mattawa Road also feature low levels of road salt contamination. Nitrate concentrations are generally less than 1 mg/L, with one sample containing 1.5 mg/L, and one trace detection of nitrite. Phosphate and total phosphorus were not detected in any of the samples.
- Groundwater from well SH-4 contained 6.8 mg/L of iron, indicating moderately reducing conditions in the groundwater at that location. This well is located at the margin of the Perch Lake Swamp and the top of the well screen is at the base of the surficial organic-rich sand; this may account for the relatively high iron concentration. Otherwise, iron concentrations range from 4 to 990 µg/L, indicating moderately to highly oxidizing conditions in the local flow system.
- Most trace elements are present at concentrations below the background concentration limits expected in Ontario regulation 153.4 [5]. The exceptions to this are cobalt (well W-5), copper (wells W-5 and W-2S), nickel (wells W-5 and W-2S), and zinc (wells W-7, W-8, W-2S, W-3, and W-4). Elevated copper and nickel concentrations are highly correlated with each other and moderately correlated with elevated nickel. This, coupled with the general decreases in their concentrations between 2016 and 2017, argue for a drilling-related source of these metals. The cause of the zinc anomalies remains unexplained.
- The radiological analyses of the 2017 September samples did not encounter elevated concentrations of tritium, alpha or beta emitting radionuclides, or gamma emitters

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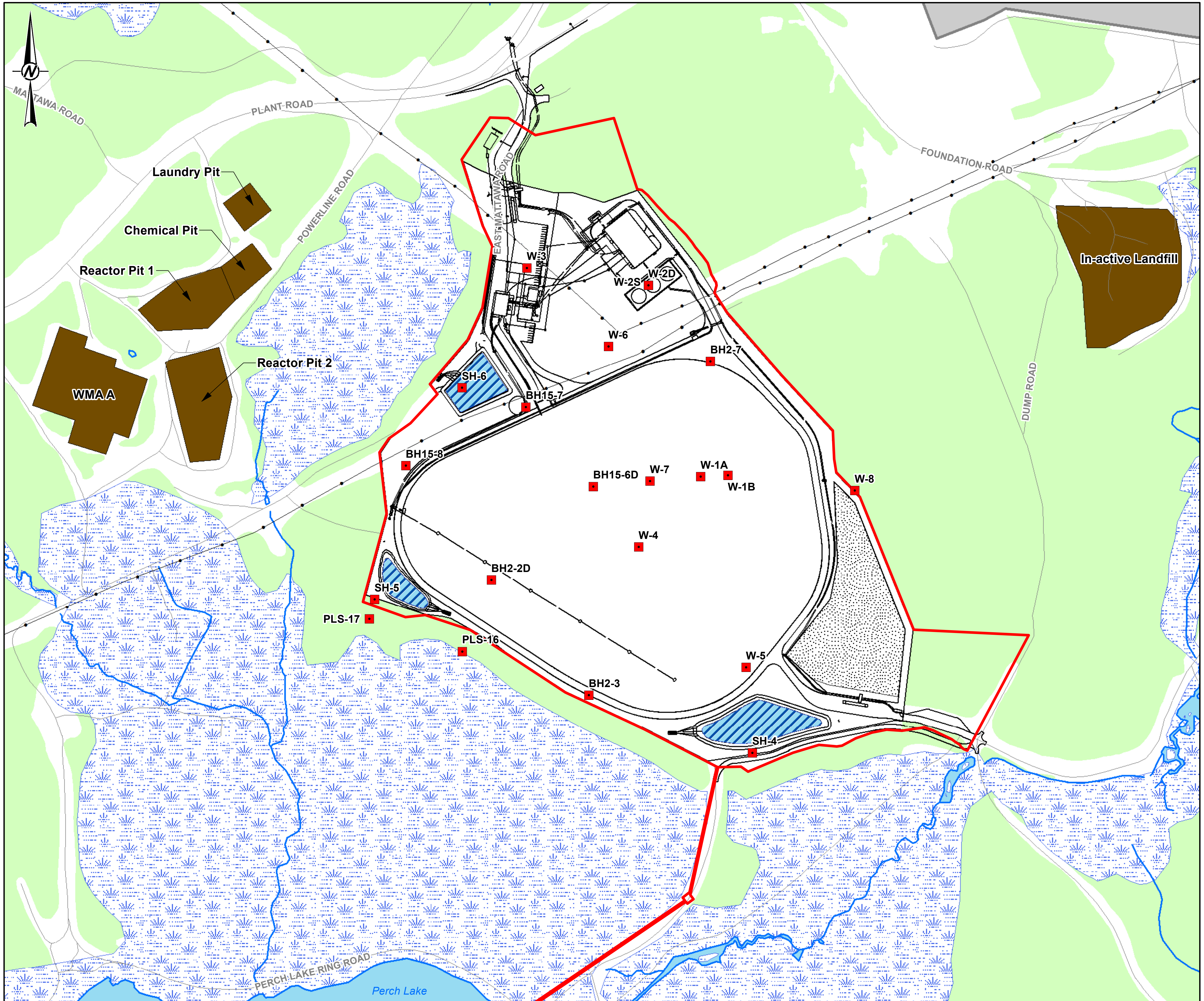

LEGEND

- GROUNDWATER MONITORING WELL (CNL 2016)
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- CRL MAIN CAMPUS
- SITE STUDY AREA (NSDF PROJECT SITE)
- WASTE MANAGEMENT AREA (WMA)[1]
- SURFACE WATER MANAGEMENT POND
- STOCKPILE AREA

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY:
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
LOCATION OF GROUNDWATER MONITORING WELLS INSTALLED IN 2016

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.2-6

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5.3.2.5 Project Interactions and Mitigation

5.3.2.5.1 Methods

This section describes the process by which interactions between NSDF Project activities and groundwater quantity and quality were identified and evaluated. Potential effects pathways are identified and mitigation developed to eliminate and/or reduce effects is presented. A pathways analysis is then used to focus the assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects will be adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects after incorporation of mitigation are further characterized in subsequent subsections of the assessment. As such, this section helps to focus the remainder of the assessment on those interactions (effects pathways) likely to result in residual adverse effects.

The first part of the analysis was to identify the potential effects pathways for all phases of the NSDF Project. The next step in the analysis was the development of environmental design features and mitigation practices that could be incorporated into the NSDF Project to eliminate and/or reduce adverse effects to hydrogeology. Environmental design features included Project design elements, environmental best practices and management policies and procedures. Environmental design features and mitigation were developed through an iterative process between the Project's engineering and environmental teams, combined with input from Project-specific or regional engagement with other interested parties. The design features and/or mitigation activities were selected considering their effectiveness for implementation and maintenance and their appropriateness within the context of the identified effects pathways.

After incorporation of mitigation, potential pathways were evaluated into the following categories using scientific knowledge, logic, experience with similar developments and the effectiveness of environmental design features and mitigation:

- **No linkage:** The pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change relative to Base Case values and therefore would have no residual effects on hydrogeology.
- **Secondary pathway:** The pathway could result in a measurable minor environmental change, but would have a negligible residual effect on hydrogeology relative to Base Case and/or guideline values and is not expected to contribute cumulatively to other Project effects or to the effects of other previous, existing or reasonably foreseeable developments to cause a significant effect.
- **Primary pathway:** The pathway is likely to result in an environmental change relative to the Base Case and/or guideline values that could contribute to residual effects on hydrogeology.

Environmental design features and mitigation that have been or could be incorporated into the Project to eliminate and/or reduce adverse effects were considered. Potential pathways that were completely removed due to implementation of environmental design or mitigation were not assessed further. Pathways that were assessed to be secondary and demonstrated to have a negligible residual effect to hydrogeology through simple qualitative or semi-quantitative evaluation of the pathway were also not advanced for further assessment. Primary pathways were carried forward for more detailed quantitative and qualitative effects analysis to characterize the residual effects of the Project.

5.3.2.5.2 Results

Pathways through which all stages of the Project may interact with and result in changes to measurement indicators for hydrogeology is provided in Table 5.3.2-7.

Table 5.3.2-7: Pathways Analysis for the Hydrogeology Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation	Pathway Assessment
■ Project activities during the construction phase: ▪ Site preparation ▪ Construction of the ECM (including blasting of bedrock during ECM construction) ▪ Development of surface water management structures ▪ Construction of the WWTP and other support facilities ▪ On-site road and access development	■ The construction of the NSDF Project will physically alter groundwater levels and flows	■ The NSDF Project footprint has been designed to limit disturbance to the natural environment. ■ Discharge of treated effluent primarily to the exfiltration gallery area will help to reduce water loss from the hydrogeological system. ■ Discharge of treated effluent to Perch Lake via transfer line will help reduce high water table conditions in the area of the exfiltration gallery.	Primary

Table 5.3.2-7: Pathways Analysis for the Hydrogeology Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation	Pathway Assessment
■ Project activities during the construction phase (as listed above) ■ Project activities during the operations phase: ▪ Phased development of disposal cells in the ECM ▪ On-site transportation of waste and placement in the ECM ▪ Progressive closure of disposal cells and installation of final cover ▪ Operation of the WWTP ▪ Existing presence of fencing around perimeter of ECM ▪ Surface water management ▪ Domestic waste (solid and liquid) management; and, ▪ Routine operational management and monitoring activities.	■ Surface water runoff from the NSDF site can contain contaminants, which can cause changes to groundwater quality	■ Procedures for surface water management will be developed and implemented for the NSDF Project. ■ The target surface water quality objective is provided in the *Stormwater Management Planning and Design Manual* (MOE 2003). ■ Surface water from all external areas will be conveyed by ditches, swales and culverts to SWMPs that will address water quality and water quantity criteria established for the wetland receiving waters and, ultimately, Perch Creek. ■ The SWMPs are designed to address erosion and sediment control concerns during construction by providing interim sediment control and by providing water quality/quantity controls during the operations, closure and post-closure phases. ■ The current SWMP design reflect the overall storage required to control post-closure flows to predevelopment levels for the 2-year through to 100-year rainfall events at the site. This volume also contains the storage required for sediment control during the construction phase and water quality control during the operations phase. ■ Where drainage crosses roadways, culverts are sized to convey the 25-year design event without road overtopping ■ For each SWMP, the water level will be sampled to estimate the inflow and outflow of each pond. ■ The outlet water quality will be sampled periodically to confirm that surface water discharges meet applicable environmental criteria.	No Linkage

Table 5.3.2-7: Pathways Analysis for the Hydrogeology Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation	Pathway Assessment
■ Project activities during the operations phase	■ Leakage of leachate from the ECM may affect groundwater quality during operations	■ Design of the ECM includes base grading configured in a herringbone pattern with ridges and valleys to promote leachate transport to the leachate collection system for removal. ■ The base liner design includes primary and secondary liner systems designed to have redundancy in case of premature degradation and are a combination of natural and synthetic barrier systems. These include a compacted clay liner (CCL), two geosynthetic clay liners (GCL) and an HDPE geomembrane. ■ Clay materials were selected for the CCL and GCL components of the liner system as these materials are anticipated to maintain their function as hydraulic barriers throughout and beyond the design life of the disposal facility (i.e., 550 years). ■ The HDPE geomembrane design for the liner will be compatible with the leachate generated by the waste and provide a long service life. ■ The base liner system will include an underlying compacted clay liner to supplement the primary and secondary liner system. ■ The leachate collection system design will provide accessible access points for inspections, maintenance, repairs, and replacements. ■ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water and groundwater quality. ■ Appropriate responses to leachate leakage and contamination will be implemented as described in the Operations and Maintenance Plan and Contingency Plan.	No linkage

Table 5.3.2-7: Pathways Analysis for the Hydrogeology Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation	Pathway Assessment
■ Project activities during the operations and closure phases: ▪ Surface water management ▪ Operation of the WWTP ▪ Discharge of treated effluent from the WWTP	■ Discharge of treated effluent from the WWTP to the ground (via an exfiltration gallery) can cause changes to groundwater quality.	■ The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses the best available technology that is economically achievable, and capable of meeting regulatory requirements. ■ Effluent discharge targets for wastewater discharges are protective of the environment and human health. ▪ Discharge targets for non-radiological contaminants are sourced from federal and provincial guidelines for protection of aquatic biota. ▪ Discharge targets for radionuclides are the Canadian Drinking Water Guidelines with the exception of tritium for which a site-specific target is developed (Section 3.4.2.5.1). ■ Treated effluent will be sampled and confirmed that it meets the effluent discharge targets before release to the environment. ■ When applied, the proposed exfiltration gallery will promote the exfiltration of treated water into the local groundwater regime where further retention of radioactivity by the geosphere is anticipated. ■ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water and groundwater quality. ■ Appropriate procedures will be in place to effectively identify spill occurrences in the event treated effluent is released to areas other than directly to the exfiltration gallery and initiate appropriate emergency responses	Secondary
	■ Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) can cause changes to groundwater levels and flows through evapotranspiration.		Primary
■ Project activities during the operations and closure phases: ▪ Surface water management ▪ Operation of the WWTP ▪ Discharge of treated effluent from the WWTP	■ Leakage of leachate from the ECM may affect groundwater quality during operations and closure phases.	■ Design of the ECM includes base contours developed using a herringbone pattern with ridges and valleys to promote leachate transport to the leachate collection system for removal ■ The base liner design includes primary and secondary liner systems designed to have redundancy in case of premature degradation and are a combination of natural and synthetic barrier systems ■ The HDPE geomembrane design for the liner will be compatible with the leachate generated by the waste and provide a long service life ■ The base liner system will include an underlying compacted clay liner to supplement the primary and secondary liner system ■ The leachate collection system design will provide accessible access points for inspections, maintenance, repairs, and replacements ■ Appropriate responses to leachate leakage and contamination will be implemented as described in the Operations and Maintenance Plan and Contingency Plan	No Linkage

Table 5.3.2-7: Pathways Analysis for the Hydrogeology Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation	Pathway Assessment
■ Project activities during the closure and post-closure phases: ▪ Installation of final cover, restoration and grading of SSA ▪ On-going long-term performance monitoring, transfer of NSDF Project into Institutional Control ▪ Liner and final cover degradation as a result of normal evolution	■ Leakage of leachate from the ECM during the post-closure phase (i.e., after Year 2400) from liner and final cover degradation as a result of normal evolution can cause changes to groundwater quality.	■ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound and minimize leachate generation. ■ The final cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity. ■ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the final cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. ■ The ECM final grading and drainage plan also includes collection ditches along the top of the ECM berm road to collect side slope drainage. ■ The design life for the ECM is 550 years to meet the required time period to allow for radioactive decay of the waste placed in the facility (i.e., until it has decayed to levels that do not present a risk to the public and environment). ■ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to groundwater quality.	Primary

ECM = engineered containment mound; WWTP = Wastewater Treatment Plant; HDPE = high density polyethylene; SWMPs = surface water management ponds; SSA = Site Study Area; LLW = low-level waste.

5.3.2.5.2.1 No Linkage Pathways

The following pathways were assessed as having no measurable environmental change and hence, no linkage to residual effects on hydrogeology VCs.

- **Surface water runoff from the CRL site can contain contaminants, which can cause changes to groundwater quality.**

A variety of mitigation strategies will be implemented during all project phases to reduce the potential for changes to soil, water and vegetation quality from surface water runoff from the SSA. These include surface water management, erosion and sediment control measures, surface water management ponds, maintenance and inspection activities, and monitoring.

Site operations include surface water management for the ECM and all external areas. Surface water from all external areas will be conveyed by ditches, swales and culverts to surface water management ponds that will address water quality and water quantity criteria established for the wetland receiving waters and, ultimately, Perch Creek. Contact water, which is exposed to waste within the ECM, will drain from the active cells of the ECM and be conveyed to the WWTP. Non-contact water drainage from completed cells and yet-to-be completed cells will be directed either by gravity to the external surface water management system or to temporary holding ponds within the ECM, then pumped to the three surface water management ponds.

During the construction phase, erosion and sediment control measures will be in place to mitigate the effects of soil erosion and sediment transport. The measures include use of erosion control blankets, as needed, to control erosion on steep slopes. Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site (i.e., CNL's Management of Land and Habitat Procedure [CNL 2018c]) will be used around disturbed areas within the SSA, where appropriate. Furthermore, an Environmental Management Plan has been developed as part of the design plan for the site outlining the erosion and sediment control measures and surface water management pond construction schedule discussed. It additionally outlines administrative protocols such as training, contractor document submissions and staffing required for effective surface water management throughout all phases of the NSDF Project.

The surface water management ponds are designed to address erosion and sediment control concerns during construction by providing interim sediment control and by providing water quality/quantity controls during operations, closure and post-closure. The current surface water management pond footprints reflect the overall storage required to control post-closure flows to predevelopment levels for the 2-year through to 100-year rainfall events at the site. This volume also contains the storage required for sediment control during construction and water quality control during operations. The target surface water quality objective of 60% TSS removal that provides basic water quality treatment for discharge to the receiving wetland is provided in the *Stormwater Management Planning and Design Manual* (MOE 2003). SWMP #1 will meet 80% TSS removal which will provide enhanced water quality treatment. SWMP #2 will provide 76% TSS removal and SWMP #3 will provide 60% TSS removal during operations, which will be sufficient because the receiving waterbody is a wetland and not a watercourse. The wetland functions as a sediment trap that will provide additional treatment prior to surface water reaching any watercourses in wetlands.

Roadway, sidewalk and parking lot winter maintenance activities that may release road salt to the environment, include snow plowing/shoveling and de-icing practices, salt and sand storage and snow stockpiling, and removal and disposal. The winter maintenance practices outlined in the current CRL Salt Management Plan provide for effective management of salt use and will be applied to the NSDF Project as necessary. As per the plan, the application of road salt on the NSDF site will be to be limited as salt residual within contact water and/or leachate may compromise the treatment effectiveness of the WWTP systems. Instead, alternative products in winter road management, such as a sand-stone mixtures, are currently being considered.

Facility inspections will be completed on a defined schedule to confirm that inlets and outlets are clear of debris and to confirm that there are no major erosion issues at the inlet or outlet. As well, the integrity of berms and outlet structures will be confirmed by visual inspections that would identify soil erosion. Inspections will identify sediment clean-out requirements. Sediments will be extracted by excavation equipment and will be disposed of based on sediment sampling, testing and classification according to MECP standards or stockpiled, dewatered and reused on-site for daily ECM cover operations. The sediment removal assessment follows procedures identified in the *Stormwater Management Planning and Design Manual* (MOE 2003).

The implementation of proposed mitigation at the SSA will reduce the potential for changes to soil, water and vegetation quality from runoff from the NSDF Project. This pathway was determined to have no linkage to effects to groundwater quality.

- **Leakage of leachate from the ECM may affect groundwater quality during operations and closure phases.**

Design of the ECM includes base contours that have been developed using a herringbone pattern with ridges and valleys to promote leachate transport to the leachate collection system for removal. The base liner design includes both primary and secondary liner systems that are designed to have redundancy in case of premature degradation and are a combination of natural and synthetic barrier systems. The primary liner will include a leachate collection system with the secondary liner housing a leak detection system. The composite base liner will contain perforated high density polyethylene (HDPE) collection and monitoring pipes. The HDPE geomembrane was selected as it is compatible with the leachate generated by the waste and is expected to perform as an effective hydraulic and diffusion barrier over the 550-year design life (see Section 3.4.1.4). The base liner system will include an underlying compacted clay liner to supplement the primary and secondary liner system. The leachate collection and monitoring system design will provide accessible access points for monitoring, inspections, maintenance, repairs and replacements.

The primary liner system will contain the leachate collection system and will convey leachate to a single collection point for removal from the ECM, for transfer to the WWTP for treatment. The primary liner system serves as the primary source of protection for the natural environment below the ECM from leachate migration, and will maintain a maximum depth of leachate on the geomembrane liner of less than or equal to 300 mm. The secondary liner system will contain the leak detection system, which will be used to detect leaks in the unlikely event that the primary liner system fails. The secondary liner will also protect the natural environment from leachate migration if the primary liner system fails. Leachate collected by the leachate collection system will be pumped to the on-site WWTP for treatment.

Perimeter berms consist of three main geotechnical elements or layers, each contributing to the soundness and integrity of the berm itself and the whole ECM. A slope stability analysis was completed to provide the information needed to support the design of the base slopes, sidewalls and side slopes of the ECM. The slope stability analysis addresses the range of anticipated loading conditions, under both short-term and long-term scenarios, to confirm that the slope designs will satisfy minimum factor-of-safety requirements for stability. Size and shape of the berms and each of the elements and layers were determined using a seismic design basis.

The implementation of the above mitigation will limit the potential for changes to groundwater quality from the SSA. As such, this pathway is determined to have no linkage to effects on hydrogeology.

5.3.2.5.2.2 Secondary Pathways

The following pathways were assessed as potentially having a measurable minor environmental change, but negligible residual effect on the hydrogeology VCs relative to the Base Case.

- **Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) can cause changes to groundwater quality.**

The WWTP for the NSDF Project will be a new, stand-alone facility with a new discharge point. The WWTP will treat leachate generated in the ECM during the operation phase. The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses best available technology that is economically achievable, and capable of meeting regulatory requirements. In the event that the WWTP is required beyond its design life, the unit would be refurbished to enable continued treatment of leachate, or other treatment options would be investigated.

The chemical and radionuclide concentrations in leachate are calculated using a partitioning model that assumes that the ratio of the contaminant concentration in the solid phase to the contaminant concentration in the leachate is constant. These factors conservatively estimate the leachate characteristics. The radionuclide concentrations in wastewater are a combination of the leachate concentrations and the leachate volume, combined with the contact water and decontamination volumes. The contact water is assumed to have very low radionuclide concentrations because of the effects of daily ECM cover and water management practices within the disposal cell. Similarly, decontamination water is assumed to have very low radionuclide concentrations as radionuclide loading from decontamination activities would be very low. These values present a reasonable and conservative estimate of concentrations in wastewater such that the WWTP design is capable of treating wastewater to meet effluent discharge targets.

Treated effluent from the WWTP will be released to an exfiltration gallery to promote the exfiltration of treated water into the local groundwater regime. Treated effluent will be sampled and confirmed that it meets the effluent discharge targets before release to the environment. Overall, with the implementation of the above mitigation, the discharge of treated effluent is expected to have negligible residual effects on groundwater quality.

5.3.2.5.2.3 Primary Pathways

Primary pathways identified for hydrogeology and that are evaluated in the residual effects analysis (Section 5.3.2.6) include:

- **the construction of the NSDF Project will physically alter groundwater levels and flows;**
- **discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) can cause changes to groundwater levels and flows; and**
- **leakage of leachate from the ECM during the post-closure phase (i.e., after Year 2400) from liner and final cover degradation as a result of normal evolution can cause changes to groundwater quality.**

5.3.2.6 Residual Effects Analysis

5.3.2.6.1 Groundwater Flow

5.3.2.6.1.1 Methods

Residual effects from the Application Case are evaluated based on the results of hydrogeological modelling (Golder 2019b). The hydrogeological modelling was completed to estimate the groundwater flow pathways from the ECM, and the rates of groundwater flow from the SSA to downstream receptors. This was accomplished by constructing a groundwater flow model based on the conceptual model and calibrating it to the existing conditions. Calibration involved an iterative process where steady-state model runs were completed with adjustments to the model input parameters (within acceptable ranges) until model results provided an acceptable match to observed conditions (groundwater elevations, groundwater flow directions, baseflow estimates and advective flowpaths from the Reactor Pit 2 source area). After an acceptable model calibration was achieved, the calibrated model was then modified to represent the SSA under operations and post-closure conditions and steady-state simulations were completed to evaluate the changes in groundwater flow patterns and water table elevations from the SSA.

MODFLOW-2005 (Harbaugh 2005) was used to complete the simulations. Visual MODFLOW® (Version 4.6.0.156) was used as the numeric flow engine for the simulations and the MODFLOW-NWT solver was used to solve the groundwater flow equations (Niswonger et al. 2011). MODPATH (Pollock 1989), a companion code to MODFLOW, was used to complete the particle tracking analyses necessary to illustrate the flowpaths from the WWTP and ECM. Details of the conceptual model development, modelling approach, model extent and discretization, boundary conditions, hydrostratigraphy and parameterization and model calibration are reported in Golder (2019b).

Two operations phase scenarios were evaluated with the model as follows:

- **Operations Scenario A –** Average water table conditions with approximately 11,000 m^3/yr collected within the footprint of one open cell with half of this volume applied in the model as surficial recharge at the exfiltration gallery over a four-month period.
- **Operations Scenario B –** High water table conditions with all treated effluent routed to Perch Lake (i.e., no discharge at the exfiltration gallery). It should be noted that WWTP discharge is anticipated to occur under high water table conditions when the capacity of the exfiltration gallery is limited.

For the operations scenarios, zero infiltration was applied over the footprint of the open and closed cells (precipitation is being collected via the liner) (Golder 2019b). For Operations Scenario A, water collected within the footprint of the open cell is sent to the WWTP and in part discharged in the model as surficial recharge at the exfiltration gallery. Based on groundwater flow modelling sensitivity analysis results, the exfiltration gallery capacity is estimated to be approximately 50% of the wastewater volume of 11,000 m^3/yr. Runoff is collected from the closed cells and an equivalent volume is applied as recharge in the model to the SWMPs outfall areas.

Three scenarios were evaluated using the model under post-closure conditions as summarized below:

- **Post-closure – Final Cover Intact:** A final cover is in place above the waste in the ECM, extending to the crest of the berm surrounding the facility. In this area, zero recharge is applied in the groundwater flow model. Runoff that occurs from precipitation falling on the final cover is directed to the SWMPs. It is assumed that during the post-closure phase the pond liners will no longer be effective and the runoff collecting in the ponds will infiltrate through the bottom of the pond. This scenario was evaluated with and without consideration of evapotranspiration (Golder 2019b).
- **Post-closure – Final Cover Compromised:** The final cover is assumed to be compromised resulting in infiltration through the mound into the waste materials. The base liner is assumed to remain intact resulting in a “bathtub” effect with spillover along the low point of the base liner, located in the southern portion of the ECM. For this scenario, the surface runoff from the ECM was assumed to have a negligible effect on local groundwater conditions, and no additional water was applied beyond the natural surficial recharge.
- **Post-closure – Final Cover and Liner Compromised:** Both the final cover and liner are assumed to be compromised resulting in infiltration through the waste materials and into the underlying geological materials.

5.3.2.6.1.2 Application Case Results

The main findings of the operations and post-closure phase base case simulations are discussed in Golder (2019) and summarized below:

Operations Phase

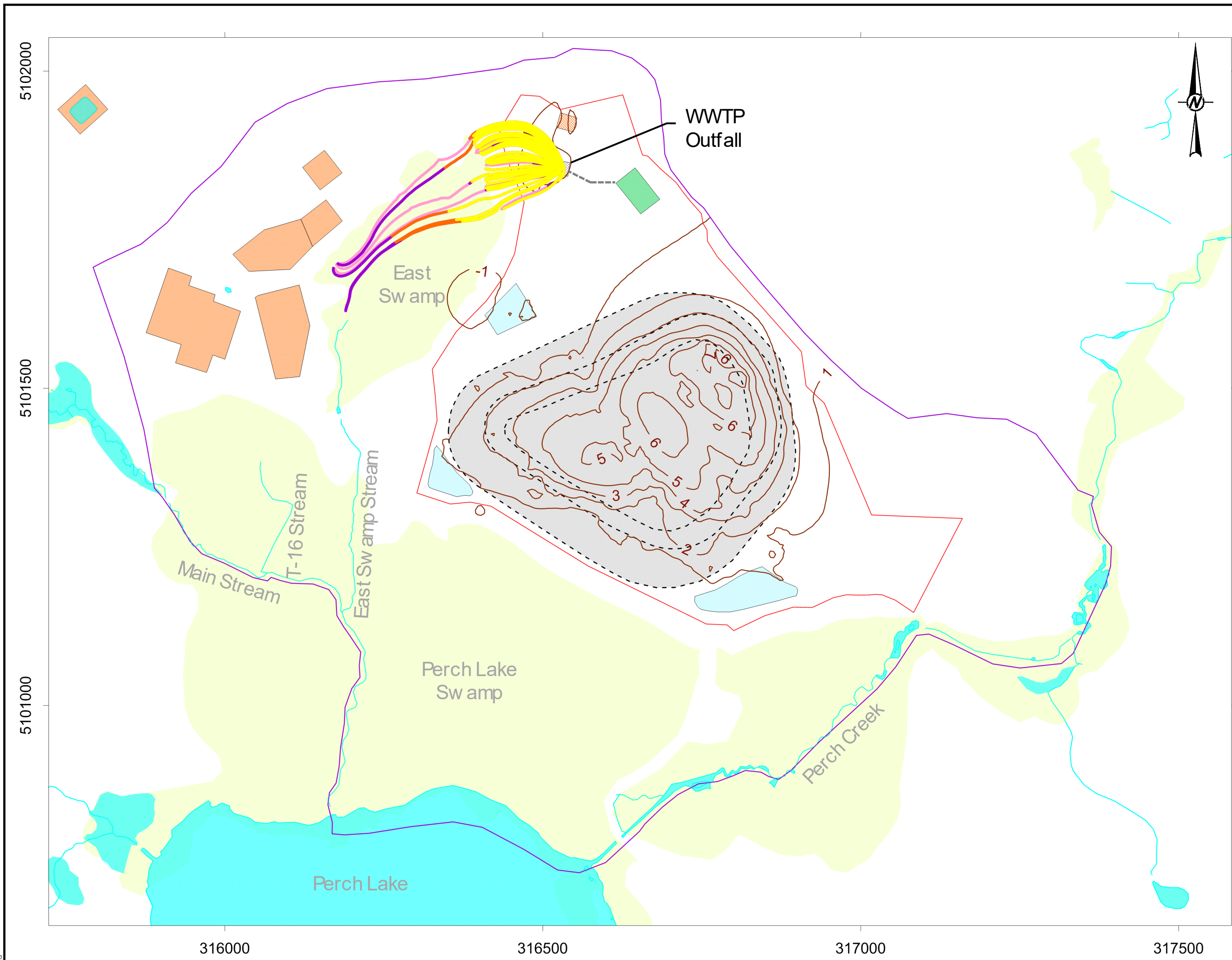
- For the operations scenario where the WWTP is operational (Scenario A), groundwater particles released from the exfiltration gallery area travel towards the west, ultimately discharging at the East Swamp. The majority of the particles discharge to the East Swamp immediately downgradient from the exfiltration gallery, whereas the remaining particles follow a deeper flowpath and discharge at the East Swamp Stream after approximately 3 years (Figure 5.3.2-7). During the operations phase, the additional infiltration applied at the exfiltration gallery results in a localized increase in water table elevation of up to 1 m compared to the current conditions.
- For Operations Scenarios A and B (i.e., scenarios where the SWMPs are lined) there was localized drawdown in the simulated water table in the vicinity of the SWMPs. The maximum drawdown for all scenarios was approximately 1 m and was limited to the area of SWMP #1. The extent of the drawdown beneath the lined ponds is limited by infiltration applied at the pond spillover location (i.e., immediately downgradient of the pond locations). (Figure 4.3 and Figure 4.4 in Golder 2019b).
- Post-closure

- For the Post-closure Scenario with an intact final cover (i.e., the scenario where runoff is directed to the SWMPs, and the pond liners are compromised), there were localized rises in the simulated water table in the vicinity of the SWMPs. The maximum rise was approximately 2 m in the vicinity of the SWMP #1 (Figure 4.5 in Golder 2019b). The extent of the rise in the water table was limited to the area located between the SWMP#1 and the boundary of East Swamp, extending approximately 50 m northwest of the SWMP #1 (as defined by the -1 m drawdown contour). The simulated change in groundwater elevation in the area of the ponds remained below ground surface (under high water table conditions). As such, the infiltration of runoff applied in the pond areas is anticipated to have a limited impact on the surface water regime.
- For the Post-closure Scenario where the final cover was assumed to be compromised the groundwater particles follow a flowpath towards the south-southeast, with the majority of particles discharging to Perch Creek (a small portion of the particles released from the westernmost and easternmost spillover area locations discharged at surface to the Perch Lake Swamp). Groundwater travel times between the spillover and Perch Creek for the majority of particles ranged from approximately 5 years to 15 years with the majority of particles arriving between approximately 7 years to 10 years (Figure 5.3.2-8). Based on the position of the water table, the groundwater particles began at the spillover location travelling through the till unit, then transitioned to the upper sand units before reaching their ultimate discharge location. An example of a conservative (i.e., early arriving) groundwater particle is illustrated on Figure 5.3.2-8 (in Golder 2019b; see the path with points marked from A through D). At this location, the groundwater particle reaches Perch Creek in approximately 6 years, and has a groundwater velocity ranging from 0.15 m/day to 0.26 m/day depending on its position in the groundwater flowpath.
- Between the ECM and Perch Creek a similar groundwater particle flowpath to that described above was simulated for the Post-Closure Scenario where the final cover and liner were assumed to be compromised. Some particles that originated from the northwestern perimeter of the ECM travelled through a longer flowpath to the west before ultimately discharging to Perch Lake. The conservative example illustrated on Figure 5.3.2-9 is based on a flowpath from the southern end of the ECM to Perch Creek, where groundwater velocities ranged from 0.12 to 0.25 m/day (depending on the position along the flowpath). Total travel times between the ECM and Perch Creek ranged from approximately 6.5 to 12 years.
- For the Post-Closure scenario with a compromised final cover and liner, the simulated groundwater pathway flow rates from the ECM location to Perch Creek were approximately 141 m^3/day. Of this, approximately 92 m^3/day originates from the ECM leachate (i.e., the spillover) and 49 m^3/day originates from upgradient sources (Figure 5.3.2-10).
- For the Post-Closure Scenario with a compromised cover and liner, the simulated groundwater pathway flow rates from the ECM location to Perch Creek were approximately 137 m^3/day (as measured from the groundwater discharge location in Perch Creek). Of this, approximately 92 m^3/day originates from the ECM leachate and 45 m^3/day originates from upgradient sources (see Figure 5.3.2-9).
- As shown on Figure 5.3.2-10, for both the operations and post-closure phases, minor localized changes to the directions of groundwater flow occur in the vicinity of the SSA as a result of captured and/or redirected water, while the overall groundwater flowpaths are the same as under current conditions (i.e., the calibrated model).

- The final cover is designed to minimize water infiltration by directing percolating or surface water away from the disposed waste. Therefore, the quantities of leachate generated within the ECM will decline over time and it is expected that leachate generation rates will eventually trend toward zero through time as the time length of the post-closure phase increases.

General

- Collection of water (infiltration and/or runoff) over the ECM footprint resulted in a lowering of the water table for all operations and post closure scenarios, though this was generally limited to the local footprint of the ECM and the area to the northeast of the ECM (i.e., towards the groundwater flow divide). The maximum simulated reduction in groundwater elevation occurred over the central and eastern portions of the ECM, to a maximum of approximately 7 m for average water table conditions and 9 m for high water table conditions. The magnitude and distribution of water table lowering was approximately equal among the high water table condition scenarios (Operations Scenario B, and the Post-closure scenarios). For the Post-Closure Scenario where the cover and liner were assumed to be compromised the recharge applied over the ECM footprint (300 mm/yr) was less than the recharge applied over the same area in the “high water table” calibrated model; this resulted in a lowering of the water table of up to approximately 8 m in the northern portion of the ECM compared to high water table conditions (see Figure 4.7 in Golder 2019b).
- The simulated water table remains beneath the threshold value of 1.5 m below the primary liner elevation for all scenarios. In general, the minimum separation distance between the liner and the simulated water table occurred in the southern portion of the ECM. It should be noted that separation between the water table and liner is important for the construction phase (for compaction of the clay liner) and that no impact on ECM performance would be expected in the event that the water table reaches the ECM during operations or in the post closure phase.
- The findings from the sensitivity simulations are discussed in Golder 2019b. In general, the overall groundwater flowpaths from the ECM to Perch Creek estimated using the sensitivity simulations are similar to the results of the calibrated model (i.e., current conditions at the site).



LEGEND

- Groundwater Model Boundary
- Simulated Change in Water Table Elevation – Calibration minus Forecast (m)
- Site Study Area (NSDF Project Site)

Groundwater Particle Traces

- 0 to 1-year
- 1 to 2-year
- 2 to 5-year
- Steady-State

- Stream
- ECM Outline
- Waste Management Area
- Swamp

NOTE(S)

1. SCENARIO A REPRESENTS THE CASE WHERE 1 CELL IS ACTIVE, 11,000 M3 IS COLLECTED IN THE ECM WITH HALF OF THIS VOLUME DISCHARGED TO THE WTP EXFILTRATION GALLERY OVER A FOUR MONTH PERIOD;
2. RECHARGE DISTRIBUTION IS REPRESENTATIVE OF LONG TERM AVERAGE CONDITIONS
3. RUNOFF COLLECTION AND RE-ROUTING TO SWM PONDS FOR THE REMAINING CELLS;
4. PARTICLE TRACES ARE SHOWN FROM THE WTP INFILTRATION AREA;

REFERENCE(S)

1. PERCH LAKE SUB-BASINS OBTAINED FROM E. ROBERTSON & P.J. BARRY (1985) THE WATER AND ENERGY BALANCES OF PERCH LAKE (1969–1980), ATMOSPHERE-OCEAN, 23:3, 238-253, DOI: 10.1080/07055900.1985.96492270)

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
GROUNDWATER FLOW MODEL RESULTS – OPERATIONS SCENARIO A

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.2-7

Path: S:\Clients\Canadian Nuclear Laboratories\NSDF\99 PROJ\1547525 NSDF EIS\40 PROD\0009 EIS Section 5\Section 5.3 Geology Hydrogeology\1547525-0009-CH-0025.mxd

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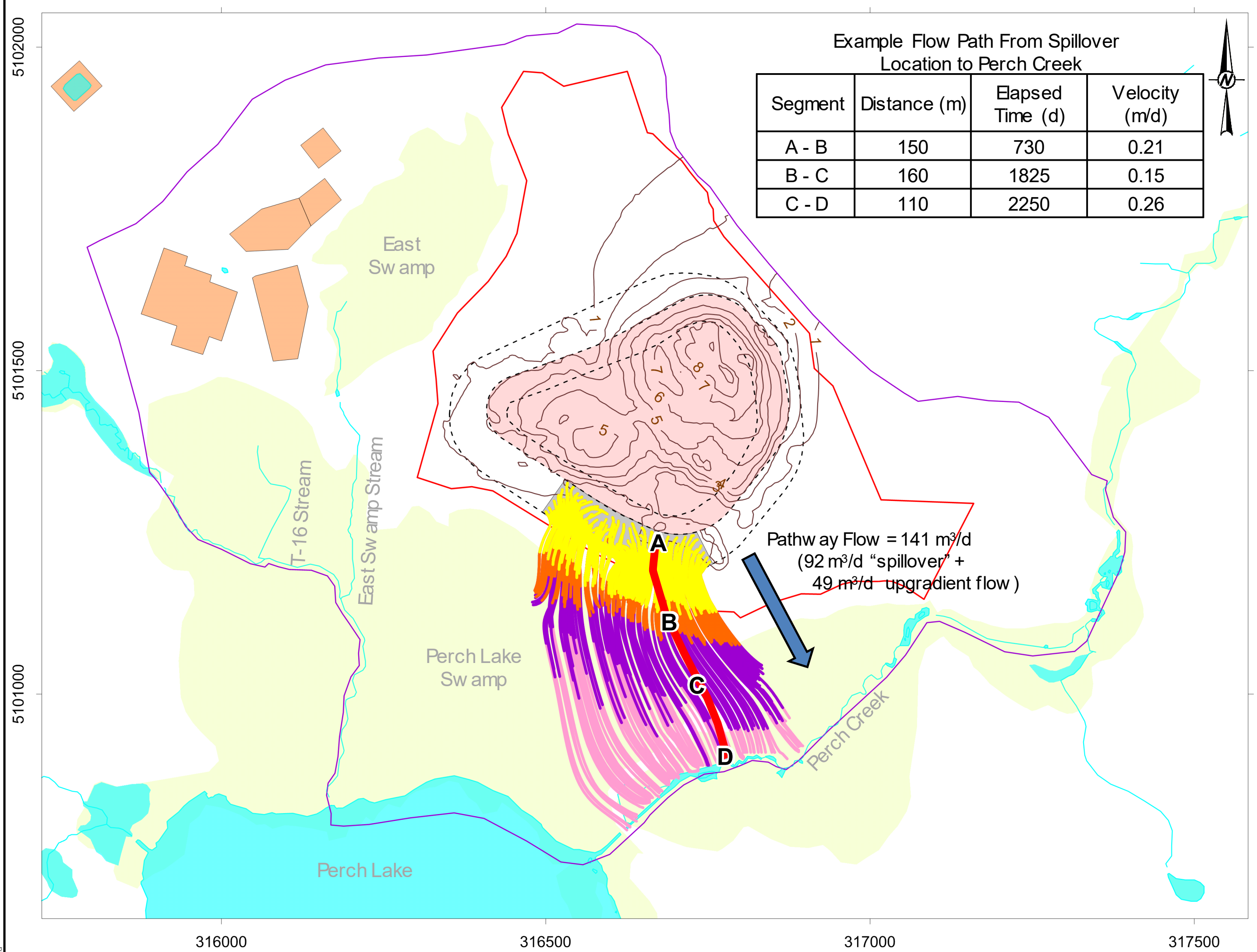


Segment	Distance (m)	Elapsed Time (d)	Velocity (m/d)
A - B	150	730	0.21
B - C	160	1825	0.15
C - D	110	2250	0.26

LEGEND

- Groundwater Model Boundary
- Simulated Change in Water Table Elevation – Calibration minus Forecast (m)
- Site Study Area (NSDF Project Site)
- Groundwater Particle Traces
  - 0 to 1-year
  - 1 to 2-year
  - 2 to 5-year
  - Steady-State
- Stream
- ECM Outline
- Spillover Infiltration Area
- Closed Cells
- Waste Management Area
- Swamp

NOTE(S)

1. NATURAL/BACKGROUND INFILTRATION THE EXFILTRATION GALLERY AND PONDS;
2. NO RUNOFF COLLECTION;
3. 0.3 M/YR INFILTRATION OCCURS THROUGH THE COVER. THIS IS APPLIED AS INFILTRATION AT THE SPILLOVER LOCATION.

REFERENCE(S)

1. PERCH LAKE SUB-BASINS OBTAINED FROM E. ROBERTSON & P.J. BARRY (1985) THE WATER AND ENERGY BALANCES OF PERCH LAKE (1969–1980), ATMOSPHERE-OCEAN, 23:3, 238-253, DOI: 10.1080/07055900.1985.96492270)

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

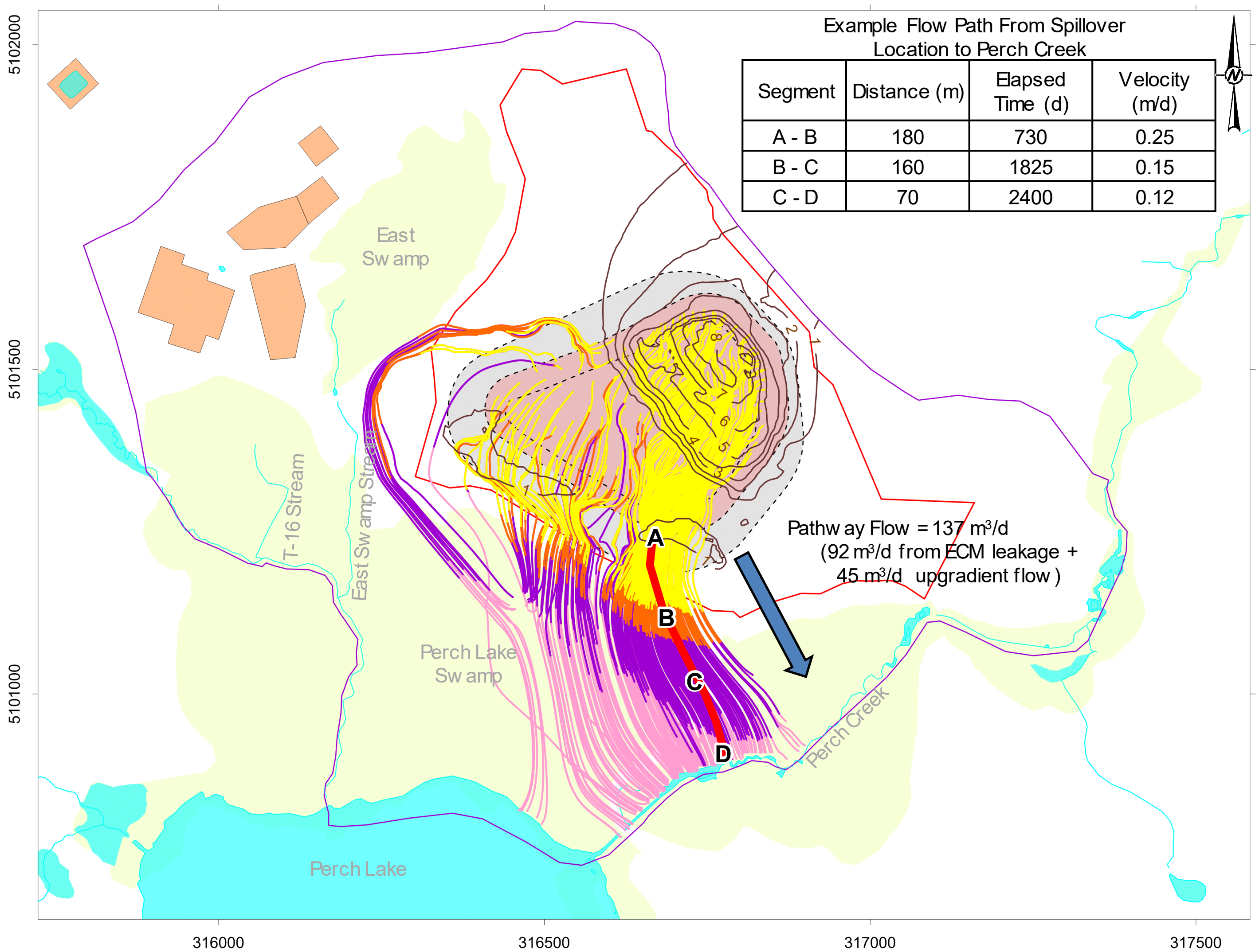
PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
GROUNDWATER FLOW MODEL RESULTS – POST CLOSURE WITH COMPROMISED ENGINEERED COVER

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	**5.3.2-8**



LEGEND

- Groundwater Model Boundary
- Simulated Change in Water Table Elevation – Calibration minus Forecast (m)
- Site Study Area (NSDF Project Site)

Groundwater Particle Traces

- 0 to 1-year
- 1 to 2-year
- 2 to 5-year
- Steady-State
- Stream
- ECM Outline
- Spillover Infiltration Area
- Closed Cells
- Waste Management Area
- Swamp

NOTE(S)

1. NATURAL/BACKGROUND INFILTRATION THE EXFILTRATION GALLERY AND PONDS;;
2. NO RUNOFF COLLECTION;
3. 0.3 M/YR INFILTRATION OCCURS THROUGH THE COVER, WHICH IS APPLIED THROUGHOUT THE ECM FOOTPRINT.

REFERENCE(S)

1. PERCH LAKE SUB-BASINS OBTAINED FROM E. ROBERTSON & P.J. BARRY (1985) THE WATER AND ENERGY BALANCES OF PERCH LAKE (1969–1980), ATMOSPHERE-OCEAN, 23:3, 238-253, DOI: 10.1080/07055900.1985.96492270)

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
GROUNDWATER FLOW MODEL RESULTS – POST CLOSURE WITH COMPROMISED ENGINEERED COVER AND LINER

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	NFB/MIB
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.3.2-9

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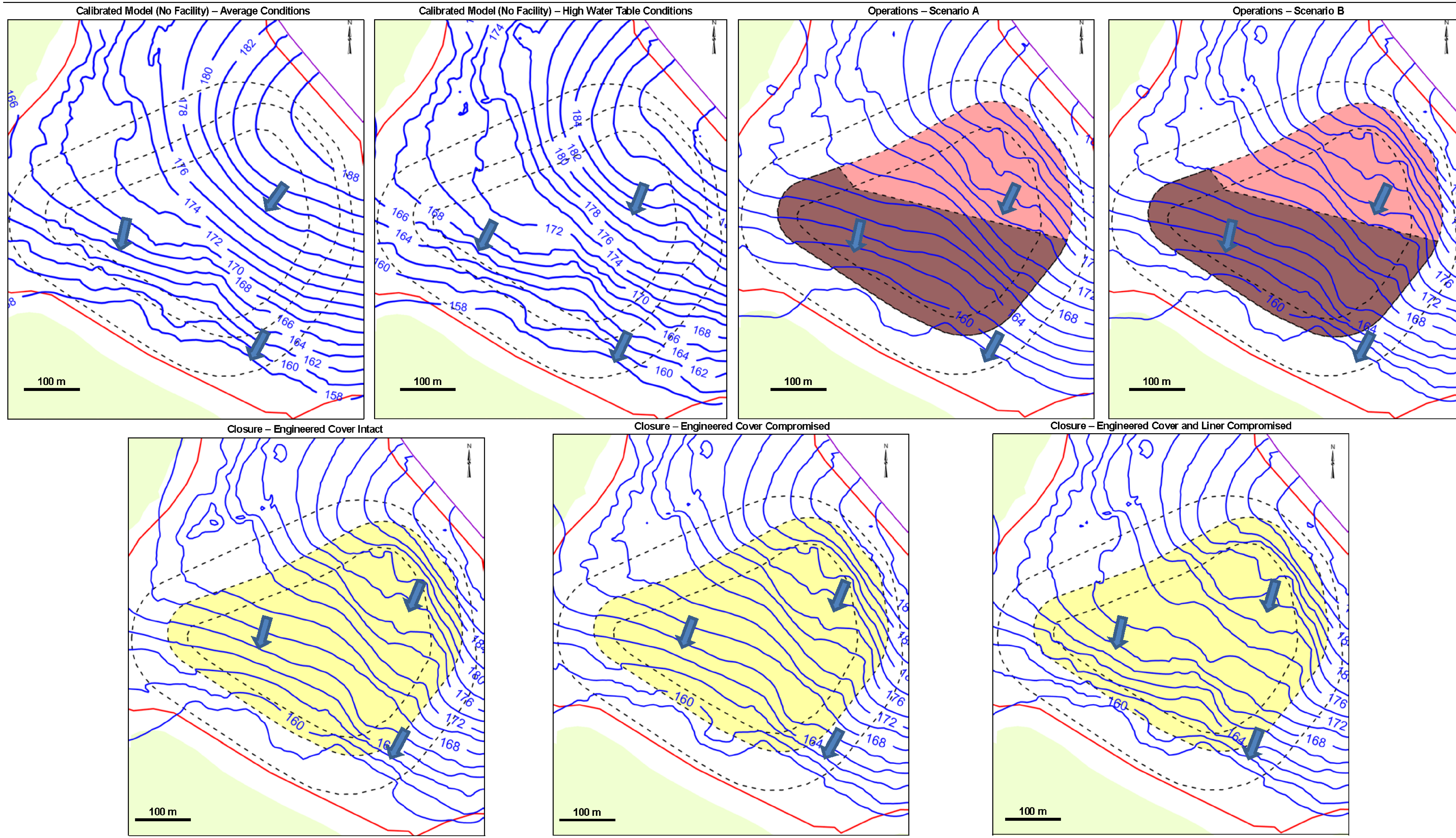

LEGEND

- Model Boundary
- ECM Outline
- Simulated Groundwater Table Elevation
- Stream
- Site Study Area (NSDF Project Site)
- Wetland
- Phase 1 Liner
- Phase 2 Sacrificial Liner
- Closed Cells
- Interpreted Groundwater Flow Direction

CLIENT CANADIAN NUCLEAR LABORATORIES LTD.		PROJECT NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT CHALK RIVER, ONTARIO	
CONSULTANT GOLDER	DATE: NOVEMBER 2020 PREPARED: NFB DESIGN: SO REVIEW: CS APPROVED: AB	TITLE **SIMULATED GROUNDWATER TABLE ELEVATION - CALIBRATED MODEL AND ALL FORECAST SCENARIOS**	
		PROJECT NO. 1547525 / PHASE 0009	REV. FINAL 2 / FIGURE **5.3.2-10**

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5.3.2.6.2 Groundwater Quality

5.3.2.6.2.1 Methods

As discussed in Section 5.3.2.5.2, during the operations phase and the beginning of the post-closure phase when the WWTP is active, leachate from the ECM will be collected and treated prior to discharge (i.e., secondary pathway). Therefore, the assessment of groundwater quality is focused on predicting changes in the groundwater contaminant concentrations from the leakage of leachate from the ECM during the post-closure phase, after the WWTP has been decommissioned. The assessment of residual effects on groundwater quality for the post-closure phase is documented in the *Post-Closure Safety Assessment Report for the NSDF Project* (PostSA; Arcadis and Quintessa 2020b) and summarized herein.

Operations Phase

During the operations phase the potential impact on groundwater is from discharge of treated wastewater to ground via the exfiltration gallery. Groundwater flow from the exfiltration gallery is through the East Swamp with groundwater discharging to East Swamp Stream. The treated effluent discharge will meet federal and provincial guidelines for protection of aquatic biota for non-radiological constituents and will meet drinking water guidelines for radiological constituents (CNL 2019c). One exception is tritium, for which the discharge target is 360,000 Bq/L. The discharge target, although exceeding the drinking water guideline for tritium of 7,000 Bq/L is well below the no-effects concentration for biota of 17,400,000 Bq/L for the CRL site (CNL 2019d).

Impacts on groundwater quality from discharge of the treated effluent to ground via the exfiltration gallery will be negligible. Effluent will be monitored to verify that discharge targets are met. The potential impacts of groundwater discharge on surface water quality (i.e., East Swamp Stream) are assessed in the surface water quality assessment (see Section 5.4.2). Surface water quality modelling confirms that environmental concentrations of contaminants are below No-effect concentrations for radiological dose to biota. For non-radiological contaminants, concentrations are maintained below the CCME’s guidance levels for the protection of aquatic biota or are below levels that would result in potential adverse effects on aquatic life. Therefore, no exposure from non-radiological constituents to non-human biota is calculated.

Post-closure Phase

Groundwater quality effects were represented for the post-institutional control period, when the final cover, leachate collection and water treatment systems are no longer maintained. Prior to this period the ECM final cover and base liner will be maintained, leachate will be collected and treated, and no uncontrolled or untreated release to groundwater is expected.

Conceptually, during post-institutional control it is expected that rain may infiltrate through the final cover into the waste, resulting in leachate generation. As leachate accumulates within the ECM during this period it was assumed that leachate will enter the groundwater flowpath through either a breach in the base liner or an overtopping in the southeast portion of the ECM (Arcadis and Quintessa 2020b). With sufficient deterioration of the base liner, leachate will begin to drain from the waste at a rate faster than it can be generated and the waste will begin to dry.

For leachate released from the ECM through a breach in the base liner it was assumed that contaminants would be transported to Perch Creek via the groundwater flow system, where it would discharge and eventually flow to the Ottawa River. These scenarios are referred to as natural evolution scenarios in the PostSA (Arcadis and Quintessa 2020b).

The groundwater transport model is described in the PostSA (Arcadis and Quintessa 2020b). Groundwater transport modelling considers advective transport (i.e., the movement of contaminants in groundwater at the mean groundwater velocity) and decay. The transport modelling does not credit reduction in concentrations along the groundwater flowpath from dispersion.

5.3.2.6.2.2 Application Case Results

Operations Phase

Impacts on groundwater from discharge of treated WWTP effluent will be negligible as the treated effluent will meet effluent discharge targets that are protective of the environment and human health. The discharge targets for non-radiological contaminants are sourced from federal and provincial guidelines for protection of aquatic biota. The discharge targets for radionuclides are the Canadian Drinking Water Guidelines with the exception of tritium for which a site-specific target is developed (Section 3.4.2.5.1). Potential impacts of groundwater discharging to surface water is assessed in the surface water quality assessment (See Section 5.4.2).

Post Closure Phase

The effects on the groundwater quality during the post-closure phase is assessed with respect to the potential effect on ecological receptors in the *Ecological Risk Assessment for the NSDF Project* (EcoRA; Arcadis 2020a). The natural evolution scenarios addressed are:

- failure of the cover resulting in water overtopping the berm and moving via groundwater from the ECM to Perch Creek; and
- failure of the base liner resulting in leaching to groundwater and leachate transported via groundwater to Perch Creek.

Groundwater transport predictions are made over a 10,000-year time frame. Maximum predicted concentrations are used to assess impacts on ecological receptors.

Radionuclides

Maximum concentrations in groundwater along the flowpath from the ECM to Perch Creek are assessed and compared against no-effect concentrations for the radionuclides for ecological receptors in the EcoRA (Arcadis 2020a). Biota exposure to groundwater only occurs once groundwater has migrated into surface water. This is captured through the use of surface water data, which implicitly includes the contribution from groundwater. Despite the above, groundwater quality can also be assessed (for perspective only) using a hypothetical invertebrate (earthworm) in contact with groundwater.

Predicted radionuclide concentrations are below no-effect concentrations for all radionuclides. No residual effects are expected. Section 5.7 and Section 5.8 provide further discussion on the assessment of doses to ecological receptors and human health associated with contaminant migration from the ECM via groundwater.

Non-Radionuclides

Effects on groundwater quality for non-radiological constituents were assessed with respect to their potential effect on ecological receptors. The hypothetical receptor considered is an earthworm exposed to groundwater.

A preliminary screening was conducted to identify constituents for potential concern (COPCs) for inclusion in the assessment and is documented in the EcoRA (Arcadis 2020a). Four COPCs were identified, aluminum, copper, lead and uranium. The EcoRA eliminated aluminum and uranium from the assessment on the basis of factors such as negligible concentrations relative to background and limited mobility. Only copper and lead screened into the assessment. For both copper and lead, predicted concentrations in groundwater were below benchmark values and no residual effects are predicted.

For the COPCs that screened in (i.e., copper and lead), the exposure assessment concluded no residual effects on ecological receptors (see Section 5.7).

5.3.2.7 Prediction Confidence and Uncertainty

Hydrogeological modelling was completed to estimate the groundwater flow pathways from the ECM and the rates of groundwater flow from the SSA to downstream receptors. To achieve this objective, a deterministic approach was used where a 3D numerical (MODFLOW) groundwater model was constructed and calibrated to represent the "best estimate" of groundwater flow conditions based on the conceptual model described above. The model was calibrated through an iterative process where steady-state model runs were completed with adjustments to the model input parameters (within acceptable ranges) until model results provided an acceptable match to observed conditions (groundwater elevations, groundwater flow directions, baseflow estimates, and advective flowpaths from the Reactor Pit 2 source area). Additional simulations were completed in order to address the uncertainty associated with the "best estimate" configuration and to examine the sensitivity of model results to some of the key controlling parameters of the hydrogeological system and assumptions made in the development of the conceptual model. A total of ten sensitivity scenarios were evaluated, which addressed potential variation in the hydraulic conductivity of the bedrock and sand units, the recharge distribution, the position of the model boundaries, and various aspects of the ECM design (e.g., the liner, blast zone, cover evapotranspiration and exfiltration gallery flow). Complete details of the model calibration and sensitivity analysis are included in Golder (2019b).

Contaminants released to groundwater are transported uniquely based on their chemical form and specific hydrogeological characteristics. A key parameter influencing the mobility of contaminants in groundwater is the water-soil distribution coefficient. The PostSA (Arcadis and Quintessa 2020b) includes a sensitivity analysis case that tests the uncertainty of the distribution coefficient on groundwater transport predictions.

To address the uncertainty associated with bedrock structures additional simulations investigated the presence of a hypothetical or undetected bedrock fracture zone in below the ECM in direct hydraulic connection with Perch Creek (as detailed in Golder, 2020a and 2020b). For the case where a hypothetical bedrock fracture zone was considered to exist under current conditions the resulting groundwater travel times between the ECM and Perch Creek were similar with the hypothetical bedrock fracture zone included as compared to the base post closure scenarios (i.e. typically 7 to 10 years for the majority of groundwater with an overall range of 5 to 15 years). Simulations completed to represent a future "activation" of a hypothetical bedrock fracture zone resulted in an earlier arrival time for a portion of the plume (i.e., an arrival time of approximately 2 to 15 years as opposed to 5 to 15 years for the base post closure scenario).

5.3.2.8 Monitoring and Follow-up

A groundwater monitoring network will be developed including installation of groundwater monitoring wells to monitor hydraulic and chemical conditions in preferential flow zones in both vertical and horizontal orientations, with an emphasis on locations downgradient from the ECM. The GWMP developed for the NSDF Project will be integrated into the overall CNL Groundwater Monitoring Program, and will be compliant with Canadian Standards Association (CSA) N288.7-15 5, *Groundwater Protection Programs at Class I Nuclear Facilities and Uranium Mines and Mills* (CSA Group 2015). The Standard indicates the need for both upgradient (background) and downgradient monitoring well locations. The CSA N288.7-15 Standard also includes a process step where contaminants of potential concern are evaluated for sampling.

The GWMP will begin prior to operations. Base Case groundwater data will be collected and used to confirm groundwater conditions. Groundwater monitoring will continue through operations, closure and post-closure. The number of parameters and locations may change based on annual review of monitoring data. Initial sampling frequency will likely be twice per year (Spring and Fall) consistent with the existing site GWMP (Table 5.3.2-8).

Table 5.3.2-8: Monitoring and Follow up Programs for Hydrogeology

Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Hydrogeology	The NSDF Project may affect groundwater quality during operations, closure and post-closure (institutional control)	▪ Verify environmental assessment predictions on groundwater from the ECM and WWTP operation ▪ Verify the effectiveness of mitigation	▪ Groundwater elevation measurements to determine groundwater flow direction and gradients ▪ Sampling to confirm groundwater quality to detect potential releases of constituents from the ECM containment area ▪ Initial sampling frequency will likely be twice per year (Spring and Fall)	▪ Groundwater monitoring will continue through operations, closure and post-closure (institutional control). ▪ The number of parameters, locations and frequency may change based on annual review of monitoring data	▪ NSDF Project groundwater monitoring will be integrated into the overall CNL Groundwater Monitoring Program, and will be compliant with CSA N288.7-15

ECM = engineered containment mound; WWTP = Wastewater Treatment Plant.

5.3.2.9 Conclusions

Valued Components refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community or the public (The Agency 2018). Hydrogeology is recognized as an important component of the environment that may be affected by the NSDF Project and changes to hydrogeology could, in turn, lead to effects on other VCs selected for assessment. Acknowledging that changes to groundwater quantity and quality are considered to be important aspects of the natural and human environment, hydrogeology is referred to as an intermediate component. The hydrogeology assessment does not include the assessment of the significance of these changes; rather, results of the analysis of changes in measurement indicators for hydrogeology are provided to other disciplines for inclusion in their assessment (Table 5.3.2-3).

The residual effects on hydrogeology are related to the alteration of groundwater levels and flows due to the construction of the NSDF Project and potential changes to groundwater quantity and quality due to leakage from the ECM following post-closure activities (Table 5.3.2-9). Residual effects to groundwater from leakage of leachate from the ECM during operations are not anticipated due to the implementation of environmental design features, mitigation and operational monitoring plans. Environmental design features and mitigation implemented to reduce residual effects on groundwater quantity and quality include:

- discharge of treated effluent to the exfiltration gallery area will help to reduce water loss from the hydrogeological system;
- procedures for surface water management will be developed and implemented;
- the composite base liner design will include both primary and secondary liner systems, including a compacted clay liner, two geosynthetic clay liners which are anticipated to maintain their function as hydraulic barriers throughout and beyond the design life of the disposal facility (i.e., 550 years);
- the primary liner will include a leachate collection system with the secondary liner housing a leak detection system;
- the HDPE geomembrane was selected as it is compatible with the leachate generated by the waste and will achieve a long service life; and
- sampling of the treated effluent discharge will be completed in accordance with CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018d).

A conceptual groundwater model was developed that identified the key hydrostratigraphic units controlling groundwater flow, the hydraulic properties of these units, and the directions and rates of groundwater flow. The general findings from this assessment indicated that groundwater flow primarily occurs through the sandy overburden units (the Upper Sand, Middle Sand and Basal Sand/Till), whereas the bedrock is considered to be of low transmissivity. Groundwater flow patterns generally follow topography, with recharge occurring in the upland areas and with the ultimate discharge location at Perch Lake or Perch Creek. Groundwater recharge and discharge occurs locally in streams within the lower Perch Lake Basin.

Hydrogeological modelling was completed to estimate the groundwater flow pathways from the ECM and the rates of groundwater flow from the SSA to downstream receptors. This was accomplished by constructing a groundwater flow model based on the conceptual model and calibrating it to the existing conditions. In general, minor localized changes to the directions of groundwater flow are predicted to occur in the vicinity of the SSA as a result of captured and/or redirected water, while the overall groundwater flowpaths are the same as under current conditions. However, with final cover placement, quantities of leachate generated within the ECM will decline and it is expected that leachate generation rates will eventually trend toward zero throughout post-closure. The flux of radionuclides from the ECM to groundwater through the post-closure phase was calculated. The discharge of this groundwater to surface water in Perch Creek was included in an evaluation of doses to receptors.

Early waste management practices included burying LLW in sand trenches with no engineered barriers thus impacting the surrounding soils as well as the groundwater within the Perch Lake Basin. Although appropriate risk management actions have taken place (i.e., interception and treatment of strontium-90 groundwater plumes), large scale remediation of the contamination sources may be necessary to ensure appropriate long-term management of this legacy waste. The NSDF Project design is based on containment and isolation of the LLW inventory from the environment including engineered barriers such as the base liner system which mitigates impacts to the surrounding groundwater. Therefore, decommissioning and environmental remediation activities, which will generate waste for disposal in the ECM, are anticipated to positively affect measurement indicators for hydrogeology such as groundwater quality outside the SSA.

A groundwater monitoring network will be developed including installation of groundwater monitoring wells to monitor hydraulic and chemical conditions in preferential flow zones in both vertical and horizontal orientations along the critical flow pathways, with an emphasis on locations downgradient of the ECM. The main emphasis of the GWMP is to monitor locations that are downgradient from the ECM. The GWMP developed for the NSDF Project will be integrated into the overall CNL GWMP, and will be compliant with CSA N288.7-15. Groundwater monitoring will continue through operations, closure and post-closure.

Table 5.3.2-9: Summary of Predicted Residual Adverse Effects for Hydrogeology Valued Components

Valued Components	Residual Adverse Effects	Project Effect Occurs in	Contributing Project Activity	Proposed Mitigation
Groundwater quantity	The construction of the NSDF Project will physically alter groundwater levels and flows.	Construction through to post-closure	■ Project activities during the construction phase: ■ Site preparation ■ Construction of the ECM ■ Development of surface water management structures ■ Construction of the WWTP and other support facilities ■ On-site road and access development.	■ The NSDF Project has been designed to limit disturbance to the natural environment. ■ Discharge of treated effluent primarily to the exfiltration gallery area will help to reduce water loss from the hydrogeological system. ■ Discharge of treated effluent to Perch Lake via pipeline will help reduce high water table conditions in the area of the exfiltration gallery.

Table 5.3.2-9: Summary of Predicted Residual Adverse Effects for Hydrogeology Valued Components

Valued Components	Residual Adverse Effects	Project Effect Occurs in	Contributing Project Activity	Proposed Mitigation
Groundwater quality	Adverse changes to groundwater quality from the discharge of treated effluent from the WWTP to the exfiltration gallery.	Operations	■ Discharge of treated effluent to the exfiltration gallery.	■ The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses the best available technology that is economically achievable, and capable of meeting regulatory requirements. ■ Effluent discharge targets for wastewater discharges are protective of the environment and human health. ▪ Discharge targets for non-radiological contaminants are sourced from federal and provincial guidelines for protection of aquatic biota. ▪ Discharge targets for radionuclides are the Canadian Drinking Water Guidelines with the exception of tritium for which a site-specific target is developed (Section 3.4.2.5.1). ■ Treated effluent will be sampled and confirmed that it meets the effluent discharge targets before release to the environment. ■ When applied, the proposed exfiltration gallery will promote the exfiltration of treated water into the local groundwater regime where further retention of radioactivity by the geosphere is anticipated. ■ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water and groundwater quality. ■ Appropriate procedures will be in place to effectively identify spill occurrences in the event treated effluent is released to areas other than directly to the exfiltration gallery and initiate appropriate emergency responses.

Table 5.3.2-9: Summary of Predicted Residual Adverse Effects for Hydrogeology Valued Components

Valued Components	Residual Adverse Effects	Project Effect Occurs in	Contributing Project Activity	Proposed Mitigation
Groundwater quantity and quality	Leakage of leachate from the ECM during the post-closure phase (i.e., after Year 2400) from liner and final cover degradation as a result of normal evolution can cause changes to groundwater quality.	Closure and Post-closure	■ Installation of final cover, restoration and grading of Site Study Area (SSA). ■ On-going long-term performance monitoring, transfer of NSDF Project into Institutional Control. ■ Liner and final cover degradation as a result of normal evolution.	■ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound and minimize leachate generation. ■ The final cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity. ■ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the final cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. ■ The ECM final grading and drainage plan also includes collection ditches along the top of the ECM berm road to collect side slope drainage. ■ The design life for the ECM is 550 years to meet the required time period to allow for radioactive decay of the waste placed in the facility (i.e., until it has decayed to levels that do not present a risk to the public and environment). ■ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to groundwater quality.

ECM = engineered containment mound; LLW = low-level waste

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5.4 Surface Water Environment

This section of the Environmental Impact Statement for the Canadian Nuclear Laboratories (CNL) Near Surface Disposal Facility (NSDF) Project seeks to understand and characterize potential residual effects of the NSDF Project and other previous, existing, and reasonably foreseeable developments on the physical aspects of the environment. Section 5.4.1 focuses on hydrology and Section 5.4.2 focuses on surface water quality.

5.4.1 Hydrology

5.4.1.1 Scope of the Assessment

This section focuses on hydrology, which includes surface water quantity, flow and direction. It considers those surface water features in the vicinity of the NSDF Project including wetlands, streams, creeks, lakes and rivers. The hydrology assessment follows the overall environmental assessment approach and methods described in Section 5.1. The assessment was completed following the key steps listed below:

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries and assessment cases** for the hydrology assessment (refer to Sections 5.4.1.2 Valued Components and Section 5.4.1.3 Assessment Boundaries). The VCs and measurement indicators used to assess Project-related changes to hydrology, are described, along with the spatial and temporal boundaries at which the assessment occurred and the assessment cases considered.
- **Step 2 – Describe the existing conditions** (refer to Section 5.4.1.4 Description of the Environment). Existing conditions in the local and regional areas are described, including the combined effects of previous and existing developments (Base Case). The existing environment represents the historical and current environmental pressures that have shaped the observed patterns in the environment (i.e., natural variation). The existing conditions provide a reference to which the effects of the NSDF Project can be compared.
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 5.4.1.5 Project Interactions and Mitigation). The NSDF Project components and/or activities with the potential to affect hydrology are identified and mitigation developed to limit or avoid effects is presented. A pathways analysis is then used to focus further assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects are adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects to hydrology after incorporating mitigation are carried forward to Step 4 for further analysis and residual effects characterization.
- **Step 4 – Present the methods and results of the residual effects analysis** (refer to Section 5.4.1.6 Residual Effects Analysis). This section outlines the methods used to predict and characterize residual effects to hydrology from primary effect pathways. The analysis results are also presented including the characterization of incremental effects from the NSDF Project, as well as cumulative effects of the NSDF Project in combination with other reasonably foreseeable developments (if applicable). A key outcome of this section is the predicted changes to surface water quantity that are passed on to other disciplines for their assessment.

- **Step 5 – Describe the level of certainty and management of uncertainty** (refer to Section 5.4.1.7 Prediction Confidence and Uncertainty). Evaluate the available literature, data and models used for the assessment, and describe the level of certainty that can be placed on predicted residual effects. This section will also identify how the uncertainty has been managed so that the effects are not underestimated.
- **Step 6 - Classify and determine the significance of the predicted residual effects**. This step was not required as the hydrology VC is an intermediate component which does not include an assessment endpoint to determine significance.
- **Step 7 – Identify monitoring and follow-up** required to confirm effects predictions and address uncertainty (refer to Section 5.4.1.8 Monitoring and Follow-up).
- **Step 8 – Present a consolidated summary of conclusions** and outcomes of the assessment of residual effects on hydrology (refer to Section 5.4.1.9 Conclusions).

Section 5.4.1 also describes how the input from engagement influenced the scope of the hydrology assessment. Information and areas of interest raised by the public, communities of interest, and Indigenous peoples during engagement that influenced the scope of the hydrology assessment are summarized in Table 5.4.1-1. Other general areas of interest and questions raised during the engagement that pertain to the surface water environment assessment (if any) are documented in CNL's Indigenous Engagement Report (CNL 2020) and CNL's Stakeholder's Activity Reports (CNL 2017a,b, 2019a).

Table 5.4.1-1: Summary of Areas of Interest Raised During Engagement Activities that Influenced the Scope of the Hydrology Assessment

Areas of Interest	How the Area of Interest was Included in the Assessment
Potential for contamination in the Ottawa River from the NSDF Project.	The spatial boundaries of the assessment were selected to include consideration of potential effects to the Ottawa River. Surface water quality modelling was completed to estimate contaminant concentrations within the Perch Creek basin, which flows directly into the Ottawa River. Meeting effluent discharge targets within the Perch Creek and Perch Lake is protective of the Ottawa River. The Regional Study Area was expanded to include a reach of the Ottawa River extending 8 km downstream of CRL in response to comments received from the public.

5.4.1.2 Valued Components

Valued Components (VCs) refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community or the public (The Agency 2018). Hydrology, which includes surface water quantity, flow and direction, is recognized as an important component of the environment that may be affected by the NSDF Project, and changes to hydrology could, in turn, lead to effects on other VCs selected for assessment. For example, changes to the characteristics of hydrology, such as water quantity, have a large influence on the local and regional diversity, contributing to the spatial and temporal distribution of aquatic and terrestrial ecosystems. Subsequently, changes to these characteristics by NSDF Project activities could affect fish and wildlife, and land and resource use (Table 5.4.1-2).

Table 5.4.1-2: Valued Components for Hydrology Assessment

Valued Component	Rationale for Selection
Hydrology	■ The NSDF Project may affect existing availability of the spatial and temporal distribution of water quantity for aquatic and terrestrial biodiversity, which can in turn affect land and resource use. ■ Societal values concerning changes in water quantity are an important consideration in understanding potential effects of the NSDF Project.

Acknowledging that changes to hydrology are considered to be important aspects of the natural and human environment, hydrology is referred to as an intermediate component (i.e., it does not have an assessment endpoint). Changes to intermediate component VCs must be understood to facilitate assessment of project interactions. The hydrology assessment, therefore, is analyzed for incremental and cumulative (if applicable) changes in the relevant measurement indicators associated with hydrology (Table 5.4.1-3). The changes are characterized in terms of magnitude, duration and geographic extent, but are not classified using rankings for effects criteria. The hydrology assessment also does not include the assessment of the significance of these changes; rather, results of the analysis of changes in measurement indicators for hydrology are provided to other disciplines for inclusion in their assessment (Table 5.4.1-3).

Table 5.4.1-3: Measurement Indicators for the Hydrology Assessment

Valued Component	Measurement Indicators	Discipline Assessments where Effects on Hydrology are Considered
Hydrology	■ Peak flow rates, time to peak flow and total runoff volumes ■ Stream channel parameters (e.g., channel depths, widths) and shoreline integrity	■ Section 5.4.2 Surface Water Quality ■ Section 5.5 Aquatic Environment ■ Section 5.6 Terrestrial Environment ■ Section 5.9 Land and Resource Use

5.4.1.3 Assessment Boundaries

5.4.1.3.1 Spatial Boundaries

The spatial boundaries selected for the hydrology assessment were chosen because they permit description of existing conditions in sufficient detail to enable potential Project-VC interactions and effects to be identified, understood and assessed, including understanding and assessing the contribution of the NSDF Project to cumulative effects. The spatial boundaries selected for the hydrology are consistent with the surface water quality and aquatic biodiversity assessment are presented on Figure 5.4.1-1 and are described below:

- **Site Study Area (SSA):** The SSA is the NSDF Project footprint (i.e., where Project activities would be undertaken, including the NSDF Project's proposed facilities, buildings and infrastructure).
- **Local Study Area (LSA):** The LSA is selected in consideration of the NSDF Project footprint and the spatial extent of potential direct effects of the Project on the VCs. The LSA includes the SSA and is bounded by Perch Lake and Perch Creek, and adjacent wetlands and swamps.
- **Regional Study Area (RSA):** The RSA is defined as the area within which the potential effects of the NSDF Project may interact with the effects of other existing or reasonably foreseeable developments. The RSA for hydrology is determined by the spatial extent of the Perch Creek and Perch Lake Watershed. A portion of the Ottawa River (i.e., roughly 8 km downstream in the Ottawa River to Harrington Bay) is also included in the RSA.

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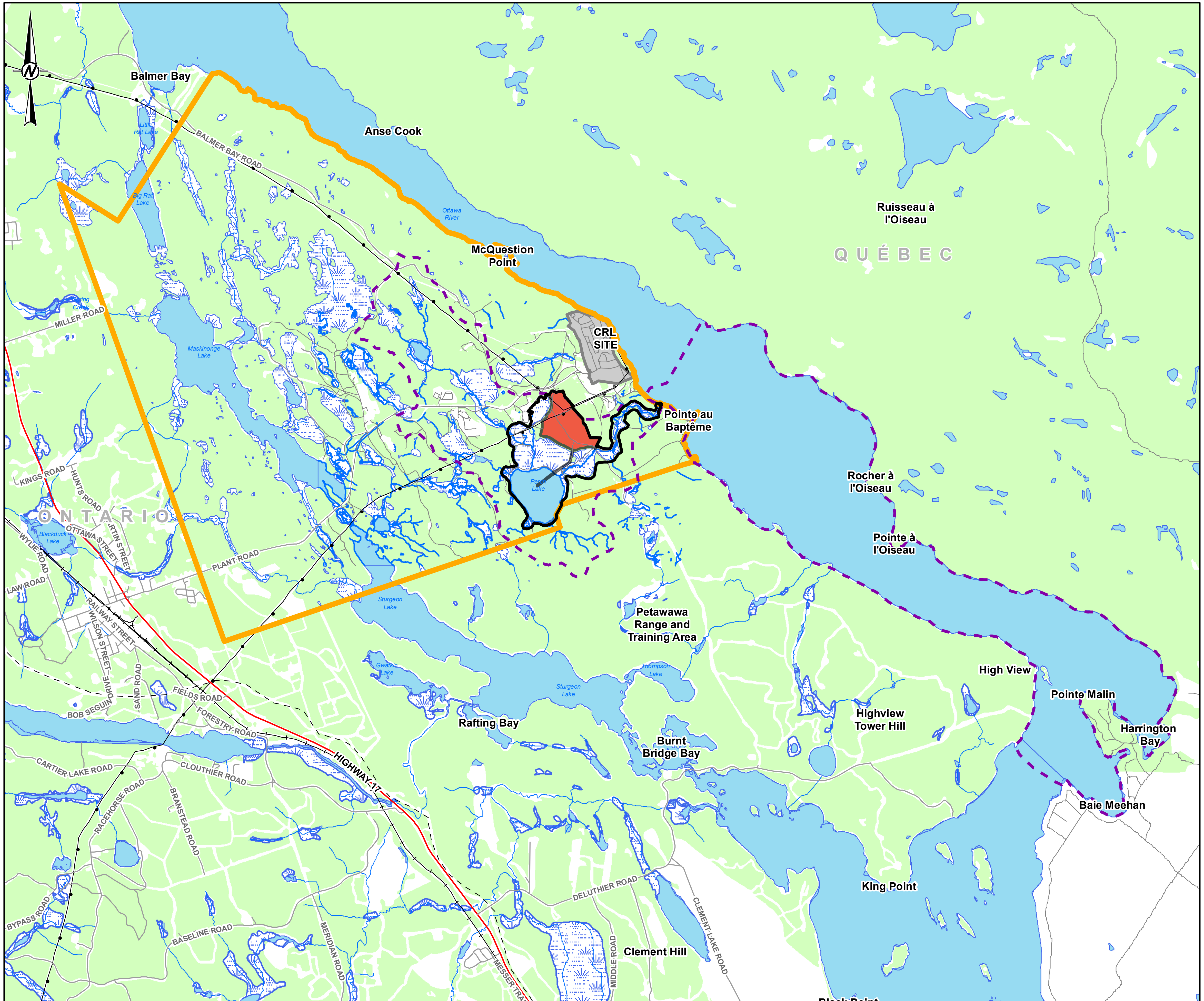

LEGEND

- HIGHWAY
- ROAD
- RAILWAY
- HYDRO LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- SITE STUDY AREA (NDSF PROJECT SITE)
- CRL MAIN CAMPUS
- CRL SITE
- LOCAL STUDY AREA
- REGIONAL STUDY AREA

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NOTE(S)

REFERENCE(S)

1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
SPATIAL BOUNDARIES SELECTED FOR THE HYDROLOGY AND SURFACE WATER QUALITY ASSESSMENT

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0018	FINAL 2	5.4.1-1

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5.4.1.3.2 Temporal Boundaries

- Temporal boundaries (i.e., project phases) establish the timeframe during which NSDF Project effects are assessed. The temporal boundary represents the timeframe during which project activities are actively occurring, and considers the duration of predicted residual effects. The duration of an effect is defined as the amount of time between the start and end of a project activity or stressor (which is related to the project phases) plus the time required for the residual effect to be reversed. In some cases, a residual effect may be irreversible within the temporal boundaries of the project or if the effects were predicted to last so far into the future that they could not be predicted with any level of certainty (e.g., a residual effect that lasts for thousands of years). The following phases were identified for the NSDF Project:
- **Construction Phase**: This phase includes site preparation and all activities associated with the construction of the NSDF Project. This phase includes activities such as installing the necessary supporting and/or ancillary facilities and infrastructure to facilitate NSDF Project operations, inactive commissioning and systems testing, and transportation of construction materials. Construction activities are expected take place from 2021 to 2023.
- **Operations Phase**: This phase includes all activities associated with waste placement, water management, WWTP operations, vehicle movements into and from the SSA and maintenance activities. Operations activities are expected to last approximately 50 years (i.e., 2024 to 2070).
- **Closure Phase:** This phase includes activities necessary to complete the installation of the final cover and implementation of long-term monitoring. Closure activities are expected to start in 2070 and continue through to 2100, after which the NSDF Project will transfer into the post-closure phase.
- **Post-closure Phase:** This phase has two discrete periods: institutional control and post-institutional control. The institutional control period includes implementation of controls throughout 2100 to 2400 (i.e., 300 years). During institutional control, environmental monitoring will continue to demonstrate compliance with the environmental assessment predictions. Post-institutional control occurs after year 2400 and continues indefinitely.

The temporal boundaries for the hydrology assessment include consideration of effects of the NSDF Project during the construction, operations and post-closure phases as it is during these phases that the NSDF footprint will have the largest change on the existing surface drainage and peak flows.

5.4.1.3.3 Assessment Cases

The assessment cases considered in the hydrology assessment are the Base Case and Application Case (the Reasonably Foreseeable Developments Case has not been considered for the reasons outlined below):

- **Base Case –** This scenario represents existing conditions and characterizes combined effects from previous and existing developments and activities. The Base Case reflects the effects of existing disturbances, such as forestry, transportation, agricultural, mining, and residential and recreational development. Current effects from the existing Chalk River Laboratories (CRL) facilities and operations, for example, are considered part of the Base Case.
- **Application Case –** This scenario represents predictions of the effects of the Base Case combined with the effects that may result from the NSDF Project. The Application Case considers potential effects from the NSDF Project during construction through to the closure and post-closure phases.

- **Reasonably Foreseeable Development (RFD) Case –** This scenario represents predictions of the cumulative effects of the Application Case, which includes the Base Case, plus projects that are currently under application review or that have officially entered a regulatory application process, and are therefore considered reasonably foreseeable (see Section 8.0 Summary of Cumulative Effects for descriptions of RFDs). Because RFDs will either have no spatial overlap or are likely to positively affect hydrology, an RFD Case is not presented as part of this assessment. RFDs expected in the CRL site (i.e., the RSA) include new and upgrades to research and development facilities, construction and operation of a Small Modular Reactor (SMR), new support infrastructure, and on-going decommissioning and environmental remediation activities. New support infrastructure and research and development facilities will generally be located within existing disturbed areas on the CRL site (i.e., minimal disturbance to largely undeveloped areas). Through application of effective erosion and sediment control practices, and surface water management systems, potential effects from revitalization activities and through development of the SMR are not expected to spatially overlap with potential effects to surface water quantity from the NSDF Project. No process water intakes from or discharges to surface or groundwater are identified in the description of the planned SMR (Global First Power 2019). The end state plan for the CRL site is to return lands disturbed by site activities to a condition that is physically stable and safe in keeping with the land use and landscape of the day. Therefore, decommissioning and environmental remediation activities are anticipated to positively affect hydrology.

5.4.1.4 Description of the Environment

5.4.1.4.1 Methods

Existing hydrological conditions (e.g., flow, direction, quantity, velocity) within and surrounding the CRL site, including the Ottawa River, were obtained from published hydrology reports and available baseline data. Regional and local hydrology described in the 2010 *Environmental Impact Statement for Atomic Energy of Canada Limited for the National Research Universal Reactor Long-Term Management Project* (SENES 2010) is summarized in the following sections. The hydrological baseline conditions for Perch Lake and Perch Creek are also presented. Rainfall data were sourced from the Ministry of Transportation. All hydrology modelling results and design information presented in this section can be found in the NSDF *Surface Water Management Plan* (AECOM 2019).

5.4.1.4.2 Results

5.4.1.4.2.1 Drainage Conditions

The drainage basin slopes from a highpoint ridge (elevation 195 metres above sea level [masl]) along the eastern limit of the CRL site, westerly towards Perch Lake and the wetlands located on the western boundary (elevation 160 masl). CNL completed previous studies in support of proposed geological waste management facilities at the CRL site in which data on the geological environment were compiled and used to develop a descriptive geosphere model of the site. These studies are documented in CNL's *Geologic Waste Management Facility Descriptive Geosphere Site Model Report Phase 1* (CNL 2016a) and *Geologic Waste Management Facility Integrated Geosynthesis Report Phase 1* (CNL 2016b). These studies describe the surface soils as primarily fine sands underlain by glacial tills (Golder 2016). Currently, much of the area is heavily treed and undisturbed, indicating good infiltration capacity. Overburden depth to bedrock ranges from less than 1 m up to 24 m in thickness (Golder 2019a). Groundwater table depth varied significantly throughout the site and varies seasonally. The average groundwater depths ranged from 0.06 m in the vicinity of the wetlands to 15.95 m in the northern section of the SSA which corresponds to the thickest overburden (Golder 2019a). A depiction of the drainage basin is presented on Figure 5.4.1-2. Surface water flow is generally dispersed as shallow sheet flow, with the only channel flow occurring within the wetlands at the southern and western boundaries of the basin.

5.4.1.4.2.2 Ottawa River

The CRL site is located entirely within the Ottawa River watershed, which has several sub-watersheds (i.e., drainage basins). Chalk River and the Petawawa River are the two major tributaries near the CRL site. Approximately 12% of the CRL site drains directly into the Ottawa River (Figure 5.4.1-2). The confluence of the Petawawa River and the Ottawa River is approximately 20 km downstream of the CRL site.

Daily flow measurements of the Ottawa River taken at the Des-Joachims hydroelectric dam (approximately 32 km upstream of the NSDF site) were obtained from the Ottawa River Regulation Planning Board for the time period of June 1950 to December 2016 (Table 5.4.1-4). To account for seasonal variations, to exclude data outliers and to ensure an appropriate level of conservatism, the 5th percentile and 95th percentile data values were used for the minimum and maximum values respectively. The resulting flow rates are 336 m^3/s (minimum flow rate) and 1,560 m^3/s (maximum flow rate). The mean flow rate was calculated to be 807 m^3/s. The flow past the Des-Joachims hydroelectric dam is regulated according to the demands of the generating station.

The water level in the Ottawa River along the CRL site boundary is controlled by a set of rapids at Cotnam Island (located approximately 40 km downstream of the CRL site boundary), and by adjustments to the discharge rate at the Des-Joachims hydroelectric dam. The Ottawa River water levels at the CRL site boundary have also been measured daily since 1950. The highest recorded river level at the CRL site boundary (as of April 2007) is 113.6 masl, which was recorded in April 1979 (AECL 2008). The lowest level is 110.6 masl recorded in August 1971 (as of June 2002).

Table 5.4.1-4: Summary of Ottawa River Flows at the Des-Joachims Hydroelectric Dam and Water Level Data at Pembroke (1950-2016)

Flow Data	Flow Rate (m^3/s)	Water Level Data	Water Level (masl)	Date of Occurrence for Water Level
Average Flow Rate	807	Average Water Level	111.5	not applicable
Maximum Monthly (95th Percentile)	1,560	Maximum Monthly	113.1	May 1960
Minimum Monthly (5th Percentile)	336	Minimum Monthly	110.8	August 2005

masl = metres above sea level.

Ottawa River water level data were also sourced from the Pembroke Station, which is approximately 36 km downstream of the CRL site. Water level data has been collected daily between 1950 and 2019 and is presented as an average over a monthly period in Appendix 5.4-1 (Ottawa River Elevations Recorded at Pembroke Station between 1950 and 2019). Review of the data shows that lowest water levels are typically recorded in September, while highest water levels are usually observed in May. The lowest monthly water level recorded was 110.8 masl in August 2005, while the highest monthly water level recorded was 113.1 masl in May 1960. The average water elevation recorded at this station is 111.5 masl.

5.4.1.4.2.3 Perch Creek and Perch Lake Watershed

The NSDF Project is located entirely within the Perch Creek and Perch Lake Watershed (Figure 5.4.1-2), at the southern edge of the Canadian Shield in the Ottawa River Valley (Robertson and Barry 1985). Ground surface elevations range from a low of approximately 156 masl within the low-lying and relatively flat terrain bordering the north side of Perch Lake, to a high of 197 masl along the crest of the ridge to the east of East Mattawa Road that separates the Perch Lake and Ottawa River drainage basins (Golder 2016). The watershed includes Waste Management Areas A and B as well as the Liquid Dispersal Areas which encompasses the Reactor Pits, the Laundry Pit and the Chemical Pit. From Perch Lake, surface water (Perch Creek) flows in a north-easterly direction through Perch Creek to its confluence with the Ottawa River. The Perch Creek basin drains approximately 18% of CRL site area and drains to the Ottawa River through Perch Lake and Perch Creek (CNL 2016c).

The Perch Creek and Perch Lake Watershed is defined by seven-basins, six of which drain into Perch Lake (Robertson and Barry 1985) (Figure 5.4.1-2). Basins 1 to 5 drain into the lake through surface streams with discernible channels (Sub-basins 1 to 5) while the sixth basin (Sub-basin B) lacks a discernible stream channel for drainage into Perch Lake. The seventh basin (Border) drains through Perch Creek below the lake outlet and into the Ottawa River. Sub-basin elevation and areas are provided in Table 5.4.1-5.

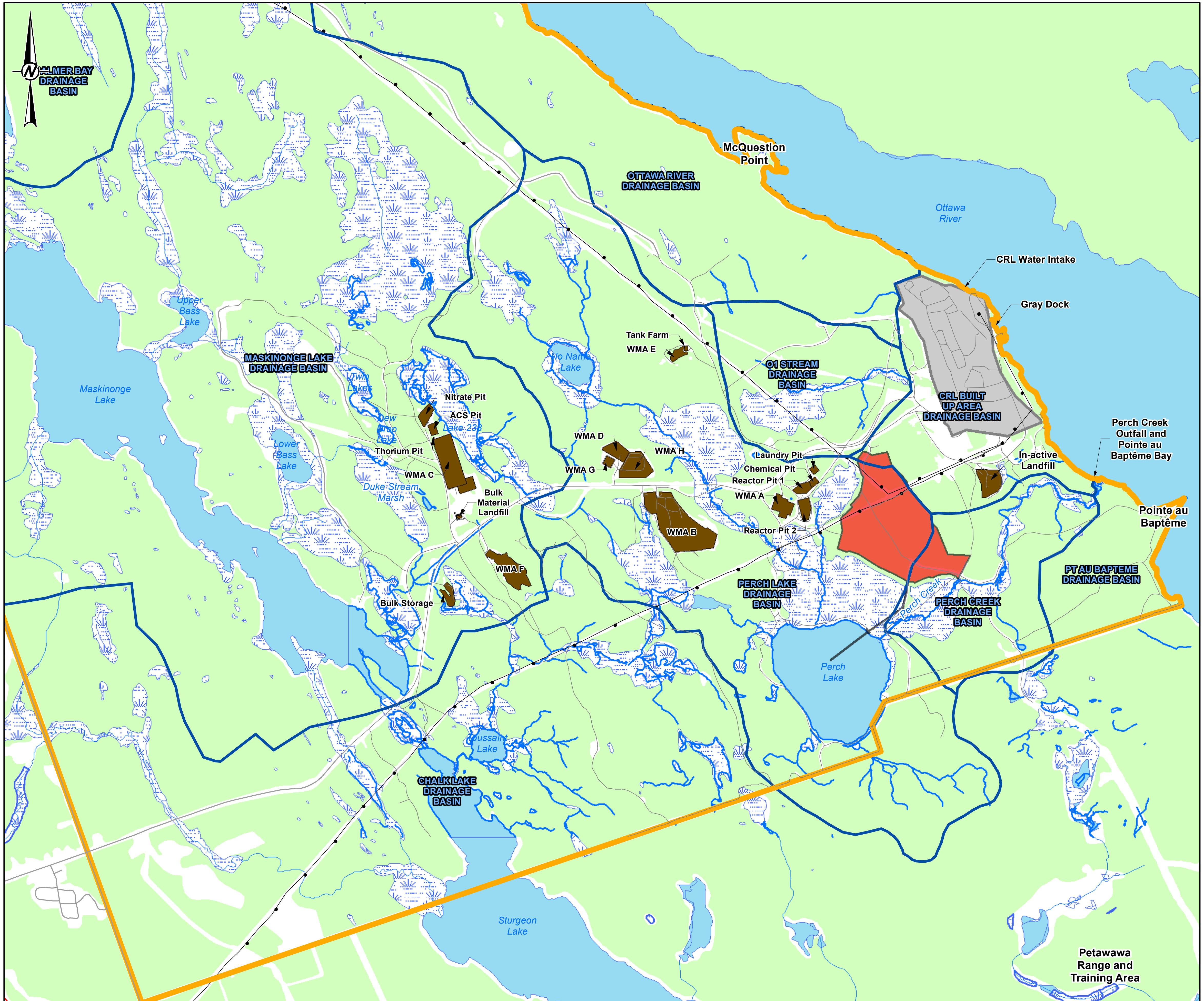
Table 5.4.1-5: Perch Creek Sub-Basin Weir Elevations and Areas

Basin	Elevation[(a)] (masl)	Area (km^2)	Area (ha)
Sub-basin 1	156.27	0.93	93
Sub-basin 2	156.37	3.6	360
Sub-basin 3	156.43	0.81	81
Sub-basin 4	156.28	0.24	24
Sub-basin 5	157.52	0.11	11
Sub-basin B	ND	0.093	9.3
Border	ND	0.056	5.6
Perch Lake	155.95	0.46	46
Perch Creek	ND	1.02	102
Totals			
To lake		5.84	584
To lake outlet		6.30	630
To basin outlet		7.3	730

Source: Robertson and Barry 1985.

(a) measured at weirs, installed in 1969.

masl = metres above sea level; ND = no data available.



LEGEND

- ROADS
- RAILWAY
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- DRAINAGE BASIN
- SITE STUDY AREA (NSDF PROJECT SITE)
- CRL MAIN CAMPUS
- CRL SITE
- WASTE MANAGEMENT AREA (WMA) [1]

500 0 500
1:25,000 METRES

NOTE(S)
1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)
1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
DRAINAGE BASINS WITHIN THE CHALK RIVER LABORATORIES PROPERTY

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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Physical characteristics of Perch Lake such as wetted area, maximum depth and average depth were measured by Robertson and Barry (1985) and via a series of studies carried out between 1965 and 1974 (Barry 1975). More recently, Perch Lake was surveyed from June 18 to 22, 2018 in the creation of an updated bathymetry map. The bathymetry map relied upon data points measured from a combination of a single-beam sonar unit and a GPS unit. Depth profiles were measured along the latitudinal width and longitudinal length of Perch Lake. The survey also included depth measurements along the shallow perimeter of Perch Lake using a meter stick (where the sonar was unable to take accurate measurements due to vegetation interference). Based on recent field data and aerial imagery, Perch Lake is characterized by an approximate wetted area of 46 ha, maximum depth of 4 m, and an estimated drainage area of 730 ha and an average depth of 2 m. The results of the June 2018 bathymetric survey suggest negligible change in lake volume in comparison to the measured data from Robertson and Barry (1985) based on the water depth.

In late summer and fall, the water level usually drops by as much as 0.25 m. Most of Perch Lake is open water except for littoral zones along the shore, including a region of floating, emergent and submerged vegetation, which amounts to about 30% of the lake's surface (Yankovich et al. 2000). The outer fringe of this zone is known as Perch Lake Marsh. This open marsh may be considered as part of the lake, with which it is physically continuous. To the north, there are extensive wetlands, notably Perch Lake Swamp, South Swamp, East Swamp and West Swamp. The lake is confined in part by sand outcrops along the northern and southern shores, and by bedrock along the western shores.

The hydrology of Perch Lake was studied extensively from 1969 to 1988 (e.g., Robertson and Barry 1985; Yankovich et al. 2000) through the collection of measurements in a system of dikes and ditches that enabled all surface flows in and out of the lake to be accurately measured. Five of the tributaries to Perch Lake and the outlet stream (Perch Creek) include V-notch weirs. The lake outlet and two of the inlet streams (inlet 2 and 5) are each equipped with a modified V-notch weir. Streams for inlets 1, 3 and 4 are each equipped with 90° V-notch weirs. Most of the weir installations were completed in 1969. The weir at inlet 5 was installed in 1972.

Mean annual flow at the outlet of Perch Lake is 0.057 m^3/s, based on the 11-year average water budget (1969 to 1980) for the hydrologic year (September 1 to August 31; Table 5.4.1-6). Flow results from measurements taken at the weir locations are summarized in Table 5.4.1-6.

Table 5.4.1-6: Perch Lake Hydrology for Inlet Streams (Sub-Basin 1-5) and the Outlet Stream Based on Annual Average Water Budget (1969-1980)

	Mean Annual Flow (m^3/yr)	Mean Annual Flow (m^3/s)	Depth Equivalent (m)	Standard Deviation	Coefficient of Variation
Inlet 1	2.15×10^5	0.007	0.23	0.57	0.27
Inlet 2	9.66×10^5	0.031	0.27	3.22	0.33
Inlet 3	1.47×10^5	0.005	0.18	0.68	0.46
Inlet 4	8.30×10^4	0.003	0.35	0.23	0.28
Inlet 5	3.10×10^4	0.001	0.28	0.11	0.36
Total inflow	1.44×10^6	0.046	0.25	4.94	0.34
Precipitation	3.48×10^5	0.011	0.773	0.46	0.13
Total input	1.79×10^6	0.057	0.285	5.05	0.28
Outflow	1.79×10^6	0.057	0.284	5.2	0.29
Evaporation	3.09×10^5	0.010	0.687	0.25	0.08
Groundwater	3.05×10^5	0.010	0.052	0.7	0.23

Source: Robertson and Barry 1985.

In 1988, the wooden weir box at the Perch Lake outlet began to fail, and flow measurements at Perch Lake outlet were discontinued (CNL 2016c). Over the measurement period, the annual average flow out of Perch Lake was 1,700,000 m^3. In the mid-1980s a concrete dam fitted with a compound V-notch weir was constructed on Perch Creek approximately 950 downstream of Perch Lake Outlet, and routine streamflow measurements have been collected at the Perch Creek weir since 1992. Between 1992 and 2015 the annual average flow through the Perch Creek weir has been 2,040,000 m^3 (CNL 2016c). The annual average total outflow from Perch Creek to the Ottawa River (i.e., Perch lake outflow and water added along Perch Creek) is 2,210,000 m^3.

Perch Creek is the dominant surface water feature that drains the Perch Creek Basin directly into the Ottawa River. Perch Creek ranges from about 5 to 10 m in width and generally has a depth of less than 1 m. Figure 5.4.1-3 shows the location of the creek marked by the Perch Creek weir northeast of Perch Lake at the extent of the wetlands, approximately 700 m downstream of Perch Lake (Photo 5.4.1-1).

Photo 5.4.1-1: Upstream View of the Perch Creek Weir, August 2012

Below the Perch Creek weir, the creek enters a mixed deciduous woodlot and overhead cover increases substantially (Sowden and Power 1981). The stream gradient also increases sharply, exceeding a 10% slope in sections. A series of small waterfalls (or cascades) occur just downstream of the weir which then lead to a riffle-pool sequence, followed by slow-flowing water in the lower reach of the creek. The substrate in the middle reach is rock, gravel and coarse sand; the substrate in the lower section of the creek is dominated by silt and sand. The overall slope of Perch Creek is approximately 3%.

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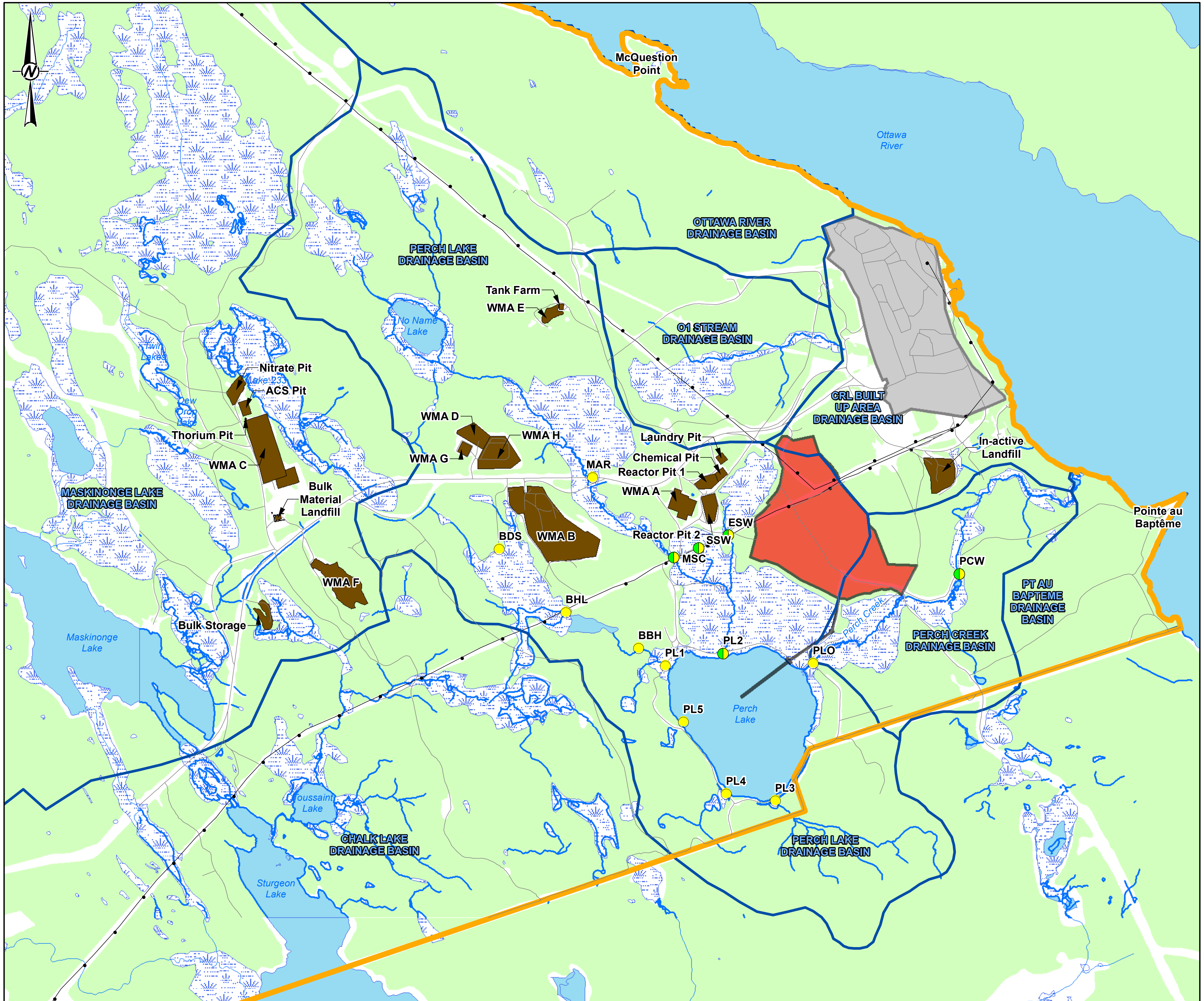

LEGEND

- ROADS
- RAILWAY
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- DRAINAGE BASIN
- SITE STUDY AREA (NSDF PROJECT SITE)
- CRL MAIN CAMPUS
- CRL SITE
- WASTE MANAGEMENT AREA (WMA) [1]
- SAMPLING LOCATION
- WEIR
- SAMPLING LOCATION AND WEIR

500 0 500

1:20,000 METRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT CHALK RIVER, ONTARIO

TITLE
LOCATIONS OF SURFACE WATER MONITORING STATIONS AND WEIRS

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.4.1-3

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Flow rates from the Perch Creek weir were measured by CNL from 2009 to 2015 (CNL 2016c), as summarized in Table 5.4.1-7 and on Figure 5.4.1-4. The highest flows typically occur in conjunction with spring melt (i.e., freshet) events in April, while lower flows are encountered during the summer season, particularly in August. The overall annual mean flow from years 2009 to 2015 was estimated to be approximately 0.063 m^3/s.

Table 5.4.1-7: Perch Creek Monthly Mean Flows (m^3/sec), 2009 to 2015

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
2009	0.030	0.012	0.029	0.191	0.104	0.059	0.041	0.031	0.039	0.049	0.072	0.060	0.060
2010	0.041	0.027	0.048	0.191	0.104	0.059	0.041	0.031	0.039	0.049	0.072	0.060	0.064
2011	—	0.027	0.048	0.191	0.104	0.059	0.041	0.031	0.039	0.049	0.072	0.060	0.066
2012	0.059	0.027	0.222	0.060	0.043	0.020	0.004	0.003	0.008	0.007	0.007	0.007	0.039
2013	0.042	0.027	0.037	0.228	0.163	0.062	0.019	0.012	0.079	0.096	0.050	0.055	0.073
2014	0.042	0.027	0.056	0.377	0.070	0.032	0.099	0.011	0.012	0.026	0.084	0.050	0.074
2015	0.042	0.025	0.074	0.245	0.105	0.028	0.020	0.004	0.034	0.035	0.113	0.049	0.065
Max	0.059	0.027	0.222	0.377	0.163	0.062	0.099	0.031	0.079	0.096	0.113	0.060	0.074
Min	0.030	0.012	0.029	0.060	0.043	0.020	0.004	0.003	0.008	0.007	0.007	0.007	0.039
Mean	**0.045**	**0.027**	**0.081**	**0.215**	**0.098**	**0.043**	**0.037**	**0.015**	**0.035**	**0.044**	**0.066**	**0.047**	**0.063**

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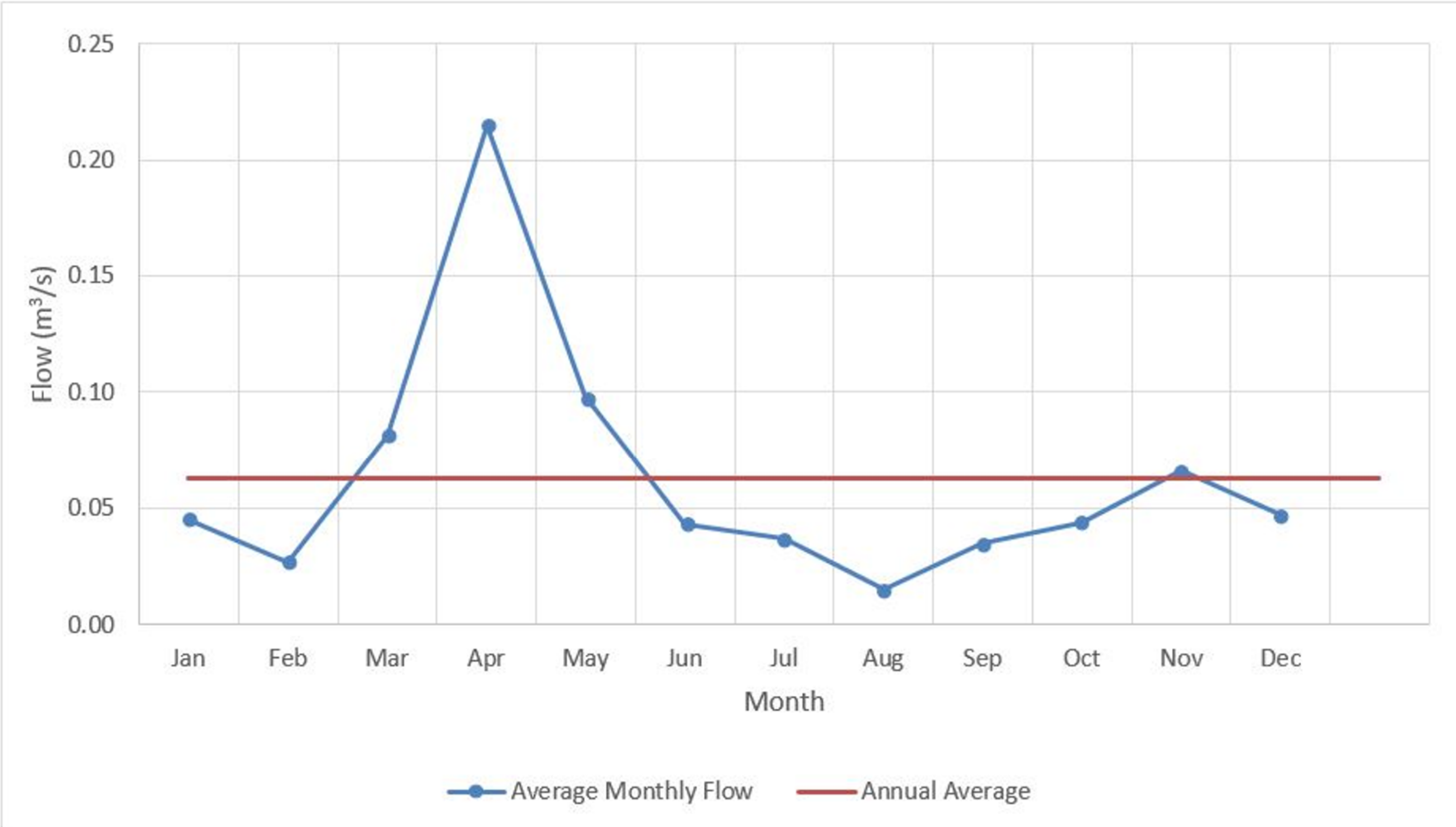

LEGEND

REFERENCE(S)

CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	PR
PREPARED	PR
REVIEWED	CS
APPROVED	AB

TITLE
PERCH CREEK MONTHLY MEAN FLOWS 2009 TO 2015

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	**5.4.1-4**

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5.4.1.4.2.4 Site Study Area

Development of the SSA involves the construction of three surface water management ponds (SWMP #1, SWMP #2, SWMP #3). SWMP #1 is proposed for the northern section of the site, will receive runoff from the buildings and parking lots, and will discharge to the East Swamp. SWMP #2 is proposed for the southern section of the site, where it will receive runoff from the post-closure engineered containment mound (ECM) and the nearby lay down/stockpile areas. SWMP #3 is proposed in the western section of the site and will also receive runoff from the post–closure ECM. Both SWMP #2 and SWMP #3 will discharge to the Perch Lake Swamp wetland complex. The current SWMP footprints reflect the overall storage required to control closure flows to pre-development levels for the 2-year through to 100-year rainfall events at the site. This volume also contains the storage required for sediment control during construction and water quality control (more than 80% total suspended solids [TSS] removal for SWMP #1, 76% TSS removal for SWMP #2 and 60% TSS removal for SWMP #3) during operations. The current footprints typically assume a maximum 100-year operating water level at a 3 m depth with 1 m of freeboard that includes allowance for climate change effects and rain on snowmelt.

The surface water runoff within the SSA under existing (Base Case) conditions was modelled using Visual Otthymo 4.0 software for the 2-year through to 100-year rainfall events and the regional storm event for the area was also modelled along with the probable maximum precipitation. Visual Otthymo is a hydrologic management model that is capable of simulating runoff from single storm events. It is well suited to hydrologic studies of watersheds and sub-watersheds and is a useful tool in creating master drainage plans, site stormwater designs and surface water management design. Rainfall intensity data inputted into the model was sourced from the Town of Arnprior as the storm data were more recent than that available from Environment and Climate Change Canada for the area. Modelling simulations included consideration of 6-hour, 12-hour and 24-hour Soil Conservation Service Type II storm distributions but since the 12-hour distribution generated the highest peak flows it was used in the conveyance and pond designs.

Under pre-development conditions four distinct catchment areas are seen: The north catchment is a 5.8 ha area to the north of the site which has overland flow to the East Swamp. The south catchment area is 4.8 ha and has overland flow towards Perch Creek. The west catchment is approximately 22.2 ha and drains south westerly to the Perch Lake Swamp. The east catchment is approximately 0.7 ha and drains overland off-site to the east (Figure 5.4.1-5). Discharge model outputs for these catchments for the 1:2 year, 1:5 year and 1:100 year 12-hour events are summarized in Tables 5.4.1-8 through 5.4.1-11 below (AECOM 2019).

Table 5.4.1-8: Hydrologic Model Results for Base Conditions in North Catchment

Model Output	Storm Event		
	1:2 Year	1:5 Year	1:100 Year
Peak Runoff Flow Rate (m^3/s)	0.18 m^3	0.34 m^3	0.94 m^3
Time to Peak (hours)	6.25	6.25	6.00
Total Area Runoff (m^3)	422 m^3	806 m^3	2,239 m^3

Table 5.4.1-9: Hydrologic Model Results for Base Conditions in South Catchment

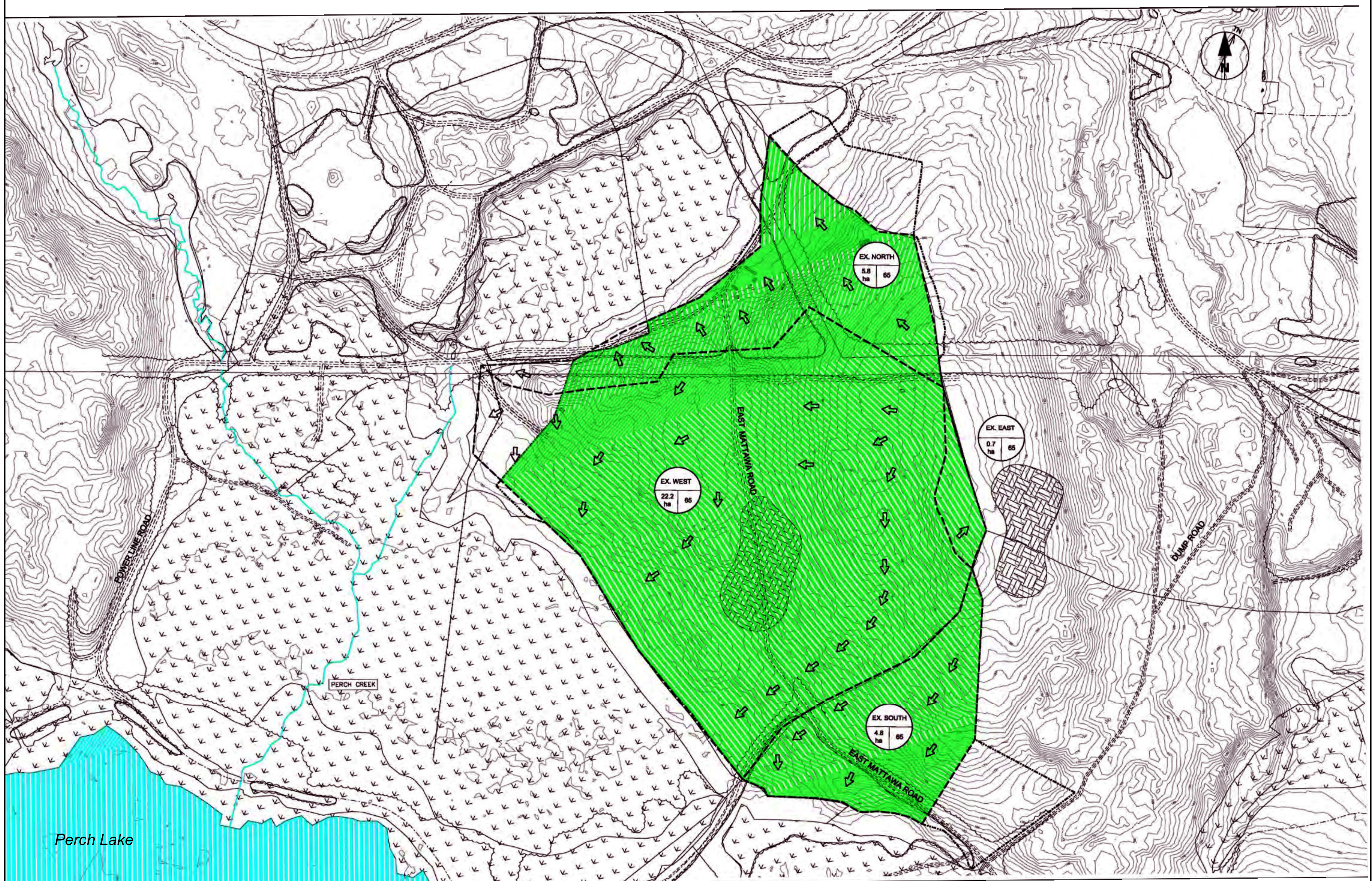
Model Output	Storm Event		
	1:2 Year	1:5 Year	1:100 Year
Peak Runoff Flow Rate (m^3/s)	0.08 m^3	0.15 m^3	0.42 m^3
Time to Peak (hours)	6.4	6.4	6.17
Total Area Runoff (m^3)	359 m^3	684 m^3	1,902 m^3

Table 5.4.1-10: Hydrologic Model Results for Base Conditions in West Catchment

Model Output	Storm Event		
	1:2 Year	1:5 Year	1:100 Year
Peak Runoff Flow Rate (m^3/s)	0.28 m^3	0.55 m^3	1.59 m^3
Time to Peak (hours)	6.58	6.5	6.25
Total Area Runoff (m^3)	1,658 m^3	3,168 m^3	8,798 m^3

Table 5.4.1-11: Hydrologic Model Results for Base Conditions in East Catchment

Model Output	Storm Event		
	1:2 Year	1:5 Year	1:100 Year
Peak Runoff Flow Rate (m^3/s)	0.01 m^3	0.02 m^3/s	0.06 m^3
Time to Peak (hours)	6.42	6.42	6.17
Total Area Runoff (m^3)	52.3 m^3	99.8 m^3	277 m^3



LEGEND

- SITE BOUNDARY
- SITE AREA
- EXISTING BUA FENCE
- DRAINAGE AREA BOUNDARY
- BEDROCK OUTCROPPING
- WETLAND (TO BE CONFIRMED BY CNL)
- OVERLAND FLOW ROUTE
- AREA (ha.) / AREA NO. / CURVE NUMBER
- WATERCOURSES

NOTE(S)

REFERENCE(S)

1. MAP OBTAINED FROM C4.2 SURFACE WATER MANAGEMENT PLAN (232-508600-PLA-002 REV1.PDF, PAGE 53 AECOM FIGURE 2).

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
BASE CONDITIONS CATCHMENT AREAS

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0018	FINAL 2	5.4.1-5

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The catchment areas change under post-development conditions (Figure 5.4.1-6) and a comparison of pre- and post conditions is possible through a look at the overall discharge from the site. The base condition runoff for the 1:2 year, 1:5 year and 1:100 year 12-hour events are summarized in Table 5.4.1-12:

Table 5.4.1-12: Hydrologic Model Results for Base Conditions from the Entire Site

Model Output	Storm Event		
	1:2 Year	1:5 Year	1:100 Year
Peak Runoff Flow Rate (m^3/s)	0.42 m^3	0.83 m^3	2.38 m^3
Total Area Runoff (m^3)	2,492 m^3	4,757 m^3	13,216 m^3

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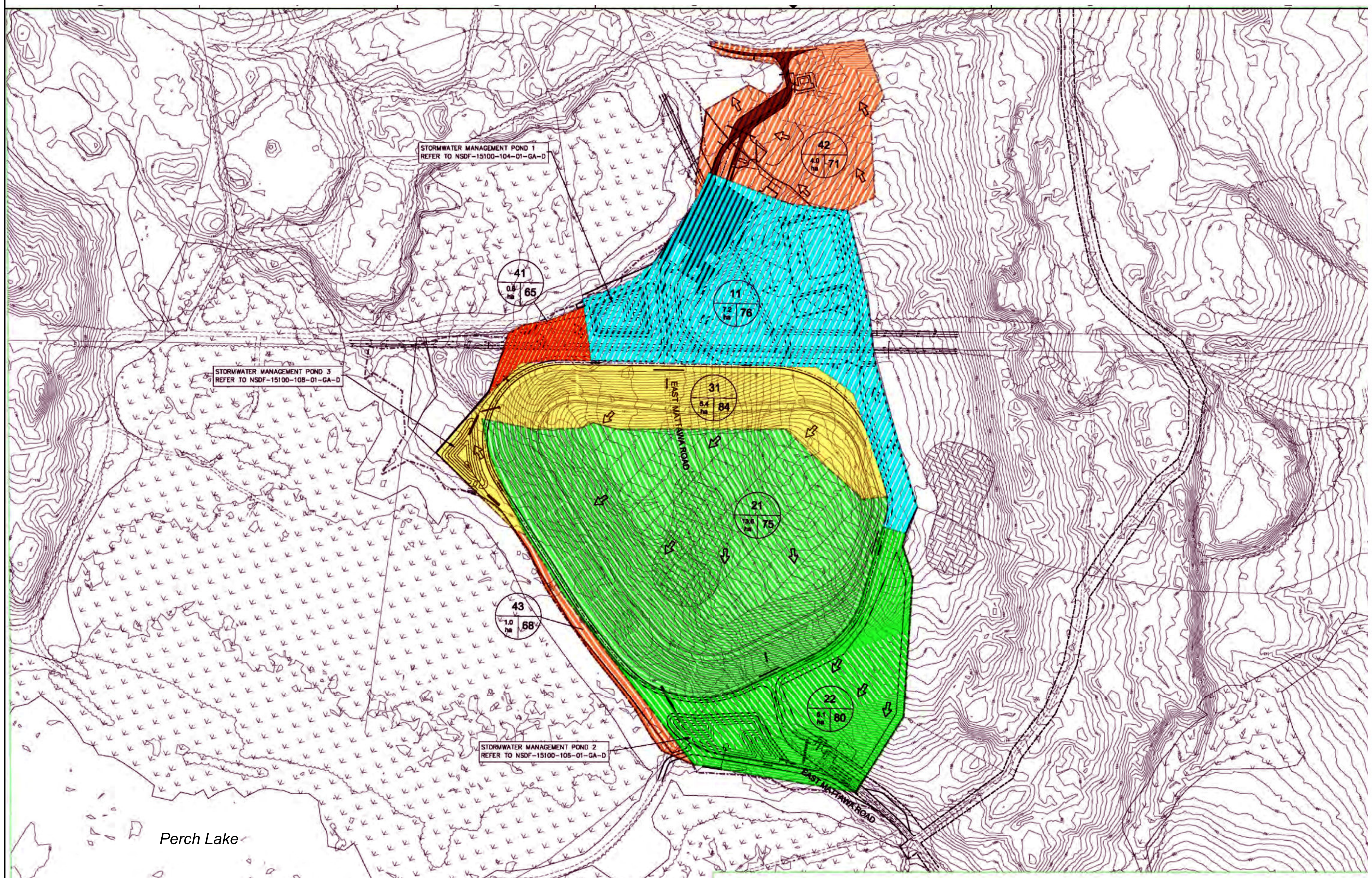

LEGEND

- SITE BOUNDARY
- DRAINAGE AREA BOUNDARY
- DITCH / SWALE FLOW DIRECTION
- BEDROCK OUTCROPPING
- WETLAND (TO BE CONFIRMED BY CNL)
- CULVERT
- OVERLAND FLOW ROUTE
- AREA (ha) / AREA NO. / CURVE NUMBER
- SWM POND 1 DRAINAGE AREA
- SWM POND 2 DRAINAGE AREA
- SWM POND 3 DRAINAGE AREA
- EXTERNAL DRAINAGE AREA

NOTE(S)

REFERENCE(S)

1. MAP OBTAINED FROM C4.2 SURFACE WATER MANAGEMENT PLAN (232-508600-PLA-002 REV1.PDF, PAGE 53 AECOM FIGURE 2).

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
POST-CLOSURE CATCHMENT AREAS

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0018	FINAL 2	5.4.1-6

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5.4.1.5 Project Interactions and Mitigation

5.4.1.5.1 Methods

This section describes the process by which interactions between NSDF Project components and activities and hydrology were identified and evaluated. Potential effects pathways are identified, and mitigation developed to eliminate and/or reduce effects is presented. A pathways analysis is then used to focus the assessment on key interactions between the NSDF Project and the environment by evaluating the different effect pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects will be adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects after incorporation of mitigation are further characterized in subsequent subsections of the assessment. As such, this section helps to focus the remainder of the assessment on those interactions (effects pathways) likely to result in residual adverse effects.

The first part of the analysis was to identify the potential effects pathways for all phases of the NSDF Project. The next step in the analysis was the development of environmental design features and mitigation that could be incorporated into the NSDF Project to eliminate and/or reduce adverse effects to hydrology. Environmental design features included project design elements, environmental best practices, and management policies and procedures. Environmental design features and mitigation were developed through an iterative process between the Project's engineering and environmental teams, combined with project-specific input from engagement with other interested parties. The design features and/or mitigation were selected considering their effectiveness for implementation and maintenance, and their appropriateness within the context of the identified effect pathways.

After incorporation of mitigation, potential pathways were evaluated into the following categories using scientific knowledge, logic, experience with similar developments, and the effectiveness of environmental design features and mitigation:

- **No linkage:** The pathway is removed by environmental design features or mitigation such that the NSDF Project would not be expected to result in a measurable environmental change relative to Base Case values and therefore would have no residual effects to hydrology.
- **Secondary pathway:** The pathway could result in a measurable minor environmental change, but would have a negligible residual effect on hydrology relative to Base Case and/or guideline values and is not expected to contribute cumulatively to other NSDF Project effects or to the effects of other previous, existing or reasonably foreseeable developments to cause a significant effect.
- **Primary pathway:** The pathway is likely to result in an environmental change relative to the Base Case and/or guideline values that could contribute to residual effects to hydrology.

Environmental design features and mitigation that have been or could be incorporated into the NSDF Project to eliminate or reduce adverse effects were considered. Potential pathways that were completely removed due to implementation of environmental design or mitigation were not assessed further. Pathways that were assessed to be secondary and demonstrated to have a negligible residual effect to hydrology through simple qualitative or semi-quantitative evaluation of the pathway were also not advanced for further assessment. Primary pathways were carried forward for more detailed quantitative and qualitative effects analysis to characterize the residual effects of the NSDF Project.

5.4.1.5.2 Results

Pathways through which all phases of the NSDF Project may interact with and result in changes to measurement indicators for hydrology are provided in Table 5.4.1-13.

Table 5.4.1-13: Pathways Analysis for the Hydrology Valued Component

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
General project activities during the operations phase	Discharge of treated domestic wastewater/sanitary sewage may cause a change in water levels, flows and channel and bank stability at downstream locations.	■ The grey water/sanity sewage will be managed through a gravity sewer network connected to the two sewage disposal systems as described in Section 3.4.4.4. These systems are completely separate from the ECM leachate and other contact water sewer conveyance for the on-site WWTP. ■ Sewage discharges to the sewage disposal system will conform with CNL's *Acceptability Criteria for Routine and Non-Routine Discharge of Liquids on the CRL Site* (CNL 2015b).	No Linkage
Project activities during the operations and closure phases: ■ Surface water management ■ Operation of the WWTP ■ Discharge of treated effluent from the WWTP	Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) and the discharge of non-contact water to adjacent wetlands may cause changes to water levels, flows and channel and bank stability in downstream waterbodies and water levels in the adjacent wetlands.	■ Discharge of treated effluent to the exfiltration gallery area will help to reduce water loss from the hydrogeological system. ■ Design consideration was given during the selection of the discharge location of treated effluent for environmental effects of scour on the receiving waterbodies. As such, the preferred design (i.e., discharge to the exfiltration gallery and Perch Lake diffuser) was chosen as the favourable alternative as they resulted in negligible scour potential. ■ Outlet flows from all three SWMPs will be dispersed by level spreaders that will provide an even flow distribution to the wetlands with an appropriately wide dispersal pattern. ■ The WWTP system's outlet utilizes a headwall which discharges to a level spreader for the purposes of preventing erosion and sedimentation at the outlet for the exfiltration gallery. ■ The outlet locations of the SWMPs are limited by the site boundary (greater than 5 m separation required) so that there is no discharge from the spreader directly to the wetland. ■ Annual inspection and maintenance activities will identify any erosion problems. ■ Inspections will be undertaken and maintenance activities completed, as required, after major storm events and after the annual spring melt to confirm there are no major erosion issues.	Secondary
Project activities during the construction phase: ■ Site Preparation ■ Construction of the ECM ■ Blasting (as required) ■ Development of surface water management structures ■ Construction of the WWTP and other support facilities ■ On-site road and access development ■ Construction of transfer line and Perch Lake diffuser ■ Domestic waste (solid and liquid) management ■ Soil spoils haulage to a soil storage area	The construction of the NSDF Project will physically alter drainage patterns in the Perch Creek and Perch Lake Watershed and may change downstream discharge, water levels, channel and bank stability, and water levels in adjacent wetlands.	■ The NSDF Project footprint has been designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. ■ A 30 m buffer will be established along identified wetlands near the SSA; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion. ■ Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site will be used during construction around disturbed areas, where appropriate. ■ During the construction phase, erosion and sediment control measures in place to mitigate the effects of sediment transport include the use of erosion control blankets, as needed, to control erosion on steep slopes, check dams in ditches and swale. ■ Surface water from all external areas will be conveyed by ditches, swales and culverts to SWMPs to address water quality and water quantity criteria established for the wetland receiving waters and, ultimately, Perch Creek. ■ Where drainage crosses roadways, culverts are sized to convey the 25-year design event without road overtopping. ■ The SWMPs are designed to address erosion and sediment control concerns during construction by providing interim sediment control and by providing water quality/quantity controls during operations, closure and post-closure. ■ Annual maintenance activities will identify any erosion problems. ■ Inspections will be undertaken and maintenance activities completed, as required, after major storm events and after the annual spring melt to confirm there are no major erosion issues.	Primary
	Changes to the hydrology within the Perch Creek and Perch Lake Watershed as a result of the intake of water from the Ottawa River for construction activities.		Secondary
Project activities during the operations, closure and post-closure phases: ■ Installation of final cover, restoration and grading of the site ■ Continued operation of surface water management structures	The installation of the ECM will physically alter drainage patterns, and may change downstream discharge, water levels in adjacent wetlands and channel and bank stability.	■ The final cover and site grading are designed to promote positive drainage from the Site Study Area and reduce erosion or abrasion of the final cover. ■ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound and minimize leachate generation. ■ The final cover system design incorporates a series of shallow, trapezoidal and lined drainage channels that are designed to convey water at low velocity. ■ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the final cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. ■ The ECM final grading and drainage plan includes collection ditches along the top of the ECM berm road to collect side slope drainage. ■ The SWMPs are designed to address erosion and sediment control concerns by providing water quality/quantity controls during operations, closure and post-closure. ■ Environmental monitoring will be completed as required during the institutional control period for the NSDF Project to confirm that the final cover is functioning as intended.	Primary

ECM = engineered containment mound; WWTP = Wastewater Treatment Plant.

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5.4.1.5.2.1 No Linkage Pathways

The following pathway was assessed as having no measurable environmental change relative to Base Case values and therefore would have no effects to hydrology.

- **Discharge of treated domestic wastewater may cause a change in water levels, flows and channel and bank stability at downstream locations.**

The NSDF Project's sanitary conveyance system is designed to convey the peak sewage flows generated by up to 65 full-time employees (although this will be adjusted based on operational demand) whom will work at the NSDF Project. The NSDF sanitary sewage will be managed through a gravity sewer network connected to a sewage disposal system. This system is completely separate from the ECM leachate and other contact water sewer conveyance for the on-site Wastewater Treatment Plant (WWTP).

There are two site sewage disposal systems proposed to service the NSDF Project, including:

- one larger system adjacent to East Mattawa Road servicing the WWTP, Vehicle Decontamination Facility, Operations Support Center, Administrative Office and North Kiosk; and
- one smaller system for the South Kiosk.

Each of these two systems will contain a pump station septic tank and piped leach field. The NSDF gravity sewers have been sized to convey the peak sewage flow rate of 13 L/s. The sanitary system uses a network of gravity sewers to convey sewage from the Vehicle Decontamination Facility, the Operations Support Center, the Administration Building, the North Kiosk and the WWTP to a sanitary pumping station located near the staff operations center. The sanitary pumping station transfers the collected sewage using a force main that discharges to a second gravity sewer network located near the perimeter road on the east side of the SSA. The second gravity sewer terminates at the South Kiosk. Both north and south sewage disposal systems use a leach field through which sewage effluents are disposed into the soil.

Sewage discharges to the sewage disposal systems will conform to CNL requirements for discharge to septic systems provided in CNL's Environmental Protection Program procedure *Acceptability Criteria for Routine and Non-Routine Discharge of Liquids on the CRL Site* (CNL 2015b). As such, discharge of treated domestic wastewater for the NSDF Project to downstream locations is considered to have no linkage to effects on hydrology.

5.4.1.5.2.2 Secondary Pathways

The following pathways were assessed as potentially having a measurable minor environmental change, but negligible effect on the hydrology relative to Base Case.

- **Changes to the hydrology within the Perch Creek and Perch Lake Watershed as a result of the intake of water from the Ottawa River for construction activities.**

The NSDF Project construction phase will be carried out from 2021 to 2023. During the construction phase, CNL anticipates an average daily usage of approximately 110 m^3/day to 150 m^3/day for construction activities (e.g., dust suppression, clay mixing and fire protection). Construction water use is expected to peak at approximately 750 m^3/day. Water usage will be lower during the winter season (December through to March) when construction activities will be less. The water may also be used for commissioning activities including hydrostatic testing of the WWTP storage tanks, the leachate collection and piping systems. Construction water will be sourced from an existing intake on the Ottawa River to fill temporary storage containers.

The intake of water from the Ottawa River for construction purposes (i.e., up to a maximum of 276,000 m^3/yr based on the peak daily usage) is anticipated to have a negligible effect on the overall Ottawa River annual flow rate of 25 billion m^3/yr (as recorded at the Des-Joachims monitoring point) and on the downstream hydrology. The proposed diverted annual volume for construction represents 0.0011% of the total annual flow rate of the Ottawa River at Des-Joachims using conservative assumptions of annual volumes based on peak daily flow and construction taking place during throughout the winter months. Actual water use for construction is anticipated to be lower than proposed; for example, during winter months, site activities do not require as much water as during the open water construction periods.

Similarly, changes to the hydrology within the Perch Creek and Perch Lake Watershed as a result of the intake of water from the Ottawa River for construction activities at the SSA are anticipated to be minor as the annual intake amount is approximately 15% of the mean annual outflow from the Perch Creek and Perch Lake Watershed. Water is used for various construction activities, such as dust management control. Water used for dust management will primarily evaporate or infiltrate and any associated runoff will be collected and conveyed to the SWMPs. Overall, water use for construction activities was determined to have a negligible effect on hydrology.

- **Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch lake (via a transfer line) and the discharge of non-contact water to the adjacent wetlands may cause changes to water levels, flows and channel and bank stability in downstream waterbodies and water levels in the adjacent wetlands.**

The NSDF Project will generate two water streams which will have the potential to impact water flows and levels in wetlands including:

- treated effluent from the WWTP which will be routed to the exfiltration gallery or Perch Lake; and
- non-contact water (i.e., water that has not been contaminated through contact with the ECM) which will be managed through a series of SWMPs.

A Surface Water Management Plan will be implemented to mitigate effects from wastewater discharges. Most of the wastewater flow will be generated from non-contact water produced during active filling of the ECM; contributions by leachate and decontamination activities represent a small fraction of the overall wastewater that will be treated by the WWTP. The total annual volume of water to be treated is 11,000 m^3. The volume represents approximately 0.6% of the average total outflow from Perch Lake (1,700,000 m^3/yr), or 0.5% of the average total outflow from Perch Creek (2,200,000 m^3/yr). Operational treated effluent discharge is expected to be a maximum of approximately 11 m^3/hr with an average effluent discharge rate below 1 m^3/hr. Flow rates within Perch Creek are approximately 252 m^3/hr; the maximum effluent discharge rate is roughly 4% of the average Perch Creek flows and approximately 11.5% of East Swamp weir flows. During the operations phase, the additional infiltration applied at the exfiltration gallery results in a localized increase in water table elevation of up to 1 m compared to the current conditions (see Section 5.3.2.6).

An exfiltration gallery is proposed at the discharge outlet for the treated effluent to promote the exfiltration of treated water into the local groundwater regime. Treated effluent will also be discharged directly to Perch Lake via a transfer line. The transfer line to Perch Lake has been designed to manage the full annual volume of treated effluent, if required, which will prevent the potential for overland flow at the exfiltration gallery.

The major flow system for all three SWMPs, which manage non-contact water, discharge on the NSDF Project site and from there flow into the adjacent wetlands. The SWMP outlet structures are located within the NSDF Project site boundary and are 5 m or more from the edge of the site, which in these locations follows a 30 m setback from the wetland. Flows from the SWMPs are dispersed by level spreaders that provide an even, flow distribution with an appropriately wide dispersal pattern before travelling 35 m or more overland to the edge of the wetland.

Annual maintenance activities will identify any erosion problems. Facility inspections will be completed twice annually to confirm that inlets and outlets are clear of debris and to confirm that there are no major erosion issues at the inlet or outlet. In addition, a maintenance review will be completed after major storm events and after the annual spring melt to confirm there are no major erosion issues at the dispersion outlets. Overall, changes to downstream discharge, water levels and channel and bank stability resulting from operational discharges of treated effluent and non-contact water will be localized to the receiving wetland. Therefore, this interaction was determined to have a negligible effect on hydrology.

5.4.1.5.2.3 Primary Pathways

The following primary pathways were identified as having residual effects on hydrology, and are therefore carried forward to the residual effects analysis.

- **The construction of the NSDF Project will physically alter drainage patterns in the Perch Creek and Perch Lake Watershed, and may change downstream discharge, water levels and channel and bank stability, and water levels in adjacent wetlands.**
- **The installation of the ECM will physically alter drainage patterns and may change downstream discharge, water levels in adjacent wetlands channel and bank stability during operations, closure, and post-closure.**

5.4.1.6 Residual Effects Analysis

5.4.1.6.1 Methods

The design of the SWMPs and associated systems use standard surface water management principles by controlling erosion, capturing sediment and allowing infiltration of non-contact water. The current SWMP footprints reflect the overall storage required to control closure flows to pre-development levels for the 2-year through to 100-year rainfall events at the site. This volume also contains the storage required for sediment control during construction and water quality control during operations. Where drainage crosses roadways, culverts are sized to convey the 25-year design event without road overtopping. Three SWMPs provide both quality and quantity control during construction, operations and closure phases. Flows from the ponds will be dispersed by a form of level spreader to provide even flow distribution to wetlands with an appropriate dispersal pattern to limit erosion and scouring of the wetland.

Closure activities include the installation of a final cover over the ECM to limit ponding and water infiltration into the waste. The final cover system will be constructed at slopes between 5% (overall slope for the top slope portion of the final cover) and 25% (4H:1V) for the side slope portion of the final cover. The top slopes and side slopes of the final cover are designed to be flat enough to satisfy slope stability factor of safety criteria and erosion control criteria. Runoff control for the final cover is designed to limit ponding and infiltration of water into the ECM, erosion of the final cover and waste material, and destabilization of the structure. The ECM design approach is to control the direction and velocity of the runoff to prevent erosion and abrasion of the final cover. During the closure phase, surface water within the extents of the ECM will be conveyed through a series of rip-rap lined down-drains and lined channels into the ECM perimeter road ditch which drains into SWMPs #2 and #3 before being discharged to the wetland receiving waters and ultimately, Perch Creek.

The collection, conveyance and/or detention of runoff for the SSA upon closure of the ECM was modelled using Visual Otthymo 4.0 software for 1:2 year, through to the 1:100-year storm events. Rainfall intensity data were sourced from the Town of Arnprior. Modelling simulations included consideration of 6-hour, 12-hour and 24-hour Soil Conservation Service Type II storm distributions but since the 12-hour distribution generated the highest peak flows it was used in the conveyance and pond designs.

5.4.1.6.2 Application Case Results

5.4.1.6.2.1 Construction Phase

The SWMPs are designed to address erosion and sediment control concerns during construction by providing interim sediment control and by providing water quality/quantity controls during operations, closure and post-closure. The current SWMP footprints reflect the overall storage required to control post-closure flows to pre-development levels for the 2-year through to 100-year rainfall events at the site. This volume also contains the storage required for sediment control during construction and water quality control during operations. The target surface water quality objective of 60% TSS removal that provides basic water quality treatment for discharge to the receiving wetland is provided in the *Stormwater Management Planning and Design Manual* (MOE 2003). SWMP #1 will meet 80% TSS removal which will provide enhanced water quality treatment. SWMP #2 will provide 76% TSS removal and SWMP #3 will provide 60% TSS removal during operations, which will be sufficient because the receiving waterbody is a wetland and not a watercourse. The wetland functions as a sediment trap that will provide additional treatment prior to surface water reaching any watercourses in wetlands.

During the construction phase, erosion and sediment control measures will be in place to mitigate the effects of soil erosion and sediment transport. The measures include the use of erosion control blankets, as needed, to control erosion on steep slopes, check dams in ditches and swales, and the three proposed SWMPs that will be constructed to serve as interim sediment control facilities during construction, and then as surface water management facilities during the operations, expansion and post-closure periods. Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site (i.e., CNL's Management of Land and Habitat Procedure) will be used around disturbed areas, where appropriate. Furthermore, an Environmental Management Plan has been developed as part of the design plan for the site outlining the erosion and sediment control measures and SWMP construction schedule discussed. It also outlines administrative protocols such as training, contractor document submissions and staffing required for effective surface water management throughout all phases of the NSDF Project.

Site operations include surface water management for the ECM and all external areas. Surface water from all external areas will be conveyed by ditches, swales and culverts to SWMPs that will address water quality and water quantity criteria established for the wetland receiving waters and, ultimately, Perch Creek. Contact water, which is exposed to waste within the ECM, will drain from the active cells of the ECM and be conveyed to the WWTP. Non-contact water drainage from completed cells and yet-to-be completed cells will be directed either by gravity to the external surface water management system or to temporary holding ponds within the ECM, then pumped to the three SWMPs.

Facility inspections will be completed on a defined schedule to confirm that inlets and outlets are clear of debris and to confirm that there are no major erosion issues at the inlet or outlet. As well, the integrity of berms and outlet structures will be confirmed by visual inspections (e.g., to identify any animal burrowing activity or active soil erosion). Inspections will also include an annual sediment level monitoring component within each pond to identify sediment accumulation rates that may require clean-out requirements. If necessary, pond sediment will be extracted by excavation equipment and will be disposed of based on sediment sampling, testing and classification according to MECP standards, or stockpiled, dewatered and reused on-site for the daily ECM cover operations. Sediment removal will follow procedures identified in the *Stormwater Management Planning and Design Manual* (MOE 2003).

All proposed physical works are located within the SSA, affecting a relatively small area (5.1%) of the total contributing basin area for Perch Creek (720 ha; Robertson and Barry 1985). Any changes to existing drainage patterns will largely be restricted to this small sub-basin. In addition, the change from the forest cover under the existing conditions to the final cover of the ECM will result in decreased infiltration and increased runoff volumes from the footprint of the NSDF Project. Furthermore, all non-contact and contact water will be managed within the SSA, as per the Surface Water Management Plan that will be developed, reducing the potential for the NSDF Project to affect downstream discharge, water levels and channel and bank stability. Overall, changes to downstream discharge, water levels and channel and bank stability resulting from construction of the NSDF Project will be localized to the receiving wetlands. Therefore, this interaction was determined to have a negligible effect on hydrology.

5.4.1.6.2.2 Operations Phase

Phase 1 operations of the facility (the first 20-25-year operational period) is identified as the worst-case scenario for surface water runoff from the SSA. The Phase 1 and 2 excavations will be completed simultaneously, however during Phase 1 operation the Phase 2 excavation will be covered with an impermeable liner. The critical flow period throughout the life cycle is seen here where Phase 1 is operational and the Phase 2 excavation is impermeable.

The scenario was modelled using Visual Otthymo 4.0 software for the 1:2 year, through to the 1:100-year storm events. Summary results for the 12-hour event-controlled run-off from the entire site during Phase 1 operations are presented in Table 5.4.1-14 below (AECOM 2019). For comparison, pre-development results are also presented.

Table 5.4.1-14: Hydrologic Model Results for Base Conditions and Phase 1 Operations from the NSDF

Model Output Peak Runoff Flow Rate	Storm Event		
	1:2 Year	1:5 Year	1:100 Year
Pre-development (m^3/s)	0.42 m^3	0.83 m^3	2.38 m^3
Operational Phase 1 (m^3/s)	0.62 m^3	0.78 m^3	1.75 m^3

Though the SWMPs have been designed to control post-development flows to pre-development runoff rates they have not been designed to limit the operational Phase 1 run-off associated with the 1:2-year storm event. Pre-development runoff rates from that event have been modelled as 0.42 m^3/s, under Phase 1 operations this flow rate increases to 0.62 m^3/s. This ditches around the site are designed to safely convey the additional volumes and increased flow rates.

5.4.1.6.2.3 Post-closure Phase

During the post-closure phase, runoff from the site is transported by culverts and ditches to three SWMPs located to the North, West and South, these ponds collect and control much of the runoff from the site. There is however a combined 2.2 ha area with uncontrolled overland flow from the site (referred to as #4). Therefore, four distinct drainage areas can be modelled. SWMP #1 is within a 7.2 ha area which is located in the northern section of the site and captures runoff from the buildings and parking lots in that area. Runoff from this catchment is collected in SWMP #1 and ultimately discharges to the East Swamp. SWMP #2 is within an 18.7 ha area which captures runoff from lay down areas and the ECM mound, and ultimately discharges to the Perch Lake Swamp wetland complex. SWMP #3 located to the east is within a 5.4 ha catchment area which collects runoff from the ECM mound and ultimately discharges through SWMP#3 to the Perch Lake Swamp wetland complex (Figure 5.4.1-6).

Tables 5.4.1-15 through 5.4.1-18 provide a summary of the controlled post-development (i.e., closure phase) runoff rates for the SWMPs and the entire site (AECOM 2019). A comparison of the peak discharge rates pre-development versus post-development for the entire site is provided in Table 5.4.1-19. Overall, the results show that the surface water management system is designed so that flows during the closure phase are controlled to pre-development levels; preventing increased erosion rates in the receiving waterbodies due to increased discharge rates.

Table 5.4.1-15: Hydrologic Model Results for Controlled Post-development SWMP #1

Model Output	Storm Event		
	1:2 Year	1:5 Year	1:100 Year
Peak Runoff Flow Rate (m^3/s)	0.12 m^3	0.14 m^3	0.22 m^3
Time to Peak (hours)	6.83	6.92	6.75
Total Area Runoff (m^3)	1,650 m^3	2,553 m^3	5,335 m^3

Table 5.4.1-16: Hydrologic Model Results for Controlled Post-development SWMP #2

Model Output	Storm Event		
	1:2 Year	1:5 Year	1:100 Year
Peak Runoff Flow Rate (m^3/s)	0.28 m^3	0.40 m^3	0.63 m^3
Time to Peak (hours)	6.75	6.83	6.67
Total Area Runoff (m^3)	3,132 m^3	5,225 m^3	12,005 m^3

Table 5.4.1-17: Hydrologic Model Results for Controlled Post-development SWMP #3

Model Output	Storm Event		
	1:2 Year	1:5 Year	1:100 Year
Peak Runoff Flow Rate (m^3/s)	0.02 m^3	0.19 m^3	0.27 m^3
Time to Peak (hours)	6.58	6.67	6.58
Total Area Runoff (m^3)	914 m^3	1,593 m^3	3,736 m^3

The change in catchment areas between pre-development and post-development prevent a direct comparison by drainage areas, however an overall look at the site discharge allows for such a comparison. The ultimate condition runoff for the 1:2 year, 1:5 year and 1:100 year are summarized in Table 5.4.1-18:

Table 5.4.1-18: Hydrologic Model Results for Post-Closure Conditions from the NSDF

Model Output	Storm Event		
	1:2 Year	1:5 Year	1:100 Year
Peak Runoff Flow Rate	0.43 m^3/s	0.75 m^3/s	1.20 m^3/s
Total Area Runoff	5,856 m^3	9,648 m^3	21, 926 m^3

Table 5.4.1-19: Comparison of Peak Discharge Rates Pre development versus Post development for the NSDF

Peak Runoff Rates	Storm Event		
	1:2 Year	1:5 Year	1:100 Year (12 hr duration)
Pre-development	0.42 m^3/s	0.83 m^3/s	2.38 m^3/s
Post-development	0.43 m^3/s	0.75 m^3/s	1.20 m^3/s

5.4.1.7 Prediction Confidence and Uncertainty

The hydrologic model is considered to provide a reasonable prediction of the current surface water runoff rates and volumes, as well as the increases expected due to development of the site. The surface water runoff was modelled using Visual Otthymo 4.0 software for the 2-year through to 100-year rainfall events and the regional storm event for the area was also modelled along with the probable maximum precipitation. Visual Otthymo is a hydrologic management model that is capable of simulating runoff from single storm events. It is well suited to hydrologic studies of watersheds and sub-watersheds surface water designs and surface water management design. Rainfall intensity data inputted into the model was sourced from the Town of Arnprior as the storm data were more recent than that available from Environment Canada for the area. This rainfall distribution is a synthetic distribution and presents a heavy front-loaded storm with reduced infiltration leading to higher runoffs than may be seen with intensities more evenly distributed throughout the storm. This results in conservative model outputs with the resultant surface water management systems capable of handling larger storm events than those modelled.

5.4.1.8 Monitoring and Follow-up

Monitoring and follow-up programs for hydrology are related to operational performance monitoring (i.e., verify the SWMPs are performing as designed) and environmental monitoring (i.e., confirm that the ecological function and structure of the wetland system is maintained; Table 5.4.1-20).

Table 5.4.1-20: Monitoring and Follow-up Programs for Hydrology

Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Hydrology	The installation of the ECM will physically alter drainage patterns, and may change downstream discharge, water levels in adjacent wetlands and channel and bank stability.	Operational monitoring – Verify the SWMPs are performing as designed.	Monitoring of water levels and sediment build up in the SWMPs.	The water level at the SWMPs will be monitored during construction and operations. The need for and duration of monitoring will be revaluated based on an annual review of monitoring data.	Integrated into the NSDF Project Environmental Protection Plan to be developed and implemented for the NSDF Project.
		Environmental monitoring – Confirm that the ecological function and structure of the wetland system is maintained.	Monitoring of wetland water elevations and surface water flows to verify changes from the presence of the ECM.	Water level and surface water flows monitoring of the wetland system will be initiated pre-construction (baseline) and continue through construction and operations. The need for and duration of monitoring will be evaluated based on an annual review of monitoring data.	Water level and surface water flows monitoring of the wetland system will be integrated into the CNL Environmental Monitoring Program.

ECM = engineered containment mound; SWMP = surface water management pond.

5.4.1.9 Conclusions

Valued components refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community or the public (The Agency 2018). Hydrology, which includes surface water quantity, flow and direction, is recognized as an important component of the environment that may be affected by the NSDF Project and changes to hydrology could, in turn, lead to effects on other VCs selected for assessment. Acknowledging that changes to hydrology are considered to be important aspects of the natural and human environment, hydrology is referred to as an intermediate component. The hydrology assessment also does not include the assessment of the significance of these changes; rather, results of the analysis of changes in measurement indicators for hydrology are provided to other disciplines for inclusion in their assessment (Table 5.4.1-3).

All physical works are located within the SSA, affecting a relatively small area (5.1%) of the total contributing basin area for Perch Creek (720 ha). The total annual volume of water to be treated is approximately 11,000 m^3. The volume represents approximately 0.006% of the average total outflow from Perch Lake (1,700,000 m^3/yr), or 0.005% of the average total outflow from Perch Creek (2,200,000 m^3/yr). Operational treated effluent discharge is expected to be less than 1 m^3/hr. Flow rates within Perch Creek are approximately 252 m^3/hr; the effluent discharge rate is roughly 0.4% of the average Perch Creek flows and approximately 11.5% of East Swamp weir flows. Furthermore, the receiving wetlands are expected to buffer the discharge, further reducing flow rates into Perch Creek.

Residual effects to the hydrology VC are associated with the operational phase and the eventual closure of the NSDF Project, which will physically alter drainage patterns in the Perch Creek basin. In addition, the change from the forest cover under the existing conditions to the final cover of the ECM will result in decreased infiltration and increased runoff volumes from the footprint of the NSDF Project. The main physical works related to the NSDF Project is the ECM, the WWTP and supporting infrastructure. The design of the SWMPs and associated systems use standard surface water management principles by controlling erosion, capturing sediment and allowing infiltration of non-contact water. The current SWMP footprints reflect the overall storage required to control closure flows to pre-development levels for the post-development flows to pre-development levels for the 2-year through to 100-year rainfall events at the site. Where drainage crosses roadways, culverts are sized to convey the 25-year design event without road overtopping. A summary of residual effects is included in Table 5.4.1-21.

Closure activities include the installation of a final cover over the ECM to limit ponding and water infiltration into the waste. Modification to the drainage ditches and conveyance channels will be made to promote positive drainage from the site and limit erosion or abrasion of the final cover. During the closure phase, all surface water within the extents of the ECM will be conveyed through a series of rip-rap lined channels and down-drains into the ECM perimeter road ditch which drains into SWMP #2 and SWMP #3 before being discharged to the wetland receiving waters and ultimately, Perch Creek. Modelling results show that the surface water management system is designed so that flows during the closure phase are controlled to pre-development levels; thus, preventing increased erosion rates in the receiving waterbodies due to increased discharge rates.

Monitoring and follow-up programs for hydrology are related to operational monitoring (i.e., verify the SWMPs are performing as designed) and environmental monitoring (i.e., confirm that the ecological function and structure of the wetland system is maintained.

Table 5.4.1-21: Summary of Predicted Residual Adverse Effects for Hydrology Valued Components

Valued Component	Residual Adverse Effects	Project Effect Occurs in	Contributing Project Activity	Proposed Mitigation
Hydrology	The construction of the NSDF Project will physically alter drainage patterns in the Perch Creek and Perch Lake Watershed and may change downstream discharge, water levels, channel and bank stability, and water levels in adjacent wetlands.	Construction	▪ Site Preparation ▪ Construction of the ECM ▪ Development of surface water management structures ▪ Construction of the WWTP and other support facilities ▪ On-site road and access development ▪ Construction of transfer line and Perch Lake diffuse	▪ The NSDF Project footprint has been designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. ▪ A 30 m buffer will be established along identified wetlands near the SSA; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion. ▪ Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site will be used during construction around disturbed areas, where appropriate. ▪ During the construction phase, erosion and sediment control measures in place to mitigate the effects of sediment transport include the use of erosion control blankets, as needed, to control erosion on steep slopes, check dams in ditches and swale. ▪ Surface water from all external areas will be conveyed by ditches, swales and culverts to SWMPs to address water quality and water quantity criteria established for the wetland receiving waters and, ultimately, Perch Creek. ▪ Where drainage crosses roadways, culverts are sized to convey the 25-year design event without road overtopping. ▪ The SWMPs are designed to address erosion and sediment control concerns during construction by providing interim sediment control and by providing water quality/quantity controls during operations, closure and post-closure. ▪ Annual maintenance activities will identify any erosion problems. ▪ Inspections will be undertaken and maintenance activities completed, as required, after major storm events and after the annual spring melt to confirm there are no major erosion issues.

Table 5.4.1-21: Summary of Predicted Residual Adverse Effects for Hydrology Valued Components

Valued Component	Residual Adverse Effects	Project Effect Occurs in	Contributing Project Activity	Proposed Mitigation
Hydrology	The installation of the site grading and final cover of the ECM and decommissioning of infrastructure will physically alter the Perch Creek watershed area and drainage patterns, and may change downstream discharge, water levels and channel and bank stability and water levels in adjacent wetlands.	Operations, Closure and Post-closure	■ Installation of the final cover of the ECM, restoration and grading of the site ■ Continued operation of surface water management structures	■ The final cover and site grading is designed to promote positive drainage from the SSA and reduce erosion or abrasion of the final cover. ■ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound and minimize leachate generation. ■ The final cover system design incorporates a series of shallow, trapezoidal, rip-rap lined drainage channels that are designed to convey water via drainage channels that are designed to convey water at low velocity. ■ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the final cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. ■ The ECM final grading and drainage plan includes collection ditches along the top of the ECM berm road to collect side slope drainage. ■ The SWMPs are designed to address erosion and sediment control concerns by providing water quality/quantity controls during operations, closure and post-closure. ■ Environmental monitoring will be completed as required during the institutional control period for the NSDF Project to confirm that the final cover is functioning as intended.

ECM = engineered containment mound.

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5.4.2 Surface Water Quality

5.4.2.1 Scope of the Assessment

Section 5.4.2 focuses on surface water quality and follows the overall environmental assessment approach and methods described in Section 5.1. The assessment is completed in the key steps listed below:

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries, and assessment cases** for the surface water quality assessment (refer to Sections 5.4.2.2 Valued Components and Section 5.4.2.3 Assessment Boundaries). The VCs and measurement indicators used to assess project-related changes to surface water quality are described, along with the spatial and temporal boundaries at which the assessment occurred and the assessment cases considered.
- **Step 2 – Describe the existing conditions** (refer to Section 5.4.2.4 Description of the Environment). Existing conditions in the local and regional areas are described, including the combined effects of previous and existing developments (Base Case). The existing environment represents the historical and current environmental pressures that have shaped the observed patterns in the environment (i.e., natural variation).
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 5.4.2.5 Project Interactions and Mitigation). NSDF Project components and/or activities with the potential to affect surface water quality are identified and mitigation developed to limit or avoid effects is presented. A pathways analysis is then used to focus further assessment on key interactions between the project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects to surface water quality. Where effects are adequately mitigated and do not require further analysis (i.e., where mitigation removes the pathway altogether and limits the effects to minor changes), rationale for concluding the assessment at this stage is articulated. Primary pathways that may lead to residual effects to surface water quality after incorporating mitigation are carried forward to Step 4 for further analysis and residual effects characterization.
- **Step 4 – Present the methods and results of the residual effects analysis** (refer to Section 5.4.2.6 Residual Effects Analysis). The residual effects analysis section outlines the methods used to predict and characterize residual effects to surface water quality from primary effects pathways. The analysis results for a select group of COPCs screened into the assessment are also presented including the characterization of incremental effects from the NSDF Project, as well as cumulative effects of the NSDF Project in combination with other reasonably foreseeable developments (if applicable). The analysis results for each of the COPCs screened into the assessment are presented in the Surface Water Quality Technical Supporting Document. A key outcome of this section is the predicted changes to surface water quality that are passed on to other disciplines for their assessment.
- **Step 5 – Describe the level of certainty and management of uncertainty** (refer to Section 5.4.2.7 Prediction Confidence and Uncertainty). The prediction confidence and uncertainty section evaluates the available literature, data, and models used for the assessment, and describes the level of certainty that can be placed on predicted residual effects. This section will also identify how the uncertainty has been managed so that the effects are not underestimated.
- **Step 6 – Classify and determine the significance of the predicted residual effects**. This step was not required as the surface water quality VC is an intermediate component which does not include an assessment endpoint to determine significance.

- **Step 7 – Identify monitoring and follow-up** required to confirm effects predictions and address uncertainty (refer to Section 5.3.2.8 Monitoring and Follow-up).
- **Step 8 – Present a consolidated summary of conclusions and outcomes of the assessment** of residual effects on surface water quality (refer to Section 5.4.2.9 Conclusions).

Section 5.4.2 also describes how the input from engagement influenced the scope of the surface water quality assessment. Information and areas of interest raised by the public, communities of interest, and Indigenous peoples during engagement that influenced the scope of the surface water quality assessment are summarized in Table 5.4.2-1. Other general areas of interest and questions raised during the engagement that pertain to the surface water quality assessment (if any) are documented in CNL's Indigenous Engagement Report (CNL 2020) and CNL's Stakeholder's Activity Reports (CNL 2017a,b, 2019a).

Table 5.4.2-1: Summary of Areas of Interest Raised During Engagement Activities that Influenced the Scope of the Surface Water Quality Assessment

Areas of Interest	How the Area of Interest was Included in the Assessment
Potential for contamination in the Ottawa River from the NSDF Project.	The spatial boundaries of the assessment were selected to include consideration of potential effects to the Ottawa River. Surface water quality modelling was completed to estimate contaminant concentrations within the Perch Creek basin, which flows directly into the Ottawa River. Meeting effluent discharge targets within the Perch Creek and Perch Lake Watershed is considered to be protective of the Ottawa River. The Regional Study Area was expanded to include a reach of the Ottawa River extending 8 km downstream of the CRL site in response to comments received from the public.

5.4.2.2 Valued Components

Valued Components (VCs) refer to environmental features that may be affected by a development and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community, or the public (The Agency 2018). Surface water quality is recognized as an important component of the environment that may be affected by the NSDF Project and changes to surface water quality could, in turn, lead to effects on other VCs selected for assessment. For example, changes to the characteristics of surface water quality have a large influence on aquatic, human, and wildlife health. Subsequently, changes to these characteristics by NSDF Project activities could affect aquatic organisms and the use of water as a drinking water source for people or wildlife (Table 5.4.2-2). The assessment of surface water quality focused on predicting changes in the concentrations of selected non-radiological and radiological parameters to the receiving environment as a result of the NSDF Project. The selected parameters (or Constituents of Potential Concern [COPC]) were identified through a screening process of the WWTP design and waste characterization information for the NSDF Project, which focussed on those that were known to be important to human and aquatic life. More detail is provided in Section 5.4.2.6.1.4. Changes to radiological parameters are discussed in Section 5.7 (Ambient Radioactivity and Ecological Health).

Acknowledging that changes to surface water quality are important aspects of the natural and human environment, surface water quality is referred to as an intermediate component (i.e., it does not have an assessment endpoint). Changes to intermediate component VCs must be understood to facilitate assessment of project interactions. The surface water quality assessment, therefore, is analyzed for incremental and cumulative (if applicable) changes in the relevant measurement indicators associated with surface water quality (Table 5.4.2-3). The changes are characterized in terms of magnitude, duration, and geographic extent, but they are not classified using rankings for effects criteria. For example, the magnitude of change in a water quality parameter may be described as the relative change from baseline; however, this change would not be classified (or ranked) as low, moderate, or high. The surface water quality assessment also does not include the assessment of the significance of these changes; rather, assessment results for surface water quality (i.e., projected changes in water quality measurement indicators) are provided to other disciplines for inclusion in their assessment (Table 5.4.2-3).

Table 5.4.2-2: Valued Components for the Surface Water Quality Assessment

Valued Component	Rationale for Selection
Surface Water Quality	■ Water quality to support aquatic and human health is defined by the concentration or value of various physical and chemical constituents of water, such as temperature, suspended particulate matter, major ions (e.g., chloride, potassium), nutrients (e.g., nitrogen, phosphorus), metals, trace organic compounds, and radiological compounds that occur in dissolved or soluble form (e.g., aluminum and iron) and suspended matter (comprising inorganic or organic material). ■ Changes in the quality of water can affect aquatic and terrestrial sustainability and biodiversity, and the use of water for recreational purposes or as a drinking water source for people and wildlife. ■ Societal values concerning changes in water quality are an important consideration in understanding potential effects of the NSDF Project.

Table 5.4.2-3: Measurement Indicators for the Surface Water Quality Assessment

Valued Component	Measurement Indicators	Discipline Assessments where Effects on Surface Water Quality are Considered
Surface Water Quality	Concentrations of non-radiological and radiological constituents in surface water, which will be compared to baseline concentrations and effluent discharge targets.	■ Section 5.5 Aquatic Environment ■ Section 5.6 Terrestrial Environment ■ Section 5.7 Ambient Radioactivity and Ecological Health ■ Section 5.8 Human Health

5.4.2.3 Assessment Boundaries

5.4.2.3.1 Spatial Boundaries

The spatial boundaries selected for the surface water quality assessment were chosen because they permit description of existing conditions in sufficient detail to enable potential Project-VC interactions and effects to be identified, understood and assessed, including the contribution of the NSDF Project to cumulative effects. The spatial boundaries selected for the surface water quality are consistent with the hydrology and aquatic biodiversity assessment are presented on Figure 5.4.1-1 and are described below:

- **Site Study Area (SSA):** the SSA is the NSDF Project footprint (i.e., where project activities would be undertaken including proposed facilities, buildings, and infrastructure).
- **Local Study Area (LSA):** The LSA is defined as the area within which there is potential for measurable changes to measurement indicators resulting from the proposed NSDF Project activities. The LSA includes the SSA and is bounded by Perch Lake and Perch Creek, and adjacent wetlands and swamps.

- **Regional Study Area (RSA):** The RSA is defined as the area within which the potential effects of the NSDF Project may interact with the effects of other existing or reasonably foreseeable developments. The RSA is determined by the spatial extent of the Perch Creek and Perch Lake Watershed and includes Perch Lake and its tributaries and Perch Creek. The RSA also includes a portion of the Ottawa River (i.e., roughly 8 km downstream in the Ottawa River to Harrington Bay).

5.4.2.3.2 Temporal Boundaries

Temporal boundaries (i.e., project phases) establish the timeframe during which NSDF Project effects are assessed. The temporal boundary represents the timeframe during which project activities are actively occurring and considers the duration of predicted residual effects. The duration of an effect is defined as the amount of time between the start and end of a project activity or stressor (which is related to the project phases) plus the time required for the residual effect to be reversed. In some cases, a residual effect may be irreversible within the temporal boundaries of the project or if the effects were predicted to last so far into the future that they could not be predicted with any level of certainty (e.g., residual effect lasts for thousands of years). The following phases were identified for the NSDF Project:

- **Construction phase**: This phase includes site preparation and all activities associated with the construction of the NSDF Project. This phase includes activities such as installing the necessary supporting and/or ancillary facilities and infrastructure to facilitate NSDF Project operations, inactive commissioning and systems testing, and transportation of construction materials. Construction activities are expected take place from 2021 to 2023.
- **Operations phase**: This phase includes all activities associated with waste placement, water management, Wastewater Treatment Plant (WWTP) operations, vehicle movements into and from the SSA, and maintenance activities. Operations activities are expected to last approximately 50 years (i.e., 2024 to 2070).
- **Closure phase:** This phase includes activities necessary to complete the installation of the final cover and implementation of long-term monitoring. Closure activities are expected to start in 2070 and continue through to 2100, after which the NSDF Project will transfer into the post-closure phase.
- **Post-closure phase:** This phase has two discrete periods: institutional control and post-institutional control. The institutional control period includes implementation of controls throughout 2100 to 2400 (i.e., 300 years). During institutional control, environmental monitoring will continue to demonstrate compliance with the environmental assessment predictions. Post-institutional control occurs after year 2400 and continues indefinitely.

The assessment of potential effects to the receiving surface water environment is focused on the construction and operations phases. The assessment of potential effects during the closure and post-closure phases is presented in Section 5.7 (Ambient Radioactivity and Ecological Health) and Section 5.8 (Human Health).

5.4.2.3.3 Assessment Cases

The assessment cases considered in the surface water quality assessment include the Base Case and Application Case:

- **Base Case –** This scenario represents existing conditions and characterizes combined effects from previous and existing developments and activities. The Base Case reflects the effects of existing disturbances, such as forestry, transportation, agricultural, mining and residential and recreational development. Current effects from the existing CRL facilities and operations, for example, are considered part of the Base Case.
- **Application Case –** This scenario represents predictions of the effects of the Base Case combined with the effects that may result from the NSDF Project. The Application Case considers potential effects from the NSDF Project during construction through the operations phase. The assessment of potential effects during the Closure/Post-closure phases is presented in Section 5.7 (Ambient Radioactivity and Ecological Health).
- **Reasonably Foreseeable Development (RFD) Case –** This scenario represents predictions of the cumulative effects of the Application Case, which includes the Base Case, plus projects that are currently under application review or that have officially entered a regulatory application process and are therefore considered reasonably foreseeable.

  RFDs expected within the CRL site (i.e., the RSA) that may interact with surface water quality include new or upgrades to research and development facilities, construction and operations of the SMR, new support infrastructure, and on-going decommissioning and environmental remediation activities. New support infrastructure and research and development facilities will generally be located within existing disturbed areas on the CRL site (i.e., minimal disturbance to largely undeveloped areas) where erosion and sediment control practices and surface water management systems already in place will be implemented. Disturbance of an approximately 3.5 ha may be required for development of the SMR based on the candidate site selected, but no watercourses are identified within any of the three candidate sites (Global First Power 2019); therefore, the footprint of the SMR will be approximately 10% of the footprint of the SSA. The Project Description document for the SMR notes that the nearest waterbody to Site A is “No Name” Lake within the Perch Creek and Perch Lake Watershed and the nearest waterbody to Sites B and C is the Ottawa River within the Ottawa River direct watershed. It is noted that a small amount of radioactive liquid waste from decontamination activities during the operations of the SMR will be monitored and stored in a holding tank, for further processing (Global First Power 2019). A septic field may be used to manage sewage the SMR site, depending on the candidate site chosen that would follow required standards and would be located approximately 2 km from the NSDF Project site. Consequently, potential effects from revitalization activities and through development of the SMR are not expected to spatially overlap with potential effects to surface water quality from the NSDF Project.

  The NSDF Project will enable the remediation of contaminated lands and legacy waste management areas, and decommissioning of outdated infrastructure at the CRL site and CNL’s other business locations to support future CNL work. The end-state plan for the CRL site will be to return lands disturbed by site activities to a condition that is physically stable and safe in keeping with the land use and landscape of the day. Therefore, decommissioning and environmental remediation activities are anticipated to positively affect surface water quality.

5.4.2.4 Description of the Environment

Surface water monitoring at on-site lakes and streams, off-site streams, and locations in the Ottawa River both upstream and downstream of the CRL site is routinely conducted to describe the radiological and non-radiological water chemistry in the LSA and RSA (Figure 5.4.1-1). Monitoring of radiological and non-radiological parameters is performed in accordance with CNL's *Environmental Monitoring Program* (CNL 2018a). Methods for the collection of *in situ* field data and water samples follow approved methods in the *Protocol for the Sampling and Analysis of Industrial/Municipal Waste Water* (MOECC 2016) with minor modifications. As part of the surface water quality monitoring program design, CNL has provided a characterization of the naturally occurring and existing baseline metal, organic, and radionuclide constituents in surface water and sediments within the CRL site in *Environmental Risk Assessment of Chalk River Laboratories* (CNL 2019b).

Regional and local surface water quality data described in the *Chalk River Laboratories: A Description of the Environmental Baseline for Environmental Assessments* (AECL 2008) and in the *Environmental Monitoring in 2018 at Chalk River Laboratories* (CNL 2019c) are included in the following sections. The available existing Base Case conditions for Perch Lake and Perch Creek are also summarized. The focus of this description is on the non-radiological parameters, with a brief summary of the radiological parameters; a fuller description of the monitoring locations for radiological parameters and the existing Base Case conditions for the radiological parameters is provided in Section 5.7.4.5.

5.4.2.4.1 Ottawa River Watershed

The CRL site, as well as the surrounding area, is located entirely within the Ottawa River watershed. The Chalk River and Petawawa River are the two major downstream tributaries near the CRL site. Surface drainage from approximately 18% of the CRL site flows through Perch Creek and subsequently into the Ottawa River (CNL 2019c), which includes the CRL Built-Up Area Drainage Basin, where most of the operational nuclear and industrial facilities are located. The CRL Built-Up Area Drainage Basin also includes several landfill facilities, including the non-radiological landfill currently in operation, and two groundwater contaminant plumes from the National Research Experimental and National Research Universal reactor facilities that slowly discharge to the Ottawa River through regions of the riverbed. Wastewater effluents and streams with the potential to release contaminants to the Ottawa River are subject to routine monitoring, as appropriate, providing a means of measuring and controlling releases to the environment (CNL 2019c).

Sampling for non-radiological parameter concentrations for the Ottawa River is conducted at one location adjacent to the CRL site (i.e., CRL Water Intake) and at several locations upstream and downstream of the CRL site as part of the Provincial Water Quality Monitoring Network (PWQMN). Due to the lack of PWQMN stations near the Perch Creek confluence, PWQMN data are not applicable in establishing existing surface water quality conditions for the RSA. The PWQMN stations that were ultimately removed from further consideration included Petawawa (16 km downstream of the CRL site) and the Mattawa River situated approximately 108 km northeast of Perch Lake just before its confluence with the Ottawa River.

Sampling locations for radiological parameters of surface water include Rolphton (28 km upstream), Deep River (9 km upstream), CRL Intake, Pointe au Bapteme (CRL downstream boundary), Highview (8 km downstream), Harrington Bay (9 km downstream), Fort William (14 km downstream), Petawawa (18 km downstream), and Pembroke (28 km downstream). Only monitored radiological concentrations at the CRL Intake location were used in establishing the baseline Ottawa River radiological concentrations for surface water quality modelling. No sampling for radiological parameters is undertaken at the Perch Creek outlet to the Ottawa River. A data summary for the radiological parameters measured at these stations is provided in Table 5.7.4-9.

Table 5.4.2-4 provides a summary of Ottawa River water quality monitoring results for non-radiological parameters at the CRL water intake and compares data collected in 2018 to annual average water quality data for the previous five years where data were available (i.e., 2011 to 2015 or 2014 to 2018). Some of the annual averaged concentrations provided for several parameters are higher than surface water quality guidelines (e.g., CCME [1999]); these elevated parameters include aluminum, copper, lead, zinc, and iron. These data provided the existing baseline condition data for the Ottawa River used in the surface water quality assessment.

Table 5.4.2-4: Summary of Ottawa River Water Quality Monitoring Results from 2010 to 2018 at CRL Water Intake

Parameter	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	Previous 5-Year Average[(a)]
pH	pH	7.10	6.91	7.06	6.97	6.79	6.84	6.69	6.66	6.94	6.78[(b)]
Nitrates	mg/L	0.17	0.16	0.16	0.18	0.17	<0.18	—	—	—	0.18[(c)]
Dissolved Organic Carbon	mg/L	6.87	7.23	7.32	7.38	7.18	7.71	—	—	—	7.36[(c)]
Total Organic Carbon	mg/L	7.16	7.49	7.56	7.59	7.47	7.91	—	—	—	7.60[(c)]
Phosphorus	mg/L	0.10	0.10	0.10	0.06	<SRI	<0.01	—	—	—	0.054[(c)]
Conductivity	µS/cm	65	61.1	57.7	62.4	57.7	54.2	56.07	57.08	56.43	56.3[(b)]
Total Suspended Solids	mg/L	3.0	3.0	3.0	2.65	1.25	<3.1	6	V <3	V <3	3.3[(b)]
Aluminum	µg/L	242	274	274	467	405	998	370	585	795	631[(b)]
Boron	µg/L	3.0	7.0	3.8	4.3	6.1	<47	6	V <42	V<83	37[(b)]
Cadmium	µg/L	0.05	0.04	0.05	0.02	0.02	<0.04	0.04	<T 0.03	<SRI	0.026[(b)]
Chromium	µg/L	0.7	0.50	0.78	1.32	1.53	<0.83	0.5	<SRI	V<1.5	0.87[(b)]
Copper	µg/L	5.47	210	4.6	4.1	5.9	<7.5	8	<SRI	V<2	4.7[(b)]
Lead	µg/L	0.25	4.75	2.25	1.00	9.7	<6.75	8	V<5	<SRI	5.89[(b)]
Lithium	µg/L	0.18	0.78	0.53	0.75	0.68	<0.5	0	<SRI	<SRI	0.24[(b)]
Nickel	µg/L	0.3	1.25	1.45	1.25	4.72	<9.5	15.8	25.5	V<17.0	14.5[(b)]
Strontium	µg/L	26.8	27.3	27.3	27.9	22.5	32	26	28	33	28[(b)]
Vanadium	µg/L	0.63	0.43	0.35	0.73	0.59	<1.13	0.8	V<0.5	V<0.7	0.74[(b)]
Zinc	µg/L	1.43	34.1	2.4	8.0	12.2	<3.33	8	<T 8	<T <8	7.9[(b)]
Iron	µg/L	314	324	284	368	388	655	632	479	350	501[(b)]
Uranium	µg/L	0.09	0.08	0.07	0.09	0.06	<0.11	0.1	<T 0.1	<T <0.1	0.094[(b)]
Mercury	µg/L	0.01	0.01	0.01	<SRI	0.01	<0.01	0	<SRI	<SRI	0.004[(b)]
Phenolics	µg/L	1.9	2.55	1.67	0.90	1.15	<2.2	—	—	—	1.7[(c)]
Solvent Extractables	mg/L	1.35	1.48	1.68	0.98	1.60	<2.25	—	—	—	1.6[(c)]

Table 5.4.2-4: Summary of Ottawa River Water Quality Monitoring Results from 2010 to 2018 at CRL Water Intake

Parameter	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	Previous 5-Year Average(a)
Temperature Influent Mean	°C	9.02	7.15	6.46	7.71	8.13	8.95	9.0	8.1	6.1	7.7(b)

Source: CNL (2018a)

Note: Shading = summary concentration higher than surface water quality guideline value (e.g., CCME [1999]).

(a) Averages were determined by setting the SRI to zero.

(b) Averages were calculated from 2014 to 2018 data.

(c) Five-year averages were calculated from 2011 to 2015 data for parameters that were not sampled in 2016, 2017, and 2018.

µS/cm = microSiemens per centimetre; µg/L = micrograms per litre; SRI = smallest reportable increment; T = trace amount; V = data that has been averaged and includes one or more, but not all, measurements that were either a trace amount, below detection limits, below critical levels, or were a smallest reportable increment; < = less than.

5.4.2.4.2 Perch Creek and Perch Lake Watershed

The SSA is located within the Perch Creek and Perch Lake Watershed, which drains to the Ottawa River (Figure 5.4.1-2). The Perch Creek and Perch Lake Watershed represents the LSA for this project because most of the drainage from the SSA will be directed to the Perch Creek and Perch Lake Watershed. Additionally, this watershed contains many of the site's operating waste management areas; in particular, the waste management areas of the earliest vintage in the evolution in waste storage practices at CRL, including the Liquid Dispersal Areas. Because of its history, this basin is the most historically affected region of the CRL site.

Physical characteristics of Perch Lake include a wetted area of approximately 45 ha, a drainage area of 730 ha and a mean depth of 2 m (Robertson and Barry 1985). A recent bathymetric survey completed in 2018 identified a maximum depth of 4 m, and confirmed that most of the lake is shallow, less than 3 m in depth (CNL 2018b). Based on the 2018 bathymetric survey, the contour of the lake remains similar to that of the 1985 study, and as such, it can be assumed that the hydrology of Perch Lake has remained relatively constant over the past 30 years (i.e. no significant change in annual flow and water volume).

Most of Perch Lake is open water except for littoral zones along the shore, including a region of floating, emergent, and submerged vegetation, which amounts to about 30% of the lake's surface (Yankovich et al. 2000). The outer fringe of this zone is known as Perch Lake Marsh. Due to the physical connectivity between the marsh and the lake, this open marsh may be part of the lake. To the north, there are extensive wetlands, notably Perch Lake Swamp, South Swamp, East Swamp, and West Swamp. The lake is confined in part by sand outcrops along the northern and southern shores, and by bedrock along the western shores. The northern shoreline of Perch Lake was altered in the 1960s with the construction of the Perch Lake Ring Road. As part of this construction activity, sand fill was used to create a 1 to 2 m berm along this stretch of shoreline. There are no other documented alterations to Perch Lake, and as such it is anticipated that the physical characteristics of the lake have not appreciably been modified (CNL 2018b).

Perch Lake is characterized by high levels of nutrients (Yankovich et al. 2000) and can be described as dystrophic-eutrophic because it shows clear signs of nutrient enrichment, with approach to maturity in lake evolution. The water in Perch Lake is highly coloured water with an acidic pH (ranging from 5.5 to 6.8) and a low total suspended solids content. The colour of the water is the result of humic and fulvic acids. On average, the lake is frozen from late November to April. Following melting of the ice, the water warms up rapidly and summer temperatures can exceed 30°C; the highest temperature recorded was 34°C. During summer, the deeper parts of the lake become stratified with surface water temperatures about 5°C higher than the deep-water zone (Yankovich et al. 2000). The bottom waters of Perch Lake often become depleted in oxygen in summer and in winter, but without reaching full anaerobic conditions; no massive fish kills have been observed during these conditions.

Perch Creek is the dominant surface water feature that drains the Perch Creek and Perch Lake Watershed directly into the Ottawa River. The upper third of Perch Creek is characterized by a low gradient, supporting extensive emergent vegetation and a thick layer of organic detritus. Below the Perch Creek weir, there is a substantial increase in overhead riparian cover and stream gradient. A series of small waterfalls (or cascades) and run sequences grade into slow-run sequences grade into slow flowing water in the lower reach of the creek. Substrate is predominately rock, gravel and coarse in the middle section of the creek, transitioning to a dominance of finer-grained material (e.g., silt) in the lower reach of the creek.

Surface water sampling locations are monitored routinely by CRL throughout the Perch Creek and Perch Lake Watershed (Figure 5.4.1-3). Monitoring data for these sampling stations includes a range of select non-radiological and radiological parameters (Table 5.4.2-5). Within the LSA, the closest monitored surface waters to the SSA are the East Swamp weir (ESW), Perch Lake Inlet #2 (PL2), and Perch Creek weir (PCW; Figure 5.4.1-3). The ESW is located immediately west of the SSA. This monitoring location is downstream of the CRL Liquid Dispersal Area, Laundry Pit, Reactor Pit 2, and Chemical Pit. The PL2 monitoring location is further downstream and receives discharge from the East Swamp Stream, South Swamp Stream, and Main Stream. The PCW monitoring station represents a downstream location of Perch Lake and is the final monitoring station in Perch Creek prior to its confluence with the Ottawa River. Perch Lake (PL4), is characterized as a reference sampling location for the Perch Creek and Perch Lake Watershed. It is located at Inlet 4 along the southern perimeter of Perch Lake which drains a sub-watershed not affected by CNL operations. Perch Lake is not routinely monitored; however, for the purposes of the EIS, aquatic monitoring, including sampling for field and laboratory non-radiological and radiological water quality data, was conducted in Spring 2018.

In order to assess the effects of non-radiological and radiological contaminants and physical stressors on surface water quality, the monitoring results were screened against the Risk Benchmark values (RBs) for non-radiological parameters adopted by the CRL site listed in Table 5.4.2-5 and No Effects Concentrations (NEC) for radiological parameters listed in Table 5.4.2-6. The tables include existing baseline concentrations in the Perch Creek and Perch Lake Watershed.

The Risk Benchmarks for non-radiological constituents are based on the Lowest Observable Effect Level (LOEL) with acute exposure at which population level effects may occur. They are based on:

- Federal and provincial guidelines for acute exposure; and
- Lowest observable effect concentrations from the literature.

Exceedance of an RB does not necessarily indicate that ecological effects would occur, but instead indicates that there may be some potential for effects (CNL 2019b).

The NEC for radiological constituents represents the concentration below which no adverse effects are expected at the population level. The NECs are derived from radiation benchmarks established for the protection of biota (i.e., 100 microGray per hour [μGy/hr] for terrestrial biota and 400 μGy/hr for aquatic biota). An exceedance of a NEC does not indicate an effect, rather that there may be the potential for effects.

Some non-radiological parameters in the Perch Lake and Perch Creek watershed have been identified as having high existing environmental concentrations compared to screening criteria from federal and provincial water quality guidelines for chronic exposure. These non-radiological parameters are closely monitored in surface waters at the CRL site and (i.e., 2010 to 2017). In 2018, parameters having elevated concentrations included pH, copper, aluminum, barium, iron, lead, manganese, phosphorus, and silver (CNL 2018b). Barium, iron, lead, phosphorus, and silver concentrations were consistently elevated in the Perch Lake and Perch Creek watershed. In most cases, with the exception of iron, these metals were present at concentrations similar to those seen in reference (i.e., unaffected) monitoring locations in the Perch Creek and Perch Lake Watershed (CNL 2019b), indicating that these parameters are naturally elevated in the basin (or outside of the guideline range as for pH). Aluminum, copper, and manganese concentrations are elevated at a limited number of sampling locations (CNL 2018b).

Other parameters, such as chromium, lead, and nickel, were measured in 2018 at concentrations that were notably higher than previous years at all monitoring stations; in particular, copper concentrations measured at PL1 and PCW in 2018 are notably higher than previous years. All other non-radiological parameters were present at levels comparable to those observed in previous years and at the reference locations (i.e., Perch Lake Inlet 4).

Concentrations of non-radiological parameters do not exceed the risk benchmarks, with the exception of lead, which with a concentration of 8 µg/L slightly exceeds the risk benchmark of 7 µg/L (Table 5.4.2-5). As noted above, lead concentrations are similar to those at locations in the Perch Lake Basin that are unaffected by CRL operations.

The existing baseline radiological parameter concentrations for the sampling stations within the Perch Creek and Perch Lake Watershed show localized exceedances above NEC for gross beta (as strontium-90). An exceedance of a NEC does not necessarily indicate that ecological effects would occur, but instead indicates that there may be some potential for effects (CNL 2019b). A more detailed discussion of baseline radioactivity in surface waters within the Perch Creek and Perch Lake Watershed is provided in Section 5.7.4.5.

Table 5.4.2-5: Summary of Existing Baseline Water Quality in the Perch Creek and Perch Lake Watershed and Risk Benchmark Values for Non radiological Parameters

Monitoring Parameters	Units	Existing Baseline Concentration Range[(a)]	Risk Benchmark[(b)]	Risk Benchmark Reference
Non-radiological Parameters				
Aluminum	µg/L	<MDL – 545	100	AESRD (2014)
Ammonia	mg/L	No data	No data	-
Antimony	µg/L	0.027 – 0.050	180	Suter and Tsao (1996)
Barium	µg/L	17 – 18	110	Suter and Tsao (1996)
Boron	µg/L	6.5 – 13.1	29,000	CCME (1999)
Cadmium	µg/L	0.013 – 0.058	1	CCME (1999)
Calcium	mg/L	7.0 – 7.6	No data	-
Chloride	mg/L	0.25 – 273	640	CCME (1999)
Chromium	µg/L	0.768 – 1.38	1,700	Suter and Tsao (1996)
Cobalt	µg/L	0.24 – 0.45	1,500	Suter and Tsao (1996)
Copper	µg/L	<MDL – 51	Narrative[(c)]	AESRD (2014)

Table 5.4.2-5: Summary of Existing Baseline Water Quality in the Perch Creek and Perch Lake Watershed and Risk Benchmark Values for Non radiological Parameters

Monitoring Parameters	Units	Existing Baseline Concentration Range[(a)]	Risk Benchmark[(b)]	Risk Benchmark Reference
Fluoride	mg/L	No data	3	SCHER (2011)
Hardness	mg/L	4 – 337	No data	-
Iron	mg/L	1.65 – 2.87	3.4	SAVEX (2013)
Lead	µg/L	<MDL – 8	7	AESRD (2014)
Magnesium	mg/L	1.829 – 2.530	No data	-
Manganese	µg/L	52 – 130	2,300	Suter and Tsao (1996)
Mercury	µg/L	<MDL – 0.027	2.4	Suter and Tsao (1996)
Molybdenum	µg/L	0.3	16,000	Suter and Tsao (1996)
Nickel	µg/L	<MDL – 4	1,400	Suter and Tsao (1996)
Nitrate	mg/L	<MDL – 0.12	550	CCME (1999)
Nitrite	mg/L	No data	Narrative[(d)]	AESRD (2014)
Phosphorus	mg/L	<MDL – 0.2	No data	-
Potassium	mg/L	0.647 – 1.038	No data	-
Selenium	µg/L	<MDL – 3	20	Suter and Tsao (1996)
Silver	µg/L	1	4.1	Suter and Tsao (1996)
Sodium	mg/L	2.1 – 24.6	No data	-
Strontium	µg/L	16 – 110	15,000	Suter and Tsao (1996)
Sulfate	mg/L	0.85 – 3.80	No data	-
Thallium	µg/L	0.02	110	Suter and Tsao (1996)
Tin	µg/L	0.002	2,700	Suter and Tsao (1996)
Uranium	µg/L	<MDL – 0.11	33	CCME (1999)
Vanadium	µg/L	<MDL – 4	280	Suter and Tsao (1996)
Zinc	µg/L	<MDL – 25	120	Suter and Tsao (1996)

a) Existing baseline water quality data ranges for all assessment nodes between 2010 to 2018 (CNL 2015b, CNL 2019b).

b) Risk benchmarks apply to the select non-radiological parameters for the entire CRL site.

c) Other factors need to be considered in the risk assessment (e.g., water hardness).

d) The risk benchmark varies with chloride (AESRD 2014). For chloride concentrations greater than 10 mg/L, the nitrite risk benchmark concentration = 0.6 mg N/L.

MDL = method detection limit; µg/L = micrograms per litre; mg/L = milligrams per litre.

Table 5.4.2-6: Summary of Existing Baseline Water Quality in the Perch Creek and Perch Lake Watershed and No Effects Concentrations for Radiological Parameters

Monitoring Parameters	Units	Existing Baseline Concentration Range[(a)]	No Effects Concentration[(b)]	No Effects Concentration Reference
Radiological Parameters				
Carbon-14	Bq/L	<MDL	164	CNL (2019b)
Caesium-137	Bq/L	<MDL – 0.5	72.7	CNL (2019b)
Cobalt-60	Bq/L	<MDL – 0.54	135	CNL (2019b)
Gross Alpha as Americium-241	Bq/L	0.0037 – 0.3[(d)]	0.385[(c,e)]	ERICA (2019)
Gross Beta as Strontium-90	Bq/L	0.001 – 923	183[(f)]	CNL (2019b)
Tritium	Bq/L	15 – 7,443	17,400,000	CNL (2019b)

a) Existing baseline water quality data ranges for all assessment nodes between 2010 to 2018 (CNL 2015a, CNL 2019b).

b) No Effects Concentrations apply to the select radiological parameters for the entire CRL site

c) No effect concentration for americium-241. Americium-241 is present in low concentrations in groundwater in the lower Perch Creek and Perch Lake Watershed downgradient of Legacy Waste Management Areas.

d) Outliers for gross alpha has been removed from the dataset.

e) The concentration is the Environmental Media Concentration from the Erica Tool multiplied by a factor of 40.

f) Strontium-90 is the main contributor to gross beta in Perch Lake and Perch Creek watershed. The no effect concentration for Strontium-90 (183 Bq/L).

MDL = method detection limit; Bq/L = Becquerels per litre

5.4.2.5 Project Interactions and Mitigation

5.4.2.5.1 Methods

This section describes the process by which interactions between NSDF Project components and activities and surface water quality were identified and evaluated. Potential effects pathways to surface water and mitigation developed to eliminate and/or reduce these effects are presented in this section. An assessment of these pathways then focuses on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects are adequately mitigated, they are not carried forward for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether). Primary pathways that may lead to residual effects after incorporation of mitigation are then further characterized in subsequent subsections of the assessment. As such, the “Project Interactions and Mitigation” section helps to focus the remainder of the assessment on those interactions (effects pathways) likely to result in residual adverse effects.

The first part of the analysis was to identify the potential effects pathways for all phases of the NSDF Project. The next step in the analysis was the development of environmental design features and mitigation that could be incorporated into the NSDF Project to eliminate and/or reduce adverse effects to surface water quality. Environmental design features included NSDF Project design elements, environmental best practices, and management policies and procedures. Environmental design features and mitigation were developed through an iterative process between the NSDF Project’s engineering and environmental teams, combined with input from Project specific or regional engagement with other interested parties. The environmental design features and/or mitigation were selected considering their effectiveness for implementation and maintenance, and their appropriateness within the context of the identified effects pathways.

Potential pathways were evaluated into the following categories using scientific knowledge, logic, experience with similar developments, and the effectiveness of environmental design features and mitigation:

- **No linkage:** This pathway is removed by environmental design features or mitigation such that the NSDF Project would not be expected to result in a measurable environmental change relative to existing conditions, and therefore would have no residual effects to surface water quality.
- **Secondary pathway:** The pathway could result in a measurable minor environmental change but would have a negligible residual effect on surface water quality relative to existing conditions and/or guideline values. Additionally, the pathway is not expected to contribute cumulatively to other NSDF Project effects or to the effects of other previous, existing, or reasonably foreseeable developments to cause a significant effect.
- **Primary pathway:** The pathway is likely to result in an environmental change relative to the existing conditions and/or guideline values and could contribute to residual effects to surface water quality.

Environmental design features and mitigation that have been or could be incorporated into the NSDF Project to eliminate and/or reduce adverse effects were considered. Potential pathways that were completely removed due to implementation of environmental design or mitigation were not assessed further. Pathways that were assessed to be secondary and demonstrated to have a negligible residual effect to surface water quality through simple qualitative or semi-quantitative evaluation of the pathway were also not advanced for further assessment. Primary pathways were carried forward for more detailed quantitative and qualitative effects analysis to characterize the residual effects of the NSDF Project.

5.4.2.5.2 Results

Pathways through which all stages of the NSDF Project may interact and result in changes to measurement indicators for surface water quality are provided in Table 5.4.2-7.

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Table 5.4.2-7: Pathways Analysis for the Surface Water Quality Valued Components – Construction, Operations, Closure and Post closure

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Project activities during the construction phase: ■ Site Preparation ■ Construction of the ECM ■ Blasting (as required) ■ Development of surface water management structures ■ Construction of the WWTP and other support facilities ■ On-site road and access development	Changes to local hydrology from surface disturbances may cause changes to water levels, flows, channel and bank stability, and sediment yield, at downstream locations, affecting water quality	■ The NSDF Project has been designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials ■ A 30 m buffer will be established along identified wetlands near the SSA; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion ■ Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site will be used during construction around disturbed areas, where appropriate ■ During the construction phase, erosion and sediment control measures will include the use of erosion control blankets to control erosion on steep slopes, and the use of check dams in ditches and swale ■ Surface water from all external areas will be conveyed by ditches, swales and culverts to surface water management ponds to address water quality and water quantity criteria established for the wetland receiving waters and, ultimately, Perch Creek ■ Where drainage crosses roadways, culverts will be sized to convey the 25-year design event without road overtopping ■ The surface water management ponds have been designed to address erosion and sediment control concerns during construction by providing interim sediment control and by providing water quality/quantity controls during operations, closure, and post-closure. ■ Annual inspections and maintenance activities will identify and address any erosion problems ■ Inspections will be undertaken, and maintenance activities completed, as required, after major storm events and after the annual spring melt to confirm there are no major erosion issues	No Linkage
	Changes to the hydrology within the Perch Creek and Perch Lake Watershed as a result of the intake of water from the Ottawa River for construction activities may cause changes to surface water quality		No Linkage
	Surface water drainage through the SSA during construction of the ECM may transport blasting residuals and metals directly into downstream waterbodies, affecting surface water quality	■ A blasting plan, as part of the EPP, will be developed by the Contractor and implemented for the NSDF Project ■ Runoff from the SSA will be managed (e.g., surface water management ponds) to avoid adverse environmental effects in downstream waterbodies ■ Additional guidance for the NSDF Project blasting limits will be obtained from *OPSS 120 – General Specification for the Use of Explosives* (OPSS 2014) ■ Blasting activities will follow industry standard Best Management Practices, and applicable federal regulations and DFO guidelines for use of explosives ■ Any runoff in contact with blasting residues at the SSA will be managed where appropriate (e.g., surface water management ponds) during the construction phase	No Linkage
	The high-pressure horizontal directional drilling installation of the transfer line to Perch Lake may result in a release of drilling mud (i.e., frac-out), which may cause changes to surface water quality	■ The transfer line to Perch Lake will be installed using high-pressure horizontal directional drilling methods. The mitigation described in the DFO *Ontario Operational Statement – High-Pressure Directional Drilling* (DFO 2007) will be applied, including creation of, and adherence to, a Frac-out Response Plan and Spill Contingency Plan during installation, and full-time environmental monitoring during all phases of transfer line works within the Perch Lake Swamp. The monitoring will evaluate adherence to environmental protection measures and provide for observations to identify signs of surface frac-out of drilling mud. Evidence of frac-out will trigger implementation of the Frac-out Response Plan	Secondary

Table 5.4.2-7: Pathways Analysis for the Surface Water Quality Valued Components – Construction, Operations, Closure and Post closure

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Project activities during the construction phase: ■ Site Preparation ■ Construction of the ECM ■ Blasting (as required) ■ Development of surface water management structures ■ Construction of the WWTP and other support facilities ■ On-site road and access development	Physical disturbances in Perch Lake from the installation of diffuser and transfer line construction and footprint may affect water quality	■ The selection of final routing alignment and foundation design considered the routing alignments and foundation designs that would result in the least potential for in-lake environmental effects ■ Work will be completed within the in-water work timing window of July 16 to March 14 to avoid spawning and egg/larval development periods for spring spawning fish species (DFO 2013; MNRF 2013); the construction duration is anticipated to be short term (i.e., <30 days) ■ Mitigation, including erosion and sediment control practices (e.g., silt fences, silt curtains), will be used during construction around disturbed areas, where appropriate. Key fish habitat protection measures will include turbidity curtains to isolate any suspended sediments to the construction work areas within the lake ■ Industrial equipment will be well maintained and free of leaks, invasive species, and noxious weeds. Machinery will be operated from above the high-water mark or from a barge to minimize the disturbance of the lakebed, riparian area, and shoreline. Vegetative mats and riparian protection measures will be used when mobilizing to and from the site ■ Clearing of any riparian vegetation and organic materials will be minimized, materials removed will be salvaged and replaced once the project is completed. Disturbed riparian areas and shorelines will be re-vegetated and restored to the original stable gradient and contour. All construction materials will be removed from site upon completion of the project ■ A site-specific Erosion and Sediment Control Plan will be developed and implemented for this activity ■ A site-specific 'Spill Management Plan' will be developed and implemented for this activity. Any refueling will occur at least 30 m away from the lake or waterbodies ■ Mitigation as described for drilling activities in the DFO *Ontario Operational Statement - High-Pressure Directional Drilling* (DFO 2007) will be followed ■ Environmental monitoring of ESC measures will be completed by a qualified professional. Environmental monitoring will include turbidity and total suspended solids monitoring; the monitoring details will be described in an 'Erosion and Sediment Control Plan' provided by the Project contractor prior to construction	Secondary

Table 5.4.2-7: Pathways Analysis for the Surface Water Quality Valued Components – Construction, Operations, Closure and Post closure

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
■ Project activities during the construction phase (as listed above) and; ▪ Hauling of construction materials ■ Project activities during the operations phase: ▪ Phased development of disposal cells in the ECM ▪ On-site transportation of waste and placement in the ECM ▪ Progressive closure of disposal cells and installation of final cover ▪ Operation of the WWTP ▪ Existing presence of fencing around perimeter of ECM ▪ Surface water management ▪ Domestic waste (solid and liquid) management; and, ▪ Routine operational management and monitoring activities.	Discharge of domestic wastewater may cause a downstream change in surface water quality	■ The grey water/sanity sewage will be managed through a gravity sewer network connected to the two sewage disposal systems as described in Section 3.4.4.4. These systems are completely separate from the ECM leachate and other contact water sewer conveyance for the on-site WWTP ■ Sewage discharges to the sewage disposal systems will conform with CNL's *Acceptability Criteria for Routine and Non-Routine Discharge of Liquids on the CRL Site* (CNL 2015b)	No Linkage
	Non-radiological air emissions and dust emissions (including sulphur dioxide, nitrogen oxides and particulate matter) and subsequent deposition may cause a change in surface water quality	■ Implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018c), which includes operational control monitoring and verification monitoring ■ The NSDF *Environmental Protection Plan* (AECOM 2018a) includes: ▪ restricting or suspending activities if unacceptable amounts of dust are generated due to winds or other site conditions ▪ use of water spraying or misting techniques (e.g., water trucks) as the primary dust control method ▪ use of fixatives (e.g., chemical suppressant) for dust control, and for use as daily ECM cover ▪ suspension of excavating, loading, hauling and disposal operations when wind speeds exceed the specified criterion ▪ vehicles that come into contact with potential contamination sources will be required to pass through the vehicle decontamination facility ■ On-site vehicles and equipment engines will meet Tier 2 emission standards and be maintained in good working order ■ Idling of vehicles will be limited on-site	Secondary
	Surface water runoff from the SSA can contain contaminants and suspended solids, which can affect water quality	■ Procedures for surface water management will be developed and implemented for the NSDF Project ■ The target surface water quality objective is provided in *Stormwater Management Planning and Design Manual* (MOE 2003). ■ Surface water from all external areas will be conveyed by ditches, swales and culverts to surface water management ponds that will address water quality and water quantity criteria established for the wetland receiving waters and, ultimately, Perch Creek ■ The surface water management ponds are designed to address erosion and sediment control concerns during construction by providing interim sediment control and by providing water quality/quantity controls during operations, closure and post-closure ■ The current surface water management pond design reflects the overall storage required to control post-closure flows to predevelopment levels for the 2-year through to 100-year rainfall events at the site. This volume also contains the storage required for sediment control during construction and water quality control during operations ■ Where drainage crosses roadways, culverts are sized to convey the 25-year design event without road overtopping ■ For each surface water management pond, the water level will be sampled to estimate the inflow and outflow of each pond ■ The outlet water quality will be sampled periodically to confirm that surface water discharges meet applicable environmental criteria	No Linkage

Table 5.4.2-7: Pathways Analysis for the Surface Water Quality Valued Components – Construction, Operations, Closure and Post closure

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Project activities during the operations and closure phases: ■ Surface water management ■ Operation of the WWTP ■ Discharge of treated effluent from the WWTP	Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) may cause changes to water levels, flows, and channel and bank stability, and scouring of the wetland, affecting water quality at downstream locations	■ Discharge of treated effluent to the exfiltration gallery area will help to reduce water loss from the hydrogeological system. ■ Design consideration was given during the selection of the discharge location of treated effluent for environmental effects of scour on the receiving waterbodies. As such, the preferred design (i.e., discharge to the exfiltration gallery and Perch Lake diffuser) was chosen as the favourable alternative as they resulted in negligible scour potential ■ Outlet flows from all three surface water management ponds will be dispersed by level spreaders that will provide an even flow distribution to the wetlands with an appropriately wide dispersal pattern ■ The WWTP system's outlet will utilize a headwall structure, which will discharge to a level spreader for the purposes of preventing erosion and sedimentation at the outlet for the exfiltration gallery ■ The outlet locations of the surface water management ponds are limited by the site boundary (i.e., greater than 5 m separation required) so there will be no discharge from the spreaders directly to the wetland ■ Annual inspections and maintenance activities will identify and address any erosion problems ■ Inspections will be undertaken and maintenance activities completed, as required, after major storm events and after the annual spring melt to confirm there are no major erosion issues	No Linkage

	Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) can cause changes to downstream surface water quality	■ The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses best available technology that is economically achievable and capable of meeting regulatory requirements
		■ Effluent discharge targets for wastewater discharges are protective of the environment and human health
		  ▪ Discharge targets for non-radiological contaminants are sourced from federal and provincial guidelines for protection of aquatic biota.
		  ▪ Discharge targets for radionuclides are the Canadian Drinking Water Guidelines with the exception of tritium for which a site-specific target is developed (Section 3.4.2.5.1)
		■ Treated effluent will be sampled to confirm it meets treatment targets before release to the environment
		■ When applied, the proposed exfiltration gallery will promote the exfiltration of treated water into the local groundwater regime where further retention of radioactivity by the geosphere is anticipated
		■ The Perch Lake diffuser design provides additional dilution of treated effluent at the point of release
		■ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water quality
		■ Appropriate procedures will be in place to effectively identify spill occurrences in the event treated effluent is released to areas other than directly to the exfiltration gallery or to Perch Lake and initiate appropriate emergency responses
			Primary

Table 5.4.2-7: Pathways Analysis for the Surface Water Quality Valued Components – Construction, Operations, Closure and Post closure

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
	Leakage of leachate from the ECM during the operations and closure phases may cause changes to downstream surface water quality	■ Design of the ECM includes base contours developed using a herringbone pattern with ridges and valleys to promote leachate transport to the leachate collection system for removal ■ The base liner design includes primary and secondary liner systems designed to have redundancy in case of premature degradation and are a combination of natural and synthetic barrier systems. These include a compacted clay liner (CCL), two geosynthetic clay liners (GCL) and an HDPE geomembrane ■ Clay materials were selected for the CCL and GCL components of the liner system as these materials are anticipated to maintain their function as hydraulic barriers throughout and beyond the design life of the disposal facility (i.e., 550 years) ■ The HDPE geomembrane design for the liner will be compatible with the leachate generated by the waste and provide a long service life ■ The base liner system will include an underlying compacted clay liner to supplement the primary and secondary liner system ■ The leachate collection system design will provide accessible access points for inspections, maintenance, repairs, and replacements ■ Appropriate responses to leachate leakage and contamination will be implemented as described in the Operations and Maintenance Plan and Contingency Plan	No Linkage
	Physical disturbances in Perch Lake from the installation of diffuser and transfer line construction and footprint may affect water quality	■ Installation of drill pilings to be completed by staged construction and restricted to the vicinity of the barge location where installation is occurring ■ Active work areas in the lake will be contained by turbidity curtains to isolate and limit the extent of any suspended sediments ■ Use of heavy machinery along the shoreline will be mitigated using erosion and sediment control measures	Secondary
	The high-pressure horizontal directional drilling installation of the transfer line to Perch Lake may result in a release of drilling mud (i.e., frac-out), which may cause changes to surface water quality	■ On-going environmental monitoring will be conducted during drilling activities ■ Mitigation as described for drilling activities in the DFO *Ontario Operational Statement - High-Pressure Directional Drilling* (DFO 2007) will be followed	Secondary

Table 5.4.2-7: Pathways Analysis for the Surface Water Quality Valued Components – Construction, Operations, Closure and Post closure

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Project activities during the operations and closure phases: ■ Surface water management ■ Operation of the WWTP ■ Discharge of treated effluent from the WWTP	Temperature changes in Perch Lake as a result of the direct discharge of treated effluent from the WWTP to Perch Lake may result in thermal effects (e.g., degassing) in the lake	■ The temperature of the treated effluent to be released to Perch Lake will be routinely monitored. The monitoring at the WWTP will be used to identify treated effluent conditions (elevated temperature conditions) that will prohibit its release to Perch Lake so that it can be held in storage until it can be released ■ Most of the discharge transfer line between the WWTP and Perch Lake will be buried below the frost line. Additionally, the transfer line will be double-walled with an air space between inner and outer wall for most of its length ■ The design of the submerged diffuser will result in the rapid dispersal of treated effluent in Perch Lake during discharge	No Linkage
	Temperature changes in Perch Lake or other surface water bodies as a result of the direct discharge of discharge from the surface water management ponds may result in thermal effects to water quality (e.g., degassing) in the receiving water bodies	■ There are no direct discharges of SWMPs to surface water bodies, including Perch Lake	No Linkage
Project activities during the closure and post-closure phases: ■ Installation of final ECM cover, restoration and grading of the site ■ On-going long-term performance monitoring, transfer of NSDF Project into institutional control	Installation of the final cover of the ECM and decommissioning of Project infrastructure may change downstream discharge, water levels, and channel/bank stability, affecting surface water quality	■ The final cover is designed to promote positive drainage from the SSA and reduce erosion or abrasion of the cover ■ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound and minimize leachate generation ■ The cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity ■ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the cover and underlying waste materials, destabilization of the ECM structure, and damage to access roads ■ The ECM final grading and drainage plan includes collection ditches along the top of the ECM berm road to collect side slope drainage ■ Environmental monitoring will be completed as required during the institutional control period for the NSDF Project to confirm that the final cover is functioning as intended	Secondary
Project activities during the closure and post-closure phases: ■ Installation of final cover, restoration and grading of SSA ■ On-going long-term performance monitoring, transfer of NSDF Project into institutional control	Leakage of leachate from the ECM after the end of the post-institutional control period (i.e., after Year 2400) from liner and final cover degradation as a result of normal evolution can cause changes to downstream surface water quality	The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the ECM and minimize leachate generation The final cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the final cover and underlying waste materials, destabilization of the ECM structure and damage to access roads ■ The ECM final grading and drainage plan also includes collection ditches along the top of the ECM berm road to collect side slope drainage. ■ The design life for the ECM is 550 years to meet the required time period to allow for radioactive decay of the waste placed in the facility (i.e., until it has decayed to levels that do not present a risk to the public and environment) ■ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water and groundwater quality	Primary

ECM = engineered containment mound; WWTP = Wastewater Treatment Plant; SSA = Site Study Area; ESC = erosion and sediment control; HDPE = high density polyethylene; DFO = Fisheries and Oceans Canada; LLW = low-level waste.

5.4.2.5.2.1 *No Linkage Pathways*

The following pathways were assessed as having no measurable environmental change relative to Base Case values and therefore would have no effects to surface water quality.

- **Changes to local hydrology from surface disturbances may affect downstream water levels, flows, channel and bank stability, and sediment yield, affecting surface water quality**

The sediment quality conditions in Perch Lake and at the Ottawa River have been determined in previous programs. Current data are not available for Perch Lake or Perch Creek, but in-river sediments in the Ottawa River have been evaluated more recently (CNL 2015a). 'Offshore' sediment surveys have been conducted at a location adjacent to the process sewer outfall at CRL, particularly to evaluate historic sediment contamination that was limited to a small zone around the immediate diffuser discharge area. The results of the offshore sediment evaluation have concluded a negligible (and declining) risk to aquatic biota in the river, in terms of radiological and non-radiological sediment chemistry, sediment toxicity, and biotic population and community assessments.

Sediment quality data in Perch Lake are less available and are not routinely monitored under the current annual environmental programs. However, Perch Lake possesses a sustainable aquatic community structure, which has persisted through elevated contaminant exposure in the upper watershed resulting from historic contamination due to releases from Waste Management Areas and Liquid Dispersal Areas. The projected potential contribution from the NSDF Project to exposure of aquatic species in East Swamp is expected to be less than 1% of the current levels of exposures, which provides further confidence that sediment quality in Perch Lake and its downstream waters is not anticipated to be affected. Sediment quality constituents of potential concern (COPCs) in Perch Lake and Perch Creek have been identified, but are limited to chromium and copper and several sediment polycyclic aromatic hydrocarbons, and 'on-site' specific benchmarks and background levels have been formalized (CNL 2019b). These benchmarks will provide a useful reference should sediment quality monitoring be required.

The following mitigation will be implemented for the NSDF Project to limit changes to sediment quality to Perch Lake, its downstream watershed, and ultimately, the Ottawa River. During construction, erosion and sediment control practices (e.g., surface water management ponds, silt fences, runoff management) consistent with those applied at the CRL site during construction around disturbed areas, will be integrated into the NSDF Project, where appropriate. These practices will include erosion control blankets, to control erosion on steep slopes, ditches, swales and culverts for the conveyance of surface runoff to surface water management ponds, which will be designed to manage flows to control erosion potential and sediment transport through augmenting settlement by flow control.

During operations, the surface water management system established in the construction phase will control clean surface water quantity and quality while preventing contact with contaminated areas. The surface water management system will include surface water management ponds that will have the storage capacity to manage flows up to back-to-back 100-year rainfall events at the site, and a WWTP for the treatment of site leachate and wastewater (e.g., infiltration and suspended particulate settling) prior to discharge to the downstream receiving watershed and, ultimately, Perch Creek. Additionally, the design of discharge from the surface water management ponds will be dispersed by level spreaders to an even flow distribution to wetlands with an appropriately wide dispersal pattern, further reducing erosion potential.

As a result of the mitigation applied on-site during the life of the NSDF Project, water quality projections in Perch Lake and its downstream flow-paths over the life of the NSDF Project are expected to remain within Risk Benchmark values or existing baseline concentrations. In addition, flows from the NSDF Project to the Perch Creek and Perch Lake Watershed flow regime are expected to be minor (i.e., approximately 0.63% of the average total outflow from Perch Lake will be sourced from contact surface water from the SSA). Overall, this pathway was determined to have no linkage to effects on surface water quality.

- **Changes to the hydrology within the Perch Creek and Perch Lake Watershed as a result of the intake of water from the Ottawa River for construction activities may cause changes to surface water quality**

The NSDF Project construction phase will be carried out from 2021 to 2023. During the construction phase, CNL anticipates an average daily usage of approximately 110 m^3/day to 150 m^3/day for construction activities (e.g., dust suppression, clay mixing and fire protection). Construction water use is expected to peak at approximately 750 m^3/day. Water usage will be lower during the winter season (December through to March) when construction activities will be less. The water may also be used for commissioning activities during construction including hydrostatic testing of the WWTP storage tanks, the leachate collection, and piping systems. Construction water will be sourced from the Ottawa River and accessed via overland hoses and pipes to fill temporary storage containers.

The intake of water from the Ottawa River for construction purposes (i.e., up to a maximum of 276,000 m^3/yr based on the peak daily usage) is anticipated to have a negligible effect on the overall Ottawa River annual flow rate of 25 billion m^3/yr (as recorded at the Des-Joachims monitoring point) and the downstream hydrology. The proposed diverted annual volume for construction represents 0.0011% of the total annual flow rate of the Ottawa River at Des-Joachims using conservative assumptions of annual volumes based on peak daily flow and construction taking place throughout the winter months. Actual water use for construction is anticipated to be lower than proposed; for example, during winter months, site activities do not require as much water as during the open water construction periods. Consequently, no changes to surface water quality in the Ottawa River are anticipated.

Similarly, changes to the surface water quality within the Perch Creek and Perch Lake Watershed as a result of the intake of water from the Ottawa River for construction activities at the SSA are as the annual intake amount is approximately 15% of the mean annual outflow from the Perch Creek and Perch Lake Watershed. Water is used for various construction activities, such as dust management control. Water used for dust management will primarily evaporate or infiltrate and any associated runoff will be collected and conveyed to the SWMPs. Overall, water use for construction activities was determined to have a no linkage to effects on surface water quality.

- **Surface water drainage through the SSA during construction of the ECM may transport blasting residuals and metals directly into downstream waterbodies, affecting surface water quality**

Use of ammonium nitrate/fuel oil and water-resistant bulk emulsion explosives during the construction of the ECM has the potential to affect surface water quality in the Perch Creek and Perch Lake Watershed through runoff coming into contact with residual nitrogen material (e.g., nitrate and ammonia) in the construction area. A blasting plan will be developed by the Contractor as part of the EPP for the NSDF Project, which will comply with existing guidelines (Wright and Hopky 1998; DFO 2019; OPSS 2014). Any runoff in contact with blasting residues at the SSA will be managed according to the NSDF *Surface Water Management Plan* (AECOM 2019) (e.g., surface water management ponds and associated systems) during the construction phase. In addition, the potential for transporting blasting residuals into downstream waterbodies is minimized as blasting operations are limited to a relatively short period of time during the construction phase.

Any runoff in contact with blasting residues at the SSA will be managed according to the NSDF *Surface Water Management Plan* (AECOM 2019) (e.g., directed to surface water management ponds and associated systems to enhance settling of particulates in the ponds) during the construction phase. In addition, the potential for transporting blasting residuals into downstream waterbodies is minimized as blasting operations are limited to a relatively short period of time during the construction phase.

Consequently, the use of explosives for the development of the ECM in the SSA is considered to potentially influence runoff quality with respect to minor increases in nitrate and ammonia concentrations for a short period in the construction phase. As such, this interaction is determined to have no linkage to effects on surface water quality in the receiving and downstream environment.

- **Discharge of domestic wastewater may cause a downstream change in surface water quality**

The NSDF Project's sanitary conveyance system is designed to convey the peak sewage flows generated by up to 65 full-time employees (although this will be adjusted based on operational demand) whom will work at the NSDF Project. The NSDF sanitary sewage will be managed through a gravity sewer network connected to a sewage disposal system. This system is independent of the ECM leachate and other contact water sewer conveyance for the on-site WWTP.

There are two site sewage disposal systems proposed to service the NSDF Project. A detailed description of the systems is presented in Section 3.4.4.4.

Sewage discharges to the sewage disposal systems will conform to CNL requirements for discharge to septic systems provided in CNL's Environmental Protection Program procedure, *Acceptability Criteria for Routine and Non-Routine Discharge of Liquids on the CRL Site* (CNL 2015b). As such, discharge of treated domestic wastewater for the NSDF Project to downstream locations is considered to have no linkage to effects on surface water quality.

- **Surface water runoff from the SSA can contain contaminants and suspended solids, which can affect water quality**

A variety of mitigation strategies will be implemented during all project phases to reduce the potential for changes to soil, water and vegetation quality from surface water runoff from the CRL site. These include surface water management, erosion and sediment control measures, surface water management ponds, maintenance and inspection activities, and monitoring.

Site operations include surface water management for the ECM and all external areas. Surface water from all external areas will be conveyed by ditches, swales and culverts to surface water management ponds that will address water quality and water quantity criteria established for the wetland receiving waters and, ultimately, Perch Creek. Contact water, which is exposed to waste within the ECM, will drain from the active cells of the ECM and be conveyed to the WWTP. Non-contact water drainage from completed cells and yet-to-be completed cells will be directed either by gravity to the external surface water management system or to temporary holding ponds within the ECM, then pumped to the three surface water management ponds.

During the construction phase, erosion and sediment control measures will be in place to mitigate the effects of soil erosion and sediment transport. The measures include use of erosion control blankets, as needed, to control erosion on steep slopes. Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site (i.e., CNL's *Management of Land, Habitat and Wildlife* procedure [CNL 2018d]) will be used around disturbed areas within the CRL site, where appropriate. Furthermore, an Environmental Management Plan has been developed as part of the design plan for the site outlining the erosion and sediment control measures and surface water management pond construction schedule discussed. It additionally outlines administrative protocols such as training, contractor document submissions and staffing required for effective surface water management throughout all phases of the NSDF Project.

The surface water management ponds are designed to address erosion and sediment control concerns during construction by providing interim sediment control and by providing water quality/quantity controls during operations, closure and post-closure. The current surface water management pond footprints reflect the overall storage required to control post-closure flows to predevelopment levels for the 2-year through to 100-year rainfall events at the site. This volume also contains the storage required for sediment control during construction and water quality control during operations. The target surface water quality objective of 60% TSS removal that provides basic water quality treatment for discharge to the receiving wetland is provided in the *Stormwater Management Planning and Design Manual* (MOE 2003). Surface water management pond #1 will meet 80% total suspended solids removal which will provide enhanced water quality treatment. Surface water management pond #2 will provide 76% removal and SWMP #3 will provide 60% total suspended solids removal during operations which will be sufficient because the receiving waterbody is a wetland and not a watercourse. The wetland functions as a sediment trap that will provide additional treatment prior to surface water reaching any watercourses in wetlands.

Roadway, sidewalk and parking lot winter maintenance activities that may release road salt to the environment, include snow plowing/shoveling and de-icing practices, salt and sand storage and snow stockpiling, and removal and disposal. The winter maintenance practices outlined in the current *CRL Salt Management Plan* (AECL 2013) provide for effective management of salt use and will be applied to the NSDF Project as necessary. As per the plan, the application of road salt in the SSA will be to be limited as salt residual within contact water and/or leachate may compromise the treatment effectiveness of the WWTP systems. Instead, alternative products in winter road management, such as a sand-stone mixtures, are currently being considered.

Facility inspections will be completed on a defined schedule to confirm that inlets and outlets are clear of debris and to confirm that there are no major erosion issues at the inlet or outlet. As well, the integrity of berms and outlet structures will be confirmed by visual inspections that would identify soil erosion. Inspections will identify sediment clean-out requirements. Sediments will be extracted by excavation equipment and will be disposed of based on sediment sampling, testing and classification according to Ministry of Environment, Conservation and Parks standards or stockpiled, dewatered, and reused on-site for daily ECM cover operations. The sediment removal assessment follows procedures identified in the *Stormwater Management Planning and Design Manual* (MOE 2003).

The implementation of proposed mitigation at the CRL site will reduce the potential for changes to soil, water and vegetation quality from runoff from the CRL site. This pathway was determined to have no linkage to effects to surface water quality.

- **Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) and the discharge of non-contact water to the adjacent wetlands may cause changes to water levels, flows, and channel and bank stability, affecting water quality at downstream locations**

The NSDF Project will generate two water streams which will have the potential to impact water flows and levels in wetlands including:

- treated effluent from the WWTP which will be routed to the exfiltration gallery or directly to Perch Lake; and
- non-contact water (i.e., water that has not been contaminated through contact with the ECM), which will be managed through a series of SWMPs.

The NSDF *Surface Water Management Plan* (AECOM 2019) will be implemented to mitigate effects from wastewater discharges. Most of the wastewater flow will be generated from non-contact water produced during active filling of the ECM; contributions by leachate and decontamination activities represent a small fraction of the overall wastewater that will be treated by the WWTP. The total annual volume of water to be treated is 11,000 m^3. The volume represents approximately 0.6% of the average total outflow from Perch Lake (1,700,000 m^3/yr), or 0.5% of the average total outflow from Perch Creek (2,200,000 m^3/yr). Operational treated effluent discharge is expected to be a maximum of approximately 11 m^3/hr with an average effluent discharge rate below 1 m^3/hr. Flow rates within Perch Creek are approximately 252 m^3/hr; the maximum effluent discharge rate is roughly 0.4% of the average Perch Creek flows and approximately 11.5% of East Swamp weir flows. During the operations phase, the additional infiltration applied at the exfiltration gallery results in a localized increase in water table elevation of up to 1 m compared to the current conditions (see Section 5.3.2.6).

An exfiltration gallery is proposed at the discharge outlet for the treated effluent to promote the exfiltration of treated water into the local groundwater regime. Treated effluent will also be discharged directly to Perch Lake via a transfer line. The transfer line to Perch Lake has been designed to manage the full annual volume of treated effluent, if required, which will prevent the potential for overland flow at the exfiltration gallery.

The major flow system for all three SWMPs, which manage non-contact water, will outlet to adjacent wetlands and will be dispersed by level spreaders that will provide an even flow distribution to the wetlands with an appropriately wide dispersal pattern. Current SWMPs outlet locations are limited by the site boundary (greater than 5 m separation required) so that there is no discharge from the spreader directly to the wetlands. Local topography between the level spreaders and the wetlands, as well as any setbacks, has influenced the location of the on-site level spreaders.

Annual inspection and maintenance activities will be undertaken by CRL to identify any erosion problems. Facility inspections will be completed twice annually to confirm that inlets and outlets are clear of debris and to confirm that there are no major erosion issues at the inlet or outlet. In addition, inspections and maintenance activities will be completed after major storm events and after the annual spring melt to confirm there are no major erosion issues at the dispersion outlets.

As a result of the design of the WWTP and surface water management pond outlets, discharges from these facilities to receiving wetlands and Perch Lake are not predicted to result in appreciable changes to water levels, flows, and channel and bank stability, that would affect water quality at downstream locations. As a result, this pathway was determined to have no linkage to effects to surface water quality.

- **Temperature changes in Perch Lake as a result of the direct discharge of treated effluent from the WWTP to Perch Lake may result in thermal effects (e.g., degassing) in the lake**

Federal and provincial guidelines exist for discharges to receiving waterbodies. These are described in Environment Canada (2014).

The Canadian Council of Ministers of the Environment (CCME 1999) requirements can be summarized as follows:

- Discharges to receiving waters should be such that thermal stratification and subsequent turnover periods are not altered significantly from those existing prior to the operational discharge period.
- Discharges to receiving waters should not affect the thermal condition such that the maximum weekly average temperature is exceeded.
- Discharges to receiving waters should be such that the short-term exposures to maximum temperatures are not exceeded. Exposures should not be so lengthy or frequent as to adversely affect aquatic species determined to be valued in the receiving waterbody.

The Ontario Provincial Water Quality Objective (PWQO) for temperature (MOEE 1994) provides specific guidelines for temperature as a result of discharges to a receiving waterbody in Ontario. It requires that:

- the natural thermal regime of any body of water shall not be altered to impair the quality of the natural environment;
- the temperature at the edge of a mixing zone shall not exceed the natural ambient water temperature at a representative control location by more than 10ºC; and
- the maximum temperature of the receiving body of water, at any point in the thermal plume outside a mixing zone, shall not exceed 30ºC or the temperature of a representative control location plus 10 degrees or the allowed temperature difference, whichever is the lesser temperature.

To mitigate the potential for thermal effects in Perch Lake during periods of direct discharge to the lake, a combination of design aspects, monitoring, and adaptive management processes will mitigate any potential for adverse thermal effects to water quality. Further, during summer months under dry conditions, most discharge is expected to be directed to the exfiltration gallery instead of to Perch Lake.

The WWTP is designed to accommodate temperatures ranging from 0°C to 38°C; however, the temperature of the treated effluent to be discharged to Perch Lake will largely be dependent on the ambient conditions and the length of storage in the collection tanks and break tanks within the WWTP. The potential worst-case condition is expected to be during warm summer periods, especially if treated effluent is stored for extended periods allowing the temperature of the stored water to increase. To mitigate the potential for temperature build-up in the collection tanks, water storage times will be reduced. It is understood that under these warm conditions, the surface waters in Perch Lake will be warm, with some thermal stratification in the deeper zones of the lake. Mitigating elevated temperature conditions in the treated effluent to be discharged will manage large temperature differentials between the treated effluent discharge and Perch Lake around the diffuser; however, disruption of the thermal profile around this discharge is expected. This disruption will result in mixed conditions, with no anticipated adverse effect to water quality.

The treated effluent transfer line from the WWTP to Perch Lake comprises two key sections: a section between the WWTP and the point in the upstream pumping location, and the section downstream of the pumping location to the submerged diffuser. Between pumping periods, treated effluent may remain in the transfer line within these two sections. For most of these pipeline sections, the high-density polyethylene (HDPE) pipe will be buried below the frost line (below 2 m depth) and the pipe will be double walled with an air space between inner and outer wall for most of its length. Due to adiabatic conditions between the ground and pipe, the temperature of any remaining treated effluent in the transfer line in these sections is anticipated to gradually become consistent with the ground temperature around the transfer line; treated effluent remaining in the section of the pipe near Perch Lake will gradually assume the same water temperature as the lake at the same depth. During treated effluent to discharge, the small diameter transfer line results in water transfers between the WWTP and Perch Lake being relatively rapid; marked temperature changes during pumping are not anticipated; treated effluent temperatures at the point of release in Perch Lake are expected to be similar to the release point in the WWTP.

The design of the submerged diffuser will result in the rapid dispersal of treated effluent in Perch Lake during discharge. This will minimize the area in the lake that may be thermally affected.

Further monitoring of temperature of the stored treated effluent to be discharged directly to Perch Lake and at the point of release and at the edge of the mixing zone in Perch Lake. The monitoring at the WWTP will be used to identify treated effluent conditions (elevated temperature conditions) that will prohibit its release to Perch Lake so that it can be held in storage until it can be released. Monitoring at the edge of the mixing zone will provide confidence in the dispersion of the treated effluent, and that the thermal regime integrity in Perch Lake is maintained.

It is expected that the temperature of the treated effluent discharged directly to Perch Lake will be similar to the surface water temperatures in Perch Lake during discharge under most seasonal conditions. During warm summer conditions, minimizing storage periods in the collection tanks at the WWTP will reduce temperature build-up in the treated effluent. The design of the WWTP, including the number and capacity of collection tanks and the treated effluent transfer system, and the water transfer line and submerged diffuser will limit the potential for changes to the thermal regime in Perch Lake outside the Federal and Provincial guidelines during periods of operational discharge. As such, this pathway is determined to have no linkage to surface water quality.

- **Temperature changes in Perch Lake or other surface water bodies as a result of the direct discharge of discharge from the surface water management ponds may result in thermal effects to water quality (e.g., degassing) in the receiving water bodies**

The primary application of all three SWMPs is to manage non-contact water at the NSDF Project. The SWMPs will flow to adjacent wetlands and will be dispersed by level spreaders that will provide an even flow distribution to the wetlands. The SWMPs will therefore not discharge directly to a water body, including Perch Lake. As such, this pathway is determined to have no linkage to surface water quality.

- **Leakage of leachate from the ECM during the operations and closure phases may cause changes to downstream surface water quality.**

Design of the ECM includes base contours that have been developed using a herringbone pattern with ridges and valleys to promote leachate transport to the leachate collection system for removal. The base liner design includes both primary and secondary liner systems that are a combination of natural and synthetic barrier systems, which will be designed to provide redundancy in case of premature degradation. The primary liner includes a leachate collection system with the secondary liner housing a leak detection system. The composite base liner contains perforated high-density polyethylene (HDPE) collection and pipes. The HDPE geomembrane was selected as it is compatible with the leachate generated by the waste and is expected to perform as an effective hydraulic and diffusion barrier over the 550-year design life (see Section 3.4.1.4). The base liner system includes an underlying compacted clay liner to supplement the primary and secondary liner system. The leachate collection system design provides access points for inspections, maintenance, repairs and replacements.

The primary liner system will contain the leachate collection system and will convey leachate to a single collection point for removal from the mound, for transfer to the WWTP for treatment. The primary liner system serves as the primary source of protection for the natural environment below the mound from leachate migration. The secondary liner system will contain the leak detection system, which will be used to detect leaks in the unlikely event that the primary liner system fails. Leachate collected by the leachate collection system will be pumped to the on-site WWTP for treatment.

Perimeter berms consist of three main geotechnical elements, or layers, each contributing to the soundness and integrity of the berm itself and the whole ECM. A *Slope Stability Analysis* (AECOM 2018b) was completed to provide the information needed to support the design of the base slopes, sidewalls and side slopes of the ECM. The *Slope Stability Analysis* (AECOM 2018b) addresses the range of anticipated loading conditions, under both short-term and long-term scenarios, to confirm that the slope designs will satisfy minimum factor-of-safety requirements for stability. Size and shape of the berms and each of the elements and layers were determined using a seismic design basis, including the National Building Code of Canada (NBCC).

The implementation of the above mitigation will limit the potential for changes to groundwater and surface water quality from the NSDF Project. As such, this pathway is determined to have no linkage to surface water quality.

5.4.2.5.2.2 Secondary Pathways

The following pathways were assessed as potentially having a measurable minor change to the receiving environment, but resulting in a negligible effect to surface water quality relative to the Base Case.

- **The installation of the final cover of the ECM and decommissioning of NSDF Project infrastructure may change downstream discharge, water levels, and channel and bank stability, affecting surface water quality.**

Closure activities include the installation of an engineered cover and a final cover over the ECM to limit ponding and water infiltration into the waste. Modification to the drainage ditches and conveyance channels will be made to promote positive drainage from the site and limit erosion or abrasion of the final cover. Runoff control for the final cover is designed to limit ponding and infiltration of water into the ECM, erosion of the final cover and waste material, and destabilization of the structure. The ECM design approach is to control the direction and velocity of the run-off to prevent erosion and abrasion of the final cover. Any surface water infiltrating the final cover will be collected by the leachate collection system and sent to the WWTP. The three surface water management ponds will remain to promote infiltration and settlement of suspended solids and restrict discharge rates to the nearby wetland. Decommissioning of the WWTP and all associated surface water management structures will be completed after the leachate quantity and quality no longer requires treatment. If the WWTP is required beyond its design life, the unit would be refurbished to enable continued treatment of leachate or other treatment options investigated. Environmental monitoring will be completed as required during the institutional control period for the NSDF Project to confirm that the final cover is functioning as intended.

Mitigation associated with the installation of a final cover over the ECM and decommissioning of the NSDF Project infrastructure to manage hydrological changes through surface disturbance during these closure activities is expected to limit potential changes to downstream discharge, water levels, and channel and bank stability in Perch Creek. As such, negligible effects are predicted to surface water quality in the receiving and downstream environment.

- **Non-radiological air emissions and dust emissions (including nitrogen and sulphur oxides, and particulate matter) and subsequent deposition may cause a change in surface water quality.**

The construction and operation phase of the NSDF Project will generate non-radiological air and dust emissions such as carbon monoxide, sulphur oxides (includes sulphur dioxide), nitrogen oxides (includes nitrogen dioxide), particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) or less than 10 microns in diameter (PM_{10}) and suspended particulate matter (SPM). Air emissions, such as sulphur oxides and nitrogen oxides, can result from the use of fossil fuels in generators, vehicles, and machinery. Vehicle exhaust and fugitive dust from unpaved and paved roads are the largest contributors of particulate matter (SPM, PM_{10} and $PM_{2.5}$) during both construction and operations phases (Section 5.2.1.6.2).

Implementation of applicable mitigation is anticipated to limit predicted residual effects from NSDF Project emissions to air quality (and subsequently to surface water quality) include meeting Tier 2 emission standards for on-site vehicles and equipment engines, use of vehicles that are maintained in good working order and idling of vehicles on site will be limited consistent with CNL's Environmental Protection Program. Dust control will be conducted to support waste placement operations in accordance with the *Dust Management Plan* (AECOM 2018c) during loading, transportation, placement, and compaction operations. Work areas that have the potential for generating dust will require implementation of dust suppression applications. The primary dust control method will include water spraying or misting techniques (e.g., water trucks). Fixatives (e.g., chemical suppressant) may also be used for dust control and for use as daily ECM cover. Water application and the use of fixatives will be controlled to limit potential effects on leachate and surface water runoff generated by the ECM.

Predicted concentrations for the Application Case during both construction and operations phases are below applicable air quality guidelines and/or standards with the exception of nitrogen dioxide, which will not meet the 2020 1-hour Canadian Ambient Air Quality Standards (Section 5.2.1.6.2, Table 5.2.1-14). The contributing factor to the high magnitude nitrogen dioxide emissions is the heavy-duty construction equipment and the conservative assumption that all equipment will run simultaneously and continuously during working hours. In reality, individual equipment will be idling or off for varying parts of the workday that cannot be predicted but will result in lower emissions than currently estimated. The likelihood that all equipment operates simultaneously for an hour or more along with unfavourable weather conditions to produce the maximum concentrations modelled is very low. With the implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018c) and through the implementation of the *Dust Management Plan* (AECOM 2018c) for the NSDF Project, air and dust emissions and subsequent deposition are expected to result in minor and local changes to water quality relative to Base Case conditions. Therefore, this pathway was determined to have negligible effects on surface water quality.

- **Physical disturbances in Perch Lake from the installation of diffuser and transfer line construction and footprint may affect water quality.**

Water management strategies for treated effluent include the use of a proposed discharge transfer line (320 m) with a diffuser positioned in Perch Lake (Figure 5.5.2.1). As part of the installation of the discharge transfer line, the open water section of the transfer line will include a foundation installed with steel pile supports for both the transfer line and diffuser. This design was selected from four discharge options and was considered both technically and economically feasible. The preferred design to support the transfer line was also chosen over a gravel fill foundation, as it provided a much smaller footprint on the lakebed. The discharge transfer line will be constructed using 0.10 m diameter pipe and will be supported by approximately five pairs of piles spaced at approximately 50 m intervals along the discharge transfer line. The submerged diffuser will comprise one 28.2 mm (inside diameter) port, extending 0.8 m above the lakebed sediments to limit disturbance. The diffuser will rest on a pile cap supported by approximately four piles. The footprint of the discharge transfer line was estimated using the entire pipe length across Perch Lake of 320 m multiplied by a pipe diameter of 0.10 m, resulting in a conservative estimation of the permanent footprint of the transfer line as 32 m^2. Additional details regarding the transfer line are available in Section 3.4.2.6.2.

Of the 320 m transfer line length, approximately 23 m of the discharge line will be within the riparian marsh/shoreline area of the lake. Excavation and dredging activities will be required for a shallow trench (2 m deep by 2 m wide) for the placement of the discharge transfer line (total affected area would less than 46 m^2). Vegetated materials and organic debris will be stockpiled during dredging/excavation and then used to remediate disturbed areas as construction stages are completed.

The construction (temporary) footprint for the installation of the transfer line will be minimized where possible. Within the riparian marsh/shoreline section of the transfer line, vegetation mats will be used to mitigate disturbance to shoreline areas from any heavy equipment. The construction (temporary) footprint also includes a barge launch pad within a footprint of approximately 300 m^2 (i.e., 10 m × 30 m), occupying a riparian / shoreline area and possibly extending into the water to a depth of less than 1 m. The barge launch pad will be required to support the barge and drill rig assembly. The launch pad will be lined with geogrid/geotextile material and gravel. The pad will be removed post-construction and affected riparian and shoreline areas will be remediated through the re-vegetation of the disturbed area.

For the open water section of the transfer line in Perch Lake, drill pilings are expected to be completed by staged construction and therefore, it is assumed that an active work area at any given time will be restricted to the vicinity of the barge location where a pile or piles will be installed (Golder 2018). These active work areas will be contained by turbidity curtains to isolate and limit the extent of any suspended sediments (i.e., 5 m wide temporary work area).

Potential changes in sediment concentrations from the use of heavy machinery during the construction period will be mitigated using erosion and sediment control measures, such as turbidity curtains for the duration of the construction. Best management practices will be followed, including those identified in the NSDF *Environmental Protection Plan* (AECOM 2018a). Prior to construction, an Environmental Protection Plan will be developed by the Contractor listing measures for erosion and sediment control as well as spill management.

With the application of best management practices and associated mitigation and monitoring during installation and post-installation activities (removal of the turbidity barriers), changes to water quality (e.g., elevated total suspended sediment) will be limited to the area of installation that will be bound by turbidity curtains. Limited measurable changes to water quality outside of the turbidity curtains is expected, but any changes, such as elevated total suspended sediment concentrations, would be expected to be temporary in duration.

Overall, changes to water quality in Perch Lake from the placement of the discharge transfer line are expected to be minor and have negligible residual effects on surface water quality.

- **The high-pressure horizontal directional drilling installation of the transfer line to Perch Lake may result in a release of drilling mud (i.e., frac-out), which may cause changes to surface water quality.**

With high pressure drilling operations, there is a risk of the drilling mud entering the environment through tunnel collapse, spills or frac-out (the rupture of mud to the ground surface). On-going environmental monitoring during drilling works can limit the effects of a frac-out and having an appropriate response plan in place can reduce the environmental effects of frac-out. Drilling mud is considered a deleterious substance that can adversely affect aquatic organisms and habitat. Specifically, inputs of drilling mud to aquatic habitat may result in adverse effects such as fish egg suffocation and reduction of plant and insect productivity (Falk and Lawrence 1973; Land 1974; Ferrante 1981).

The mitigation described for drilling activities in the DFO *Ontario Operational Statement - High-Pressure Directional Drilling* (DFO 2007) will be followed. This mitigation includes siting of the transfer line and access to temporary laydown and staging areas largely within a previously established access road right-of-way (Perch Lake Ring Road), minimization of vegetation removal beyond previously disturbed areas, creation of, and adherence to an emergency frac-out response plan and spill contingency plan during installation, and full-time environmental monitoring during all phases of transfer line works within the Perch Lake Swamp. The monitoring activities will monitor for adherence to environmental protection measures and provide for observations for signs of surface frac-out of drilling mud. Evidence of frac-out will trigger implementation of the frac-out response plan.

Additional mitigation strategies will include:

- Machine operation will take place on land above the high-water mark of Perch Lake.
- Drilling machinery will be clean and leak free.
- Service, washing, refuelling and storage of operational liquids for the machinery will be kept at a distance from surface water features to ensure spills do not drain into the waterbody. Emergency spill kits will be kept available at the working site in the event of a fluid leak or spill. Potential pathways for spilled products (e.g., storm drains) should be mapped and plans put in place to prevent entry of deleterious products into the storm drain system.
- Where possible, drilling will be timed to occur during daylight hours, which will increase the probability of visually identifying a frac-out of drilling mud.
- Disposal of drilling mud, cuttings, and all waste will be directed to appropriate disposal facilities. All waste materials will be contained in a dugout or holding basin away from wetlands or other surface water features, or storm drains, to avoid entering natural surface water features, until they can be transported for disposal.
- Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CNL site will be used during construction of the transfer line to Perch Lake as the exit point for drilling will be within the Perch Lake riparian area.
- On-going monitoring will occur during all phases of drilling works, including fluid pressure (by drillers) and changes in turbidity in local surface water features (by environmental monitors) that would indicate surface migration (frac-out) of drilling mud.

- Material and equipment required to contain and cleanup a frac-out event will be located in close proximity to the working area. In the event of frac-out, the following processes will be followed:
  - Stop work. Contain drilling mud. Take care that cleanup effort does not result in damage to Perch Lake Swamp or Perch Lake.
  - Containment booms, silt fences, and other appropriate erosion control measures will be deployed to prevent further migration to surrounding areas. Erosion control equipment will be on-site and ready for deployment.
  - Notify the CNL facilities representative on-site.
  - Drillers to evaluate data and circumstances leading to the loss of circulation and if possible, implement methods to seal the fracture.
  - All spills will be evaluated, and work will cease, if frac-out cannot be stopped and/or thresholds of environmental regulations are exceeded (i.e., relevant water quality benchmarks in the surrounding wetlands and/or Perch Lake). A directional drilling contingency plan will be implemented if drilling is unsuccessful along the designated corridor. Enactment of this contingency plan will require review by the responsible parties with CNL prior to initiation.

The implementation of mitigation and monitoring during the drilling of the transfer line to Perch Lake will reduce the potential for a frac-out event. Some localized effects around the drilling zones may occur, but these events will be quickly identified, and the application of mitigation associated with the management and response plans would limit any effects to small, if measurable, and temporary changes to surface water.

5.4.2.5.2.3 Primary Pathways

The following primary pathways were identified as having the potential to result in residual effects to surface water quality:

- **Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) can cause changes to downstream surface water quality.**
- **Leakage of leachate from the ECM during the post-closure phase (i.e., after Year 2400) from liner and final cover degradation as a result of normal evolution can cause changes to downstream surface water quality.**

However, only the primary pathway associated with the discharge of treated effluent from the WWTP to the exfiltration gallery and to Perch Lake has been carried forward to the residual effects analysis in this section. The primary pathway associated with the leakage of leachate from the ECM in the closure/post-closure phases of the Project is discussed in Section 5.7 (Ambient Radioactivity and Ecological Health).

5.4.2.6 Residual Effects Analysis

Residual effects to surface water quality are limited to operational discharges of treated effluent from the WWTP to the exfiltration gallery and to Perch Lake, and it’s potential to change surface water chemistry in the receiving and downstream environment. This assessment includes an assessment focused on select non-radiological constituents, and a small number of radiological constituents.

5.4.2.6.1 Methods

5.4.2.6.1.1 Model Overview

The effect of the NSDF Project to surface water quality on the receiving and downstream environment was modelled using the GoldSim. GoldSim is a graphical Windows-based simulation software package developed by the GoldSim Technology Group. The GoldSim model was employed as a "graphical spreadsheet" to estimate non-radiological and radiological contaminant concentrations at focal surface water assessment nodes within the Perch Creek Basin catchment based on an instantaneous mixing zone mass balance approach. The model was run using site specific information, and projected flow data and projected wastewater effluent quality and quantity data for select COPCs provided by previous hydrologic studies, recent water quality reports, and the NSDF Project Description.

The following list summarizes the water quantity and quality reference documents used to characterize the surface water quality GoldSim model:

- Water Quantity:
  - Average monthly flow rates and precipitation data from 1969 to 1980 for five Perch Lake inlets (PL1, PL2, PL3, PL4, and PL5) and one outlet flow (PL0; Robertson and Barry 1985);
  - Monthly flow rates based on annual averages for Main Stream Culvert (MSC), South Swamp Weir (SSW), and East Swamp Weir (ESW) (CNL 2016c);
  - Projected leachate and contact wastewater generation rates as a result of normal operation and back-to-back 100-year storm events (AECOM 2019);
  - Perch Creek catchment annual flow rates downstream of Perch Lake Outlet (CNL 2016c); and
  - Average annual Ottawa River flow rates (Table 5.4.1-3).
- Water Quality:
  - Average annual non-radiological water chemistry existing environmental concentrations at surface water model nodes of interest from 2010 to 2018 (CNL 2018e, CNL 2017c, CNL 2019b);
  - Non-radiological and radiological WWTP projected treated effluent concentrations and effluent discharge targets (AECOM 2019);
  - Non-radiological and radiological monitored water chemistry for Perch Lake from a 2018 lake survey (CNL 2018b).

5.4.2.6.1.2 Model Scenarios

The GoldSim model is designed to simulate operating conditions during years 45 to 50 of the NSDF Project when the greatest amount of contact water requires treatment and when the largest volume of treated effluent from the WWTP is expected to be generated. The construction phase from 2021 to 2023 was removed from consideration as a model scenario because of its time-period (as COPCs are not expected to be generated in reasonable quantities during construction to affect receiving and downstream water quality as described in Section 5.4.2.6.2). The ECM will have a final waste capacity of 1,000,000 m^3 and will be comprised of ten cells – each with an average surface area of approximately 12,000 m^2. The model implicitly considers the contact water that is generated over the surface area of the ECM by including the back-to-back 100-year freshet storm event flows with normal operating condition flows. Thus, the normal operating condition is represented as one single annual discharge of 13,320 m^3/yr, which is comprised of:

- two weeks of 22.5 m^3/hr discharge (at 8 hours per day) corresponding to the storm event (i.e. 2,520 m^3/yr); and
- 120 days of 11.25 m^3/hr discharge (at 8 hours per day) corresponding to normal operating conditions spread over mid-March to October (i.e. 10,800 m^3/yr).

The combination of these discharge conditions represents a single bound annual discharge scenario that results in a cumulative discharge volume of 13,320 m^3. This volume is an 18% increase above the annual estimated discharge wastewater volume of 11,230 m^3, which represents the maximum projected wastewater volume generated over the life of the NSDF (AECOM 2018d). The volume generated for the back to back 100-year storm event (i.e., 2,520 m^3) represents 70% of the volume estimated for back to back 100-year storm, based on 1,800 m^3 generated for the Project from a 100-year storm event over a 24-hr period (AECOM 2018d). For the purposes of the assessment, it was assumed that the WWTP would only need to discharge at a higher rate for two weeks to reduce the volume of wastewater to a manageable volume to allow normal operating conditions to resume.

Using the single annual discharge condition as a baseline, the GoldSim model was run using two scenarios as detailed in the following sections.

Scenario 1

- Total annual WWTP discharge of 13,320 m^3/yr
- 50% discharge to East Swamp Wetland via the exfiltration gallery and 50% discharge to Perch Lake

This scenario divides the total annual discharge equally between the exfiltration gallery and Perch Lake (direct pumping to Perch Lake via transfer line). The exfiltration gallery is considered to be the downstream portion of East Swamp (upstream of East Swamp weir) and the outfall location is considered to be at the northeastern shoreline of Perch Lake.

Scenario 2

- Total annual WWTP discharge of 13,320 m^3/yr (same as Scenario 1)
- 100% discharge to Perch Lake

This scenario discharges 100% of the total annual discharge directly into Perch Lake at the deepest location in the lake.

5.4.2.6.1.3 Model Inputs and Assumptions

GoldSim was run for the two scenarios using monthly time steps for 15 years to illustrate concentration trends. The mass balance calculations assumed year-to-year continuous time series of seasonal effluent discharge from mid-March to October, instantaneous and complete mixing, and contaminants were modelled to be fully conservative (no decay and no sorption).

The model considered several nodes upstream of Perch Lake, namely, Main Stream Culvert (MSC), South Swamp Weir (SSW), and East Swamp Weir (ESW), which correspond to the surface water quality monitoring stations as shown on Figure 5.4.1-1. Similarly, downstream nodes relative to Perch Lake include Perch Creek weir (PCW) and Perch Creek Outlet (PCO) where PCO is assumed to be fully mixed at the confluence with the Ottawa River (OR).

The 1985 water balance study provided monthly estimates of inflow and outflow at the Perch Lake inlets and outlets for the model. Model inflow rates for Perch Lake inflows were assumed to be representative of a typical predominately natural watershed with high snowmelt flows occurring in April.

The 1985 water balance study estimated an annual average flow rate at the outlet of Perch Lake of approximately 1,788,000 m^3/yr – a reasonable estimate in comparison to the annual average flow rate at the same outlet of 1,700,000 m^3/yr provided by CNL (CNL 2016c). CNL also provided an estimate of the average annual flow rate at the outlet of Perch Creek of 2,210,000 m^3/yr (CNL 2016c).

Existing environmental water quality conditions for Perch Lake were limited to a baseline survey completed in 2018. Existing water quality conditions in Perch Lake were therefore derived from the flow-weighted sum of average measured parameter concentrations from the inflow monitoring stations to Perch Lake, PL1, PL2, PL3, PL4, and PL5. Relative to the total inflow to Perch Lake, PL1 received a weighting of 15%, PL2 received a weighting of 67%, and PL3 through PL5 combined received a weighting of 18%. The total incoming concentration was used to estimate an initial mass loading (model input) into Perch Lake based on the lake's 900,000 m^3 volume. The 2018 data for Perch Lake provided a basis for comparison of the flow-weighted data.

5.4.2.6.1.4 Model Screening for Constituents of Potential Concern

The COPCs included for further analysis in the GoldSim model represent a collection of key parameters that have undergone an iterative screening process throughout the life of the NSDF Project using best available information from WWTP design and waste characterization documents at the time. The initial list of COPCs for modelling focussed on those that were known to be important to human and aquatic life, and radiological parameters that have been conventionally monitored for decades by CNL. The final list of COPCs represented a total of 40 different non-radiological and radiological parameters.

Non-radiological COPCs were screened in or out based on the following screening factors:

1) Availability of Projected Wastewater Characteristics
2) Treatment Requirement
3) High Existing Environmental Conditions
4) Potential for Nutrient Enrichment Effects on Trophic States
5) Ionic Composition
6) Potential for Effects on Aquatic Life

Organic compounds were not included in the modelling as these compounds are generally only present in trace amounts, with no obvious source in the waste inventory.

Based on the above approach, the following non-radiological parameters screened into the surface water quality assessment:

- major ions – sodium, potassium, calcium, magnesium, fluoride, sulphate, and chloride (including hardness);
- nutrients – nitrate, nitrite, and phosphorus; and
- metals – aluminum, antimony, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, tin, uranium, vanadium, and zinc.

Radiological COPCs were screened based on the following:

1) The predicted treated effluent concentration for a radionuclide was greater than 1% of the No Effect Concentration (NEC) for that radionuclide.
2) Where NEC were not available for a radionuclide, screening was based on human exposure factors consistent with Arcadis and Quintessa (2020) or if it was present in elevated concentrations in surface water within the Perch Creek and Perch Lake Watershed.
3) Radionuclides of public interest or site focus.

The following radiological parameters screened into the surface water quality assessment:

- Carbon-14 – the predicted treated effluent concentration exceeds 1% of the NEC for biota.
- Caesium-137 – although treated effluent concentration is well below 1% of the NEC, it is present in slightly elevated concentrations in surface water within the Perch Creek and Perch Lake Watershed.
- Cobalt-60 – the predicted treated effluent concentration exceeds 1% of the NEC for biota.
- Gross Beta (noting that strontium-90 is the main contributor to the gross beta concentrations) – although the treated effluent concentration for strontium-90 is well below 1% of the NEC, it is present in elevated concentrations in surface water within the Perch Creek and Perch Lake Watershed.
- Tritium – is of public interest. The predicted treated effluent concentration also approaches 1% of the NEC.

5.4.2.6.1.5 Model Inputs for the Treated Effluent Discharge

For the majority of the COPCs in the assessment, the maximum projected wastewater concentration was lower than the effluent discharge target (e.g., antimony). Although in this situation targeted treatment of this COPC would not be required prior to discharge, mass loading inputs to the water quality model for the operational discharge scenarios used the effluent discharge target. This approach applied a high level of conservatism to the modelling assessment.

For a subset of the COPCs (i.e., aluminum, cobalt, iron, manganese, nitrate, nitrite, sulphate and cobalt-60), the maximum projected wastewater concentration was higher than the treated effluent discharge trigger (e.g., aluminum: wastewater concentration = 150 micrograms per litre [μg/L]; treated effluent discharge trigger = 50 μg/L). This means that treatment of the COPCs is required prior to discharge being acceptable. For these COPCs, the mass loading input to the water quality model for the operational discharge scenarios used the treated effluent discharge target concentration and assumes that the treated effluent discharge will consistently meet the effluent discharge target. This approach applied a lower level of conservatism to the modelling assessment for these COPCs.

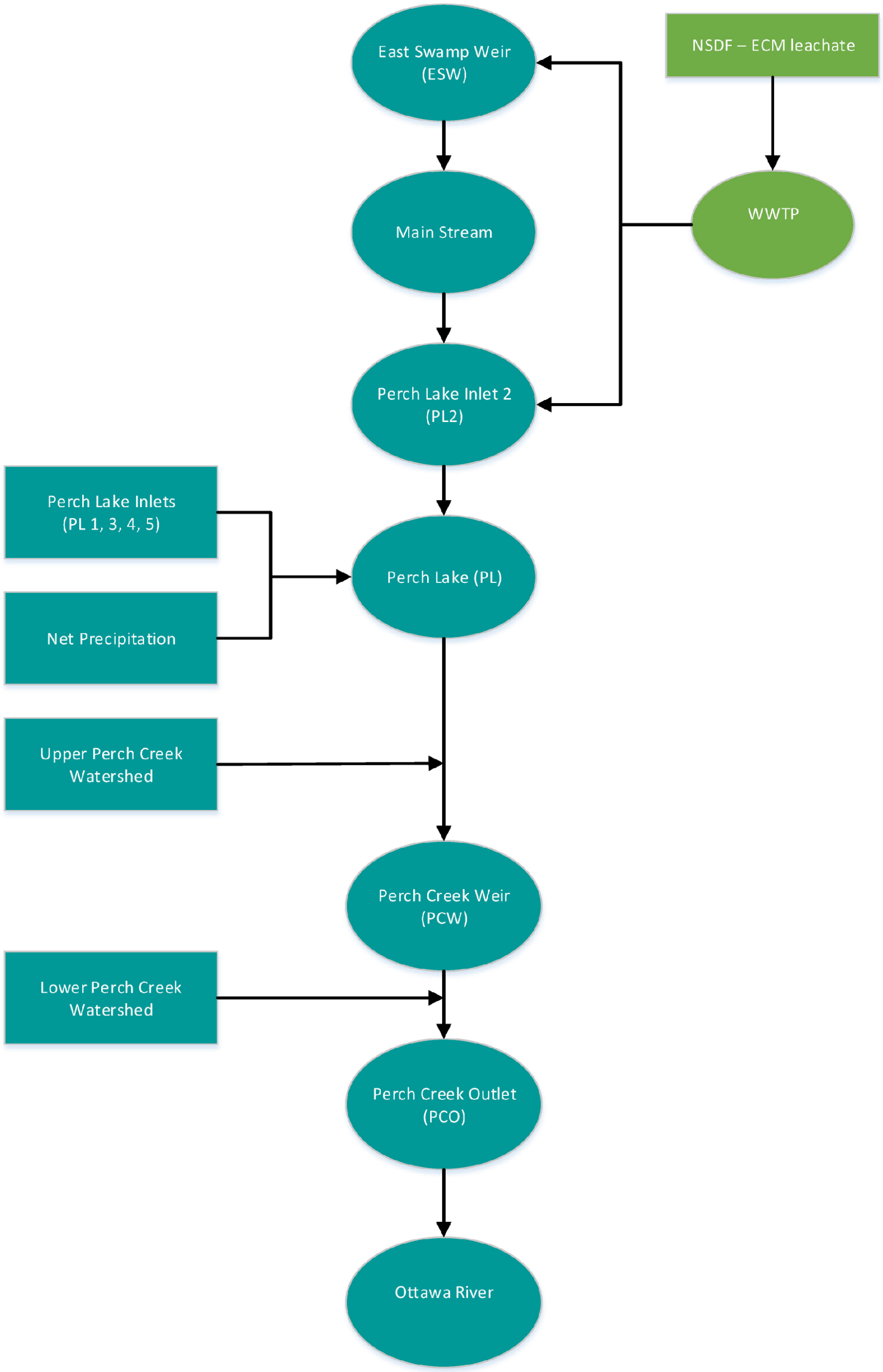
In a few instances (e.g., ammonia, phosphorus, uranium), the maximum projected wastewater concentration was not available. In these cases, the treated effluent discharge target was assigned to the treatment specifications. For these COPCs, the mass loading input for each modelling scenario used the treated effluent discharge target. For phosphorus, despite the maximum projected wastewater concentration not being available, there is confidence in the ability of the WWTP to meet the treated effluent discharge target. The WWTP treatment process for phosphorus is chemical precipitation by ferric chloride. If higher than normal phosphorus concentrations are measured in the wastewater feed to the WWTP treatment process, the ferric chloride precipitation process can be optimized for enhance phosphorus removal. If phosphorus concentrations in water in the Final Effluent Tank prior to discharge exceeds the effluent discharge target, this water will be returned to the beginning of the treatment process for further treatment.

5.4.2.6.1.6 Model Output

The assessment nodes at which water quality concentrations were estimated are listed as follows and as illustrated in the annual average water balance on Figure 5.4.2-1:

1) ESW: East Swamp Weir;
2) PL2: Perch Lake Inlet #2;
3) PL: Perch Lake;
4) PCW: Perch Creek Weir;
5) PCO: Perch Creek Outlet; and
6) OR: Ottawa River.

The Ottawa River assessment node is located 8 km downstream of the CRL Built-up Area, where it is assumed that any discharge from the Perch Creek and Perch Lake Watershed has been completely mixed.



REFERENCE(S)
1. REGIONAL TOPOGRAPHY SOURCE CNL 2019

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
CONCEPTUAL FLOW DIAGRAM OF WWTP EFFLUENT DISCHARGE AND PERCH LAKE BASIN SURFACE WATER FLOWS

CONSULTANT: GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.4.2-1

25mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

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Model results for the COPCs are presented by node and model scenario. All modelled concentrations are inclusive of the existing baseline concentrations (at nodes where existing baseline information was available). Where existing baseline data were not available, the modelled results were limited to providing only an indication of incremental increase to that parameter concentration at the assessment node. The modelled results for the screened COPCs at each assessment node in the Perch Creek and Perch Lake Watershed downstream of the NSDF Project are presented as the average, 95th percentile, and maximum concentrations as these statistical values are used to further classify the COPCs for monitoring requirements and to determine the likelihood of environmental (e.g., aquatic) effects. These summary statistics were generated from the modelled monthly concentrations over the 15-year run time during operating conditions associated with years 45 to 50 of the NSDF Project. This specific operations focus in the modelling is associated with the highest amount of contact water that requires treatment and when the largest volume of treated effluent from the WWTP is expected to be generated for discharge. All resultant modelled concentrations for each COPC were evaluated against the respective effluent discharge target (if available) and their risk benchmark or no effects concentration.

5.4.2.6.2 Application Case Results

This section provides a summary of the modelling results for a select group of COPCs based on discernible trends in the results. The more detailed GoldSim surface water quality modelling results for each of the screened non-radiological and radiological COPCs are presented in detail the Surface Water Quality Technical Supporting Document (Golder 2019b).

- Overall, the water quality modelling results indicated the following water quality projections for the Perch Creek and Perch Lake Watershed and the Ottawa River:
- Incremental changes to water quality during discharges under both discharge scenarios resulting from the operation of the NSDF Project are not expected to result in adverse effects throughout the Perch Creek and Perch Lake Watershed.
- In Scenario 1 where 50% of the discharge is directed to East Swamp Wetland (ESW) via the exfiltration gallery and 50% is directed to Perch Lake (PL), a distinct reducing COPC concentration gradient is evident between ESW and PL, which decreases further to Perch Creek Outlet (PCO).
- In Scenario 2 where 100% of the discharge is directed to Perch Lake, COPC concentrations at East Swamp Wetland (ESW) and Perch Lake Inlet 2 (PL2) remain at ambient concentrations while concentrations at PL increase relative to ambient concentrations. After Perch Lake (PL), a decreasing concentration gradient towards Perch Creek Outlet (PCO) is evident.
- Projected changes to Ottawa River (OR) quality as a result of the NSDF Project during operations are negligible. For most COPCs, incremental changes in concentration as a result of the NSDF Project are not expected to be measurable in the Ottawa River, recognizing that the annual average Perch Creek flow rate (2.3 million m^3/yr) represents less than 0.01% of annual average Ottawa River flow rate (approximately 25,000 million m^3/yr). The Ottawa River is expected to adequately rapidly assimilate the discharge from the Perch Creek and Perch Lake Watershed under all scenarios, such that aquatic life and drinking water sources are unlikely to be affected as a result of the Project discharges. Therefore, the Ottawa River water quality is expected to remain at its existing baseline conditions through the entire NSDF Project operations lifespan.

Under both operations scenarios, the modelling results indicated four clear trends in modelled COPC concentrations at the assessment nodes in the Perch Creek and Perch Lake Watershed:

- The discharge of treated effluent under both scenarios resulted in a negligible change to COPC concentrations at ESW, PL2, and PL (i.e., within 10% of baseline conditions). This was observed for the following COPCs: barium, cadmium (Table 5.4.2-8), iron, lead, and silver (Table 5.4.2-9). For these COPCs, the existing baseline concentrations at each assessment node were higher than the treated effluent discharge target.

Table 5.4.2-8: Water Quality Modeling Results for Cadmium

Cadmium	Units	ESW	PL2	PL[(a)]	PCW	PCO	OR
Criteria	µg/L	EDT: 0.09[(b)]; RB: 1.0					
Existing Baseline Concentration	µg/L	0.052	0.058	0.049	0.013	0.013[(c)]	0.026
Scenario 1 - 50% to Exfiltration Gallery, 50% Direct Discharge to Perch Lake							
Mean	µg/L	0.056	0.062	0.040	0.031	0.028	0.026
95th Percentile	µg/L	0.065	0.062	0.043	0.039	0.038	0.026
Maximum	µg/L	0.065	0.062	0.043	0.039	0.038	0.026
Scenario 2 - 100% Direct Discharge to Perch Lake							
Mean	µg/L	0.052	0.062	0.040	0.031	0.028	0.026
95th Percentile	µg/L	0.052	0.062	0.043	0.039	0.038	0.026
Maximum	µg/L	0.052	0.062	0.043	0.039	0.038	0.026

(a) Perch Lake existing baseline concentration based on a flow-weighted calculation using all available upstream data sources. Existing baseline cadmium concentrations in Perch Lake only available in 2018 (average = 0.004 µg/L). The flow-weighted average data for PL used in the modelling assessment over the lake-specific measured data for conservatism.

(b) The effluent discharge target for cadmium is hardness dependent as per CCME (1999) guidelines.

(c) PCO existing baseline concentrations were assigned PCW existing baseline concentrations since the PCO location is just downstream of the PCW location.

ESW = East Swamp weir; PL2 = Perch Lake Inlet #2; PL = Perch Lake; PCW = Perch Creek weir; PCO = Perch Creek outlet; OR = Ottawa River; µg/L = micrograms per litre; EDT = treated effluent discharge target; RB = risk benchmark.

Table 5.4.2-9: Water Quality Modeling Results for Silver

Silver	Units	ESW	PL2	PL[(a)]	PCW	PCO	OR[(b)]
Criteria	µg/L	EDT: 0.1; RB: 4.1					
Existing Baseline Concentration	µg/L	1.000	1.000	1.000	1.000	1.000[(c)]	No data
Scenario 1 - 50% to Exfiltration Gallery, 50% Direct Discharge to Perch Lake							
Mean	µg/L	0.890	1.040	0.740	0.573	0.516	NCB
95th Percentile	µg/L	1.000	1.047	0.798	0.728	0.699	NCB
Maximum	µg/L	1.000	1.047	0.798	0.728	0.700	NCB
Scenario 2 - 100% Direct Discharge to Perch Lake							
Mean	µg/L	1.000	1.047	0.740	0.573	0.516	NCB
95th Percentile	µg/L	1.000	1.047	0.798	0.728	0.699	NCB
Maximum	µg/L	1.000	1.047	0.798	0.728	0.700	NCB

Note: Shading = concentration higher than the treated effluent discharge target.

(a) Perch Lake existing baseline concentration based on a flow-weighted calculation using all available upstream data sources. Existing baseline silver concentration specifically in Perch Lake only available in 2018 (average = 1.000 µg/L), which was consistent with the flow-weighted calculation.

(b) All OR results are based on an assumed zero existing baseline concentration due to absent measured existing baseline concentration data.

(c) PCO existing baseline concentrations were assigned PCW existing baseline concentrations since the PCO location is just downstream of the PCW location.

A modelled result showing '**NCB'** indicates that an incremental increase in silver is expected not to be measurable, so the projection is no change from existing baseline concentrations.

ESW = East Swamp weir; PL2 = Perch Lake Inlet #2; PL = Perch Lake; PCW = Perch Creek weir; PCO = Perch Creek outlet; OR = Ottawa River; µg/L = micrograms per litre; EDT = treated effluent discharge target; RB = risk benchmark.

The discharge of treated effluent under Scenario 1 resulted in an incremental increase in COPC concentration at ESW and PL2 whereas the discharge of treated effluent under Scenario 2 resulted in no incremental change in COPC concentration at ESW and PL2. This was observed for ammonia, antimony, boron, calcium, chloride, cobalt (Table 5.4.2-10), fluoride, magnesium, manganese, mercury, molybdenum, nickel, nitrate, nitrite, phosphorus, potassium, selenium, sodium, strontium (Table 5.4.2-11), sulphate, thallium, tin, uranium, vanadium, zinc, carbon-14, caesium-137 (Table 5.4.2-12), cobalt-60, and tritium. The higher projected COPC concentrations at ESW and PL2 in the combined discharge scenario (Scenario 1) compared to the direct discharge to Perch Lake (Scenario 2) suggest that the assimilation of treated effluent for these COPCs through the exfiltration gallery is not as pronounced as it is via direct discharge to Perch Lake. With the exception of the modelled COPC concentrations at ESW and PL2 during operations for the combined discharge, all other modelled concentrations were similar to existing baseline concentrations at the Perch Creek assessment nodes.

Table 5.4.2-10: Water Quality Modeling Results for Cobalt

Cobalt	Units	ESW	PL2	PL[(a)]	PCW	PCO	OR[(b)]
Criteria	µg/L	EDT: 0.9; RB: 1,500					
Existing Baseline Concentration	µg/L	0.450	0.330	0.351	0.240	0.240[(c)]	No data
Scenario 1 - 50% to Exfiltration Gallery, 50% Direct Discharge to Perch Lake							
Mean	µg/L	0.505	0.356	0.278	0.215	0.194	NCB
95th Percentile	µg/L	0.609	0.366	0.299	0.274	0.263	NCB
Maximum	µg/L	0.611	0.366	0.299	0.274	0.264	NCB
Scenario 2 - 100% Direct Discharge to Perch Lake							
Mean	µg/L	0.450	0.351	0.278	0.215	0.194	NCB
95th Percentile	µg/L	0.450	0.351	0.299	0.274	0.263	NCB
Maximum	µg/L	0.450	0.351	0.299	0.274	0.264	NCB

(a) Perch Lake existing baseline concentration based on a flow-weighted calculation using all available upstream data sources. Existing baseline cobalt concentration data for Perch Lake only available in 2018 (average = 0.1 µg/L). The flow-weighted average data for PL used in the modelling assessment over the lake-specific measured data for conservatism.

(b) All OR results are based on an assumed zero existing baseline concentration due to absent measured existing baseline concentration data.

(c) PCO existing baseline concentrations were assigned PCW existing baseline concentrations since the PCO location is just downstream of the PCW location.

A modelled result showing '**NCB**' indicates that an incremental increase in cobalt is expected not to be measurable, so the projection is no change from existing baseline concentrations. ESW = East Swamp weir; PL2 = Perch Lake Inlet #2; PL = Perch Lake; PCW = Perch Creek weir; PCO = Perch Creek outlet; OR = Ottawa River; µg/L = micrograms per litre; EDT = treated effluent discharge target; RB = risk benchmark.

Table 5.4.2-11: Water Quality Modeling Results for Strontium

Strontium	Units	ESW	PL2	PL[(a)]	PCW	PCO	OR
Criteria	µg/L	EDT: 1,500[(b)]; RB: 15,000					
Existing Baseline Concentration	µg/L	39.5	44.5	45.0	43.4	43.4[(c)]	28.3
Scenario 1 - 50% to Exfiltration Gallery, 50% Direct Discharge to Perch Lake							
Mean	µg/L	218.0	73.2	53.4	41.3	37.2	28.3
95th Percentile	µg/L	555.9	99.7	57.4	53.1	51.0	28.3
Maximum	µg/L	563.6	100.5	57.4	53.1	51.0	28.3
Scenario 2 - 100% Direct Discharge to Perch Lake							
Mean	µg/L	39.5	61.6	53.4	41.3	37.2	28.3
95th Percentile	µg/L	39.5	61.6	57.4	53.1	51.0	28.3
Maximum	µg/L	39.5	61.6	57.4	53.1	51.0	28.3

(a) Perch Lake existing baseline concentration based on a flow-weighted calculation using all available upstream data sources. Existing baseline strontium concentration specifically in Perch Lake only available in 2018 (average = 41.0 µg/L). The flow-weighted average data for PL used in the modelling assessment over the lake-specific measured data for conservatism.

(b) No effluent discharge target is specified for Strontium. A COPC screening limit of 1,500 µg/L is reported from *Environmental Risk Assessment of Chalk River Laboratories* (CNL 2019b).

(c) PCO existing baseline concentrations were assigned PCW existing baseline concentrations since the PCO location is just downstream of the PCW location.

ESW = East Swamp weir; PL2 = Perch Lake Inlet #2; PL = Perch Lake; PCW = Perch Creek weir; PCO = Perch Creek outlet; OR = Ottawa River; µg/L = micrograms per litre; EDT = treated effluent discharge target; RB = risk benchmark.

Table 5.4.2-12: Water Quality Modeling Results for Caesium 137

Caesium-137	Units	ESW	PL2	PL[(a)]	PCW	PCO	OR
Criteria	Bq/L	EDT: 10; NEC: 73					
Existing Baseline Concentration	Bq/L	0.152	0.010	0.010	0.007	0.007[(b)]	0.005
Scenario 1 - 50% to Exfiltration Gallery, 50% Direct Discharge to Perch Lake							
Mean	Bq/L	1.356	0.099	0.086	0.067	0.060	0.005
95th Percentile	Bq/L	3.634	0.282	0.106	0.089	0.086	0.005
Maximum	Bq/L	3.686	0.288	0.106	0.089	0.086	0.005
Scenario 2 - 100% Direct Discharge to Perch Lake							
Mean	Bq/L	0.152	0.018	0.086	0.067	0.060	0.005
95th Percentile	Bq/L	0.152	0.018	0.106	0.089	0.086	0.005
Maximum	Bq/L	0.152	0.018	0.106	0.089	0.086	0.005

(a) Perch Lake existing baseline concentration based on a flow-weighted calculation using all available upstream data sources. Existing baseline caesium-137 concentration specifically in Perch Lake only available in 2018 (average = 0.028 Bq/L). The flow-weighted average data for PL used in the modelling assessment over the lake-specific measured data.

(b) PCO existing baseline concentrations were assigned PCW existing baseline concentrations since the PCO location is just downstream of the PCW location.

ESW = East Swamp weir; PL2 = Perch Lake Inlet #2; PL = Perch Lake; PCW = Perch Creek weir; PCO = Perch Creek outlet; OR = Ottawa River; Bq/L = Becquerels per litre; EDT = treated effluent discharge target; NEC = no effects concentration.

- Modelled COPC concentrations showed a notable incremental increase at PL2 for both discharge scenarios during the operation of the NSDF Project, but not at ESW. The COPCs included chloride (Table 5.4.2-13), nitrate, selenium, strontium, and gross beta (Table 5.4.2-14). The source of this elevated concentration at PL2 is attributed to high existing baseline concentrations at MSC measured in 2018, which was incorporated into the flow weighted existing baseline concentration calculations for PL2. These elevated concentrations then attenuated with progression through Perch Lake to PCO.

Table 5.4.2-13: Water Quality Modeling Results for Chloride

Chloride	Units	ESW	PL2	PL[(a)]	PCW	PCO	OR[(b)]
Criteria	mg/L	EDT: 120; RB: 640					
Existing Baseline Concentration	mg/L	15.7	54.0	40.7	19.9	19.9[(c)]	No data
Scenario 1 - 50% to Exfiltration Gallery, 50% Direct Discharge to Perch Lake							
Mean	mg/L	28.5	107.5	62.9	48.6	43.7	NCB
95^{th} Percentile	mg/L	52.6	107.7	67.9	61.3	58.9	NCB
Maximum	mg/L	53.1	107.7	67.9	61.4	59.0	NCB
Scenario 2 - 100% Direct Discharge to Perch Lake							
Mean	mg/L	15.7	107.4	62.9	48.6	43.7	NCB
95^{th} Percentile	mg/L	15.7	107.4	67.9	61.3	58.9	NCB
Maximum	mg/L	15.7	107.4	67.9	61.4	59.0	NCB

(a) Perch Lake existing baseline concentration based on a flow-weighted calculation using all available upstream data sources. Existing baseline chloride concentration specifically in Perch Lake only available in 2018 (average = 26.2 mg/L). The flow-weighted average data for PL used in the modelling assessment over the lake-specific measured data for conservatism.

(b) All OR results are based on an assumed zero existing baseline concentration due to absent measured existing baseline concentration data.

(c) PCO existing baseline concentrations were assigned PCW existing baseline concentrations since the PCO location is just downstream of the PCW location.

A modelled result showing 'NCB' indicates that an incremental increase in chloride is expected not to be measurable, so the projection is no change from existing baseline concentrations.

ESW = East Swamp weir; PL2 = Perch Lake Inlet #2; PL = Perch Lake; PCW = Perch Creek weir; PCO = Perch Creek outlet; OR = Ottawa River; milligrams per litre; EDT = treated effluent discharge target; RB = risk benchmark.

Table 5.4.2-14: Water Quality Modeling Results for Gross Beta

Gross Beta	Units	ESW	PL2	PL[(a)]	PCW	PCO	ORC
Criteria	Bq/L	**EDT: 5**; NEC: 183					
Measured Background Concentration	Bq/L	293	17	11	9	9[(b)]	0.041
Scenario 1 - Nine Closed Cells, One Active Cell, 50% to Exfiltration Gallery, 50% Direct Discharge to Perch Lake							
Mean	Bq/L	258	37	28	22	20	0.043
95^{th} Percentile	Bq/L	293	37	30	28	26	0.046
Maximum	Bq/L	293	37	30	28	26	0.046
Scenario 2 - Nine Closed Cells, One Active Cell, 100% Direct Discharge to Perch Lake							
Mean	Bq/L	293	37	28	22	20	0.043
95^{th} Percentile	Bq/L	293	37	30	28	26	0.046
Maximum	Bq/L	293	37	30	28	26	0.046

Note: Shading = exceedance of effluent discharge target.

(a) Perch Lake existing baseline concentration as-modelled is based on a flow-weighted calculation using all available upstream data sources. Existing baseline Gross Beta concentration specifically in Perch Lake only available in 2018 (average = 14 Bq/L). The flow weighted average data for PL used in the modelling assessment over the lake specific measured data.

(b) PCO existing baseline concentrations were assigned PCW existing baseline concentrations since the PCO location is just downstream of the PCW location.

Bq/L = Becquerels per litre; EDT = treated effluent discharge target; NEC = no effects concentration.

- Modelled COPC concentrations measured above their respective risk benchmarks or no effect concentrations. With the exception of COPCs that had baseline concentrations above their treated effluent discharge targets and risk benchmarks (e.g., iron, barium, lead, phosphorus, silver, and gross beta – above effluent discharge targets; aluminum and copper – above risk benchmarks), some COPCs were predicted to be above their treated effluent discharge targets at intermittent cases. These included sulphate (Table 5.4.2-15) and nitrite at ESW (at the 95^{th} and maximum concentrations under scenario 1, and selenium at PL2 (under both scenarios for average, 95^{th} and maximum concentrations). Manganese was measured above the treated effluent discharge target under existing baseline conditions at PCW and PCO.

Table 5.4.2-15: Water Quality Modeling Results for Sulphate

Sulfate	Units	ESW	PL2	PL[(a)]	PCW	PCO	OR[(b)]
Criteria	mg/L	EDT: 128; RB: No data					
Existing Baseline Concentration	mg/L	1.99	1.41	1.25	2.79	2.79[(c)]	No data
Scenario 1 - 50% to Exfiltration Gallery, 50% Direct Discharge to Perch Lake							
Mean	mg/L	79.22	6.60	5.69	4.41	3.97	0.000
95th Percentile	mg/L	225.45	18.23	6.93	5.88	5.65	0.001
Maximum	mg/L	228.79	18.61	6.94	5.89	5.65	0.001
Scenario 2 - 100% Direct Discharge to Perch Lake							
Mean	mg/L	1.99	1.50	5.69	4.41	3.97	0.000
95th Percentile	mg/L	1.99	1.50	6.93	5.88	5.65	0.001
Maximum	mg/L	1.99	1.50	6.94	5.89	5.65	0.001

Note: Shading = concentrations higher than treated effluent discharge target.

(a) Perch Lake existing baseline concentration based on a flow-weighted calculation using all available upstream data sources. Existing baseline sulfate concentration specifically in Perch Lake only available in 2018 (average = 2.33 mg/L). The flow-weighted average data for PL used in the modelling assessment over the lake-specific measured data.

(b) All OR results are based on an assumed zero existing baseline concentration due to absent measured existing baseline concentration data.

(c) PCO existing baseline concentrations were assigned PCW existing baseline concentrations since the PCO location is just downstream of the PCW location.

ESW = East Swamp weir; PL2 = Perch Lake Inlet #2; PL = Perch Lake; PCW = Perch Creek weir; PCO = Perch Creek outlet; OR = Ottawa River; mg/L = milligrams per litre; EDT = treated effluent discharge target; RB = risk benchmark.

5.4.2.7 Prediction Confidence and Uncertainty

Predicted residual effects are not expected to be underestimated due to following factors that have contributed to conservatism in the modelling projections:

- For the majority of the COPCs in the assessment, the maximum projected wastewater concentration was lower than the effluent discharge target.
  - For a subset of the COPCs (i.e., aluminum, cobalt, iron, manganese, nitrate, nitrite, sulphate, and cobalt-60), the maximum projected wastewater concentration was higher than the treated effluent discharge trigger (e.g., aluminum: wastewater concentration = 150 μg/L; treated effluent discharge trigger = 50 μg/L).
  - In a few COPC instances (e.g., ammonia, uranium), the maximum projected wastewater concentration was not available. In these cases, the treated effluent discharge target was assigned to the modelling assessment.
  - For one COPC (e.g., phosphorus), the maximum projected wastewater concentration was not available; however, based on the treatability of phosphorus in wastewater a treated effluent discharge target was assigned to the discharge that is expected to be achievable.
- In each discharge scenario, the water quality model was run without decay or sorption mechanisms, whereas in actuality concentrations may be subject to chemical, physical, radioactive decay, and biological processes that can remove them from the mass balance as they progress downstream.
- Background concentrations obtained from previous reports were typically presented as averages from 2010 to 2018, which include data measured below detection. For data measured below detection, the detection level was used in the averaging calculation; the true existing baseline concentrations may not have been as high as used. Nonetheless, these as-stated averages used in the model are considered a conservative estimate of the existing baseline concentrations.

Further discussion on the prediction confidence and uncertainty in the assessment is presented in the technical support document appended to this section.

5.4.2.8 Monitoring and Follow-up

Routine surface water quality monitoring will be integrated into CNL's Environmental Monitoring Program, which will be continued for the NSDF Project. The effluent water quality monitoring will be integrated into the CRL Effluent Verification Monitoring Program.

As part of the Environmental Monitoring Program, surface water monitoring in the receiving environment at the assessment nodes and effluent quality monitoring at the WWTP discharge point for radiological and non-radiological parameters will continue through the operations phase (Table 5.4.2-16) and be undertaken through closure, and post closure. The Environmental Monitoring and Effluent Verification Monitoring will be used the verify the surface water management ponds are performing as designed, mitigation associated with operation of the NSDF Project is effective, effluent discharge targets developed for the NSDF Project are achievable and sustainable at the WWTP, and that water quality in the Perch Creek and Perch Lake Watershed remains within predicted concentrations.

Table 5.4.2-16: Monitoring and Follow up Programs for Surface Water Quality

Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Surface Water Quality	■ Discharge of treated effluent from the WWTP to the exfiltration gallery and/or Perch Lake can cause changes to downstream surface water quality ■ Leakage of leachate from the ECM during the post-closure phase (i.e., after Year 2400) from liner and final cover degradation as a result of normal evolution can cause changes to downstream surface water quality.	Environmental monitoring – Verify environmental assessment predictions related to surface water quality	Monitor the quality of surface water surrounding the ECM footprint area to evaluate whether the quality of the water is affected by the ECM or by operation of surface water management pond(s)	Water quality monitoring will continue through operations, closure and post-closure (institutional control). The number of parameters and locations may change based annual review of monitoring data	Surface water monitoring in the receiving environment is integrated into the CNL Environmental Monitoring Program
		■ Operational monitoring – Verify the surface water management pond is performing as designed. ■ Demonstrate compliance with effluent discharge targets developed for the NSDF Project	■ Each pond weir outlet water quality will be sampled to identify if any contact surface water or leachate contamination of the non contact surface water is entering the surface water management ponds and to confirm total suspended solid concentrations. ■ WWTP effluent verification monitoring consistent with CSA Standard N288.5-11 (CSA Group 2011).	■ Routine visual inspections and surface water sampling during operations, closure and post-closure (institutional control) as required ■ Effluent monitoring will continue throughout operation of the WWTP	Effluent water quality monitoring will be integrated into the CRL Radioactive Effluent Verification Monitoring Program

WWTP = Wastewater Treatment Plant; CSA = Canadian Standards Association.

5.4.2.9 Conclusions

Valued components refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous peoples, the scientific community or the public (The Agency 2018). Surface water quality is recognized as an important component of the environment that may be affected by the NSDF Project and changes to surface water quality could, in turn, lead to effects on other VCs selected for assessment. Acknowledging that changes to surface water quality are important aspects of the natural and human environment, surface water quality is referred to as an intermediate component. Results of the analysis of changes in measurement indicators for surface water quality are provided to other disciplines for inclusion in their assessment (Table 5.4.2-3).

The potential for residual effects to surface water quality from the operation and closure of the NSDF Project is primarily associated the operation of the WWTP and treated and untreated effluent discharge to the Perch Creek and Perch Lake Watershed during the operations, and runoff from the ECM during post-closure phases (Table 5.4.2-20). During operations and closure, treated effluent is discharged to the Perch Creek and Perch Lake Watershed via two discharge scenarios:

- to the East Swamp Wetland through an exfiltration gallery; and
- directly to Perch Lake via direct discharge to a submerged diffuser in the deepest part of the lake.

The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses best demonstrated available technology that is economically achievable and capable of meeting regulatory requirements. In addition, effluent discharge targets for wastewater discharges are protective of the environment and human health. Discharge targets for non-radiological contaminants are sourced from federal and provincial guidelines for protection of aquatic biota. Discharge targets for radionuclides are the Canadian Drinking Water Guidelines, except for tritium for which a site-specific target has been developed (Section 3.4.2.5.1). Treated effluent will be sampled and confirmed that it meets treatment targets before release to the environment.

The GoldSim surface water quality mass balance model assessment resulted in the following key projections for operational discharge to the Perch Creek and Perch Lake Watershed:

- Incremental changes to water quality during discharges under both discharge scenarios resulting from the operation of the NSDF Project are not expected to result in adverse effects throughout the Perch Creek and Perch Lake Watershed.
- The Ottawa River is expected to rapidly assimilate all discharge from the Perch Creek and Perch Lake Watershed under both discharge scenarios. COPCs from the discharge are expected not to be measurable beyond existing baseline conditions in Ottawa River after the Perch Creek confluence. Aquatic life and drinking water sources are unlikely to be affected.
- Aluminum, copper and gross beta are predicted to exceed risk benchmarks or no effects concentrations for the operations phase. However, modelled exceedances of aluminum and copper are due to baseline concentrations at the East Swamp Weir, Perch Lake, Perch Creek Weir, Perch Creek Outlet, and in the Ottawa River, which were measured above risk benchmarks in baseline conditions. Modelled concentrations of gross beta (as Strontium 90) above no effects concentrations are limited to East Swamp Weir, which is due to elevated baseline concentrations above No Effects Concentrations.

- There were no incremental changes to barium, cadmium, iron, lead, and silver concentrations resulting from the operation of the NSDF Project throughout the Perch Creek and Perch Lake Watershed during discharges under both discharge scenarios.
- Baseline and modelled aluminium, barium, copper, iron, lead, silver, and gross beta (as Strontium-90) were present in concentrations above the treated effluent discharge target and/or the risk benchmark/no effects concentration (i.e., aluminium, copper), and will remain so during the operation of the NSDF Project.
- Incremental changes were projected under Scenario 1 (50% discharge via the exfiltration gallery and 50% direct discharge to Perch Lake) in East Swamp Weir (ESW) and Perch Lake Inlet #2 (PL2) to varying levels for most of the COPCs, with no change at these locations in Scenario 2 (direct discharge to Perch Lake). These COPCs include ammonia, antimony, boron, calcium, chloride, cobalt, fluoride, magnesium, manganese, mercury, molybdenum, nickel, nitrate, nitrite, phosphorus, potassium, selenium, sodium, strontium, sulphate, thallium, tin, uranium, vanadium, zinc, carbon-14, caesium-137, cobalt-60, and tritium. However, most of the COPC concentrations in Scenario 1 remained below treated effluent discharge targets and risk benchmarks/no effects concentrations. Any incremental COPC changes under Scenario 1 attenuated downstream of Perch Lake to the Ottawa River, with the incremental changes to the COPCs for Scenario 2 generally consistent with those for Scenario 1.
- Projected chloride, nitrate, selenium, strontium, and gross beta concentrations at Perch Lake Inlet 2 (PL2) under both scenarios indicated a non-Project related elevation in concentration at this location. This elevation was attributed to a high existing baseline concentration at MSC, which was incorporated into the flow-weighted concentration calculations for PL2. These COPCs remained below treated effluent discharge targets and risk benchmarks and no effect concentrations, except for selenium, which was above the treated effluent discharge target at PL2 for both discharge scenarios.

During the post-closure phase (i.e., after the end of the 300-year institutional control period in Year 2400), leakage of leachate from the ECM from liner and final cover degradation as a result of normal evolution can cause changes to downstream surface water quality. The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound and minimize leachate generation. The assessment of surface water quality in the post closure phase is summarized in Section 5.7.6.1.2.2 of the EIS and detailed in the *Post-Closure Safety Assessment* (PostSA; Arcadis and Quintessa 2020).

Surface water monitoring in the receiving environment is integrated into the CNL Environmental Monitoring Program. The effluent water quality monitoring will be integrated into the CRL Effluent Verification Monitoring Program.

Table 5.4.2-17: Summary of Predicted Residual Adverse Effects for Surface Water Quality Valued Component

Valued Components	Residual Adverse Effects	Project Effect Occurs in	Contributing Project Activity	Proposed Mitigation

Surface Water Quality	Adverse changes to downstream surface water quality from the discharge of treated effluent from the WWTP to the exfiltration gallery and/or Perch Lake	Operations and Closure	Discharge of treated effluent to the Perch Creek and Perch Lake Watershed	▪ The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses best available technology that is economically achievable and capable of meeting regulatory requirements
				▪ Effluent discharge targets for wastewater discharges are protective of the environment and human health
				  ▪ Discharge targets for non-radiological contaminants are sourced from federal and provincial guidelines for protection of aquatic biota
				  ▪ Discharge targets for radionuclides are the Canadian Drinking Water Guidelines with the exception of tritium for which a site-specific target is developed (Section 3.4.2.5.1)
				▪ Treated effluent will be sampled to confirm it meets treatment targets before release to the environment
				▪ When applied, the proposed exfiltration gallery will promote the exfiltration of treated water into the local groundwater regime where further retention of radioactivity by the geosphere is anticipated
				▪ The Perch Lake diffuser design provides additional dilution of treated effluent at the point of release
				▪ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water quality
				▪ Appropriate procedures will be in place to effectively identify spill occurrences in the event treated effluent is released to areas other than directly to the exfiltration gallery or to Perch Lake and initiate appropriate emergency responses

Table 5.4.2-17: Summary of Predicted Residual Adverse Effects for Surface Water Quality Valued Component

Valued Components	Residual Adverse Effects	Project Effect Occurs in	Contributing Project Activity	Proposed Mitigation
Surface Water Quality	Leakage of leachate from the ECM after the 300-year post-closure phase (i.e., after Year 2400) from liner and final cover degradation as a result of normal evolution can cause changes to downstream surface water quality	Post-closure	Liner and final cover degradation as a result of normal evolution	■ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound and minimize leachate generation ■ The final cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity ■ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the final cover and underlying waste materials, destabilization of the ECM structure and damage to access roads ■ The ECM final grading and drainage plan also includes collection ditches along the top of the ECM berm road to collect side slope drainage ■ The design life for the ECM is 550 years to meet the required time period to allow for radioactive decay of the waste placed in the facility (i.e., until it has decayed to levels that do not present a risk to the public and environment) ■ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water and groundwater quality

CRL = Chalk River Laboratories; ECM = engineered containment mound; NSDF = Near Surface Disposal Facility; LLW = low-level waste

5.5 Aquatic Environment

This section of the Environmental Impact Statement (EIS) for the Canadian Nuclear Laboratories (CNL) Near Surface Disposal (NSDF) Project seeks to understand and characterize potential residual effects of the NSDF Project on aquatic biodiversity at the Chalk River Laboratories (CRL) site. Effects of the NSDF Project are considered in the context of cumulative effects from other previous, existing and reasonably foreseeable developments on the aquatic environment.

5.5.1 Scope of the Assessment

This section focuses on aquatic biodiversity, which includes fish and fish habitat. The aquatic biodiversity assessment follows the overall environmental assessment approach and methods described in Section 5.1 Environmental Assessment Approach. The assessment was completed following the key steps listed below.

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries and assessment cases for the aquatic biodiversity assessment** (refer to Sections 5.5.2 Valued Components and Section 5.5.3 Assessment Boundaries). The VCs and measurement indicators used to assess Project-related changes to the aquatic biodiversity are described, along with the spatial and temporal boundaries at which the assessment occurred and the assessment cases considered.
- **Step 2 – Describe the existing conditions** (refer to Section 5.5.4 Description of the Environment). Existing conditions in the local and regional areas are described, including the combined effects of previous and existing developments (Base Case). The existing environment represents the historical and current environmental pressures that have shaped the observed patterns in the environment (i.e., natural variation). The existing conditions provide a reference to which the effects of the NSDF Project can be compared.
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 5.5.5 Project Interactions and Mitigation). Project components and/or activities with the potential to affect aquatic biodiversity are identified, and mitigation developed to limit or avoid effects is presented. A pathways analysis is then used to focus further assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects to aquatic biodiversity. Where effects are adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways were not identified for aquatic biodiversity; therefore, no residual effects are carried forward for further analysis and characterization.
- **Step 4 – Present the methods and results of the residual effects analysis**. This step was not required as no primary pathways were identified in the aquatic environment assessment.
- **Step 5 – Describe the level of certainty and management of uncertainty.** This step was not required as no primary pathways were identified in the aquatic environment assessment.
- **Step 6 – Classify and determine the significance of the predicted residual effects**. This step was not required as no primary pathways were identified in the aquatic environment assessment.
- **Step 7 – Identify monitoring and follow-up** required to confirm effects predictions and address uncertainty (refer to Section 5.5.6 Monitoring and Follow-up).
- **Step 8 – Present a consolidated summary of conclusions and outcomes of the assessment** (refer to Section 5.5.7 Conclusions).

Information and areas of interest raised by the public, communities of interest, and Indigenous peoples during engagement that influenced the scope of the aquatic biodiversity assessment are summarized in Table 5.5.1-1. Other general areas of interest and questions raised during the engagement that pertain to the surface water quality assessment (if any) are documented in CNL's Indigenous Engagement Report (CNL 2020) and CNL's Stakeholder's Activity Reports (CNL 2017a,b, 2019a).

Table 5.5.1-1: Summary of Areas of Interest Raised During Engagement Activities that Influenced the Scope of the Aquatic Biodiversity Assessment

Area of Interest	How the Area of Interest Was Included in the Assessment
Effects to fish from potential for contamination in the Ottawa River from the NSDF Project.	The spatial boundaries of the assessment were selected to include consideration of potential effects to the Ottawa River. Surface water modelling was completed to estimate contaminant concentrations within the Perch Creek and Perch Lake Watershed[(a)], which flows directly into the Ottawa River. Meeting effluent discharge targets within the Perch Creek and Perch Lake Watershed is considered to be protective of fish in the Ottawa River. The Regional Study Area was expanded to include reach of the Ottawa River extending 8 km downstream from CNL in response to comments received from the public

a) Includes contributing watercourses and waterbodies within the Perch Creek and Perch Lake Watershed, including Perch Creek, Perch Lake, East Swamp Stream, and Main Stream.

5.5.2 Valued Components

Valued Components (VCs) refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community or the public (The Agency 2018). Fish and fish habitat are recognized as important components of the aquatic environment that may be affected by the NSDF Project and changes to fish and fish habitat could, in turn, lead to effects on other VCs, such as land and resource use (Section 5.9). Fish and fish habitat are also within the scope of the application of Section 35 of the *Fisheries Act*, specifically the prohibition against causing harmful alteration, disruption and destruction of fish and fish habitat.

Inclusion of a fish habitat VC describes any watercourse, waterbody, or wetland providing functions for life history stages of fish. In addition to the fish habitat VC, the assessment of aquatic biodiversity examined potential changes to the fish community that use watercourses and waterbodies within the Perch Creek and Perch Lake Watershed, including large-bodied and small-bodied species, species occupying various trophic levels (e.g., carnivores, invertivores and herbivores) and species that use shoreline habitat near Point au Baptême in the Ottawa River (Table 5.5.2-1). These species are summarized within a fish community VC for all contributing watercourses and waterbodies within the Perch Creek and Perch Lake Watershed. The assessment considered that waterbodies and watercourses in the watershed contain fish, or their habitat, that are part of, or support a fishery, and that all fish within waters potentially affected by the NSDF Project are subject to the application of the *Fisheries Act*. Species are also likely to respond differently to physical effects to habitat, as well as levels of substances present in environmental media. As such, the aquatic biodiversity VCs selected for the Environmental Risk Assessment completed for the NSDF Project (summarized in Section 5.7) were selected to assess exposures to water, as well as ingestion of aquatic biota (Table 5.5.2-2).

Although residual effects to hydrology and water quality are not anticipated for the Ottawa River, species of conservation concern that may occur at downstream locations in the Ottawa River are included within the aquatic biodiversity assessment for the NSDF Project. These species include Lake Sturgeon (*Acipenser fulvescens*), American Eel (*Anguilla rostrata*), River Redhorse (*Moxostoma carinatum*) and Northern Brook Lamprey

(*Ichthyomyzon fossor*) (see Government of Canada 2015, 2016; Government of Ontario 2019) (Table 5.5.2-1). Both Northern Brook Lamprey and River Redhorse are currently designated as species of 'Special Concern' under *Ontario Regulation (O. Reg.) 230/08 Species at Risk in Ontario List,* and under Schedule 1 (i.e., list of species at risk) of the *Species at Risk Act* (SARA). Lake Sturgeon is currently designated as 'Endangered' under the Species at Risk in Ontario List and as 'Threatened' by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and is eligible for an amendment to Schedule 1 of SARA. The American Eel is currently designated as 'Endangered' under the Ontario *Endangered Species Act, 2007,* and as 'Threatened' by COSEWIC, and is eligible for an amendment to Schedule 1 of the SARA.

Table 5.5.2-1: Valued Components for Aquatic Biodiversity Assessment

Valued Component	Rationale for Selection
Perch Creek and Perch Lake Watershed Fish Habitat (i.e., Fish Habitat)[(a)]	■ Wetlands, lakes, streams and rivers provide a diversity of functions for life history stages of fish species and forage fish species. ■ The NSDF Project may affect existing availability of the spatial and temporal distribution of habitat, which can subsequently affect land and resource use.
Perch Creek and Perch Lake Watershed Fish Community (i.e., Fish Community)(a)	■ Up to 15 species have been documented within the Perch Creek and Perch Lake Watershed, some of which may use habitat in the Ottawa River at the mouth of Perch Creek. ■ Species in potentially affected waters are protected under the Fisheries Act., for example, Northern Pike (Esox lucius), Brown Bullhead (Ameiurus nebulosus) and supporting forage fish species. ■ Societal values concerning changes in local fisheries species are an important consideration in understanding potential effects of the NSDF Project.
Fish Species of Conservation Concern	■ The Lake Sturgeon (Acipenser fulvescens) population in the Ottawa River is designated as Threatened by COSEWIC; threats to the Lake Sturgeon include overexploitation, dams, habitat degradation, contaminants and introduced species; commercial fishing was the most significant factor that caused the historical decline of populations. ■ American Eel (Anguilla rostrata) is designated as Threatened by COSEWIC; threats include dams which can impede upstream migration of juvenile eels; impeded access to the Ottawa River, Lake Ontario and Lake Champlain resulted in substantial cumulative loss of formerly productive rearing habitat in the St. Lawrence River watershed. ■ The Northern Brook Lamprey (Ichthyomyzon fossor) population in the Ottawa River is designated as special concern under Schedule 1 of SARA; lampricide (chemical used to target lamprey larvae) use to manage invasive Sea Lamprey (Petromyzon marinus) is the main threat for Northern Brook Lamprey. ■ River Redhorse (Moxostoma carinatum) is designated as special concern under Schedule 1 of SARA; principal threats are habitat degradation through siltation, agricultural and urban pollution, and instream barriers such as dams, which restrict access to spawning areas and can change flow regimes during spawning periods.

a) Includes contributing watercourses and waterbodies within the Perch Creek and Perch Lake Watershed, including Perch Lake, Perch Creek, East Swamp Stream, and Main Stream.

Assessment endpoints are qualitative expressions used to assess the significance of residual effects on VCs and represent the key properties of the VC that should be protected for future generations. The assessment endpoints and measurement indicators identified for the aquatic biodiversity VCs are presented in (Table 5.5.2-2).

The assessment endpoint for fish and fish habitat is maintenance of self-sustaining and ecologically effective fish populations, which are important components of on-going fisheries productivity. Self-sustaining fish populations are healthy and viable and, by definition, robust and capable of withstanding environmental change and accommodating stochastic (i.e., random variable) processes (Reed et al. 2003).

Habitat availability, habitat distribution, and survival and reproduction were selected as the measurement indicators for the aquatic biodiversity species VCs (Table 5.5.2-2). The measurement indicators are defined as follows:

- **Habitat availability**: Changes to the amount of habitat (e.g., by altering flows or abundance of food) and quality of habitat (e.g., by altering water quality).
- **Habitat distribution**: Changes to spatial configuration and connectivity of habitats.
- **Survival and reproduction**: Changes to abundance caused by altering survival and/or recruitment (i.e., demographic parameters).

Table 5.5.2-2: Assessment Endpoints and Measurement Indicators for the Aquatic Biodiversity Assessment

Valued Component	Assessment Endpoints	Measurement Indicators
Perch Creek and Perch Lake Watershed(a) Fish Habitat	■ On-going support of fisheries productivity	■ Habitat availability (quality and quantity) ■ Habitat distribution
Perch Creek and Perch Lake Watershed(a) Fish Community	■ Self-sustaining and ecologically effective fish populations ■ On-going fisheries productivity	■ Habitat availability (quality and quantity) ■ Habitat distribution ■ Survival and reproduction
Fish Species of Conservation Concern	■ Self-sustaining and ecologically effective fish populations	■ Habitat availability (quality and quantity) ■ Habitat distribution ■ Survival and reproduction

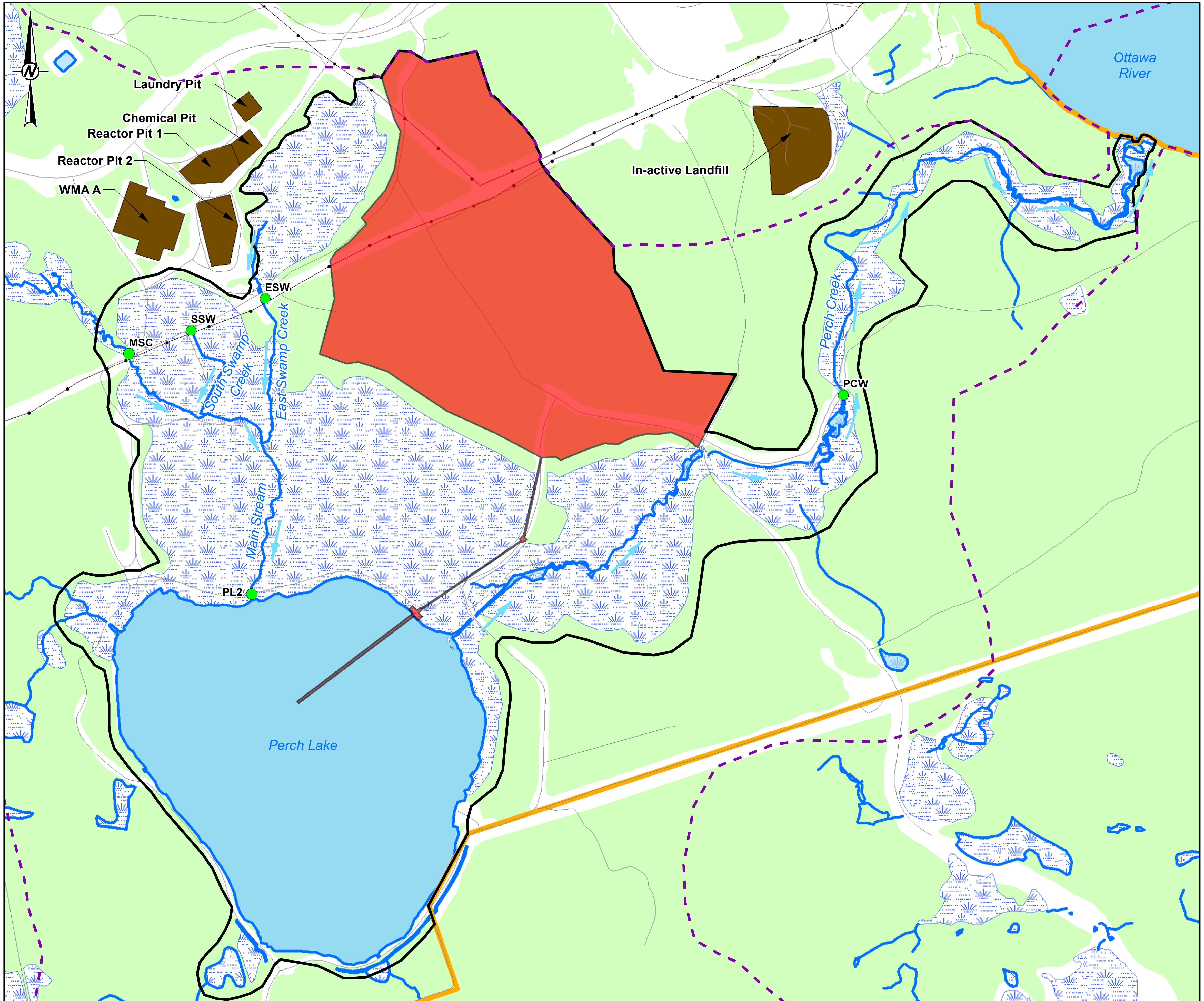
a) Includes watercourses and waterbodies within the Perch Creek and Perch Lake Watershed, including Perch Lake, Perch Creek, East Swamp Stream, and Main Stream.

5.5.3 Assessment Boundaries

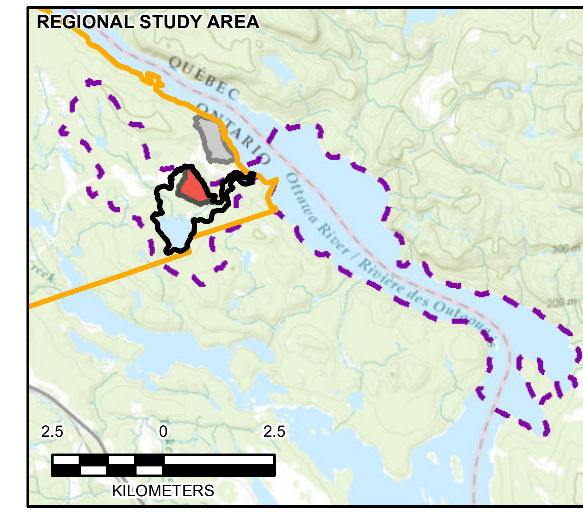
5.5.3.1 Spatial Boundaries

The spatial boundaries selected for the aquatic biodiversity assessment were chosen because they permit description of existing conditions in sufficient detail to enable potential Project-VC interactions and effects to be identified, understood and assessed, including understanding and assessing the contribution of the NSDF Project to cumulative effects. The spatial boundaries selected for the aquatic biodiversity assessment are the same as those identified for hydrology and surface water quality and are presented on Figure 5.5.3-1 and are described below.

- **Site Study Area (SSA):** The SSA is the NSDF Project footprint (i.e., where project activities would be undertaken including proposed facilities, buildings and infrastructure).
- **Local Study Area (LSA):** The LSA is defined as the area within which there is potential for measurable changes to measurement indicators resulting from the proposed NSDF Project activities. The LSA includes the SSA and is bounded by Perch Lake and Perch Creek, and adjacent wetlands and swamps.
- **Regional Study Area (RSA):** The RSA is defined as the area within which the potential effects of the NSDF Project may interact with the effects of other existing or reasonably foreseeable developments. The RSA is determined by the spatial extent of the Perch Creek and Perch Lake Watershed, which includes Perch Lake and its tributaries and Perch Creek. The RSA also includes a portion of the Ottawa River (i.e., roughly 8 km downstream in the Ottawa River to Harrington Bay).



LEGEND
- ROADS
- RAILWAY
- TRANSMISSION LINE
- FLOW DIRECTION
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- SITE STUDY AREA (NSDF PROJECT SITE)
- CRL SITE
- WASTE MANAGEMENT AREA (WMA) [1]
- LOCAL STUDY AREA
- REGIONAL STUDY AREA
- WEIR[2]



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NOTE(S)
1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.
2. PCW = PERCH CREEK WEIR
ESW = EAST SWAMP WEIR
SSW = SOUTH SWAMP WEIR
MSW = MAIN STREAM CULVERT
PL2 = PERCH LAKE 2 WEIR

REFERENCE(S)
1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
SPATIAL BOUNDARIES SELECTED FOR THE AQUATIC ENVIRONMENT ASSESSMENT

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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5.5.3.2 Temporal Boundaries

Temporal boundaries (i.e., project phases) establish the timeframe during which NSDF Project effects are assessed. The temporal boundary represents the timeframe during which project activities are actively occurring and considers the duration of predicted residual effects. The duration of an effect is defined as the amount of time between the start and end of a project activity or stressor (which is related to the Project phases) plus the time required for the residual effect to be reversed. In some cases, residual effects may be irreversible within the temporal boundaries of the project or if the effects were predicted to last so far into the future that they could not be predicted with any level of certainty (e.g., residual effect lasts for thousands of years). The following phases were identified for the NSDF Project.

- **Construction phase**: This phase includes site preparation and all activities associated with the construction of the NSDF Project. This phase includes activities such as installing the necessary supporting and/or ancillary facilities and infrastructure to facilitate NSDF Project operations, inactive commissioning and systems testing, and transportation of construction materials. Construction activities are expected take place from 2021 to 2023.
- **Operations phase**: This phase includes all activities associated with waste placement, water management, Wastewater Treatment Plant (WWTP) operations, vehicle movements into and from the SSA, and maintenance activities. Operations activities are expected to last approximately 50 years (i.e., 2024 to 2070).
- **Closure phase:** This phase includes activities necessary to complete the installation of the final cover and implementation of long-term monitoring. Closure activities are expected to start in 2070 and continue through to 2100, after which the NSDF Project will transfer into the post-closure phase.
- **Post-closure phase:** This phase has two discrete periods: institutional control and post-institutional control. The institutional control period includes implementation of controls throughout 2100 to 2400 (i.e., 300 years). During institutional control, environmental monitoring will be completed as required to confirm that the final cover is functioning as intended and to demonstrate compliance with the environmental assessment conditions. Post-institutional control occurs after year 2400 and continues indefinitely.

The temporal boundaries for the aquatic biodiversity assessment include consideration of effects of the NSDF Project from construction through post-closure.

5.5.3.3 Assessment Cases

The assessment cases considered in the aquatic biodiversity assessment are the Base Case and Application Case (the Reasonably Foreseeable Developments Case has not been considered for the reasons outlined below).

- **Base Case:** This scenario represents existing conditions and characterizes combined effects from previous and existing developments and activities. The Base Case reflects the effects of existing disturbances, such as forestry, transportation, agricultural, mining and residential and recreational development. Current effects from the existing CRL facilities and operations, for example, are considered part of the Base Case.
- **Application Case:** This scenario represents predictions of the effects of the Base Case combined with the effects that may result from the NSDF Project. The Application Case considers potential effects from the NSDF Project during construction through to the closure and post-closure phases.

- **Reasonably Foreseeable Development (RFD) Case**: This scenario represents predictions of the cumulative effects of the Application Case, which includes the Base Case, plus projects that are currently under application review or that have officially entered a regulatory application process and are therefore considered reasonably foreseeable. Because RFDs will have no spatial overlap or are likely to positively affect the fish and fish habitat, an RFD Case is not presented as part of this assessment.

  RFDs expected within the CRL site (i.e., the RSA) that may interact with the aquatic environment include new or upgrades to research and development facilities, construction and operations of the SMR, new support infrastructure, and on-going decommissioning and environmental remediation activities. New support infrastructure and research and development facilities will generally be located within existing disturbed areas on the CRL site (i.e., minimal disturbance to largely undeveloped areas) where erosion and sediment control practices and surface water management systems already in place will be implemented. Disturbance of an approximately 3.5 ha may be required for development of the SMR based on the candidate site selected, but no watercourses are identified within any of the three candidate sites (Global First Power 2019). The Project Description document for the SMR notes that the nearest water body to Site A is “No Name” lake within the Perch Creek and Perch Lake Watershed and the nearest water body to Sites B and C is the Ottawa River within the Ottawa River direct watershed. It is noted that a small amount of radioactive liquid waste from decontamination activities during the operations of the SMR will be monitored and stored in a holding tank, for further processing (Global First Power 2019). A septic field may be used to manage sewage the SMR site, depending on the candidate site chosen that would follow required standards and would be located approximately 2 km from the SSA. Accordingly, potential effects from revitalization activities are not expected to spatially overlap with potential effects to aquatic biodiversity from the NSDF Project.

  The end-state plan for the CRL site will be to return lands disturbed by site activities to a condition that is physically stable and safe in keeping with the land use and landscape of the day. Therefore, decommissioning and environmental remediation activities are anticipated to positively affect fish and fish habitat.

5.5.4 Description of the Environment

5.5.4.1 Methods

This section describes the setting and characterization for the aquatic biodiversity as relevant for the assessment of effects from the NSDF Project. It describes the existing conditions (i.e., Base Case) against which potential changes from the NSDF Project are compared and evaluated. Existing fish and fish habitat conditions within and surrounding the CRL site, including the Ottawa River, were obtained from published reports and available baseline data.

The baseline study conducted as part of this EIS focuses on methods which assess the conditions of fish in Perch Lake at the community level by examining changes to community structure. As such, the description of fish habitat, communities, and species present in the Perch Creek and Perch Lake watershed of the RSA takes into account a community-based approach in assessing the potential residual effects of the NSDF Project on aquatic biodiversity. This conventional approach is appropriate to determine the long-term ecological effects of contaminants to non-human biota (Canadian Standards Association’s Standards N288.4-10 *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [CSA Group 2010]).

5.5.4.2 Results

5.5.4.2.1 Fish Habitat

The NSDF Project is located primarily within the Perch Creek and Perch Lake Watershed of the RSA (Figure 5.5.3-1) at the southern edge of the Canadian Shield in the Ottawa River valley (Robertson and Barry 1985) and includes contributing watercourses and waterbodies within the watershed of Perch Creek. Ground surface elevations range from a low of approximately 160 metres above sea level (masl) within the low-lying and relatively flat terrain bordering the north side of Perch Lake, to a high of 196 masl along the crest of the ridge to the east of Emergency Road #3 that separates the Perch Creek and Perch Lake Watershed and Ottawa River Watershed. The watershed includes the Waste Management Areas (WMAs) A and B, the Reactor and Laundry Pits and the Liquid Dispersal Area. From Perch Lake, surface water (Perch Creek) flows in a north-easterly direction through Perch Creek to its confluence with the Ottawa River. The Perch Creek basin drains approximately 18% of CRL site area and drains to the Ottawa River through Perch Lake and Perch Creek (CNL 2016a).

The CRL site is located adjacent to the reach of the Ottawa River extending approximately 90 km between La Passe and the Des-Joachins hydroelectric dam. This reach consists of several “lakes” separated by short rapids. The river section near the CRL site is 200 to 400 m wide, slow-moving and with a steeply sloped shoreline, extending to a depth of 55 m. There is a shallow shelf extending across Point au Baptême (approximately 125 m wide) where Perch Creek enters the Ottawa River. The river bottom across the shelf is predominately fine substrate, with average depths of 1 m to 3.5 m and aquatic vegetation is abundant around the shoreline. Based on daily flow measurements of the Ottawa River taken at the Des-Joachims Generating Station (just north [upstream] of the NSDF site) from the time period of June 1950 to December 2016, flow rates for the river range from 336 m^3/s (minimum flow rate) to 1,560 m^3/s (maximum flow rate) (also see Section 5.4.1.4.2.2). The mean flow rate is 807 m^3/s. The flow past the Des-Joachims hydroelectric dam is regulated according to the demands of the generating station.

Physical characteristics of Perch Lake include a wetted area of approximately 45 ha, a drainage area of 730 ha and a mean depth of 2 m (Robertson and Barry 1985). A recent bathymetric survey completed in 2018 identified a maximum depth of 4 m, and confirmed that most of the lake is shallow, less than 3 m in depth (CNL 2018a). In late summer and fall, the water level usually drops by as much as 0.25 m. Most of Perch Lake is open water except for littoral zones along the shore, including a region of floating, emergent and submerged vegetation, which amounts to about 30% of the lake’s surface (Yankovich et al. 2000). Substrates within the lake are primarily organic sediments and surrounding shoreline soils are a mixture of sand and soils (CNL 2018a). The lake is confined, in part, by sand outcrops along the northern and southern shores, and by bedrock along the western shores.

The dominant vegetation form in Perch Lake is a floating-leafed plant cover of fragrant water-lily (*Nymphaea odorata*) and watershield (*Brasenia schreberi*). Closer to the shore, narrow leafed emergent bands of slender sedge (*Carex lasiocarpa*), twig rush (*Cladium mariscoides*) and broad-leaved arrowhead (*Sagittaria latifolia*) grow in profusion in the shallow water, as does common cattail (*Typha latifolia*) and pickerelweed (*Pontederia cordata*). In the deeper water beyond, fully or partially submerged vegetation is dominated by common bladderwort (*Utricularia vulgaris*), flat-leafed bladderwort (*Utricularia intermedia*), fennel leafed pondweed (*Potamogeton pectinatus*), big-leaf pondweed (*Potamogeton amplifolius*) and stoneworts (*Chara* sp.), grow along the bottom. Along the north shore and elsewhere, a broad-leafed emergent cover of pickerelweed contrasts with water-lilies. The outer fringe of this zone is known as Perch Lake Marsh. This open marsh may be considered to be part of the lake, with which it is physically continuous.

Previous water quality monitoring of Perch Lake recorded high nutrient levels that indicate a eutrophic condition of the lake (Yankovich et al. 2000). Total phosphorus background concentrations in Perch Lake typically range between 0.01 mg/L to 0.07 mg/L based on monitoring results from 2012 to 2017 (CNL 2018a). In May 2018, surface water measurements in Perch Lake averaged approximately 0.02 mg/L (CNL 2018b). The upper range of historical concentrations of total phosphorous indicate a eutrophic condition because those concentrations fall between 0.035 mg/L to 0.1 mg/L (as defined for eutrophic states in CCME 1999 and Wetzel 2001).

Perch Lake, like other lakes in the region, undergoes an open water condition (April to October) and ice-covered condition (November to March) throughout a yearly cycle. Following melting of the ice during spring, the water warms up rapidly and summer surface temperatures can exceed 30°C; the highest recorded temperature was 34°C (Yankovich et al. 2000). During summer, water temperatures in the lake can stratify with surface water temperatures about 5°C higher than lower depth strata (Yankovich et al. 2000). In summer 2017, lake stratification was observed during fish sampling conducted on Perch Lake (surface temperature = 26.1°C, bottom temperature = 19.6°C) (CNL 2017c). However, the strength of the temperature gradient and the duration of thermal stratification would be limited in magnitude depending on climate conditions during any given year (e.g., where high winds would promote mixed scenarios).

Dissolved oxygen (DO) levels may also stratify concurrently with changes in water temperatures, with reduced DO concentrations near the bottom of the lake. In summer 2017, DO concentration gradients were observed during fish sampling conducted on Perch Lake (surface DO = 5.8 mg/L, bottom DO = 0.2 mg/L) and Toussaint Lake (surface DO = 6.7 mg/L, bottom DO = 0.3 mg/L) (CNL 2017c). The depth stratum of the reduced DO levels (i.e., the hypolimnion) in Perch Lake was approximately from 2.5 m to 4.0 m. However, the duration of the anoxic period in the lower depth strata of Perch Lake is unknown for summer 2017. Prolonged periods of low DO levels (e.g., less than 3 mg/L) near the lake bottom may restrict sensitive fish species and developmental stages to higher in the water column, exposing biota to higher seasonal peak temperatures (e.g., Fang and Stefan 2000; Roberts et al. 2012).

Water quality samples were also collected in May 2018 (spring conditions) from multiple station locations within Perch Lake (CNL 2018a; also summarized in EIS Section 5.4). In-situ water quality measured at four locations in the lake at the time of the water quality sampling was reflective of spring water temperatures and consistent with a warm-cool water thermal regime characterized by small lakes in the region (i.e., temperatures ranged from 12.0ºC to 22.8ºC). Dissolved oxygen and pH were both within the guidelines for the protection of aquatic life (CCME 1999; DO >5.5 mg/L and pH = 6.5 to 9.0) at the majority of stations and depth sampled. Exemptions were bottom water quality readings at two stations in Perch Lake where DO concentrations were as low as 4.7 mg/L and pH values were as low as 6.26.

Dissolved oxygen concentrations can also diminish in ice-covered lakes during the winter due to sedimentary oxygen demand and water column oxygen demand (reviewed in Fang and Stefan 2000). In particular, shallow (4 m maximum depth), eutrophic lakes in winter are prone to low DO concentrations below 2.0 mg/L near the end of an extended ice cover period. Previous under-ice measurements of Perch Lake in late winter show that bottom waters can become depleted in oxygen in winter, as low as 4.0 mg/L (CNL 2019b), however, there have been no reported ‘fish kills’ during these conditions to the knowledge of the authors of this assessment. Prolonged reductions in winter DO levels below 3 mg/L has the potential to reduce available habitat and cause chronic stress for populations in the lake.

From Perch Lake, mean historical annual flows at the outlet are 0.057 m^3/s based on the 11-year average water budget (1969 to 1980) for the hydrologic year (September 1 to August 31; see Section 5.4.1.4.2.3). Flow rates from the Perch Creek weir were also measured by CNL from 2009 to 2015 (see Table 5.4.1-6). The highest flows typically occur in conjunction with spring melt (i.e., freshet) events in April, while lower flows are encountered during the summer season, particularly in August. The overall annual mean flow from years 2009 to 2015 was estimated to be approximately 0.063 m^3/s. Downstream of the outlet, Perch Creek ranges from 5 m to 10 m in width and generally has a depth of less than 1 m. The Perch Creek weir is located at the downstream extent of adjacent wetlands, approximately 700 m downstream of Perch Lake (Photo 5.5.4-1).

Photo 5.5.4-1: Upstream View of the Perch Creek Weir, August 2012

Below the Perch Creek weir, the creek enters a mixed deciduous woodlot and overhead cover increases substantially (Sowden and Power 1981). Stream gradient also increases sharply, exceeding a 10% slope in sections. A series of small waterfalls (or cascades) occur just downstream of the weir, which is expected to be a barrier to upstream movements of fish species from the Ottawa River, preventing access to upper Perch Creek and Perch Lake. The waterfalls then lead to a pool riffle sequence, followed by slow-flowing water in the lower reach of the creek. The substrate in the middle reach is rock, gravel and coarse sand; whereas the substrate in the lower section of the creek is dominated by silt and sand substrate. The overall slope of Perch Creek is approximately 3%.

To the north of Perch Lake are extensive wetlands, notably Perch Lake Swamp, South Swamp and East Swamp. The fish habitat potential of wetlands such as Perch Lake Swamp and East Swamp is predicted to be low. These wetlands may support small-bodied fish during spring conditions and potentially through the summer in areas defined by a stream bed and banks where flows are sustained over the summer. From East Swamp, the outlet stream starts immediately above a small weir where groundwater influences may sustain flows in upper sections of the creek throughout the year (CNL 2017c). Pools above and below the weir may provide year-round habitat for fish (Photo 5.5.4-2). East Swamp Stream flows for approximately 350 m before entering Main Stream, which then flows for approximately 375 m before entering Perch Lake. The main tributary stream of Perch Lake is Main Stream, which is approximately 2 km in length. Substrates for East Swamp Stream and Main Stream are predominately fines (e.g., silts, sands) (CNL 2017c).

Photo 5.5.4-2: Downstream View of the East Swamp Stream Weir, November 2017

5.5.4.2.2 Perch Creek and Perch Lake Watershed Fish Community

An inventory of fish in nine waterbodies within the CRL site was performed in summer 1980 (Sowden and Power 1981), with follow-up inventory investigations performed in 1996 and 1997 (CG&S 1997, 1998), 2016 and 2017 (CNL 2017c) and in 2018 (CNL 2018c). The baseline inventory data, although a portion of it over 20 years old, provides a historical baseline description that can be used to characterize the potential distribution of species in the assessment area. Current distributions reflect the introduction of Northern Pike to Perch Lake in the mid-to-late 1980s (Yankovich et al. 2000). Natural colonization of the lake by other species in the Ottawa River are unlikely given the small waterfalls on Perch Creek acting as a natural barrier for upstream movements of fish.

Waterbodies that were sampled as part of historical baseline studies include: Ottawa River, Perch Lake, Lower Bass Lake, Upper Bass Lake, Maskinonge Lake, Duke Stream Marsh, Perch Creek (Perch Lake outlet), Main Stream (tributary to Perch Lake), and East Swamp Stream (tributary to Perch Lake) (Figure 5.5.3-1 and Figure 5.4.1-2). Sampling gear types included experimental gill nets, hoop net traps, beach seines, minnow traps, and backpack electrofishers. Historical data on distribution, diet and growth of locally occurring fish species, with a focus on environments below waste disposal sites are provided in more detail in Sowden and Power (1981).

Forty-one fish species were collected during the 1980 field program, including 13 species collected in the Perch Creek and Perch Lake Watershed (Table 5.5.4-1; Sowden and Power 1981). One species (Blacknose Shiner) recorded in Perch Lake during earlier investigations (Ophel and Fraser 1971, as cited in Sowden and Power 1981) was not captured in the watershed in 1980, and two species (Rosyface Shiner and

Threespine Stickleback) were recorded near the mouth of Perch Creek but not in the creek or upstream locations. Within the Perch Creek basin, seven species were exclusive to lower Perch Creek, including Common Shiner, Longnose Dace, Fallfish, White Sucker, Johnny Darter, Logperch and Mottled Sculpin. It is assumed that species found in lower Perch Creek below the Perch Creek weir, also occur in the Ottawa River near the outlet of Perch Creek (e.g., shelf habitat near Point au Baptême) to meet their life history requirements (e.g., for foraging, overwintering). Species with relatively wide distributions in the Perch Creek and Perch Lake Watershed and also dominant species in upper Perch Creek included Fathead Minnow, Pearl Dace and Creek Chub. Abundant cyprinid species in Perch Lake included Bluntnose Minnow and Pearl Dace, and the dominant large-bodied species in the lake included Yellow Perch (40.4% of catch), Brown Bullhead (24.2% of catch) and Pumpkinseed (15.5% of catch). The dominant species in Main Stream were Pearl Dace and Fathead Minnow, and the only species captured in East Swamp Stream was Pearl Dace.

Table 5.5.4-1: Distributions For Focal Species in Small Watercourses and Waterbodies at the CRL Site

Common Name	Scientific Name	Trophic Category[(a)]	Feeding Habitat[(a)]	Occurrence at Nine Waterbodies and Watercourses (Sowden and Power 1981)	Occurrence at Main Stream and Upper Perch Creek (CG&S 1997, 1998)	Occurrence at Perch Lake, Toussaint Lake, Main Stream and East Swamp Stream (CNL 2017c; 2018c)
Common Shiner	*Luxilus cornutus*	Invertivore herbivore	Generalist	Lower Perch Creek	—	—
Blacknose Shiner(b)	*Notropis heterolepsis*	Invertivore-herbivore	Generalist	Ottawa River (shoreline)	Upper Perch Creek	—
Rosyface Shiner	*Notropis rubellus*	Invertivore	Specialist	Ottawa River (shoreline near Perch Creek)	—	—
Bluntnose Minnow	*Pimetheles notatus*	Omnivore	Generalist	All locations sampled except Upper Bass Lake and tributaries to Perch Lake	Upper Perch Creek	—
Fathead Minnow	*Pimetheles promelas*	Omnivore	Generalist	Duke Stream Marsh, Main Stream, Perch Lake, upper Perch Creek	Main Stream, Upper Perch Creek	—
Longnose Dace	*Rhinichthys cataractae*	Insectivore	Benthic	Lower Perch Creek	—	—
Creek Chub	*Semotilus atromaculatus*	Omnivore	Generalist	Perch Lake, upper/lower Perch Creek, Ottawa River in vicinity of Perch Creek	Main Stream, Upper Perch Creek	—
Fallfish	*Semotilus corporalis*	Invertivore-carnivore	Generalist	Ottawa River (shoreline) and lower Perch Creek	—	—
Pearl Dace	*Semotilus margarita*	Invertivore	Water column	Perch Lake, Main Stream, East Swamp Stream and lower/upper Perch Creek	Main Stream, Upper Perch Creek	Main Stream, East Swamp Stream
White Sucker	*Catostomus commersonii*	Omnivore	Benthic	Widely distributed, but not recorded above upper Perch Creek	—	—
Brown Bullhead	*Ictalurus nebulosus*	Omnivore	Benthic	Perch Lake, upper/lower Perch Creek, Maskinonge Lake and Ottawa River	Upper Perch Creek	Perch Lake
Threespine Stickleback(c)	*Gasterosteus aculeatus*	Invertivore-carnivore	Generalist	Ottawa River (shoreline near Perch Creek)	—	—

Table 5.5.4-1: Distributions For Focal Species in Small Watercourses and Waterbodies at the CRL Site

Common Name	Scientific Name	Trophic Category[(a)]	Feeding Habitat[(a)]	Occurrence at Nine Waterbodies and Watercourses (Sowden and Power 1981)	Occurrence at Main Stream and Upper Perch Creek (CG&S 1997, 1998)	Occurrence at Perch Lake, Toussaint Lake, Main Stream and East Swamp Stream (CNL 2017c; 2018c)
Pumpkinseed	*Lepomis gibbosus*	Invertivore-carnivore	Generalist	Perch Lake, upper/lower Perch Creek, Maskinonge Lake, Lower Base Lake and Upper Base Lake	Upper Perch Creek	Perch Lake
Yellow Perch	*Perca flavescens*	Invertivore-carnivore	Water column	Widely distributed, but not recorded in Duke Stream Marsh and in Perch Lake tributaries	—	Perch Lake
Northern Pike(d)	*Esox lucius*	Carnivore- insectivore	Benthic	—	—	Perch Lake
Johnny Darter	*Etheostoma nigrum*	Invertivore	Benthic	Maskinonge Lake, Upper Base Lake, Ottawa River (near Perch Creek) and Lower Perch Creek	—	—
Logperch	*Percina caprodes*	Invertivore	Benthic	Ottawa River (near Perch Creek) and lower Perch Creek	—	—
Mottled Sculpin	*Cottus bairdii*	Invertivore	Benthic	Maskinonge Lake, Ottawa River (near Perch Creek) and lower Perch Creek	—	—

a) Considers species descriptions in Scott and Crossman (1973).

b) Blacknose Shiner reported in Perch Lake by Ophel and Fraser (1971).

c) Species documented in the Ottawa River near the mouth of Perch Creek but not collected in the Perch Creek and Perch Lake Watershed in summer 1980 or earlier.

d) Northern Pike (, a top carnivore, was introduced to Perch Lake in the late 1980s (Yankovich et al. 2000), and populations have persisted through to 2018 (CNL 2018c).

— = not collected.

Following the baseline investigations by Sowden and Power (1981), Northern Pike was introduced to or recolonized Perch Lake, in the late 1980s, causing changes to the population dynamics of local species of fish (Yankovich et al. 2000). The once abundant population of Yellow Perch described in Sowden and Power (1981), was reduced in size, and forage species, such as Creek Chub, Bluntnose Minnow, Fathead Minnow, Pearl Dace and Blacknose Shiner were similarly affected (Yankovich et al. 2000). However, Perch Lake continues to support a large-bodied fish community that is similar to that recorded in 1980 (CNL 2017c), which includes a mix of coolwater species such as Perch, and warmwater species such as Brown Bullhead and Pumpkinseed (Table 5.5.4-1). All previously recorded large-bodied species were captured by gill netting in summer 2016. Of 230 fish captures in total, Brown Bullhead was the most abundant species (56% of catch), followed by Yellow Perch (38% of catch) and Pumpkinseed (2% of catch). Northern Pike was only 4% of the fish catch. A suite of methods was deployed in Perch Lake in 2018, including hoop nets, angling and minnow traps, capturing 208 fish in total. Fishing efforts confirmed the presence of relatively few Northern Pike (i.e., only one fish captured). Abundant species included Pumpkinseed (58% of catch), Brown Bullhead (23% of catch) and Yellow Perch (19% of catch) within Perch Lake (see Table 5.5.4-1; CNL 2018c).

Electrofishing of streams in the Perch Creek and Perch Lake Watershed in 1996 and 1997 characterized a community of fish dominated by Fathead Minnow, Creek Chub and Pearl Dace in Main Stream, and a community dominated by Creek Chub and Blacknose Shiner in upper Perch Creek (CG&S 1997, 1998; see Table 5.5.4-1). Other species captured in upper Perch Creek included Fathead Minnow, Pearl Dace, Pumpkinseed and Brown Bullhead. Only one species of small-bodied fish, Pearl Dace[1], was captured in Main and East Swamp Streams using dip nets in 2017 (CNL 2017c; Photo 5.5.4-3).

Photo 5.5.4-3: Pearl Dace Captured in East Swamp Stream During Sampling in Summer 2017

[1] Fish in Main and East Swamp Streams were initially identified as Finescale Dace (*Chrosomus neogaeus*) (CNL 2017c), but upon review were later classified as Pearl Dace.

Changes in the general structure of the fish community structure over time have been minor. Any temporal changes may be related to historical effects of the Northern Pike introduction (or colonization) and trends in annual hydrology. For streams, factors influencing the presence of fish appear to be related to flow conditions (e.g., volume), the presence of available refugia, such as pools, during the summer and winter, and the connectivity to Perch Lake (CG&S 1998). Although on-going environmental monitoring indicates that surface water quality of the Perch Creek and Perch Lake Watershed continues to be affected by past operations of the WMAs, the potential risk to negatively affecting fish has been deemed low (CNL 2015a, 2016a, 2019c). The potential risk to fish in the Perch Creek and Perch Lake Watershed will continue to be assessed through the conduct of the CRL Environmental Risk Assessment on a five-year cycle.

Major changes to fish productivity and community structure over time have not been observed, suggesting that the historical effects of past operations on water quality pose minimal risk to the fish community and populations in Perch Lake (CNL 2017c, CNL 2018b,c).

5.5.4.2.3 Species of Conservation Concern

Based on historical reports of fish sampling in the Ottawa River, four fish species of conservation concern occur or have the potential to occur in the river reach adjacent to the CRL site (e.g., Allumette Lake). These species include Lake Sturgeon (*Acipenser fulvescens*), American Eel (*Anguilla rostrate*), River Redhorse (*Moxostoma carinatum*) and Northern Brook Lamprey (*Ichthyomyzon fossor*).

Lake Sturgeon

Lake Sturgeon is a member of the family Acipenseridae, and is Ontario’s largest and longest-lived fish species (Golder 2011). Lake Sturgeon can reach 3 m in length and live to over 100 years in Ontario. They are a bottom-dwelling fish found in large rivers and lakes, at depths generally between 5 and 10 m. Spawning occurs in the spring in fast-flowing water at depths between 0.6 and 5 m over hard-pan clay, sand, gravel and boulders. The distribution of Lake Sturgeon once extended from western Alberta to the St. Lawrence drainage in Quebec, and from southern Hudson Bay drainages to the lower Mississippi drainage. Lake Sturgeon currently inhabit at least 229 waters (128 lakes and reservoirs and 101 rivers) in Ontario. Commercial fishing is thought to be the most significant factor that caused the historical decline of populations.

Lake Sturgeon are known to be present in the Ottawa River near the CRL site based on previous baseline and monitoring studies (e.g., Sowden and Power 1981; SENES 2010, CNL 2016a, CNL 2018c, CNL 2018d). The species has also been previously recorded in the Ottawa River reach adjacent to the CRL site (reviewed in Golder 2011). Lake Sturgeon have been known to spawn in the Allumette Rapids, downstream of the CRL site (SENES 2010). Lake Sturgeon are not listed under SARA but are designated as Threatened under the Ontario *Endangered Species Act, 2007.*

In order to track the effect of CNL’s existing operations on the Lake Sturgeon population in the Ottawa River, monitoring of fish impinged into the National Research Universal reactor’s water intake is conducted annually (CNL 2016b). Typically, few individual fish are impinged. Since monitoring began, the maximum number impinged in a single year was 10 in 2004, with every other year averaging 2 individuals. Impingement of sturgeon will continue to be monitored as long as water is being drawn from the Ottawa River at a rate strong enough to impinge fish.

In 2008, Pratt concluded that the population of Lake Sturgeon in the middle of the Ottawa River (Lac Colounge, Lower and Upper Allumette Lake) is increasing with greater than 5,000 individuals (Pratt 2008). While there are low numbers in many reaches of the Ottawa River, in the section of the Ottawa River where CRL sits, called Allumette Lake, there is a relatively healthy population of Lake Sturgeon (Pratt 2008; Haxton 2008). Studies along the Ottawa River show that Lake Sturgeon in this area prefer depths of 12 m to 20 m and are rarely found at depths of 35 to 50 m. Younger, smaller fish are more often found in more shallow regions while larger fish inhabit the deepest depth strata (Haxton 2011). The stable, self-sustaining Lake Sturgeon population adjacent to the CRL site coupled with CRL's consistently low impingement numbers of this species provides evidence that the CRL site has had minimal negative effect on the local population of Lake Sturgeon.

American Eel

The American Eel is in the order Anguilliformes, family Anguillidae. Anguilla eels are termed freshwater eels, although some species (including the American Eel) are able to complete their entire life cycle in saltwater (COSEWIC 2006). The American Eel spawn in the Sargasso Sea in the southern North Atlantic Ocean. The historic Canadian range includes all accessible fresh water, estuaries and coastal marine waters connected to the Atlantic Ocean, up to the mid-Labrador coast. Continental shelves, where Niagara Falls is the natural distributional limit in the Great Lakes, are used by juvenile eels arriving from the spawning grounds, and by mature eels just prior to the spawning migration. Eels in the continental growth phase do not show consistent habitat preference. They are primarily benthic, using substrate and bottom debris as protection and cover.

American Eel are known to be present in the Ottawa River near the CRL site (Sowden and Power 1981; SENES 2010a, CNL 2018d). American eels were previously considered abundant in this stretch of the river and have been reported in Maskinonge Lake on the CRL site but have not been observed during recent creel surveys in the region (SENES 2010). American Eel is not a federally listed species under SARA but is considered Endangered under the Ontario *Endangered Species Act, 2007*. Efforts to reintroduce American Eels to the Ottawa River were completed in 2017, as a collaborative project with Ottawa Riverkeeper and Canadian Wildlife Federation (Ottawa Riverkeeper 2017).

Dams and other barriers are the primary threat to the persistence of American Eel populations (COSEWIC 2006). Barriers generate habitat loss and fragmentation for upstream migrants and produce turbine mortality for downstream migrants. The Ottawa River is currently blocked by 19 major-dams, only the Hydro Ottawa Chaudière dam is equipped with an eel ladder and turbine by-passes for migration movements (Ottawa Riverkeeper 2017).

Northern Brook Lamprey

The Northern Brook Lamprey is a freshwater, non-parasitic fish from the family Petromyzontidae (DFO 2016a). Northern Brook Lamprey live up to seven years as ammocoetes (larval lampreys), burrowed in soft sediments of streams where they are relatively protected before metamorphosis. The adult Northern Brook Lamprey has a non-parasitic adult stage and its fertility is relatively low (i.e., it has a lower reproductive capacity compared to other lamprey species). The Northern Brook Lamprey migrates up streams to spawn near the end of its life.

In Canada, the Northern Brook Lamprey lives in rivers and lakes in the Great Lakes and Upper St. Lawrence system. Although Northern Brook Lamprey may be present in the Ottawa River reach adjacent to the CRL site (SENES 2010; CNL 2018d), there are no records of the species near the CRL site based on previous baseline and monitoring studies. Furthermore, the species has not been recorded in the river reach adjacent to the CRL site based on Fisheries and Oceans Aquatic Species at Risk (DFO 2018), and the list of Species at Risk in Ontario (Government of Ontario 2019). The application of lampricide to manage the invasive Sea Lamprey is the main threat for Northern Brook Lamprey in the Great Lakes systems (DFO 2016a). Northern Brook Lamprey are considered as species of Special Concern under both SARA and the Ontario *Endangered Species Act, 2007*.

River Redhorse

The River Redhorse is a member of the genus Moxostoma in the Catostomidae family. The River Redhorse is a long-lived species that requires a variety of connected habitats to complete its life stages (DFO 2016b). The preferred spawning habitat for the River Redhorse is moderate to large rivers with a moderate to swift current, riffle-run habitat, and clean gravel, cobble, or boulder substrate. Upon spawning, approximately mid-June, the species can be found in deeper, slower current areas with abundant aquatic vegetation and softer substrates through the summer.

This species has a disjunct distribution in Canada (DFO 2016b). It occurs in southern Ontario (Grand River, Thames River) and eastern Ontario (Bay of Quinte, Trent River, Mississippi River, Madawaska River, and throughout the Ottawa River system). It also occurs in southern and southwestern Quebec (Coulonge River, Gatineau River, Noire River, Ottawa River and Richelieu River). The species has a wide distribution throughout the Ottawa River and its tributaries.

River Redhorse are expected to be present near the CRL site (SENES 2010, CNL 2018d). River Redhorse is designated as a species of Special Concern under SARA and the Ontario *Endangered Species Act, 2007*. The species was previously recorded in the Ottawa River reach near the CRL site, as noted on the Fisheries and Oceans Aquatic Species at Risk (DFO 2018), and in the list of Species at Risk in Ontario (Government of Ontario 2019). The nearest area of the Ottawa river containing critical habitat for River Redhorse is approximately 20 km downstream of the CRL site (Figure 5.5.4-1). The principal threats affecting the future persistence of River Redhorse populations are habitat degradation through siltation, agricultural and urban pollution, and instream barriers such as dams, which restrict access to spawning areas and can change flow regimes during spawning periods (DFO 2016b).

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LEGEND

- ★ NSDF PROJECT SITE
- CRITICAL HABITAT
- EXTIRPATED, ENDANGERED, OR THREATENED
- SPECIAL CONERN

REFERENCE(S)

1. OBATINED FROM - HTTPS://WWW.DFO-MPO.GC.CA/SPECIES-ESPECES/SARA-LEP/MAP-CARTE/INDEX-ENG.HTML

CLIENT	CANADIAN NUCLEAR LABORATORIES
PROJECT	NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CONSULTANT	GOLDER
DATE	NOVEMBER 2020
DESIGNED	PR
PREPARED	SO
REVIEWED	CS
APPROVED	AB
TITLE	**FISHERIES AND OCEANS AQUATIC SPECIES AT RISK MAP 7 SHOWING RIVER REDHORSE HABITAT**
PROJECT NO.	1547525
CONTROL	0009
REV.	FINAL 2
FIGURE	**5.5.4-1**

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5.5.5 Project Interactions and Mitigation

5.5.5.1 Methods

This section describes the process by which interactions between NSDF Project components and activities on the aquatic environment were identified and evaluated. Potential effects pathways were identified, and mitigation developed to eliminate or reduce effects is presented. A pathways analysis is then used to focus the assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects will be adequately mitigated, pathways are not forwarded for further analysis (i.e., secondary pathways where mitigation will remove the pathway altogether), and the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects after incorporation of mitigation are further characterized in subsequent subsections of the assessment, as required. As such, the Project Interactions and Mitigation section helps to focus the remainder of the assessment on those interactions (effects pathways) likely to result in residual adverse effects.

The first part of the analysis was to identify the potential effects pathways for all phases of the NSDF Project. The next step in the analysis was the development of environmental design features and mitigation that could be incorporated into the NSDF Project to eliminate or reduce adverse effects to the aquatic biodiversity. Environmental design features included project design elements, environmental best practices and management policies and procedures. Environmental design features and mitigation were developed through an iterative process between the Project’s engineering and environmental teams, combined with project-specific input from engagement with other interested parties. The design features and mitigation were selected considering their effectiveness for implementation and maintenance, and their appropriateness within the context of the identified effects pathways.

After incorporation of mitigation, potential pathways were evaluated into the following categories using scientific knowledge, logic, experience with similar developments, and the effectiveness of environmental design features and mitigation:

- **No linkage:** The pathway is removed by environmental design features or mitigation such that the NSDF Project would not be expected to result in a measurable environmental change relative to Base Case values and therefore would have no residual effects to aquatic biodiversity.
- **Secondary pathway:** The pathway could result in a measurable minor environmental change, but would have a negligible residual effect on aquatic biodiversity relative to Base Case or available guideline values, and is not expected to contribute cumulatively to other Project effects or to the effects of other previous, existing or reasonably foreseeable developments to cause a significant effect.
- **Primary pathway:** The pathway is likely to result in an environmental change relative to the Base Case or available guideline values that could contribute to residual effects to aquatic biodiversity.

Environmental design features and mitigation that have been or could be incorporated into the NSDF Project to eliminate and reduce adverse effects were considered. Potential pathways that were completely removed due to implementation of environmental design or mitigation were not assessed further. Pathways that were assessed to be secondary and were demonstrated to have a negligible residual effect to aquatic biodiversity through simple qualitative or semi-quantitative evaluation of the pathway were also not advanced for further assessment. Primary pathways were carried forward for more detailed quantitative and qualitative effects analysis to characterize the residual effects of the NSDF Project.

5.5.5.2 Results

Pathways through which all phases of the NSDF Project may interact with and result in changes to measurement indicators for aquatic biodiversity are provided in Table 5.5.5-1.

Table 5.5.5-1: Pathways Analysis for Aquatic Biodiversity Valued Component

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment[a]
■ Project activities during the construction phase: ▪ Site Preparation ▪ Construction of the ECM ▪ Blasting (as required) ▪ Development of surface water management structures ▪ Construction of the WWTP and other support facilities ▪ On-site road and access development ▪ Construction of the transfer line and Perch Lake diffuser ▪ Domestic waste (solid and liquid) management	Change to local hydrology from surface disturbances may cause changes to water levels, flows and channel/bank stability at downstream locations, affecting water and sediment quality, and fish habitat quality	■ The NSDF Project footprint (SSA) has been designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily/interim cover daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. ■ A 30 m buffer will be established along identified wetlands near the SSA; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion ■ Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site will be used during construction around disturbed areas, where appropriate. ■ During the construction phase, erosion and sediment control measures include the use of erosion control blankets to control erosion on steep slopes, and the use of check dams in ditches and swale. ■ Surface water from all external areas will be conveyed by ditches, swales and culverts to surface water management ponds (SWMPs) to address water quality and water quantity criteria established for the wetland receiving waters. ■ Where drainage crosses roadways, culverts are sized to convey the 25-year design event without road overtopping. ■ The SWMPs are designed to address erosion and sediment control concerns during construction by providing interim sediment control and by providing water quality/quantity controls during operations, closure and post-closure. ■ Annual maintenance activities will identify any erosion problems. ■ Inspection and maintenance reviews will be completed after major storm events and after the annual spring melt to confirm there are no major erosion issues.	No Linkage
	Changes to the hydrology within the Perch Creek and Perch Lake Watershed as a result of the intake of water from the Ottawa River for construction activities may cause changes to surface water quality and fish habitat quality		
	Surface water drainage through the SSA during construction of the ECM may transport blasting residuals and metals directly into downstream waterbodies, affecting surface water and sediment quality (i.e., fish habitat quality), and fish survival and reproduction	■ A blasting plan, as part of the EPP, will be developed by the Contractor and implemented for the NSDF Project. ■ Runoff from the SSA will be managed (e.g., SWMPs) to avoid adverse environmental effects in downstream waterbodies. ■ Additional guidance for the NSDF Project blasting limits will be obtained from *OPSS 120 – General Specification for the Use of Explosives* (OPSS 2014). ■ Blasting activities will follow industry standard Best Management Practices, applicable federal regulations, and Fisheries and Oceans Canada guidelines for use of explosives (Wright and Hopky 1998). ■ Set-back distances required for blasting will be identified in the blasting plan (as part of the EPP to be developed by the Contractor).	No Linkage
	Blasting near fish-bearing waterbodies may result in pressure changes, vibrations ("noise") and affect fish survival and reproduction.		No Linkage

Table 5.5.5-1: Pathways Analysis for Aquatic Biodiversity Valued Component

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment[a]
■ Project activities during the construction phase: ▪ Site Preparation ▪ Construction of the ECM ▪ Blasting (as required) ▪ Development of surface water management structures ▪ Construction of the WWTP and other support facilities ▪ On-site road and access development ▪ Construction of the transfer line and Perch Lake diffuser ▪ Domestic waste (solid and liquid) management	Physical change to fish habitat and temporary riparian area disturbances from the installation of diffuser and transfer line construction and footprint may affect fish and fish habitat	■ The selection of final routing alignment and foundation design considered an assessment of environmental effects of alternate routing alignments and foundation designs ■ All in-water work will target the timing window of July 16 to October 1 to avoid critical fish spawning and egg/larval development periods for spring spawning fish species (DFO 2013, MNR 2013) while being protective of turtle overwintering habitats in and around Perch Lake. The construction duration is anticipated to be short term (i.e., <30 days). ■ Mitigation, including erosion and sediment control practices (e.g., silt fences, silt curtains), will be used during construction around disturbed areas, where appropriate. Key fish habitat protection measures will include turbidity curtains to isolate any suspended sediments in the construction work areas within the lake. ■ Industrial equipment will be well maintained and free of leaks, invasive species and noxious weeds. Machinery will be operated from above the high-water mark or from a barge to minimize the disturbance of the lakebed, riparian area, and shoreline. Vegetative mats and riparian protection measures will be used when mobilizing to and from the site. ■ Clearing of any riparian vegetation and organic materials will be minimized, materials removed will be salvaged and replaced once the project is completed. Disturbed riparian areas and shorelines will be re-vegetated and restored to the original stable gradient and contour. All construction materials will be removed from site upon completion of the project. ■ A site-specific Erosion and Sediment Control Plan will be developed and implemented for this activity. ■ A site-specific 'Spill Management Plan' will be developed and implemented for this activity. Any refuelling will occur at least 30 m away from the lake or waterbodies. ■ Mitigation as described for drilling activities in the DFO Ontario High-Pressure Directional Drilling Operational Statement (DFO 2007) will be followed. ■ Environmental monitoring of ESC measures will be completed by a qualified professional. Environmental monitoring will include turbidity and total suspended solids monitoring; the monitoring details will be described in an 'Erosion and Sediment Control Plan' provided by the Project contractor prior to construction.	Secondary
	Non-radiological air emissions and dust emissions (including sulphur dioxide, nitrogen oxides and particulate matter) and subsequent deposition may cause a change in surface water quality and fish habitat quality	■ Implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018e), which includes operational control monitoring and verification monitoring. ■ The EPP, which will be developed by the Contractor, will align with CNL's Environmental Monitoring Programs and with the NSDF *Dust Management Plan* (AECOM 2018a) will include dust management mitigation measures and will include: ▪ restricting or suspending activities if unacceptable amounts of dust are generated due to winds or other site conditions; ▪ use of water spraying or misting techniques (e.g., water trucks) as the primary dust control method; ▪ use of fixatives (e.g., chemical suppressant) for dust control and for use as daily/interim cover daily ECM cover; ▪ suspension of excavating, loading, hauling and, and disposal operations when wind speeds exceed the specified criterion; and ▪ vehicles that have come into contact with potential contamination sources will be required to pass through the vehicle decontamination facility. ■ On-site vehicles and equipment engines will meet Tier 2 emission standards as described in Section 5.2 and be maintained in good working order. ■ Idling of vehicles will be limited on-site.	Secondary
	Discharge of domestic wastewater/sanitary sewage may cause a change in surface water and sediment quality, affecting fish habitat quality	■ The grey water/sanity sewage will be managed through a gravity sewer network connected to the two sewage disposal systems as described in Section 3.4.4.4. These systems are completely separate from the ECM leachate and other contact water sewer conveyance for the on-site WWTP. ■ Sewage discharges to the sewage disposal systems will conform with CNL's procedure *Acceptability Criteria for Routine and Non-Routine Discharge of Liquids on the CRL Site* (CNL 2015b).	No Linkage

Table 5.5.5-1: Pathways Analysis for Aquatic Biodiversity Valued Component

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment[a]
■ Project activities during the construction phase (as listed above) ■ Project activities during the operations phase: ▪ Phased development of disposal cells in the ECM ▪ On-site transportation of waste and placement in the ECM ▪ Progressive closure of disposal cells and installation of final cover ▪ Operation of the WWTP ▪ Existing presence of fencing around perimeter of ECM ▪ Surface water management ▪ Domestic waste (solid and liquid) management; and, ▪ Routine operational management and monitoring activities.	Surface water runoff from the SSA can contain contaminants and suspended solids, which can affect water quality, ultimately leading to changes to fish habitat quality, survival and reproduction	■ Procedures for surface water management will be developed and implemented for the NSDF Project. ■ The target surface water quality objective is provided in *Stormwater Management Planning and Design Manual* (MOE 2003). ■ Surface water from all external areas will be conveyed by ditches, swales and culverts to SWMPs that will address water quality and water quantity criteria established for the wetlands and Perch Lake receiving waters and, ultimately, Perch Creek. ■ The SWMPs are designed to address erosion and sediment control concerns during construction by providing interim sediment control and by providing water quality/quantity controls during operations, closure and, and post-closure. ■ The current SWMP designs reflect the overall storage required to control post-closure flows to predevelopment levels for the 2-year through to 100-year rainfall events at the site. This volume also contains the storage required for sediment control during construction and water quality control during operations. ■ Where drainage crosses roadways, culverts are sized to convey the 25-year design event without road overtopping. ■ For each SWMP the water level will be sampled to estimate the inflow and outflow of each pond. ■ The outlet water quality will be sampled periodically to confirm that surface water discharges meet applicable environmental criteria.	No Linkage
	Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) can cause changes to downstream surface water quality, which can affect fish habitat quality, survival and reproduction	■ The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses best available technology that is economically achievable) and, and capable of meeting regulatory requirements. ■ Effluent discharge targets for wastewater discharges are protective of the environment and human health. ▪ Discharge targets for non-radiological contaminants are sourced from federal and provincial guidelines for protection of aquatic biota. ▪ Discharge targets for radionuclides are the Canadian Drinking Water Guidelines with the exception of tritium for which a site-specific target is developed (Section 3.4.2.5.1). ■ Treated effluent will be sampled to confirm that it meets effluent discharge targets before release to the environment. ■ When applied, the proposed exfiltration gallery will promote the exfiltration of treated water into the local groundwater regime where further retention of radioactivity by the geosphere is anticipated. ■ The Perch Lake diffuser design provides additional dilution of treated effluent at the point of release ■ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water quality. ■ Appropriate procedures will be in place to effectively identify spill occurrences in the event treated effluent is released to areas other than directly to the exfiltration gallery and initiate appropriate emergency responses.	Secondary
	Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) and the discharge of non-contact water to adjacent wetlands can cause changes to hydrology, resulting in scouring of the wetlands, which can affect fish habitat quality at downstream waterbodies	■ Discharge of treated effluent to the exfiltration gallery area will help to reduce water loss from the hydrogeological system. ■ Design consideration was given during the selection of the discharge location of treated effluent for environmental effects of scour on the receiving waterbodies. As such, the preferred design (i.e., discharge to the exfiltration gallery and Perch Lake diffuser) was chosen as the favourable alternative as they resulted in negligible scour potential. ■ Outlet flows from all three SWMPs will be dispersed by level spreaders that will provide an even flow distribution to the adjacent wetlands with an appropriately wide dispersal pattern. ■ The WWTP system's outlet utilizes a headwall which discharges to a level spreader for the purposes of preventing erosion and sedimentation at the outlet for the exfiltration gallery. ■ The outlet locations of the SWMPs are limited by the site boundary (greater than 5 m separation required) so that there is no discharge from the spreader directly to a waterbody. ■ Annual inspection and maintenance activities will identify any erosion problems. ■ Inspections will be undertaken and maintenance activities completed, as required, after major storm events and after the annual spring melt to confirm there are no major erosion issues.	No Linkage

Table 5.5.5-1: Pathways Analysis for Aquatic Biodiversity Valued Component

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment[(a)]
■ Project activities during the operations and closure phases: ▪ Surface water management ▪ Operation of the WWTP ▪ Discharge of treated effluent from the WWTP	Discharge of treated effluent through the Perch Lake diffuser may create an area of turbulence that affects water quality, affecting fish habitat quality	■ The final design considered an evaluation that addressed the environmental effects through alternate routing alignments and foundation designs that resulted in a favourable alternative that addressed economic, environmental and technical factors. ■ The diffuser will be positioned in the water column and designed to avoid excess sediment mobilization and turbulence. ■ Discharge will be directed through properly designed structures to the lake environment to prevent erosion and sediment entrainment in the receiving waters. ■ The diffuser discharge ports will be located 0.8 m above the lakebed to minimize erosion. ■ Direct discharge flow rates will be developed and maintained to address erosion concerns.	Secondary
	Leakage of leachate from the ECM during the operations and closure phases may cause changes to groundwater quality, affecting surface water quality in East Swamp Stream and downstream waterbodies, which can affect fish habitat quality, survival and reproduction	■ Design of the ECM includes base contours developed using a herringbone pattern with ridges and valleys to promote leachate transport to the leachate collection system for removal. ■ The base liner design includes primary and secondary liner systems designed to have redundancy in case of premature degradation and are a combination of natural and synthetic barrier systems. These include a compacted clay liner (CCL), two geosynthetic clay liners (GCL) and an HDPE geomembrane. ■ Clay materials were selected for the CCL and GCL components of the liner system as these materials are anticipated to maintain their function as hydraulic barriers throughout and beyond the design life of the disposal facility (i.e., 550 years). ■ The HDPE geomembrane design for the liner will be compatible with the leachate generated by the waste and provide a long service life. ■ The base liner system will include an underlying compacted clay liner to supplement the primary and secondary liner system. ■ The leachate collection system design will provide accessible access points for inspections, maintenance, repairs and replacements. ■ Appropriate responses to leachate leakage and contamination will be implemented as described in the Operations and Maintenance Plan and Contingency Plan	No Linkage
	The installation of the final cover of the ECM and decommissioning of NSDF Project infrastructure may change downstream discharge, water levels and, and channel/bank stability, affecting surface water and sediment quality (i.e., fish habitat quality)	■ The final cover is designed to promote positive drainage from the SSA and reduce erosion or abrasion of the final cover. ■ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound and minimize leachate generation. ■ The final cover system design incorporates a series of shallow, trapezoidal and lined drainage channels designed to convey water at low velocity. ■ The perimeter road ditch will route runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the final cover and underlying waste materials, destabilization of the ECM structure and, and damage to access roads. ■ The ECM final grading and drainage plan includes collection ditches along the top of the ECM berm road to collect side slope drainage. ■ Environmental monitoring will be completed as required during the institutional control period for the NSDF Project to confirm that the final cover is functioning as intended.	No Linkage
	Leakage of leachate from the ECM during the post-closure phase (i.e., after Year 2100 to 2400) from liner and final cover degradation as a result of normal evolution may cause changes to groundwater quality and downstream surface water quality in adjacent wetlands, affecting fish habitat quality, survival and reproduction.	■ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the ECM and minimize leachate generation. ■ The final cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity. ■ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the final cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. ■ The ECM final grading and drainage plan also includes collection ditches along the top of the ECM berm road to collect side slope drainage. ■ The design life for the ECM is 550 years to meet the required time period to allow for radioactive decay of the waste placed in the facility (i.e., until it has decayed to levels that do not present a risk to the public and environment). ■ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water and groundwater quality.	Secondary

a) All pathways assessed were determined to provide ‘No Linkage’ for Species of Conservation Concern VC and assessment designations are provided for Fish Habitat and Fish Community VCs.

WWTP = Wastewater Treatment Plant; ECM = engineered containment mound; SSA = Site Study Area; SWMPs = surface water management ponds; EPP = Environmental Protection Plan; OPSS = Ontario Provincial Standard Specification; DFO = Fisheries and Oceans Canada; <= less than; TSS = total suspended solids; HDPE = high-density polyethylene.

5.5.5.2.1 No Linkage Pathways

The following pathways were assessed as having no measurable effect on habitat availability, survival, and/or reproduction, and therefore, the pathways have no linkage to residual effects on aquatic biodiversity VCs.

- **Changes to local hydrology from surface disturbances may cause changes to water levels, flows and channel/bank stability at downstream locations, affecting water and sediment quality, and fish habitat quality.**
- **The installation of the final cover of the engineered containment mound (ECM) and decommissioning of NSDF Project infrastructure may change downstream discharge, water levels and channel/bank stability, affecting surface water and sediment quality (i.e., fish habitat quality).**

Changes to surface flows, water levels and water quality from NSDF Project construction and decommissioning are expected to be limited using environmental design features and mitigation. The NSDF Project footprint was designed to be as small as possible to limit disturbance to the natural environment to the extent feasible and will avoid stream and wetland habitats. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily/interim ECM cover. This approach reduces the required area for the laydown and stockpile of materials. In addition, a 30-m buffer is established along the identified wetlands near the NSDF Project; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion.

All proposed physical works are located within the SSA, affecting a relatively small area (5.1%) of the total contributing basin area for Perch Creek (720 ha; Robertson and Barry 1985). The total land area to be cleared is up to 37.4 ha, of which 35.6 ha is within the boundary of the Perch Creek and Perch Lake Watershed representing 4.8% of the contributing basin area (746 ha). The remaining small footprint (1.8 ha) will overlap with the CRL Built Up Area drainage basin. Any changes to existing drainage patterns will largely be restricted to the Perch Creek and Perch Lake Watershed. The total annual volume of water to be treated is 11,000 m^3. The volume represents approximately 0.6% of the average total outflow from Perch Lake (1,700,000 m^3/yr), or 0.5% of the average total outflow from Perch Creek (2,200,000 m^3/yr). Operational treated effluent discharge is expected to be less than 11 m^3/hr. Flow rates within Perch Creek are approximately 252 m^3/hr; the effluent discharge rate is roughly 0.4% of the average Perch Creek flows and approximately 11.5% of East Swamp weir flows. Furthermore, the receiving wetlands are expected to buffer the discharge, further reducing flow rates into Perch Creek.

All non-contact and contact water will be managed within the SSA, as per the Surface Water Management Plan that has been developed, reducing the potential for the NSDF Project to affect downstream discharge, water levels and channel/bank stability. Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site will be used during construction and decommissioning around disturbed areas.

Closure activities include the installation of an engineered cover and a final cover over the ECM to limit ponding and water infiltration into the waste. Modification to the drainage ditches and conveyance channels will be made to promote positive drainage from the site and limit erosion or abrasion of the final cover. Runoff control for the final cover is designed to limit ponding and infiltration of water into the ECM, erosion of the final cover and waste material, and destabilization of the structure. The ECM design approach is to control the direction and velocity of the run-off to prevent erosion and abrasion of the final cover. Any surface water infiltrating the final cover will be collected by the leachate collection system and sent to the WWTP. The three SWMPs will remain to promote infiltration and settlement of suspended solids and restrict discharge rates to the nearby wetland. Decommissioning of the WWTP and all associated surface water management structures will be completed after the leachate quantity and quality no longer requires treatment. If the WWTP is required beyond its design life, the unit would be refurbished to enable continued treatment of leachate or other treatment options investigated. Environmental monitoring will be completed throughout the 300-year institutional control period for the NSDF Project to confirm that the final cover is functioning as intended.

Implementation of the above described mitigation measures for the NSDF Project are expected to limit changes to downstream discharge, water levels and, and channel/bank stability in affected streams such that residual effects are not predicted for fish habitat quality. As such, this pathway was identified as a no linkage pathway for aquatic biodiversity VCs.

- **Changes to the hydrology within the Perch Creek and Perch Lake Watershed as a result of the intake of water from the Ottawa River for construction activities may cause changes to surface water quality and fish habitat quality.**

The NSDF Project construction phase will be carried out from 2021 to 2023. During the construction phase, CNL anticipates an average daily usage of approximately 110 to 150 m^3/day for construction activities (e.g., dust suppression, clay mixing and fire protection). Construction water use is expected to peak at approximately 750 m^3/day and to be lower during the winter season (December through to March) when construction activities will be less. The water may also be used for commissioning activities including hydrostatic testing of the WWTP storage tanks, the leachate collection and piping systems. Construction water will be sourced from the Ottawa River and accessed via overland hoses and pipes to fill temporary storage containers.

The intake of water from the Ottawa River for construction purposes (i.e., up to a maximum of 276,000 m^3/yr based on the peak daily usage) is anticipated to have a negligible effect on the overall Ottawa River annual flow rate of 25 billion m^3/yr (as recorded at the Des-Joachims monitoring point) and on the downstream hydrology. The proposed diverted annual volume for construction represents 0.0011% of the total annual flow rate of the Ottawa River at Des-Joachims using conservative assumptions of annual volumes based on peak daily flow and construction taking place during the winter months. Actual water use for construction is anticipated to be lower than proposed; for example, during winter months, site activities do not require as much water as during the open water construction periods. Consequently, no changes to aquatic biodiversity VCs in the Ottawa River are anticipated.

Similarly, changes to the surface water quality within the Perch Creek and Perch Lake Watershed as a result of the intake of water from the Ottawa River for construction activities at the SSA are not anticipated. Water is used for various construction activities, such as dust management control. Water used for dust management will primarily infiltrate or evaporate, any associated runoff will be collected and conveyed to the SWMPs. Overall, the water use for construction activities pathway was determined to be a no linkage pathway for aquatic biodiversity VCs.

- **Surface water drainage through the SSA during construction of the engineered containment mound (ECM) may transport blasting residuals and metals directly into downstream waterbodies, affecting surface water and sediment quality (i.e., fish habitat quality), and fish survival and reproduction.**

Use of ammonium nitrate/fuel oil and water-resistant bulk emulsion explosives during the construction of the ECM has the potential to affect surface water quality in the Perch Creek and Perch Lake Watershed through runoff coming into contact with residual nitrogen material (e.g., nitrate and ammonia) in the construction area. A blasting plan will be developed by the Contractor as part of the EPP for the Project, which will comply with existing guidelines (Wright and Hopky 1998; DFO 2019; OPSS 2014). Any runoff in contact with blasting residues at the SSA will be managed according to the Surface Water Management Plan (e.g., SWMPs and associated systems) during the construction phase. In addition, the potential for transporting blasting residuals into downstream waterbodies is minimized as blasting operations are limited to a relatively short period of time during the construction phase.

The use of explosives for the development of the ECM in the proposed NSDF Project is considered to potentially influence runoff quality with respect to minor increases in nitrate and ammonia concentrations for a short period in the construction phase. Therefore, the use of explosives for the development of the proposed NSDF Project is unlikely to result in changes in fish habitat quality in East Swamp Stream and downstream locations, including Perch Lake and Perch Creek. This pathway was determined to have no linkage to aquatic biodiversity VCs.

- **Blasting near fish-bearing waterbodies may result in pressure changes and vibrations (“noise”) and affect fish survival and reproduction**

Use of explosives near fish-bearing waters has the potential to injure or kill fish. Detonation of explosives in or near water creates compressive shock waves that rapidly rise to high peak pressures then rapidly decrease to below ambient hydrostatic pressure (Wright and Hopky 1998). The rapid decrease in pressure produced by blasting has the potential to negatively affect fish in the vicinity by damaging the swim bladder and other soft organs (Wright 1982). Fish eggs in the area affected by pressure waves can be damaged by the movement of the substrate in which they are embedded (Wright 1982).

The NSDF Project will avoid any effects to fish and fish habitat through the implementation of set-back distances and by avoiding construction and related blasting activities in waterbodies and watercourses. A detailed blasting plan will be developed by the Contractor as part of the EPP and will contain contingencies and mitigations to reduce the potential for harm to fish and fish habitat. The blasting plan will comply with Fisheries and Oceans Canada *Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters* (Wright and Hopky 1998). Additional guidance will be obtained from *OPSS 120 – General Specification for the Use of Explosives* (OPSS 2014).

The anticipated quantities of blasted rock are approximately 170,000 m^3. There will also be an allowance made for additional trench blasting that may be required to facilitate utility runs. It is anticipated that the majority of blasted rock will be recycled for use within the construction of the engineered containment mound. Rock that cannot be recycled for reuse will either be stored at the CRL site or cleared for off-site use. Set-back distances required for blasting will be determined and included in the Blasting Plan. Charge sizes, blasting sequences and any additional measures required to deaden vibrations (i.e., strategic positioning of aggregate material) will be described in the Blasting Plan.

The use of explosives for the development of the proposed NSDF Project is predicted to not measurably change survival or reproduction measurement indicators for fish species in the LSA. It is therefore anticipated that this pathway has no linkage with aquatic biodiversity VCs.

- **Discharge of domestic wastewater/sanitary sewage may cause a change in surface water and sediment quality, affecting fish habitat quality.**

The NSDF's sanitary conveyance system is designed to convey the peak sewage flows generated by up to 65 full-time employees (although this will be adjusted based on operational demand) whom will work at the NSDF Project. The NSDF sanitary sewage will be managed through a gravity sewer network connected to a sewage disposal system. This system is completely separate from the ECM leachate and other contact water sewer conveyance for the on-site WWTP.

There are two site sewage disposal systems proposed to service the NSDF site. A detailed description of the system is presented in Section 3.4.4.4.

Sewage discharges to the sewage disposal systems will conform to CNL requirements for discharge to septic systems provided in the NSDF *Environmental Protection Plan* (AECOM 2018b) and *Acceptability Criteria for Routine and Non-Routine Discharge of Liquids on the CRL Site* procedure (CNL 2015b). As such, discharge of treated domestic wastewater for the NSDF Project to downstream locations is considered to have no linkage to effects on aquatic biodiversity VCs.

- **Surface water runoff from the SSA can contain contaminants and suspended solids, which can affect water quality, ultimately leading to changes to fish habitat quality, survival and reproduction.**

A variety of mitigation strategies will be implemented during all project phases to reduce the potential for changes to soil, water and vegetation quality from surface water runoff from the CRL site. These include surface water management, erosion and sediment control measures, SWMPs, maintenance and inspection activities, and monitoring.

Site operations include surface water management for the ECM and all external areas. Surface water from all external areas will be conveyed by ditches, swales and culverts to SWMPs that will address water quality and water quantity criteria established for the wetland receiving waters and, ultimately, Perch Creek. Contact water, which is exposed to waste within the ECM, will drain from the active cells of the ECM and be conveyed to the WWTP. Non-contact water drainage from completed cells and yet-to-be completed cells will be directed either by gravity to the external surface water management system or to temporary holding ponds within the ECM, then pumped to the three SWMPs.

During the construction phase, erosion and sediment control measures will be in place to mitigate the effects of soil erosion and sediment transport. The measures include use of erosion control blankets, as needed, to control erosion on steep slopes. Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site (i.e., CNL's *Management of Land, Habitat and Wildlife* procedure [CNL 2018f] will be used around disturbed areas within the CRL site, where appropriate. Furthermore, an Environmental Management Plan has been developed as part of the design plan for the site outlining the erosion and sediment control measures and SWMP construction schedule discussed. It additionally outlines administrative protocols such as training, contractor document submissions and staffing required for effective surface water management throughout all phases of the NSDF Project.

The SWMPs are designed to address erosion and sediment control concerns during construction by providing interim sediment control and by providing water quality/quantity controls during operations, closure and post-closure. The current SWMP footprints reflect the overall storage required to control post-closure flows to predevelopment levels for the 2-year through to 100-year rainfall events at the site. This volume also contains the storage required for sediment control during construction and water quality control during operations. The target surface water quality objective of 60% TSS removal that provides basic water quality treatment for discharge to the receiving wetland is provided in the *Stormwater Management Planning and Design Manual* (MOE 2003). The SWMPs #1 will meet 80% total suspended solids removal which will provide enhanced water quality treatment. SWMP #2 will provide 76% TSS removal and SWMP #3 will meet 60% total suspended solids removal during operations which will be sufficient because the receiving waterbody is a wetland and not a watercourse. The wetland functions as a sediment trap that will provide additional treatment prior to stormwater reaching any watercourses in wetlands.

Roadway, sidewalk and parking lot winter maintenance activities that may release road salt to the environment, include snow plowing/shoveling and de-icing practices, salt and sand storage and snow stockpiling, and removal and disposal. The winter maintenance practices outlined in the current CRL *Salt Management Plan* (AECL 2013) provide for effective management of salt use and will be applied to the NSDF Project as necessary. As per the plan, the application of road salt in the SSA will be to be limited as salt residual within contact water and/or leachate may compromise the treatment effectiveness of the WWTP systems. Instead, alternative products in winter road management, such as a sand-stone mixtures, are currently being considered.

Facility inspections will be completed on a defined schedule to confirm that inlets and outlets are clear of debris and to confirm that there are no major erosion issues at the inlet or outlet. As well, the integrity of berms and outlet structures will be confirmed by visual inspections that would identify soil erosion. Inspections will identify sediment clean-out requirements. Sediments will be extracted by excavation equipment and will be disposed of based on sediment sampling, testing and classification according to Ministry of Environment, Conservation and Parks standards or stockpiled, dewatered and reused on-site for daily ECM cover operations. The sediment removal assessment follows procedures identified in the *Stormwater Management Planning and Design Manual* (MOE 2003).

The implementation of proposed mitigation at the SSA will reduce the potential for changes to soil, water and vegetation quality from surface water runoff from the NSDF Project. As such, this pathway was determined to have no linkage to aquatic biodiversity VCs.

- **Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) and the discharge of non-contact water to adjacent wetlands can cause changes to hydrology, resulting in scouring of the wetlands, which can affect fish habitat quality at downstream waterbodies**

The NSDF Project will generate two water streams which will have the potential to impact water flows and levels in wetlands including:

- treated effluent from the WWTP which will be routed to the exfiltration gallery or Perch Lake; and
- non-contact water (i.e., water that has not been contaminated through contact with the ECM) which will be managed through a series of SWMPs.

A Surface Water Management Plan will be implemented to mitigate effects from wastewater discharges. Most of the wastewater flow will be generated from non-contact water produced during active filling of the ECM; contributions by leachate and decontamination activities represent a small fraction of the overall wastewater that will be treated by the WWTP. The total annual volume of water to be treated is 11,000 m^3. The volume represents approximately 0.6% of the average total outflow from Perch Lake (1,700,000 m^3/yr), or 0.5% of the average total outflow from Perch Creek (2,200,000 m^3/yr). Operational treated effluent discharge is expected to be a maximum of approximately 11 m^3/hr with an average effluent discharge rate below 1 m^3/hr. Flow rates within Perch Creek are approximately 252 m^3/hr; the maximum effluent discharge rate is roughly 0.4% of the average Perch Creek flows and approximately 11.5% of East Swamp weir flows. During the operations phase, the additional infiltration applied at the exfiltration gallery results in a localized increase in water table elevation of up to 1 m compared to the current conditions (see Section 5.3.2.6).

An exfiltration gallery is proposed at the discharge outlet for the treated effluent to promote the exfiltration of treated water into the local groundwater regime. Treated effluent will also be discharged directly to Perch Lake via a transfer line. The transfer line to Perch Lake has been designed to manage the full annual volume of treated effluent, if required, which will prevent the potential for overland flow at the exfiltration gallery.

The major flow system for all three SWMPs, which manage non-contact water, will outlet to adjacent wetlands and will be dispersed by level spreaders that will provide an even flow distribution to the wetlands with an appropriately wide dispersal pattern. Current SWMPs outlet locations are limited by the site boundary (greater than 5 m separation required) so that there is no discharge from the spreaders directly to the wetlands. Local topography between the level spreaders and the wetlands, as well as any setbacks, has influenced the location of the on-site level spreaders.

Annual maintenance activities will identify any erosion problems. Facility inspections will be completed twice annually to confirm that inlets and outlets are clear of debris and to confirm that there are no major erosion issues at the inlet or outlet. In addition, inspection and maintenance reviews will be completed after major storm events and after the annual spring melt to confirm there are no major erosion issues at the dispersion outlets. Overall, changes to downstream discharge, water levels and channel and bank stability resulting from operational discharges of treated effluent and non-contact water will be localized to the receiving wetland. As a result of the design of SWMP outlets and the proposed low discharge rates (i.e., 1 m^3/hr), the discharge of treated effluent and non-contact water to receiving wetlands is not predicted to result in changes to water levels, flows and channel/bank stability, that would affect habitat quality at downstream locations. As a result, this pathway was determined to have no linkage to aquatic biodiversity VCs.

- **Leakage of leachate from the ECM during the operations and closure phases may cause changes to groundwater quality, affecting water surface water quality in downstream waterbodies, which can affect fish habitat quality, survival and reproduction.**

Design of the ECM includes base contours that have been developed using a herringbone pattern with ridges and valleys to promote leachate transport to the leachate collection system for removal. The base liner design includes both primary and secondary liner systems that are designed to provide redundancy in case of premature degradation and are a combination of natural and synthetic barrier systems. The primary liner includes a leachate collection system with the secondary liner housing a leak detection system. The composite base liner contains perforated high-density polyethylene (HDPE) collection and pipes. The HDPE geomembrane was selected as it is compatible with the leachate generated by the waste and is expected to perform as an effective hydraulic and diffusion barrier over the 550-year design life (see Section 3.4.1.4). The base liner system includes an underlying compacted clay liner to supplement the primary and secondary liner system. The leachate collection system design provides access points for inspections, maintenance, repairs and replacements.

The primary liner system will contain the leachate collection system and will convey leachate to a single collection point for removal from the mound, for transfer to the WWTP for treatment. The primary liner system serves as the primary source of protection for the natural environment below the mound from leachate migration. The secondary liner system will contain the leak detection system, which will be used to detect leaks in the unlikely event that the primary liner system fails. Leachate collected by the leachate collection system will be pumped to the on-site WWTP for treatment.

Perimeter berms consist of three main geotechnical elements, or layers, each contributing to the soundness and integrity of the berm itself and the whole ECM. A *Slope Stability Analysis* (AECOM 2018c) was completed to provide the information needed to support the design of the base slopes, sidewalls and side slopes of the ECM. The Slope Stability Analysis addresses the range of anticipated loading conditions, under both short-term and long-term scenarios, to confirm that the slope designs will satisfy minimum factor-of-safety requirements for stability. Size and shape of the berms and each of the elements and layers were determined using a seismic design basis, including the National Building Code of Canada.

The implementation of the above mitigation will limit the potential for changes to groundwater and surface water quality from the NSDF site. As such, this pathway is determined to have no linkage with aquatic biodiversity VCs as there will be no measurable effects on fish habitat quality and survival and reproduction measurement indicators.

5.5.5.2.2 Secondary Pathways

The following pathways were assessed as potentially having a minor effect on habitat availability, survival, and/or reproduction; however, the pathways result in a negligible residual effect on the aquatic biodiversity VCs relative to the Base Case.

- **Physical change to fish habitat and temporary riparian area disturbances from the installation of diffuser and transfer line construction and footprint that may affect fish and fish habitat.**

Water management strategies for treated effluent include the use of a proposed discharge transfer line (320 m) with a diffuser positioned in Perch Lake (Figure 5.5.5-1). As part of the installation of the discharge transfer line, the open water section of the transfer line will include a foundation installed with steel pile supports for both the transfer line and diffuser. This design was selected from four discharge options and was considered both technically and economically feasible. The preferred design to support the transfer line was also chosen over a gravel fill foundation, as it provided a much smaller footprint on the lakebed. The discharge transfer line will be constructed using 0.10 m diameter pipe and will be supported by approximately five pairs of piles spaced at approximately 50 m intervals along the discharge transfer line. The submerged diffuser will comprise one 28.2 mm (inside diameter) port, extending 0.8 m above the lakebed sediments to limit disturbance. The diffuser will rest on a pile cap supported by approximately four piles. The footprint of the discharge transfer line was estimated using the entire pipe length across Perch Lake of 320 m multiplied by a pipe diameter of 0.10 m, resulting in a conservative estimation of the permanent footprint of the transfer line as 32 m^2. Additional details regarding the transfer line are available in Section 3.4.2.6.2.

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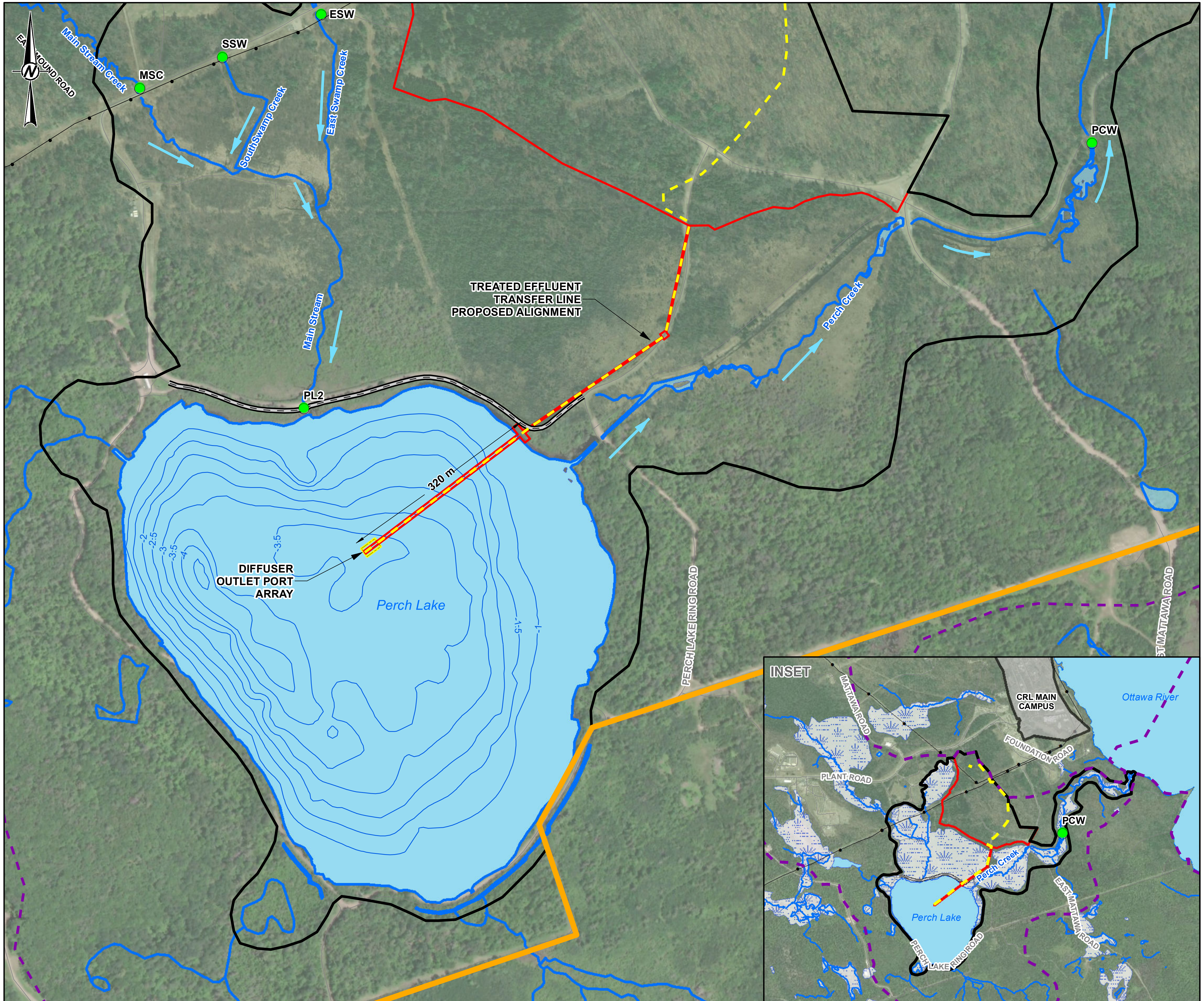

LEGEND

- WEIR[1]
- FLOW DIRECTION
- RAISED ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- BATHYMETRIC CONTOUR (0.5M INTERVAL)
- WATERBODY
- WETLAND
- TRANSFER LINE (UNDERGROUND / UNDER WATER)
- SITE STUDY AREA (NSDF PROJECT SITE)
- CRL SITE
- CRL MAIN CAMPUS
- LOCAL STUDY AREA
- REGIONAL STUDY AREA

100 0 100 200

1:34,000 METRES

NOTE(S)

1. PCW = PERCH CREEK WEIR
ESW = EAST SWAMP WEIR
SSW = SOUTH SWAMP WEIR
MSW = MAIN STREAM CULVERT
PL2 = PERCH LAKE 2 WEIR

REFERENCE(S)

1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. IMAGERY: SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
3. BATHYMETRIC CONTOURS PROVIDED BY CNL (JUNE 2018)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

TITLE
POTENTIAL DISCHARGE TRANSFER LINE LOCATION AND PERCH LAKE BATHYMETRY

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO/PR
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	3300, 3311	FINAL 2	5.5.5-1

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Of the 320 m transfer line length, approximately 23 m of the discharge line will be within the riparian marsh/ shoreline area of the lake. Excavation and dredging activities will be required for a shallow trench (2 m deep by 2 m wide) for the placement of the discharge transfer line (total affected area would less than 46 m^2). Vegetated materials and organic debris will be stockpiled during dredging/excavation and then used to remediate disturbed areas as construction stages are completed.

The construction (temporary) footprint for the installation of the transfer line will be minimized where possible. Within the riparian marsh/shoreline section of the transfer line, vegetation mats will be used to mitigate disturbance to shoreline areas from any heavy equipment. The construction (temporary) footprint also includes a barge launch pad within a footprint of approximately 300 m^2 (i.e., 10 m × 30 m), occupying a riparian / shoreline area and possibly extending into the water to a depth of less than 1 m. The barge launch pad will be required to support the barge and drill rig assembly. The launch pad will be lined with geogrid/geotextile material and gravel. The pad will be removed post-construction and affected riparian and shoreline areas will be remediated through the re-vegetation of the disturbed area.

For the open water section of the transfer line in Perch Lake, drill pilings are expected to be completed by staged construction and therefore, it is assumed that an active work area at any given time will be restricted to the vicinity of the barge location where a pile or piles will be installed (Golder 2018). These active work areas will be contained by turbidity curtains to capture and limit the extent of any suspended sediments (i.e., 5 m wide temporary work area). Construction activities will also avoid any sensitive periods for resident fish species. Specifically, in-water construction work will be completed within the recommended timing window of July 16 to March 14 to avoid any effects to spawning and egg/larval development of spring spawning fish species in Perch Lake (i.e., in-water work will avoid the restricted period of March 15 to July 15; DFO 2013).

Potential changes in sediment concentrations from the use of heavy machinery during the construction period will be mitigated using erosion and sediment control measures, such as turbidity curtains for the duration of the construction. Best management practices will be followed, including those identified in the NSDF *Environmental Protection Plan* (AECOM 2018b). Prior to construction, an Environmental Protection Plan will be developed by the Contractor listing measures for erosion and sediment control as well as spill management. With the application of best management practices and relevant mitigation applied, no measurable residual effects to fish habitat and fish community assessment endpoints are anticipated from construction. There will be no measurable changes to the productivity of the fishery in Perch Lake. The Project has a relatively small permanent footprint of the lake bottom (i.e., 32 m^2) and any changes to fish habitat quantity and quality during construction, such as elevated levels of suspended sediments, would be temporary in duration. Overall, changes to habitat quality in Perch Lake from the placement of the discharge transfer line are expected to have negligible residual effects on the Fish Community and Fish Habitat VCs, and are expected to have no linkage to the Fish Species of Conservation Concern VC.

- **Discharge of treated effluent through the Perch Lake diffuser may create an area of turbulence that affects water quality, affecting fish habitat quality.**

Water management strategies for the discharge of treated effluent include discharging a portion of the treated effluent through a transfer line with a diffuser located in a deep location of Perch Lake. The discharge transfer line will connect to a discharge point that rests on a pile cap. The submerged diffuser will extend vertically 0.8 m above the lakebed sediments to avoid disturbance of the substrates. The average discharge rate from the diffuser is anticipated to be 11.25 m^3/hr (Golder 2019), a small proportion of the annual average flow at the Perch Lake outlet which is approximately 205.2 m^3/hr (CNL 2017c). At the diffuser outlet the velocities are anticipated to be 5.01 m/s and above background standing water conditions (i.e., mean of 0.034 m/s during open water) from the discharge port in the mixing zone (Golder 2019). However, the diffuser was designed to reduce the effects of increased velocity within the lake through a vertical design of the diffuser that will reduce turbulence or sediment mobilization of the lakebed. Through consideration of a design to minimize erosion of the lakebed sediments, negligible residual effects to fish community and fish habitat are anticipated as a result of the operation of the diffuser in Perch Lake. This pathway was determined to be a no linkage pathway for the Fish Species of Conservation Concern VC.

- **Non-radiological air emissions and dust emissions (including sulphur dioxide, nitrogen oxides and particulate matter) and subsequent deposition may cause a change in surface water quality and fish habitat quality.**

The construction and operations phases of the NSDF Project will generate non-radiological air and dust emissions such as carbon monoxide, oxides of sulphur (includes sulphur dioxide), oxides of nitrogen (includes nitrogen dioxide), particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) and suspended particulate matter (SPM). Air emissions can result from the use of fossil fuels in generators, vehicles and machinery. Vehicle exhaust and fugitive dust from unpaved and paved roads is the largest contributor to particulate matter (SPM, PM_{10} and $PM_{2.5}$) during both construction and operations (see Section 5.2.1.6.2).

Implementation of mitigation measures are anticipated to limit predicted residual effects from NSDF Project emissions to air quality (and subsequently to aquatic biodiversity VCs) include: meeting Tier 2 emission standards for on-site vehicles and equipment engines, use of vehicles that are maintained in good working order and idling of vehicles on site will be limited consistent with CNL's Environmental Protection Program. Dust control will be conducted to support waste placement operations in accordance with the *Dust Management Plan* (AECOM 2018a) during loading, transportation, placement and compaction operations. Work areas that have the potential for generating dust will require implementation of dust suppression techniques. The primary dust control method will include water spraying or misting techniques (e.g., water trucks). Water application is controlled to avoid generation of free liquids. Fixatives (e.g., chemical suppressant) may also be used for dust control and for use as daily ECM cover. The use of fixatives is reviewed prior to application for potential effects on leachate and surface water runoff generated by the ECM.

Predicted concentrations for the Application Case during both construction and operations phases are below applicable air quality guidelines and/or standards with the exception of nitrogen dioxide, that will not meet the 2020 1-hour CAAQS (Section 5.2.1.6.2, Table 5.2.1-14). The contributing factor to the high magnitude nitrogen dioxide emissions is the heavy-duty construction equipment and the conservative assumption that all equipment will run simultaneously and continuously during working hours. In reality, individual equipment will be idling or off for varying parts of the workday that cannot be predicted but will result in lower emissions than currently estimated. The likelihood that all equipment operates simultaneously for an hour or more along with unfavourable weather conditions to produce the maximum concentrations modelled is very low. With the implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018e) and through the implementation of the *Dust Management Plan* (AECOM 2018a) for the NSDF Project, air and dust emissions and subsequent deposition are expected to result in minor and local changes to water quality relative to Base Case conditions. Therefore, this pathway was determined to have negligible effects on Fish Habitat and Fish Community VCs for contributing waterbodies and watercourses within the Perch Creek and Perch Lake Watershed. This pathway was also determined to have no linkage to the Fish Species of Conservation Concern VC.

- **Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) can cause changes to downstream surface water quality, which can affect fish habitat quality, survival and reproduction.**

The WWTP for the NSDF Project will be a new, stand-alone facility with a new discharge point. The WWTP will treat leachate generated in the ECM during the operations and closure phases. The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses best available technology that is economically achievable and capable of meeting regulatory requirements.

The radionuclide concentrations in wastewater will be a combination of the leachate concentrations and the leachate volume, combined with the contact water and decontamination volumes. The contact water is assumed to have very low radionuclide concentrations because of the effects of daily ECM cover and water management practices within the disposal cell. Decontamination water is assumed to have the same radiological and chemical characteristics as the wastewater from the ECM. In the absence of quantitative information, non-radiological waste constituents were developed from information gathered from other sites and the expected characteristics of wastes to be disposed of in the NSDF. These values present a reasonable and conservative estimate of concentrations in wastewater such that the WWTP design is capable of treating wastewater to meet effluent discharge targets (as described in Section 3.4.2.2, Tables 3.5.3-2 and 3.5.3-3).

Treated effluent will be sampled and confirmed that it meets effluent discharge targets before release to the environment. A portion of the treated effluent from the WWTP will be released to an exfiltration gallery to promote the exfiltration of treated water into the local groundwater regime; from here, small quantities of residual contaminants will migrate from the East Swamp Wetland to East Swamp Stream. The remaining treated effluent will be released into Perch Lake using a submerged diffuser. It is anticipated that the diffuser placement will result in a ten-fold dilution of any treated effluent discharge to Perch Lake within 100 m of the discharge (Golder 2019). The East Swamp Stream flows into Main Stream and then Perch Lake, which is connected to the Ottawa River through Perch Creek.

Both aquatic and terrestrial species will be exposed to contaminated surface water and sediment in the East Swamp Stream, Perch Lake, Perch Creek, and possibly the Ottawa River. Doses to non-human biota were calculated based on water concentrations from East Swamp Stream. Although dilution will occur in Perch Lake, Perch Creek and the Ottawa River, the exposure limits within the aquatic environment was conservatively assessed to match that of East Swamp Stream during the period of leachate management system and WWTP operations. Doses to non-human biota were calculated based on the waterborne and airborne emissions from the ECM and assessed against the most conservative criteria available such as Environmental Quality Guidelines (CCME 2019) for non-radiological contaminants and No-Effect Concentrations for non-human biota derived for the boreal Canadian Shield forest ecosystem (Arcadis 2019) for radiological contaminants. The NSDF Project is confident that there will be no adverse effects to biota during operations phase by ensuring that releases and subsequent environmental concentrations are below the relevant guidelines or are below levels that would result in potential adverse effects on aquatic life as summarized in Section 5.7.6.2.1.

Many of the site's existing WMAs, including WMAs A and B and the Liquid Dispersal Area (which includes Reactor Pit 1, Reactor Pit 2 and the Chemical Pit) may also affect the Perch Creek and Perch Lake Watershed. Contaminants are transported by groundwater to nearby wetlands, including East Swamp and via the transfer discharge line directly into Perch Lake, which will be the recipient waterbodies for the NSDF Project wastewater. Contaminants released into the Perch Lake then migrate to Perch Creek from where they reach the Ottawa River, which is the ultimate receptor for all CRL discharges. The NSDF Project's contribution to potential effects on populations of non-human biota in the Perch Creek and Perch Lake Watershed does not result in unacceptable cumulative effects. Estimated doses resulting from historic contamination, due to releases from WMAs and Liquid Dispersal Areas, fall below benchmark values for Perch Lake and Perch Creek. Potential contribution from the NSDF to exposure of aquatic species in East Swamp is less than 1% of the current levels of exposures.

For non-radiological and radiological constituents, two surface water model scenarios were completed for a select group of constituents of potential concern (COPCs) as defined in Section 5.4.2.6.1.4 and Section 5.7.6.2.1. Key elements of the COPCs selection process included identifying those COPCs that were expected to change as a result of the NSDF Project, those with available guidelines, treatment requirements, high existing environmental conditions, potential for nutrient effects, water properties and those that were expected to be toxic to aquatic organisms. The selected non-radiological COPCs included: aluminum, ammonia, antimony, boron, barium, calcium, cadmium, chloride, chromium, cobalt, copper, fluoride, iron, lead, manganese, magnesium, mercury, molybdenum, nickel, phosphorus, potassium, selenium, silver, sodium, strontium, sulfate, thallium, tin, uranium, vanadium and zinc. Radiological COPCs included: carbon-14, cesium-137, cobalt-60, gross beta and tritium.

The predicted radiological and non-radiological concentrations for the COPCs were compared to effluent discharge targets[2] and to local background at the six water quality nodes (i.e., East Swamp weir, Perch Lake Inlet 2, Perch Lake, Perch Creek weir, Perch Creek Outlet and the Ottawa River; Section 5.4.2.6.2 and Tables 5.4.2-9 to 5.4.2-18). The predicted concentrations for most COPCs met the effluent targets at all sampling nodes, with the exception of aluminum, barium, copper, iron, lead, manganese, phosphorus, selenium and silver. However, predicted concentrations were generally similar to local background concentrations at these nodes with the exception of selenium concentrations that were predicted to exceed local ambient concentrations. Predicted selenium concentrations were less than the United States Environmental Protection Agency guidelines for protection of aquatic life and therefore are predicted to not result in adverse effects on aquatic life.

For most COPCs, the incremental changes in concentration as a result of the NSDF Project are expected not to be measurable in the Ottawa River. COPCs that increase above background in the Ottawa River included only tritium and gross beta. However, these increases are expected to be within the uncertainty bounds of the surface water quality modelling. Further, results of the radiological dose assessment for the operations phase and post-closure phase also indicates that doses to ecological health VCs are below their respective No Effect Concentrations (see Section 5.7.8). As such, changes to surface water quality (and habitat quality) from the discharge of treated effluent are expected to have negligible residual effects on Fish Community and Fish Habitat VCs and no residual effects on the Fish Species of Conservation Concern VC.

- **Leakage of leachate from the ECM during the post-closure phase (i.e., after Year 2100 to 2400) from liner and final cover degradation as a result of normal evolution may cause changes to groundwater quality and downstream surface water quality in wetlands, affecting fish habitat quality, survival and reproduction.**

Potential impacts on aquatic biota from failure of cover and liner as a result of normal evolution are assessed in Section 5.7.6.3.2.1. No adverse effects are predicted to aquatic biodiversity VCs.

[2] Effluent discharge targets for radiological COPCs were composed of No Effect Concentrations for the protection of aquatic biota (See Section 5.4.2.6.1).

5.5.5.2.3 Primary Pathways

No pathways were identified as having a primary linkage to aquatic biodiversity VCs. As such, a residual effects analysis and assessment of significance is not required for the aquatic biodiversity assessment.

5.5.6 Monitoring and Follow-up

There are no monitoring or follow-up programs planned that will directly sample fish or survey fish habitat for the NSDF Project. The focus of planned monitoring will include routine monitoring of surface water quality parameters as measurement indicators of fish habitat and fish community assessment endpoints. Monitoring will verify the effects predictions and provide data to evaluate changes to measurement indicators. Routine surface water quality monitoring includes stations on East Swamp Stream, Perch Lake and Perch Creek. Operational monitoring will be completed to verify the SWMPs are performing as designed and to demonstrate compliance with effluent discharge targets developed for the NSDF Project. Surface water monitoring also includes the Ottawa River receiving environment at multiple locations downstream of CRL. The Ottawa River is expected to adequately rapidly assimilate any discharge from the Perch Creek and Perch Lake Watershed to existing conditions in the river, such that aquatic biodiversity VCs are unlikely to be affected. The number and type of parameters and number of sampling locations may change based on annual review of monitoring data. For additional information on the monitoring programs to be developed and implemented for surface water quality, see Section 5.4.2.8 and Table 5.4.2-16, respectively.

If the environmental monitoring program for surface water quality identifies that adverse environmental effects are greater than predicted, then CNL will evaluate the need for revised mitigation actions and management practices to manage effects. CNL's evaluation process for monitoring data include environmental performance criteria that are based on statistical measures and ecological health benchmarks. An exceedance of environmental performance criteria triggers CNL's non-conformance and corrective action process and includes notifying management and further investigation. Where the need for revised mitigation is identified they will be developed and implemented. The evaluation process is documented in CNL's *Environmental Monitoring Program* (CNL 2018g).

5.5.7 Conclusions

Valued components refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous peoples, the scientific community or the public (The Agency 2018). Aquatic biodiversity is an important component of the environment, and potential effects to aquatic biodiversity were evaluated using a suite of aquatic biodiversity VCs selected for the NSDF project. Aquatic biodiversity VCs included fish habitat, the fish community that use the Perch Creek and Perch Lake Watershed, and fish species that may occupy habitat near Point au Baptême (i.e., near the mouth of Perch Creek) in the Ottawa River, including species of conservation concern. Assessment endpoints for aquatic biodiversity VCs were on-going fisheries productivity, and the maintenance of self-sustaining and ecologically effective fish populations as important components of on-going fisheries productivity, and these assessment endpoints were evaluated through the study of measurement indicators for the aquatic biodiversity VCs.
The environmental assessment for aquatic biodiversity relied, in part, on water quality and water quantity results for describing habitat quality and quantity, and survival and reproduction indicators.

The following conclusions were determined during the aquatic biodiversity assessment:

- No primary pathways (measurable residual effects) were identified for aquatic biodiversity VCs for the NSDF Project.

- Secondary pathways (negligible or no-measurable residual effects) were not identified for aquatic biodiversity in the Ottawa River, including the Species of Conservation Concern VC.
- Five secondary pathways were identified that may result in negligible (i.e., non-measurable) residual effects to the assessment endpoints of Fish Habitat and Fish Community VCs for the Perch Creek and Perch Lake Watershed.
- Secondary pathways included those related to surface water changes and related effects to the fish community in Perch Lake.
- Secondary pathways also included physical disturbances to fish habitat resulting from the construction, installation and operation of the effluent transfer line and diffuser in Perch Lake.

In summary, results of the aquatic environment assessment identified only negligible residual effects on aquatic biodiversity VCs as a result of the NSDF Project. The potential for residual effects will be addressed through the implementation of mitigation, monitoring, and environmental design features, which are well-understood and include existing practices at the CRL site.

The secondary pathways related to the transfer line construction, installation and operation will be mitigated through standard best management practices and design considerations such as sediment and erosion controls, limited footprints and duration of construction within the in-water work timing window for the Perch Lake fish species, and by the design of the diffuser to limit turbulence on the lakebed. In addition to planned construction monitoring for the effluent transfer line and diffuser, routine and operational monitoring of surface water quality parameters will be completed as measurement indicators of aquatic biodiversity endpoints. Effluent water quality monitoring will be integrated into CNL's Effluent Verification Monitoring Program.

Mitigation related to potential changes in surface water quality include those finalized within procedural controls and plans developed and applied for the NSDF Project, such as the following:

- CNL's procedure for Management and Monitoring of Emissions (CNL 2018e)
- CNL Environmental Protection Procedures (as part of CNL Environmental Program)
- CNL Effluent Verification Monitoring Program
- Operations and Maintenance Plan (to be developed by CNL)
- Environmental Management Plan (as part of CNL Environmental Program)

An Environmental Protection Plan will be developed for the NSDF Project by the Contractor prior to construction and will include blasting, dust, sediment and erosion, and spill management measures and controls.

5.6 Terrestrial Environment

This section of the Environmental Impact Statement (EIS) for the Canadian Nuclear Laboratories (CNL) Near Surface Disposal Facility (NSDF) Project seeks to understand and characterize potential residual effects of the NSDF Project on terrestrial biodiversity, including potential effects to the ecological and biological processes that connect species with each other and their abiotic environment. Effects of the NSDF Project are considered in the context of cumulative effects from other previous, existing and reasonably foreseeable developments on terrestrial biodiversity.

5.6.1 Scope of the Assessment

Section 5.6 focuses on providing an assessment for terrestrial biodiversity. Terrestrial biodiversity includes all upland vegetation communities and wetlands, as well as terrestrial wildlife taxa (e.g., mammals, birds) and wildlife taxa with terrestrial and aquatic life history requirements (e.g., reptiles). Effects of the NSDF Project on aquatic biodiversity (e.g., fish) are assessed in Section 5.5. The terrestrial biodiversity assessment follows the overall environmental assessment approach and methods described in Section 5.1. The assessment was completed following the key steps listed below:

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries and assessment cases** for the terrestrial biodiversity assessment (refer to Sections 5.6.2 Valued Components and Section 5.6.3 Assessment Boundaries). The VCs and measurement indicators used to assess Project-related changes to terrestrial biodiversity are described, along with the spatial and temporal boundaries at which the assessment occurred and the assessment cases considered.
- **Step 2 – Describe the existing conditions** (refer to Section 5.6.4 Description of the Environment). Existing conditions in the local and regional areas are described, including the combined effects of previous and existing developments (Base Case). The existing environment represents the historical and current environmental pressures that have shaped the observed patterns in the environment (i.e., natural variation). The existing conditions provide a reference to which the effects of the NSDF Project can be compared.
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 5.6.5 Project Interactions and Mitigation). Project components and/or activities with the potential to affect terrestrial biodiversity are identified, and mitigation developed to limit or avoid effects is presented. A pathways analysis is then used to focus further assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects are adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Pathways that may lead to residual effects to terrestrial biodiversity after incorporating mitigation are carried forward to Step 4 for further analysis.
- **Step 4 – Present the methods and results of the residual effects analysis** for the terrestrial biodiversity assessment (refer to Section 5.6.6 Residual Effects Assessment Methods and 5.6.7 Residual Effects Assessment Results).
- **Step 5 – Describe the level of certainty and management of uncertainty** of residual effects (refer to the subsections titled Prediction Confidence and Uncertainty under Section 5.6.7). This step in the assessment evaluates the available literature, data and models used for the assessment and describes the level of certainty that can be placed on predicted residual effects. It provides a precautionary evaluation of potential

residual effects of the NSDF Project and aims to overestimate potential effects where uncertainty is present. It also identifies how uncertainty was managed for each VC so that the predicted effects of the NSDF Project are not underestimated.

- **Step 6 – Classify and determine the significance of the predicted residual effects** (refer to the subsections titled Residual Effects Classification and Sections and Determination of Significance under Section 5.6.7). This step describes the methods and presents the results of a residual effects classification and determination of significance for each terrestrial biodiversity VC. The residual effects classification uses a common set of criteria, direction, magnitude, geographic extent, duration, reversibility, frequency and likelihood to classify effects, and significance is determined in a binary fashion for each VC (i.e., either significant or not significant).
- **Step 7 – Identify monitoring and follow-up** required to confirm effects predictions and address uncertainty (refer to Section 5.6.8 Monitoring and Follow-up).
- **Step 8 – Present a consolidated summary of conclusions and outcomes of the assessment** of residual effects on terrestrial biodiversity (refer to Section 5.6.9 Conclusions).

Each assessment step integrates information from regulatory guidelines, scientific literature, the experience of the professionals conducting the assessment and issues raised during engagement. Information and concerns raised by the public, communities of interest, and Indigenous peoples during engagement that influenced the scope of the terrestrial biodiversity assessment are summarized in Table 5.6.1-1. Other general concerns and questions raised during the engagement that pertain to the human health assessment are documented in CNL's in CNL's Indigenous Engagement Report (CNL 2020) and CNL's Stakeholder's Activity Reports (CNL 2017a,b, 2019).

Table 5.6.1-1: Summary of Issues Raised during Engagement Activities that Influenced the Scope of the Terrestrial Biodiversity Assessment

Issue	How the Issue Was Included in the Assessment
Inclusion of migratory birds in the assessment	Because of their ecological importance and because they are protected by federal legislation (Migratory Birds Convention Act, 1994 [MBCA]), the suite of migratory birds with the potential to be affected by the NSDF Project was included as a terrestrial biodiversity VC. Some individual migratory bird species that are federally listed species at risk were also included as VCs assessed at the species level.
Concern over the conversion of terrestrial habitat	An evaluation of the change in habitat availability and habitat distribution in the vicinity of the Project is completed for each of the wildlife species selected as VCs.
Concern with road mortality to Blanding's turtle and what can be done to reduce this risk	Increased risk of injury/mortality of Blanding's turtle on roads is a key interaction evaluated as part of the residual effects assessment. Mitigation to be implemented to reduce this risk is described and monitoring programs are recommended for Blanding's turtle.
Inclusion of bird and other species at risk in the assessment	The species-level assessment focused on species identified on Schedule 1 of the federal Species at Risk Act (SARA). Species at risk evaluated in the assessment include Canada warbler, eastern whip-poor-will, eastern wood pewee, wood thrush and golden-winged warbler, bats, Blanding's turtle, eastern milksnake and monarch butterfly. Most of the species-level VCs identified for the terrestrial biodiversity assessment are also useful indicators for broader groups of species.

VC = valued component.

5.6.2 Valued Components

VCs refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community or the public (The Agency 2018). Identifying VCs helps to focus the assessment on the most important or representative components of the environment that are likely to be affected by the NSDF Project. This section describes how VCs were selected for the terrestrial biodiversity assessment and identifies the assessment endpoints and measurement indicators that were used to assess the effects of the NSDF Project on each VC. Because this assessment is for a designated project, as described in the *Canadian Environmental Assessment Act, 2012* (CEAA 2012) and is regulated by the Canadian Nuclear Safety Commission (CNSC), VC selection considered guidance from Appendix A of the CNSC's *REGDOC-2.9.1 Environmental Protection: Environmental Principles, Assessments and Protection Measures* (CNSC 2017). Specifically, VC selection focused on providing a "full accounting of effects on species with elevated conservation status and their habitat" (CNSC 2017).

Selection of VCs for the terrestrial biodiversity assessment was accomplished using a coarse and fine filter approach. Coarse filter VCs were identified to permit an assessment of the effects of the NSDF Project to terrestrial biodiversity broadly (e.g., large groups of species or the ecosystems and habitats that support groups of species), whereas fine filter VCs focus the assessment on individual species. Combined, the coarse and fine filter VCs are selected to provide a holistic assessment of the potential effects of the NSDF Project on terrestrial biodiversity.

To capture potential effects to terrestrial biodiversity broadly, the terrestrial vegetation communities potentially affected by the NSDF Project were selected as a VC (Table 5.6.2-1). Assessing and managing biodiversity at the ecosystem level (represented by vegetation communities) means that a large number of biodiversity features are addressed together. Terrestrial vegetation communities also represent the habitats that may support species with elevated conservation status. For example, effects of the NSDF Project on wildlife guilds (i.e., species that use the same resources, or that use different resources in related ways) that are dependent on very old growth trees, standing dead trees (i.e., "snags"), coarse woody debris and natural disturbance processes (e.g., fire, insects and disease) found in mature and older forests will be captured by the vegetation communities VC assessment. Vegetation community types present in the Regional Study Area (RSA; see Section 5.6.3.1) were included as part of the vegetation community VC. This assessment focuses on the ecological integrity of these communities, whereas potential effects from the NSDF Project on Indigenous peoples traditional vegetation use are assessed in Section 5.9 Land and Resource Use and Section 6.0 Indigenous Interests.

Because of their ecological importance and because they are protected by federal legislation (*Migratory Birds Convention Act, 1994* [MBCA]), the suite of migratory birds with the potential to be affected by the NSDF Project was also included as a terrestrial biodiversity VC. The purpose of including the group of migratory birds together as a VC was to identify appropriate mitigation so that the NSDF Project would comply with the MBCA for all migratory birds. Section 5 of the MBCA prohibits the disturbance, destruction or removal of a nest or related shelter, or egg of a migratory bird, or possession of a live migratory bird, or a carcass, nest or egg of a migratory bird.

To complement the assessment of vegetation communities and migratory birds, some VCs were also identified at the species level. Consideration at the species level is also important to understand effects to biodiversity features that sometimes are distinct from effects to ecosystems and for which targeted actions at the species level may be required (e.g., as specified in federal action plans or recovery strategies developed for species at risk). Some individual migratory birds that are federally listed species at risk were also included as VCs that were assessed at the species level.

The species-level assessment focused on species identified on Schedule 1 of the federal *Species at Risk Act* (SARA). On a federal level, designations for species at risk occurring in Canada are initially determined by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). If approved by the federal Minister of the Environment, species are added to the federal List of Wildlife Species at Risk under Schedule 1 of SARA. Once included on Schedule 1, it is prohibited to kill, harm, harass, capture, possess, collect, buy, sell or trade individuals, or to damage or destroy the residence of a species listed as Extirpated, Endangered or Threatened. Furthermore, for species that are included on Schedule 1 as Extirpated, Endangered or Threatened, species-specific critical habitat is protected on federal lands (such as the Chalk River Laboratories [CRL] site) once critical habitat is defined in a recovery strategy. Although species listed as Special Concern are not afforded the same degree of legal protection as those at higher threat levels, Section 65 of SARA requires that a management plan be developed that includes measures for the conservation of the species of Special Concern and their habitats. Federal landowners are expected to implement these measures.

Baseline biodiversity data have been collected at the CRL site since 2009, with targeted surveys for species at risk occurring annually since 2012. These surveys have determined that 23 terrestrial species at risk listed on Schedule 1 of SARA occur within the CRL site (Appendix 5.6-1).

All SARA-listed species identified in Appendix 5.6-1 with confirmed observation records within the CRL site were considered as potential VCs at the species level. Each species was evaluated to determine whether its presence was likely in the Site Study Area (SSA) or the Local Study Area (LSA) defined for the terrestrial biodiversity assessment (see Section 5.6.3.1). Species that are unlikely to occur in the LSA, for which habitat was not present in the LSA or for which effects of the NSDF Project were unlikely were excluded as VCs. Rationale for inclusion or exclusion of each species at risk identified during surveys undertaken in the CRL site is presented in Appendix 5.6-1. Species at risk identified as VCs for the terrestrial biodiversity assessment are presented in Table 5.6.2-1. Individual species for which the potential effects of the NSDF Project are similar were grouped into a single VC (e.g., bats; Table 5.6.2-1).

Table 5.6.2-1: Valued Components Selected for the Terrestrial Biodiversity Assessment

Valued Component	Rationale for Selection
Vegetation communities	▪ This VC broadly captures effects on terrestrial biodiversity. ▪ The NSDF Project is associated with footprint effects that will remove vegetation and result in physical losses of some vegetation communities (and related wildlife habitat).
Migratory birds	▪ Migratory birds and their nests are protected under the federal MBCA. ▪ There are numerous migratory bird species that breed, nest or could be present year-round in the vicinity of the Project. There is the potential for migratory birds to be indirectly and directly affected by the Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads or loss of eggs in nests during tree clearing). ▪ Comment on the Project Description received by a member of the public specifically requested assessment of this VC.
Canada warbler	▪ Canada warbler (Cardellina canadensis) is federally listed as Threatened under SARA and is protected under the MBCA. It has legal individual and habitat protection provisions under SARA and individual and nest protection under the MBCA. ▪ The CRL site is federally owned; therefore, this species is afforded protection of critical habitat because it is listed as Threatened on Schedule 1 of SARA. Critical habitat has not yet been defined for this species in the federal recovery strategy. ▪ There is the potential for Canada warbler to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads or loss of eggs in nests during tree clearing). ▪ Canada warbler is an avian species VC recorded within the LSA that represents a guild of early successional habitat specialists requiring coniferous, deciduous, moist mixed forest and regenerating habitats.
Eastern whip-poor-will	▪ Eastern whip-poor-will (Antrostomus vociferus) is federally listed as Threatened under SARA and is protected under the MBCA. It has legal individual and habitat protection provisions under SARA and individual and nest protection under the MBCA. ▪ The CRL site is federally owned; therefore, this species is afforded protection of critical habitat because it is listed as Threatened on Schedule 1 of SARA. Critical habitat has been partially defined for this species in the federal recovery strategy (ECCC 2018a). ▪ There is the potential for eastern whip-poor-will to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads or loss of eggs in nests during tree clearing). ▪ Eastern whip-poor-will is a keystone avian species VC recorded within the LSA that represents a guild of aerial insectivores requiring open forest/edge habitat in drier deciduous and coniferous habitats.

Table 5.6.2-1: Valued Components Selected for the Terrestrial Biodiversity Assessment

Valued Component	Rationale for Selection
Eastern wood-pewee	▪ Eastern wood-pewee (Contopus virens) is federally listed as Special Concern under SARA and is protected under the MBCA. It has legal individual and nest protection under the MBCA. ▪ The CRL site is federally owned; therefore, Section 65 of SARA requires that habitat is managed for conservation of this species because it is listed as Special Concern on Schedule 1 of SARA. ▪ There is the potential for eastern wood-pewee to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads or loss of eggs in nests during tree clearing). ▪ Eastern wood-pewee is an avian species VC recorded within the LSA that represents a guild of forest edge habitat species.
Golden-winged warbler	▪ Golden-winged warbler (Vermivora chrysoptera) is federally listed as Threatened under SARA and is protected under the MBCA. It has legal individual and habitat protection provisions under SARA and individual and nest protection under the MBCA. ▪ The CRL site is federally owned; therefore, this species is afforded protection of critical habitat because it is listed as Threatened on Schedule 1 of SARA. Critical habitat has been partially defined for this species in the federal recovery strategy. ▪ There is the potential for golden-winged warbler to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads or loss of eggs in nests during tree clearing). ▪ Golden-winged warbler is a keystone avian species VC recorded within the LSA that represents a guild of edge habitat specialists.
Wood thrush	▪ Wood thrush (Hylocichla mustelina) is federally listed as Threatened under SARA and is protected under the MBCA. It has legal individual and habitat protection provisions under SARA and individual and nest protection under the MBCA. ▪ The CRL site is federally owned; therefore, this species is afforded protection of critical habitat because it is listed as Threatened on Schedule 1 of SARA. Critical habitat has not yet been defined for this species in the absence of a federal recovery strategy due to recent (2017) listing. ▪ There is the potential for wood thrush to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads or loss of eggs in nests during tree clearing). ▪ Wood thrush is an avian species VC recorded within the LSA that represents a guild of deciduous and mixedwood forest habitat specialists.

Table 5.6.2-1: Valued Components Selected for the Terrestrial Biodiversity Assessment

Valued Component	Rationale for Selection
Bats ▪ Little brown myotis ▪ Northern myotis ▪ Tri-colored bat	▪ Little brown myotis (Myotis lucifugus), northern myotis (Myotis septentrionalis) and tri-colored bat (Perimyotis subflavus) have observation records within the LSA. All three bat species are federally listed as Endangered and have legal individual protection provisions under SARA. ▪ The CRL site is federally owned; therefore, these bat species are afforded protection of critical habitat because they are listed as Endangered on Schedule 1 of SARA. Critical habitat has only partially been defined for hibernacula (i.e., overwintering sites), as the largest threat to these species is associated with that habitat. The destruction of maternity roosts is also a potential threat to bat populations. Hibernacula have not been found in the LSA or RSA and are unlikely to occur in the SSA. Maternity roosts are likely present and have the potential to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (i.e., loss of roosting bats during tree clearing). ▪ There is the potential for bats to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss (loss of roost trees) and mortality (i.e., loss of pre-volant juveniles in maternity roosts during tree clearing). ▪ The bats VC represents small mammal species recorded in the LSA that rely on standing dead trees (e.g., snags) for part of their life history (maternity roosting, diurnal roosting and evening roosting).
Blanding's turtle	▪ The Great Lakes / St. Lawrence population of Blanding's turtle (Emydoidea blandingii) is federally listed as Threatened and has legal individual and habitat protection provisions under SARA. COSEWIC (2016) has assessed the population as Endangered. ▪ The CRL site is federally owned; therefore, this species is afforded protection of critical habitat because it is listed as Threatened on Schedule 1 of SARA. Critical habitat has been identified within the CRL site based on the partial definition in the recovery strategy (ECCC 2018b). Grid squares that have been identified as containing critical habitat for Blanding's turtle are intersected by the NSDF Project (ECCC 2017). ▪ There is the potential for Blanding's turtle to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads and overwinter mortality from changes in the hydrology in wetlands). ▪ The Blanding's turtle is represented through effects on species at risk in the terrestrial environment. This species further acts as an indicator species representing reptile species (e.g., snapping turtle) that use a variety of wetland habitats for hibernation, mating, foraging, thermoregulation, staging prior to nesting and for movement. They use upland, relatively open areas with suitable substrate for nesting, overland migration, thermoregulation and foraging. Blanding's turtles display fidelity to their overwintering sites and nesting sites (i.e., use the same habitat year after year). ▪ Comments and questions raised at public information sessions expressed value of the Blanding's turtle. ▪ There are Blanding's turtle observation records congregated within various waterbodies and wetlands throughout the RSA and LSA. CNL baseline studies indicate that Blanding's turtles use the wetland habitats that surround the SSA.

Table 5.6.2-1: Valued Components Selected for the Terrestrial Biodiversity Assessment

Valued Component	Rationale for Selection
Eastern milksnake	▪ Eastern milksnake (Lampropeltis triangulum) has not been observed within the LSA but is potentially present because it has been confirmed elsewhere on the CRL site. It is federally listed as Special Concern on Schedule 1 under SARA. ▪ There is the potential for eastern milksnake to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads). ▪ The CRL site is federally owned; therefore, Section 65 of SARA requires that habitat is managed for conservation of this species because it is listed as Special Concern on Schedule 1 of SARA. ▪ Eastern milksnake represents reptile species that use a variety of microhabitats. The eastern milksnake is known to congregate in hibernacula over winter.
Monarch butterfly	▪ Monarch butterfly (Danaus plexippus) has not been observed within the LSA but is potentially present because it has been confirmed elsewhere on the CRL site. It is federally listed as Special Concern and is considered Endangered by COSEWIC. ▪ There is the potential for the monarch butterfly to be indirectly and directly affected by the NSDF Project through disturbance, habitat loss and mortality (e.g., vehicle strike on roads or loss of individuals during vegetation clearing). ▪ The CRL site is federally owned. Although species listed as Special Concern are not afforded the same degree of legal protection as higher threat levels, Section 65 of SARA requires that a management plan be developed that includes measures for the conservation of the species and their habitats. ▪ The iconic migratory butterfly relies on milkweed and represents other insects that use a variety of open habitats during the summer and early fall.

MBCA = *Migratory Birds Convention Act, 1994*; COSEWIC = Committee on the Status of Endangered Wildlife in Canada; LSA = Local Study Area (see Section 5.6.3.1); SARA = *Species at Risk Act*; VC = valued component; SSA = Site Study Area; ECCC = Environment and Climate Change Canada.

Most of the species level VCs identified for the terrestrial biodiversity assessment are useful indicators for broader groups of species. For example, eastern whip-poor-will (*Antrostomus vociferus*) represents a guild of species that forage on insects while flying and require edge habitat and forest openings (Table 5.6.2-1). Blanding's turtle (*Emydoidea blandingii*) is tied closely to wetland habitats and adjacent upland areas and can be used to represent other species at risk with similar requirements, such as snapping turtles. Bats rely on mature forests that contain wildlife trees for roosting habitat, and thus represent a variety of other wildlife tree secondary cavity users (i.e., species that use cavities created by primary cavity excavator species such as woodpeckers). Consequently, understanding the potential effects of the NSDF Project on the selected VCs provides inferences about effects on other wildlife species or guilds with similar life history traits and habitat requirements (Appendix 5.6-1).

A functioning ecosystem involves interactions of multiple species ranging in size and complexity from bacteria to apex wildlife predators. Each species is likely to respond differently to physical disturbances or different levels of contaminants present in their environment or environmental media. As such, the aquatic and terrestrial VCs selected for the Environmental Risk Assessment completed for the NSDF Project (summarized in Section 5.7) were selected to assess exposures to water and ingestion of aquatic biota. Wildlife species that receive most of their exposure from ingestion of terrestrial plants and animals were also considered.

Common nighthawk (*Chordeiles minor*), chimney swift (*Chaetura pelagica*), olive-sided flycatcher (*Contopus cooperi*) and western chorus frog (*Pseudacris triseriata*) were initially considered as VCs but were ultimately not carried forward to the effects assessment for the following reasons:

- A common nighthawk survey was conducted during the summer of 2013. The survey method was adapted from MNR (2013a). Because this species is territorial and responds to other calling individuals by making a "booming" sound, common nighthawk calls were also played (infrequently) to increase the detection of the species. A total of 43 survey points were surveyed twice. Each survey consisted of a three-minute listening period to detect nighthawks. No common nighthawks were heard during the surveys. Consequently, the proposed NSDF Project is not expected to affect common nighthawks. Additionally, eastern whip-poor-wills use similar habitats to common nighthawks and so can be considered a surrogate for determining effects on common nighthawks.
- A recent study conducted by Zanchetta et al. (2014) reports only 59 records of chimney swifts using trees for nesting or roosting between 1803 and 2013. Fitzgerald et al. (2014) and COSEWIC (2018) also conclude that the loss of nesting sites is not a primary factor limiting chimney swift populations in Ontario. Forest songbird surveys did not detect chimney swifts in the forested area of the SSA, LSA or RSA (CNL 2018a). Chimney swift detection is limited to the area near the roosting chimney. CNL properties (CRL sites and Nuclear Power Demonstration Closure Project property) have two significant roosting sites (stacks) used by the species. A research project in collaboration with Dr. Joe Nocera from the University of New Brunswick studied extensively the behaviour of the chimney swift roosting in both stacks. The study helped CNL to understand the importance of the stacks used as a major stop over during the spring migration. As a result, CNL has committed to preserve the stack on the Nuclear Power Demonstration site as part of the Nuclear Power Demonstration Closure Project. CNL is likely contributing to the recovery of the species by retaining the Nuclear Power Demonstration stack. No effects from the NSDF Project are anticipated for chimney swifts.
- The forest songbird survey effort conducted on the CRL site in 2013 and 2016 involved a total of 42 survey locations and a total 3,000 minutes of recording time. Olive-sided flycatcher was only recorded once on the CRL site during these surveys and was 4 km away from the proposed NSDF Project. There was one other observation of olive-sided flycatcher approximately 3 km away from the NSDF Project in 1997. Based on these results, olive-sided flycatchers are not likely using habitats in or near the NSDF Project, and no effects to this species are anticipated.
- There is uncertainty whether western chorus frogs have potential to occur in or near the NSDF Project. Crother (2012), Dodd (2013) and Frost (2013), all consider chorus frogs located in the Great Lakes St. Lawrence region to be the boreal chorus frog (*Pseudacris maculata*); this contradicts Platz (1989), who considers all chorus frogs in southern Ontario to be western chorus frog. Nevertheless, Platz's (1989) interpretation was used for the development of the Western Chorus Frog Recovery Strategy and so, to be conservative, CNL considered it possible that western chorus frogs may occur in or near the NSDF project. Amphibian surveys were conducted at CRL in 2012 and 2016 and followed methods used in the Marsh Monitoring Program (Bird Studies Canada 2008). Surveys were conducted between April 20 and June 16 of both years. Western chorus frogs were not detected in 2012 or 2016 (CNL 2013, 2017c). In 2015, Environment and Climate Change Canada (ECCC; formerly Environment Canada) advised CNL that sightings of chorus frog (*Pseudacris triseriata* and *P. maculata*) had occurred in close proximity to the CRL site. Further discussion with ECCC in February 2017 provided a different and more adequate protocol for the

detection of the species. Changes to the current survey method were made immediately and this new protocol adopted for surveys conducted in 2017. Western chorus frogs were not detected in 2017 (CNL 2018a).

- Although habitats corresponding entirely to the definition of suitable wetland and terrestrial habitats in Table 3 of the Western Chorus Frog Recovery Strategy are not present at CRL, four areas were surveyed in 2017. Those four areas were selected as they resemble somewhat the definition of Table 3. The survey was conducted between April 12, 2017, and May 31, 2017. In addition to the Marsh Monitoring Program method where a three-minute recording period a set every hour between 20:00 and 23:00, the passive recorders were programmed to capture daytime callers. A five-minute audio file was collected every 30 minutes between 10:00 and 12:00 and between 16:00 and 18:00. All amphibian audio files were analyzed using Raven software. No western chorus frogs were detected. As such, CNL has committed to completing another amphibian survey in 2020. Because no western chorus frogs have been detected to date at CRL, the NSDF Project is not expected to affect this species.

Each VC for the terrestrial biodiversity assessment was assessed using the assessment endpoints and measurement indicators listed in Table 5.6.2-2. Assessment endpoints represent the key properties of each VC that should be protected. The assessment endpoint for terrestrial biodiversity is the maintenance of self-sustaining and ecologically effective vegetation communities or wildlife populations. Self-sustaining vegetation communities or wildlife populations are healthy and viable and, by definition, robust and capable of withstanding environmental change and accommodating stochastic processes (i.e., random environmental processes such as wildfire) (Reed et al. 2003). Maintaining viable wildlife 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).

Achieving viable wildlife populations, however, may not be sufficient to meet conservation objectives for other species that interact with the VCs being assessed (Soulé et al. 2005). For highly interactive VCs that have strong effects on ecosystem structure and function, the concept of ecologically effective populations was applied as part of the assessment endpoint for wildlife. Ecologically effective wildlife populations are populations of wildlife species that are large enough to maintain ecological function in an ecosystem.

Likewise, the maintenance of self-sustaining vegetation communities may not be sufficient to support their ecological function on the landscape; therefore, the concept of ecologically effective vegetation communities was applied as part of the assessment endpoint for vegetation communities. Ecologically effective vegetation communities are those that can support the range of native species and ecological and evolutionary processes normally provided by the ecosystem (Noss 1990).

An ecologically effective vegetation community or wildlife population differs from self-sustaining vegetation communities or wildlife populations if the abundance needed to maintain ecological function is greater than the abundance required to maintain viability for the long-term. The application of the concept of self-sustaining ecologically effective vegetation communities or wildlife populations is key to the significance determination for the terrestrial biodiversity assessment (Section 5.6.7).

Table 5.6.2-2: Assessment Endpoints and Measurement Indicators for the Terrestrial Biodiversity Assessment

Valued Component	Assessment Endpoints	Measurement Indicators
Vegetation communities	Maintenance of self-sustaining and ecologically effective vegetation communities	▪ Ecosystem availability ▪ Ecosystem distribution ▪ Ecosystem condition
Migratory birds	Maintenance of self-sustaining and ecologically effective populations	▪ Habitat availability ▪ Habitat distribution ▪ Survival and reproduction
Canada warbler *(Cardellina canadensis)*		
Eastern whip-poor-will *(Antrostomus vociferous)*		
Eastern wood-pewee *(Contopus virens)*		
Golden-winged warbler *(Vermivora chrysoptera)*		
Wood thrush *(Hylocichla mustelina)*		
Bats		
Blanding's turtle *(Emydoidea blandingii)*		
Eastern milksnake *(Lampropeltis Triangulum)*		
Monarch butterfly *(Danaus plexippus)*		

Two sets of measurement indicators were employed for terrestrial biodiversity VCs: those suitable for quantifying effects on vegetation communities and those suitable for quantifying effects on wildlife. Changes in these measurement indicators were used to evaluate potential changes in the status of each VC relative to the assessment endpoints. Each measurement indicator was assessed quantitatively where sufficient information existed to support a numerical assessment and qualitatively where necessary.

Ecosystem availability, ecosystem distribution and ecosystem condition were selected as the measurement indicators for the vegetation communities VC. The measurement indicators are defined as follows:

- **Ecosystem availability**: changes to the amount (e.g., hectares) of vegetation communities.
- **Ecosystem distribution**: changes in the way each vegetation community is distributed on the landscape. Ecosystem availability and distribution are linked, but distribution focuses on the spatial configuration (or arrangement) and connectivity of ecosystems, whereas availability focuses on the area of those ecosystems.
- **Ecosystem condition**: changes in native species richness, abundance and diversity. Ecosystem condition refers to the quality of habitat and is primarily affected by changes to structural stage and changes in the amount of moisture, amount of sunlight, competition with invasive species, dust deposition and contamination (e.g., radiological). The presence of invasive species may adversely affect ecosystem

condition. Mature forest stand age can be used as a broad indicator of ecosystem quality as wildlife habitat features required for a broad number of wildlife species, such as cavity trees and downed woody debris, are typically found in mature forest stands and less frequently found in younger seral (i.e., intermediate) stage stands. Maintenance of biodiversity in managed forest systems is an objective achieved through conservation of mature and old growth forest stands (Thompson 1997). The *Old Growth Policy for Ontario's Crown Forests* (MNR 2003) specifically describes the goal of ensuring old growth conditions and values are present in Crown forests for "conserving biological diversity at levels that maintain or restore ecological processes, while allowing for sustainable development now and in the future."

Habitat availability, habitat distribution, and survival and reproduction were selected as the measurement indicators for the terrestrial biodiversity species VCs. The measurement indicators are defined as follows:

- **Habitat availability**: changes to the size (e.g., hectares) and quality (e.g., probability of use by animals) of different habitats.
- **Habitat distribution**: changes to spatial configuration and connectivity of habitats and changes to the spatial distribution and movement of animals.
- **Survival and reproduction**: changes to abundance caused by altering mortality or recruitment rates.

5.6.3 Assessment Boundaries

5.6.3.1 Spatial Boundaries

The spatial boundaries selected for the terrestrial biodiversity assessment were chosen because they permit description of existing conditions in sufficient detail to enable potential project-VC interactions and effects to be identified, understood and assessed, including understanding and assessing the contribution of the NSDF Project to cumulative effects. The spatial boundaries selected for the terrestrial biodiversity assessment are presented on Figure 5.6.3-1 and are described below:

- **Site Study Area (SSA)**: The SSA is the NSDF Project footprint, which accounts for the direct physical disturbance and alteration of vegetation communities and wildlife habitat caused by construction and operations of the engineered containment mound (ECM) and related facilities, buildings and infrastructure. It also includes the two sections of East Mattawa Road that will be upgraded and form the north and south access roads to the ECM. These access road segments were included for terrestrial biodiversity because of the sensitivity of one VC species (Blanding's turtle) to road mortality. The SSA for terrestrial biodiversity encompasses approximately 37 hectares (ha) (Figure 5.6.3-1).
- **Local Study Area (LSA)**: The LSA is defined as the area within which there is potential for measurable changes to measurement indicators resulting from the proposed NSDF Project activities. The LSA includes the SSA (including the roads to the north and south) plus any surface waterbody (i.e., Perch Lake and Perch Creek) that was a potential discharge point for wastewater from the ECM. A 250 m buffer was applied to the SSA to capture effects from the NSDF Project that may extend beyond the footprint, including those caused by emissions of dust and sensory disturbance caused by noise and light (Figure 5.6.3-1). Any wetland feature that intersected the 250 m buffer area was included in the LSA to capture potential effects on Blanding's turtle. The resulting LSA encompasses approximately 210 ha.

- **Regional Study Area (RSA)**: The RSA is defined as the area within which the potential effects of the NSDF Project may interact with the effects of other existing or reasonably foreseeable developments. The RSA for terrestrial biodiversity is the CRL site boundary (Figure 5.6.3-1). This federally owned property is within the larger Ottawa Valley Forest Management Unit and comprises one of three parcels of federal lands within the unit (Van Dyke 2011). The RSA is approximately 4,000 ha and, because it contains the CNL nuclear facilities, it is managed differently from the surrounding landscape, which is provincial Crown land, or private land. The RSA was used as the scale at which cumulative effects to terrestrial biodiversity VCs were assessed. Beyond regional disturbance factors (e.g., forestry and climate change) were considered if they were likely to affect vegetation communities or populations of wildlife VCs that overlap with the RSA.

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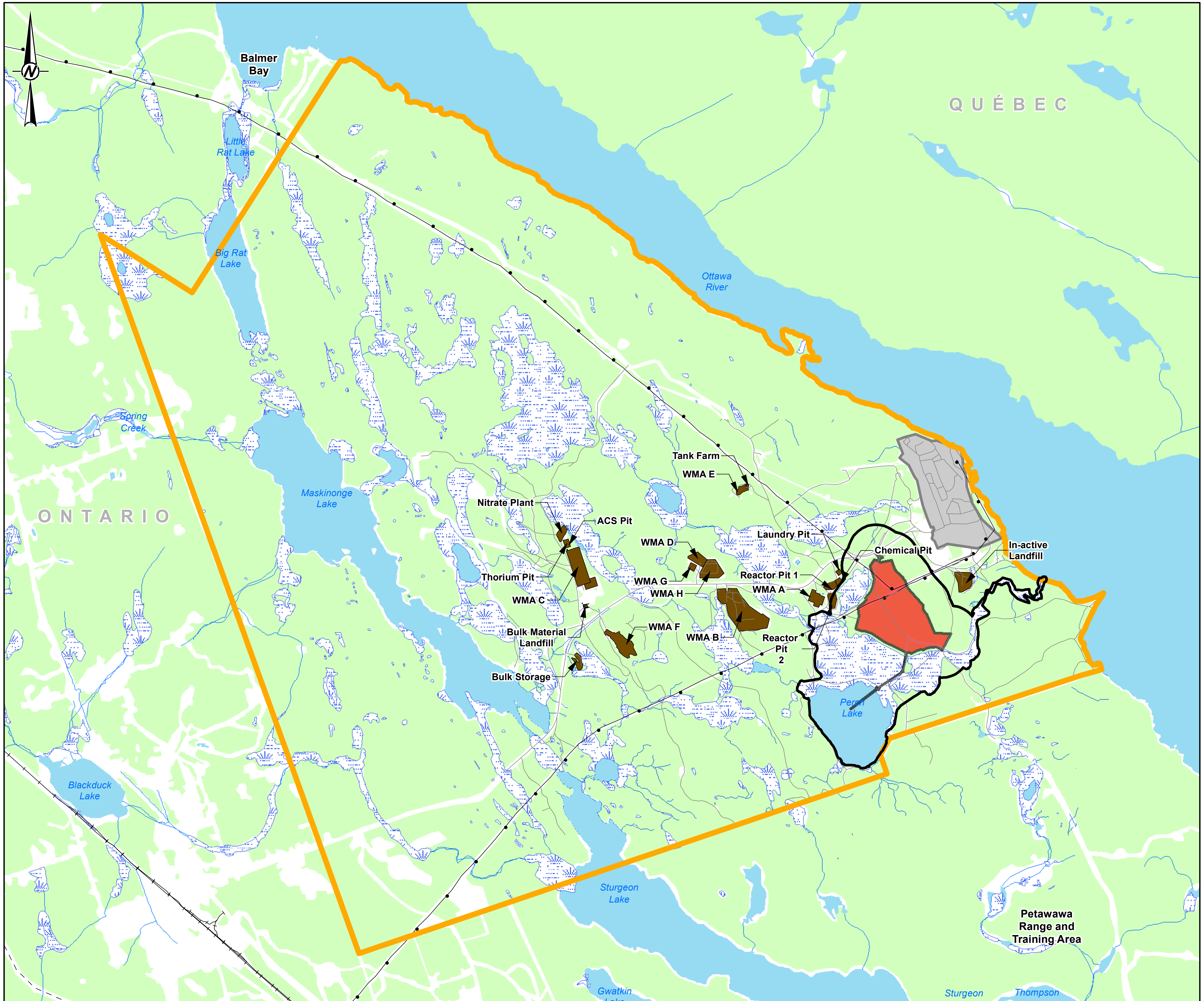

LEGEND

- ROADS
- RAILWAY
- HYDRO LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- SITE STUDY AREA
- LOCAL STUDY AREA
- REGIONAL STUDY AREA (CRL SITE)

1 0 1
1:35,000 KILOMETERS

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
SPATIAL BOUNDARIES SELECTED FOR THE TERRESTRIAL ENVIRONMENT ASSESSMENT

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.3-1

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5.6.3.2 Temporal Boundaries

Temporal boundaries (i.e., project phases) establish the timeframe during which NSDF Project effects are assessed. The temporal boundary represents the timeframe during which project activities are actively occurring, and does not include the duration of predicted residual effects. The duration of an effect is defined as the amount of time between the start and end of a project activity or stressor (which is related to the project phases) plus the time required for the residual effect to be reversed. In some cases, a residual effect may be irreversible within the temporal boundaries of the project (e.g., residual effect lasts for thousands of years). The following phases were identified for the NSDF Project:

- **Construction Phase:** This phase includes site preparation and all activities associated with the construction of the NSDF Project. This phase includes activities such as installing the necessary supporting and/or ancillary facilities and infrastructure to facilitate NSDF Project operations, inactive commissioning and systems testing, and transportation of construction materials. Construction activities are expected to take place from 2021 to 2023.
- **Operations Phase:** This phase includes all activities associated with waste placement, water management, Wastewater Treatment Plant (WWTP) operations, vehicle movements into and from the SSA, and maintenance activities. The operations phase is expected to last approximately 50 years (i.e., 2024 to 2070).
- **Closure Phase:** This phase includes activities necessary to complete the installation of the final cover and implementation of long-term monitoring. Closure activities are expected to start in 2070 and continue through to 2100, after which the NSDF Project will transfer into the post-closure phase.
- **Post-closure Phase:** This phase has two discrete periods: institutional control and post-institutional control. The institutional control period includes implementation of controls throughout 2100 to 2400 (i.e., 300 years). During institutional control, environmental monitoring will be completed as required to confirm that the final cover is functioning as intended and to demonstrate compliance with the environmental assessment predictions. Post-institutional control occurs after year 2400 and continues indefinitely.

The temporal boundaries for the terrestrial biodiversity assessment consider all NSDF Project phases, from construction through post-closure.

5.6.3.3 Assessment Cases

The assessment cases considered in the terrestrial biodiversity assessment are the Base Case, Application Case and the Reasonably Foreseeable Developments Case.

- **Base Case:** This scenario represents existing conditions and characterizes effects from previous and existing developments and activities. The Base Case reflects the effects of existing disturbances in the area, such as forestry, transportation, agricultural, mining and residential and recreational development. Current effects from the existing CRL facilities and operations, for example, are considered part of the Base Case.

  In 2019, CNL started implementing mitigation outlined in the *Blanding's Turtle Road Mortality Mitigation Plan* (Golder 2019a) to mitigate effects from existing operations and activities at the CRL site on Blanding's turtles in 2019. CNL is committed to continuing to implement mitigation in the *Blanding's Turtle Road Mortality Mitigation Plan* in the future to reduce Blanding's turtle road mortality to the extent possible. Monitoring of Blanding's turtles at CRL is on-going and will continue, and CNL is committed to implementing adaptive management such that their existing and future operations do not adversely affect Blanding's turtles. Other actions beyond implementing the *Blanding's Turtle Road Mortality Mitigation Plan* will be undertaken, as required, to achieve this objective. These actions are being initiated prior to the NSDF Project. Consequently, the Base Case for Blanding's turtle is a predicted future case that incorporates mitigation that has been committed to and is being implemented by CNL. This predicted Base Case is the reference condition to which effects from the NSDF Project on Blanding's turtles are compared.

- **Application Case:** This scenario represents the effects of the Base Case combined with the effects that may result from the NSDF Project. The Application Case considers potential effects from the NSDF Project from the construction phase through the post-closure phase.
- **Reasonably Foreseeable Development (RFD) Case:** This scenario represents predictions of the cumulative effects of the Application Case, which includes the Base Case, plus projects that are currently under application review or that have officially entered a regulatory application process and are therefore considered reasonably foreseeable. RFDs expected within the CRL site (i.e., the RSA) that may interact with terrestrial biodiversity include new or upgrades to research and development facilities, construction and operations of the SMR, new support infrastructure, and on-going decommissioning and environmental remediation activities. Additional details on these proposed activities are provided in Section 5.6.7.11.

5.6.4 Description of the Environment

The RSA is in the Ontario Shield Ecozone and Georgian Bay Ecoregion 5E. This ecoregion has predominantly mixed forests characterized by a blend of northern and southern species, representative of the Great Lakes – St. Lawrence Forest Region (MNR 2007). Lakes and rivers comprise over 10% of the surface area, and wetlands are relatively rare, only covering 2.5% of this ecoregion. Characteristic tree species of Ecoregion 5E include conifers such as eastern white pine (*Pinus strobus*), red pine (*Pinus resinosa*), eastern hemlock (*Tsuga canadensis*) and black spruce (*Picea mariana*) and deciduous species such as yellow birch (*Betula alleghaniensis*) and sugar maple (*Acer saccharum*) (MNR 2007). The natural disturbance regime in this region is a combination of fire, wind and insect damage (MNRF 2019b). Wildlife are diverse and abundant, and characteristic regional species include eastern wolf (*Canis lupus lycaon*), American black bear (*Ursus americanus*), moose (*Alces americanus*), beaver (*Castor canadensis*), painted turtle (*Chrysemys picta*), common loon (*Gavia immer*), common raven (*Corvus corax*) and ruffed grouse (*Bonasa umbellus*) (MNR 2007).

Specific details about the terrestrial biodiversity present within the RSA and LSA are presented in annual monitoring reports produced by CNL (AECL 2013, 2014a; CNL 2015, 2016a,b,c, 2017d, 2018b) and reports prepared by consultants (CG&S 1997, 1998; North-South 2002; EcoMetrix 2013). These reports constitute the broader information about terrestrial biodiversity, including species of conservation concern, which is presented in Appendix 5.6-1 and was used to generate the list of terrestrial biodiversity VCs included in this assessment. The selected VCs are intended to focus the terrestrial biodiversity assessment, and this section therefore focuses on describing the environment (i.e., existing conditions) for each terrestrial biodiversity VC in the SSA, LSA and RSA.

Existing conditions for each VC represent the outcome of past and present effects on the environment. The level of effect within the SSA, LSA and RSA has varied over time. Although human occupation along the Ottawa River has been recorded from 4,000 to 5,000 years ago, the RSA was not affected by substantial industrial activity until the 1850s (AECL 2008). Fire was the primary disturbance factor in the RSA before the 1850s, although some selective logging for eastern white pine occurred in the RSA during the early 1800s.

The Mattawa Road opened as a winter road in 1854, permitting greater access into the RSA. Farmsteads were established in 1857 and the land was cleared of forests in many places (AECL 2014b). These small farms comprised most of the land use in the RSA until the federal government expropriated the land for construction of CRL in 1944 (AECL 2014b). Since the 1940s, land uses in the RSA have been limited to operations and activities undertaken at the CRL main campus and associated facilities (AECL 2008; SENES 2010). Vegetation clearing has been limited and the majority of the property has been undisturbed since the 1940s (i.e., for approximately 75 years), with the result that forests more than 75 years old are common.

Forest fires in the RSA have been limited, although several serious fires have occurred on the adjacent Garrison Petawawa (CNL 2018b). Fire suppression activities are regularly undertaken in the RSA because fire poses a safety hazard to the nuclear facilities at the CRL site (AECL 2008). The result is that the RSA currently serves as a refugium for vegetation communities and wildlife species associated with mature forests, including a number of species at risk. In absence of natural disturbances and in absence of activities mimicking natural disturbances (i.e., sustainable forest management practices), the current forest structure is not representative of a natural forest state.

Anthropogenic disturbance of the RSA and current activity (e.g., the CRL main campus area, access roads, firebreaks and Waste Management Areas [WMAs]) is largely concentrated in the southeast corner of the RSA. Disturbance in the form of roads is also primarily within the southern third of the property, with the main access road for employees (Plant Road) running east–west and numerous secondary roads branching off the Plant Road to specific destinations (i.e., ER-3 (Emergency Road), Foundation Road, Area B Road, Laundry Pit Loop, Power Line Road, Perch Lake Ring Road). There are two cleared and maintained hydroelectric corridors for the 115 kilovolt (kV) transmission lines through the CRL site, one spanning most of the north–south length of the property and the other spanning the southern east–west length of the property.

Overall, CNL's activities in the RSA have likely improved conditions for terrestrial biodiversity relative to conditions present in the 1940s (i.e., when much of the land was being cleared for agricultural use). Consequently, much of the RSA maintains high value for terrestrial biodiversity, including the VCs identified for this assessment. Within this context, and in cases where data were limited for some VCs, existing conditions were estimated using precautionary assumptions. For example, where suitable habitat was present for a VC, the VC was assumed to use the habitat, unless survey effort was available to demonstrate that the VC was absent. The following information sources were used to describe existing conditions for terrestrial biodiversity VCs:

- reconnaissance-level walk-through of the SSA by senior Golder biologist conducted on June 30, 2016;
- results of fieldwork undertaken annually by CNL staff in the LSA between 2012 and 2018, including forest songbird surveys (five acoustic recorders, 750 minutes of audio recording analyzed), amphibian surveys (seven acoustic recorders, 336 minutes of recording analyzed), wetland bird surveys (two acoustic recorders, 200 minutes of recording analyzed), bat surveys (three acoustic recorders, 128 minutes of recording analyzed; 21 visits to eight bat boxes), and Blanding's turtles (netting at six wetlands);
- studies published in scientific journals and reports;
- previous environmental assessments and terrestrial biodiversity surveys conducted within the RSA;
- federal recovery strategies for VCs available in ECCC's species at risk database (Government of Canada 2016);

- Forest Management Plan for the Ottawa Valley Forest (Van Dyke 2011);
- Forest Management Guide for Great Lakes – St. Lawrence Landscapes (MNRF 2019b);
- Forest Resource Inventory (FRI) geographic information system (GIS) spatial data (original source from Gendron Resource Surveys 1987);
- wetland GIS spatial data (received from CNL May 2016);
- road GIS spatial data (two datasets used and merged: received from CNL May 2016 and downloaded from the Land Information Ontario data warehouse (MNRF 2019c); and
- Ontario Ministry of Natural Resources and Forestry (MNRF) Natural Heritage Information Centre Make-a-Map: Natural Heritage Areas (MNRF 2019d).

A description of the existing conditions based on these information sources is provided for each terrestrial biodiversity VC in the sections below. Existing conditions are described according to the measurement indicators selected for each VC (see Section 5.6.2). Existing conditions for vegetation communities are described first because the maps generated to describe ecosystem availability and distribution for that VC are then used to describe habitat conditions for each species level VC.

For each wildlife VC, habitat mapping based on ecosystem data was used to provide spatially explicit descriptions of habitat availability and distribution under existing conditions, representing an estimate of suitable habitat available as a result of past and present development and activities. A review of habitat requirements and species ecology was completed for each wildlife VC to identify habitat that is most likely to be limiting for the species in the RSA and the loss of which would be most likely to result in change to the species' abundance in the RSA. The limiting habitat was selected as the focus of the assessment.

5.6.4.1 Vegetation Communities

5.6.4.1.1 Ecosystem Availability

Ecosystem availability was described using available FRI data. Vegetation communities are typically classified in central and southern Ontario using the Ecological Land Classification system; however, classification of "ecosite," a descriptive unit under the Ecological Land Classification system, is not included in the FRI spatial data available for the RSA. According to the *Forest Management Plan for the Ottawa Valley Forest* (Van Dyke 2011), ecosite descriptions have not been developed for any of the federally owned lands within the Ottawa Valley Forest Management Unit.

The FRI dataset available for the RSA consists of spatially explicit polygons (i.e., map units) that provide information on forest tree species composition, as well as other non-forested categories of land cover. The FRI data are typically derived by aerial photo interpretation with varying degrees of confirming derived habitat calls through field visitation (i.e., ground-truthing), depending on the age of the dataset; it is believed the FRI dataset for the RSA is based on mapping work conducted in 1987 and corrected in 2009; however, the dates associated with polygon delineation were not provided with the dataset. Forest cover information from the FRI dataset that was used for this assessment included forest unit (described below); forest tree species composition (as two-letter species codes); polygon / stand area (in hectares); and age (in years). It should be noted these data are intended to be used by forest managers to guide forestry activity, not specifically for assigning habitat classification. Forest units are categories of forest stands within the larger Forest Management Unit (i.e., the Ottawa Valley Forest in this case). These units have similar species composition, similar successional trends (from natural and/or silvicultural disturbance) and are managed under the same silvicultural system (Van Dyke 2011). For the purposes of defining vegetation community types that are useful for classifying ecosystems and wildlife habitat value, the following categories were derived from FRI data:

- **Mixed forest:** forest stands containing deciduous and coniferous trees in upper canopy. The mixed forest communities identified that occur within the RSA include red oak (*Quercus rubra*) – eastern white pine forest. Dominant tree species in mixed stands surveyed as part of the North-South Environmental Inc. (North-South) survey work in 2002 were recorded as red maple (*Acer rubrum*), poplar (i.e., aspen sp. [*Populus* sp.]) and eastern white pine. Woody debris and snags (i.e., standing dead trees, with high wildlife nesting value) were reported as abundant in mixed and deciduous forest types. Dominant shrub layer species recorded in both mixed and deciduous forests included striped maple (*Acer pensylvanicum*), mountain maple (*Acer spicatum*), immature sugar maple (*Acer saccharum*) and red maple, birch (*Betula* sp.), balsam fir (*Abies balsamea*), eastern white pine, maple-leaved viburnum (*Viburnum acerifolium*), beaked hazelnut (*Corylus cornuta*), round-leaved dogwood (*Cornus rugosa*) and eastern leatherwood (*Dirca palustris*). Herbaceous species dominant in the understory include wild sarsaparilla (*Aralia nudicaulis*), large-leaved aster (*Eurybia macrophylla*), spinulose wood fern (*Dryopteris carthusiana*), northeastern lady fern (*Athyrium filix-femina* var. *angustum*), wild lily-of-the-valley (*Maianthemum canadense* ssp. *canadense*), eastern teaberry (*Gaultheria procumbens*) and late lowbush blueberry (*Vaccinium angustifolium*).
- **Deciduous forest:** forest stands containing only deciduous trees in upper canopy. The deciduous forest communities identified that occur within the RSA include sugar maple – large-toothed aspen (*Populus grandidentata*) forest, poplar – red maple forest with deciduous understory, and poplar – red maple – oak (*Quercus* sp.) forest. Dominant shrub layer species in these forests are similar to those in the mixed forests. Dominant tree species in deciduous stands surveyed as part of the North-South survey work in 2002 were recorded as red maple and poplar. Along Mattawa Road, forests containing maple and beech (*Fagus* sp.) and considered to have more southern Great Lakes influence are more common. Woody debris and snags were reported as abundant in mixed and deciduous forest types.
- **Coniferous forest:** forest stands containing only coniferous trees in upper canopy. The North-South survey work (North-South 2002) classified the forested area within the north portion of the SSA, north of the east–west transmission line right-of-way (ROW) and straddling the north–south transmission line ROW, as white pine / red pine forest. This community was characterized as having 20 to 40 cm diameter at breast height red pine and/or white pine in a closed canopy. White pine is sub-dominant, followed by red maple and, less commonly, by white birch (*Betula papyrifera*), white spruce (*Picea glauca*) and red oak. The tall shrub layer was determined to be very sparse in areas and consists of immature white pine, beaked hazelnut, striped maple and immature balsam fir. The herbaceous layer is dominated by eastern teaberry, wild sarsaparilla, late lowbush blueberry, white-grained mountain-ricegrass (*Oryzopsis asperifolia*), large-leaved aster and bracken fern (*Pteridium aquilinum*). Rock outcrops and woody debris were both noted to be common.

- **Wetlands:** primarily marsh and swamp type wetlands (with some bog and fen type) as determined through FRI and CNL wetland mapping based on surveys conducted by CG&S (1997, 1998). Wetlands are highly important wildlife habitat features and can be very sensitive to physical disturbances or changes to hydrological processes, depending on wetland type. For example, wetland plant species that are sensitive to nutrient enrichment can be out-competed by other more common species if nutrient levels are altered (Granger et al. 2005). Within the RSA, wetlands provide important habitat for bat foraging and maternity roosting (if mature treed swamps) and Blanding's turtle hibernation, mating, foraging, thermoregulation, staging prior to nesting and for movement.
- **Flooded areas:** saturated areas not included under the classification of wetlands or aquatic habitat that were mapped in the FRI dataset. This includes areas originally mapped and coded as FL (flooded), M1 (lowlands – emergent vegetation), M2 (lowlands – sedges, grasses) and M3 (lowlands – shrubs, herbs, sedges). Flooded areas constitute a minor component of the RSA (1 ha, or less than 1%).
- **Unclassified (cleared):** an FRI designation for non-forested areas created for uses other than timber production, including roads, hydroelectric corridors or any anthropogenically altered area cleared of trees (MNRF 2017). The North-South (2002) survey report provides information on the composition of the vegetation community within the hydroelectric corridors in the RSA. The dominant species are primarily herbaceous, as the ROWs must be operationally maintained at low vegetation height. Species recorded include the following native plants: sweet fern (*Comptonia peregrina*), bracken fern, spreading dogbane (*Apocynum androsaemifolium*), field horsetail (*Equisetum arvense*) and heart-leaved aster (*Symphyotrichum cordifolium*). On steep slopes where there is bare ground and sparse vegetation cover, there are patches of exposed sand that are described as reminiscent of sand barrens, a significant vegetation community in Ontario; however, their small size and lack of provincially significant species occurrence precludes them from being designated as such. In these steep, exposed sandy areas, dominant species recorded include dry spike sedge (*Carex siccata*) and common scouring rush (*Equisetum hyemale*).

The classification of forest stand types (mixed, deciduous and coniferous) was conducted using the composition of deciduous and/or coniferous tree species within each FRI polygon and assigning it as "mixed", "deciduous" or "coniferous." If a stand had both coniferous and deciduous tree species present based on the assessment conducted as part of FRI mapping, it was classified as "mixed"; if a stand had only deciduous or coniferous tree species present, it was classified as such. The FRI codes for forest units could not be used because each forest unit can consist of more than one forest type. For example, a single forest unit, such as Mixed Uniform Shelterwood, can contain mixed, coniferous and deciduous forest stands. Consequently, forest unit was not used to define the forest stand type, although forest units can inform species composition (Appendix 5.6-2).
Other information associated with each forested vegetation community category, such as leading tree species and stand age, was used to identify the availability of suitable habitat for wildlife VCs (refer to Section 5.6.7.1).

Spatial data delineating the availability of wetlands within the terrestrial biodiversity study areas was provided by CNL and merged with the FRI dataset. Where CNL-derived wetland polygons overlapped FRI unclassified area polygons (i.e., roads, hydroelectric corridors), the unclassified area designation took priority; otherwise, the CNL wetland layer took priority. The CNL wetland layer was considered a better overall spatial representation of wetlands in the RSA, although the FRI data were considered a better representation of disturbance.

Although there are coniferous tree plantations within the RSA and these were delineated by FRI mapping as separate FRI polygons, the species composition and inclusion of relatively old stand ages distinguish them from typical coniferous tree plantations in Ontario that are more heavily managed and frequently disturbed. For this reason, plantations are described and considered but were not distinguished as a distinct vegetation community—they were considered as either coniferous or mixed forests (depending on recorded tree species composition). Availability of vegetation communities within the RSA and LSA under existing conditions are presented in Table 5.6.4-1.

Table 5.6.4-1: Availability of Vegetation Communities under Existing Conditions

Vegetation Community	Description	RSA		LSA	
		Area (ha)	Percent (%)	Area (ha)	Percent (%)
Mixed forest	Forested areas with deciduous and coniferous tree composition	1,929	50.1	71	33.6
Deciduous forest	Forested areas with only deciduous tree composition	643	16.7	6	2.8
Coniferous forest	Forested areas with only coniferous tree composition	199	5.2	5	2.4
Wetlands	Marshes, swamps as determined through FRI and detailed survey and mapping (CG&S 1997, 1998)	522	13.5	61	29.0
Flooded areas	This includes areas originally mapped and coded as FL (flooded), M1 (lowlands – emergent vegetation), M2 (lowlands – sedges, grasses) and M3 (lowlands – shrubs, herbs, sedges)	1	<0.1	0	0.0
Unclassified (cleared)	Based on FRI data, indistinguishable among hydroelectric corridor, road surface, buildings; includes all anthropogenically altered ground surfaces	268	7.0	27	12.8
Aquatic habitat (lakes, streams)		274	7.1	41	19.4
Slivers/Gaps (GIS gaps in spatial data coverage)		16	0.4	0	0.0
	Total	**3,853**	**100.0**	**210**	**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.

<= less than; FRI = Forest Resource Inventory; RSA = Regional Study Area; LSA = Local Study Area; GIS = geographic information system.

The RSA is primarily forested (72% of total area, including lake and stream features). Forests are predominantly mixedwood and deciduous, dominated by species such as aspen and red maple, with stands of eastern white pine and spruce species (*Picea* spp.) in some places. The RSA contains a number of small lakes and streams (e.g., Maskinonge Lake, Clear Lake, Chalk Lake, Perch Lake and Perch Creek), which make up 7% of the total area. Wetlands are also common, making up another 13.5% of the total RSA. The remaining 7% contains “unclassified” (i.e., anthropogenically modified) areas, consisting of roads, two 115 kV hydroelectric corridors, WMAs and all other developed areas such as the CRL main campus area.

The LSA is located in the southeastern corner of the RSA, in a primarily undisturbed area adjacent the most heavily anthropogenically altered areas in the RSA, including the CRL main campus and various WMAs. The LSA is a mix of forested (38.8%) vegetation communities and wetlands (29%). The proportion of wetlands in the LSA is relatively high compared to the rest of the RSA and surrounding region in general, reflecting how the LSA for terrestrial biodiversity was derived (see Section 5.6.3.1). Wetlands consist of South Swamp to the south of the SSA, East Swamp to the northwest of the SSA (which will receive treated effluent released from the WWTP via the exfiltration gallery) and the marsh wetlands surrounding Perch Lake and Perch Creek. Aquatic habitat, largely composed of Perch Lake and Perch Creek, covers 19.4% of the LSA. Anthropogenically altered ("unclassified") areas in the form of roads, hydroelectric corridors and one inactive Liquid Dispersal Area (LDA; Reactor Pit 1) comprise the remaining 12.8% of LSA.

The SSA is approximately 38 ha and consists primarily of second-growth, mature, mixed forest, dominated by poplar species, red oak, eastern white pine and, and spruce species. It also contains a 1.2 km long segment of East Mattawa Road and two linear areas cleared as 30 to 45 m wide ROW for overhead hydroelectric lines. The East Mattawa Road corridor was not captured in the FRI data, but the hydroelectric corridors were. Inclusion of the true extent of East Mattawa Road would result in a minor decrease to the mixed forest total coverage of the SSA, because it bisects a mixed forest stand.

There are two areas of immature coniferous forest stands in the SSA: one is a tree research plantation containing 100% Norway spruce (*Picea abies*) and the other is a portion of a stand of spruce, balsam fir and larch species (*Larix* spp.). The Norway spruce research plantation is within the western portion of the SSA and was planted in the 1950s. Personnel with the Petawawa Research Forest have confirmed this plantation is no longer required for research purposes. There is also a portion of one deciduous forest stand, within the northwest end of the SSA, which contains poplar species, yellow birch and red oak.

There are no wetlands, flooded areas or aquatic habitat features within the majority of the SSA. However, the transfer line to Perch Lake intersects wetland and aquatic habitat. The surficial geology around the SSA consists primarily of sands, underlain by dense sandy silt till containing cobbles and boulders. Organic soils (e.g., peat) have deposited in the low-lying areas. The overburden thickness at the site typically ranges from approximately 0 to 10 m, depending on bedrock topography. The vegetation communities present within the SSA reflect these soil conditions.

In addition to mapping using FRI data, a spatial query of the MNRF Make-a-Map system for natural heritage areas was conducted to identify any designated provincially significant natural features that may be present within the RSA. These would include designated provincially significant wetlands and areas of natural and scientific interest. According to the query, there are no designated provincially significant natural features within the RSA (MNRF 2019d).

5.6.4.1.2 Ecosystem Distribution

Because the RSA has remained largely undisturbed since the 1940s, it consists primarily of natural vegetation communities distributed according to natural ecological patterns. Forested vegetation communities make up 72% of the RSA, with a mosaic of forested areas interspersed with wetland areas and lakes that make up a combined 20.6% of the total area (Table 5.6.4-1). The degree of anthropogenic disturbance is generally on a north–south gradient, with the most northern part of the RSA generally undisturbed (with the exception of a hydroelectric corridor) and the southern part of the RSA most disturbed, where the CRL main campus, main employee access road (Plant Road) and other secondary access roads, as well as other WMAs are located. Anthropogenically altered ("unclassified") areas of the RSA comprise a total of 7% of the total area. Distribution of vegetation communities within the RSA in the Base Case are presented on Figure 5.6.4-1.

Distribution of vegetation communities within the LSA and SSA in the Base Case is presented on Figure 5.6.4-2. By virtue of how the LSA was derived, there are swamp and marsh-type wetlands surrounding the perimeter of the LSA on the south (Perch Lake Swamp, Perch Lake Fringe, Outlet Swamp); west (South Swamp, East Swamp); and east sides (Outlet Swamp surrounding Perch Creek). The remaining portion of the LSA is forested with poplar, red oak and eastern white pine dominated stands that are partially fragmented by 12.8% coverage of unclassified (anthropogenically cleared) areas. These altered areas are primarily made up of Plant Road and the two hydroelectric corridors, as well as a portion of the cleared area surrounding Reactor Pit 2. Plant Road and the hydroelectric corridors are linear features that bisect natural forested ecosystems across the LSA boundaries. East Mattawa Road is another linear feature on the landscape that exists, but was not captured by FRI mapping (i.e., so is not included in the calculated coverage of unclassified areas). There is also one isolated stand of Norway spruce (i.e., research plantation) within the LSA that is within a larger stand of poplar and red-oak dominated forest.

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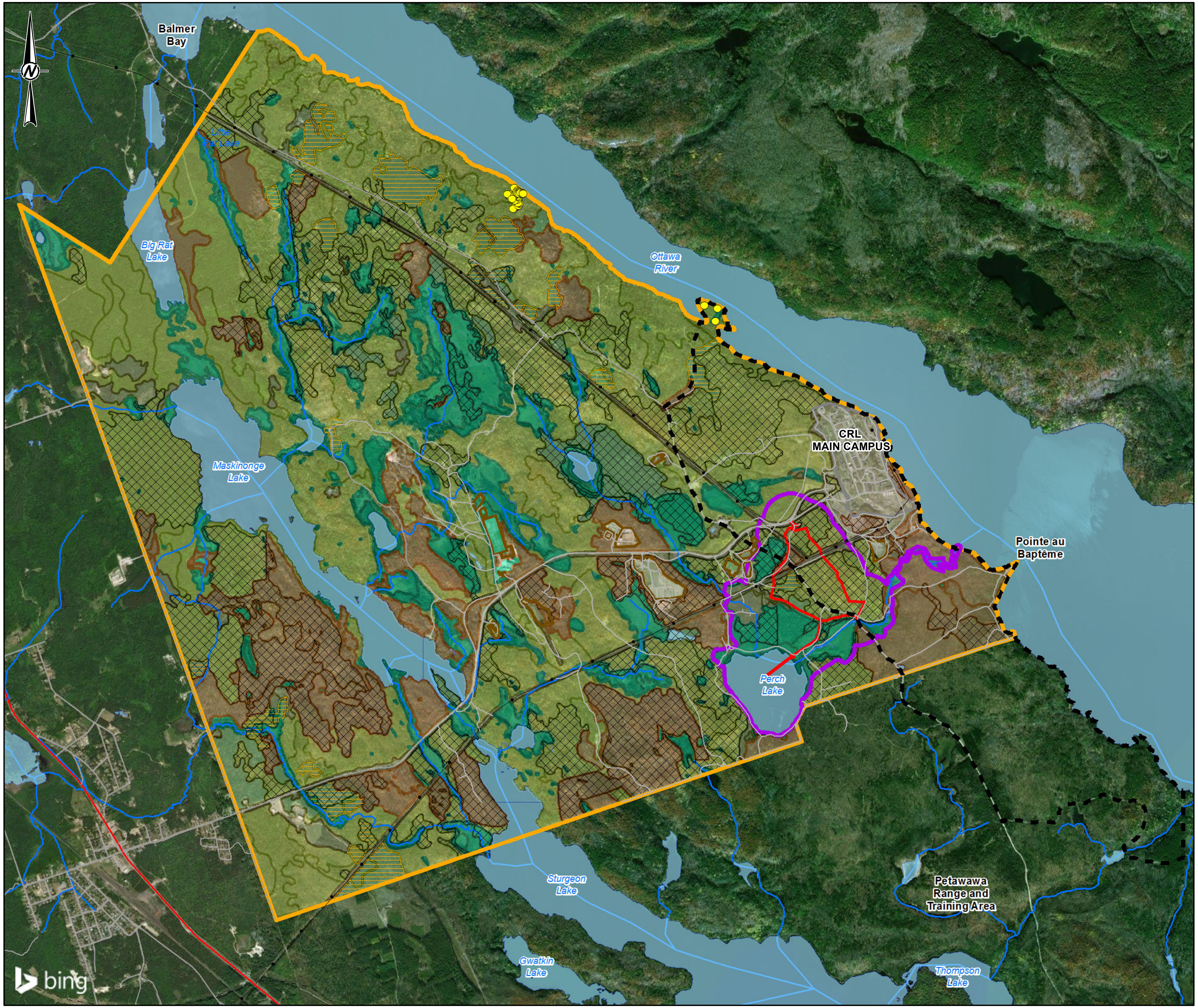

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- NORTH-SOUTH 2002 STUDY AREA

VEGETATION COMMUNITIES

- MIXED FOREST
- DECIDUOUS FOREST
- CONIFEROUS FOREST
- WETLANDS
- FLOODED AREA
- UNCLASSIFIED (CLEARED)
- MATURE FOREST STAND
- PLANTATION

SARA LISTED PLANT SPECIES OBSERVATION

- BUTTERNUT OBSERVATION

1 0 1
1:35,000 KILOMETRES

NOTE(S)
1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)
1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
VEGETATION COMMUNITIES AVAILABILITY AND DISTRIBUTION IN THE RSA – BASE CASE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.4-1

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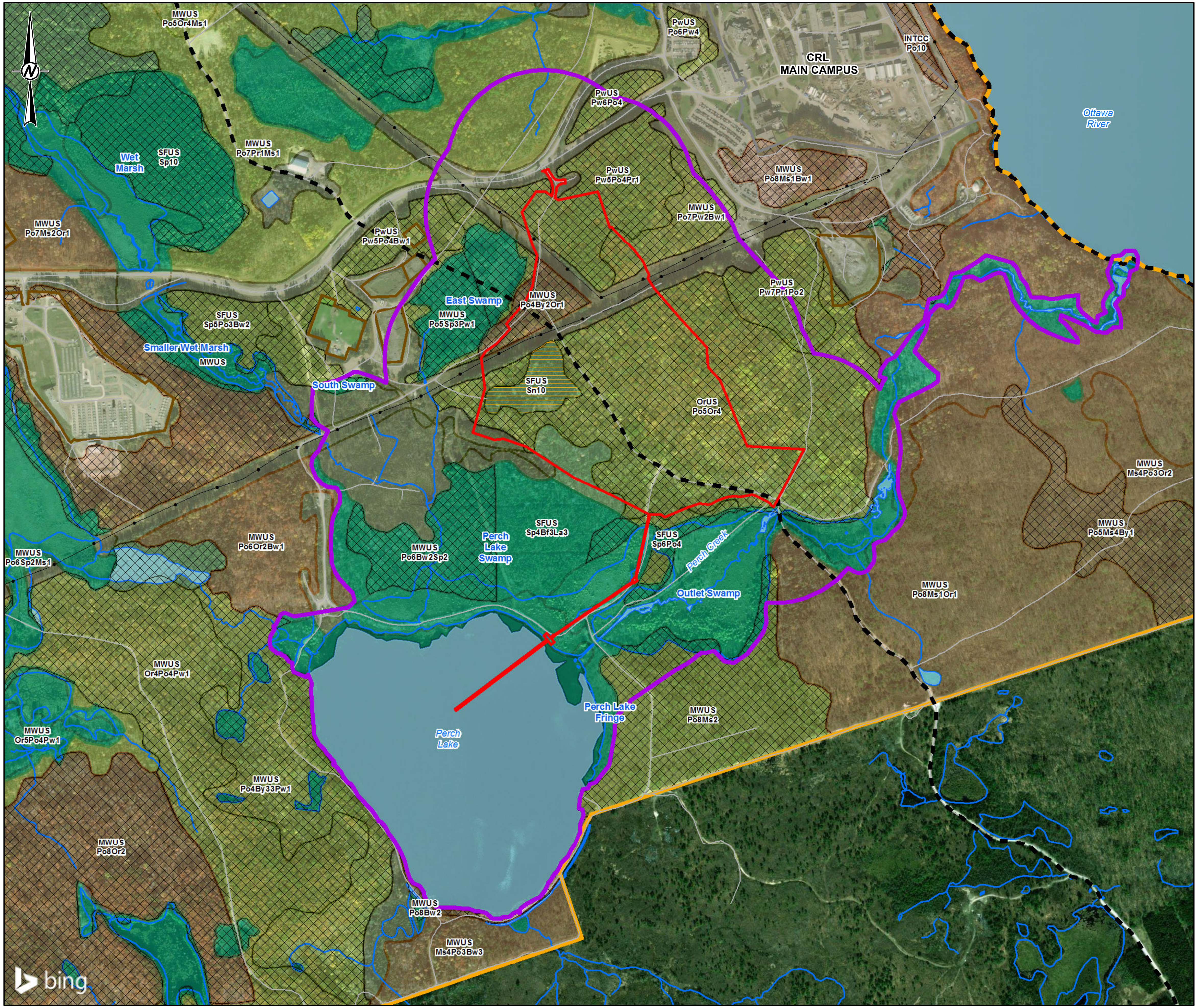

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
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VEGETATION COMMUNITIES

- MIXED FOREST
- DECIDUOUS FOREST
- CONIFEROUS FOREST
- WETLANDS
- FLOODED AREA
- UNCLASSIFIED (CLEARED)
- MATURE FOREST STAND
- PLANTATION

FOREST UNIT CODES:

Forest Unit	Description
MWUS	Mixed Uniform Shelterwood
PWUS	White Pine Uniform Shelterwood
SFUS	Spruce - Fir Uniform Shelterwood
INTCC	Intolerants Clear Cut
ORUS	Red Oak

FOREST COVER SPECIES CODES:

FRI Code	Tree Species	Coniferous (C) or Deciduous Species (D)
Bf	Balsam Fir (*Abies balsamea*)	C
Bw	Dwarf White Birch (*Betula minor*) or Paper Birch (*B. papyrifera*)	D
By	Yellow Birch (*B. alleghaniensis*)	D
La	American Larch (Tamarack) (*Larix laricina*)	C
Ms	Red Maple (Soft Maple) (*Acer rubrum*)	D
Or	Northern Red Oak (*Quercus rubra*)	D
Po	Poplar species (*Populus* sp.)	D
Pr	Red Pine (*Picea resinosa*)	C
Pw	Eastern White Pine (*Pinus strobus*)	C
Sp	Spruce species (*Picea* sp.)	C

250 0 250

1:10,000 METRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

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4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT CHALK RIVER, ONTARIO

TITLE

VEGETATION COMMUNITIES AVAILABILITY AND DISTRIBUTION IN THE LSA AND SSA – BASE CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.4-2

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5.6.4.1.3 Ecosystem Condition

Structural stage was used as a quantitative measure of ecosystem condition. Other factors affecting ecosystem condition such as abundance and distribution of native and non-native plant species and the presence of any significant ecosystem communities (e.g., sand barrens, provincially significant wetlands) were considered qualitatively and relied upon information contained in previous studies conducted within the RSA.

Structural age class for each FRI forest unit polygon within the RSA was obtained using the *Forest Management Plan for the Ottawa Valley Forest* (Van Dyke 2011) and the *Forest Management Guide for Great Lakes-St. Lawrence Landscapes* (MNRF 2019b). In cases where the two sources had a different structural age class assigned to the same polygon, the youngest age ranges were considered “mature” to provide a conservative assessment of the potential for the NSDF Project to affect mature forest stands. The ages for each structural stage specific to each forest unit are provided in Appendix 5.6-2.

Structural age classes for each forested vegetation community are defined as follows:

- **Pre-sapling**: very young forest created by stand-replacing natural disturbance, clear-cut harvest or final removal shelterwood harvest where the remaining stand is very young (Van Dyke 2011).
- **Sapling**: general term for young trees beyond seedling but not yet at pole stage, at vigorous growth stage and consisting of trees without dead bark and only occasional dead branches (NRCan 2016).
- **Immature**: definition as it relates to forest management—in even-aged management this refers to stands of trees past regeneration stage, but not yet mature; and in uneven-aged management it refers to established trees too young for commercial harvest (NRCan 2016).
- **Mature**: definition as it relates to forest management—in even-aged management this refers to stands of trees sufficiently developed to be harvestable and that are at or near rotation age (i.e., age at which the stand can be economically and sustainably harvested) (NRCan 2016).
- **Old growth**: distinguishable from younger stands based on the structure, ecological function and species composition. There is an accumulation of woody debris and the presence of species and functional processes representative of the potential climax natural community (in the absence of disturbance; NRCan 2016). The age of onset varies based on dominant tree species. For example, poplar trees are relatively short-lived compared to other tree species. As a result, poplar-dominated forests are considered old growth at 95 years, whereas red pine-dominated forests are considered old growth at 140 years (Watkins 2011).

Older aged forest stands are ecologically important because they provide greater habitat complexity and have higher species diversity. Although wildlife trees and coarse woody debris can occur in any aged forest stand, snags, cavity trees and other types of wildlife trees and the wildlife tree users that are associated with them, are more common in mature and old growth forest stands. Older structural stages are more difficult to return on the landscape because it takes many decades for mature forests to develop. Structural stages of forested vegetation communities are summarized below in Table 5.6.4-2.

The forest type and structural age class with the largest spatial coverage within the RSA is immature mixed forest (32%). Considering all forest types combined, immature forest comprises 42% of the total RSA. Mature mixed forest is the second most common forest type and structural age class by area coverage in the RSA (17.8%), and when considering all forest types combined, mature forest is also the second largest structural stage (27.8%). Pre-sapling and sapling forest areas are relatively uncommon on the RSA landscape (combined for all forest types only comprising 2.2%). This is not surprising given the restricted activity and forest fire suppression within the CRL site. There are no old forest stands in the RSA.

Within the LSA, there is a relatively older assemblage of forest stands compared to the RSA, with 32.2% spatial coverage of all combined forest types in the mature age class. The LSA has no pre-sapling, sapling or old forest stands; all stands are either immature or mature. Compared to the RSA, the LSA has a higher proportion of mature forest stands, and therefore provides a greater proportion of high-quality habitat for mature-forest dependant species, including those that depend on cavities and other features associated with wildlife trees. Almost all of the forest in the LSA is mixed forest. Woody debris and snags are abundant in mixed forest types in the RSA.

Table 5.6.4-2: Structural Stages of Forested Vegetation Communities in the Regional and Local Study Areas by Forest Type (Base Case

Forest Type	Structural Stage Category	RSA		LSA	
		Area (ha)	Percent(a) (%)	Area (ha)	Percent (%)
Mixed	Pre-sapling	4.2	0.1	0	0.0
	Sapling	9.2	0.2	0	0.0
	Immature	1,232.2	32.0	6.1	2.9
	Mature	684.2	17.8	64.9	30.9
	Old	0	0.0	0	0.0
Deciduous	Pre-sapling	25.1	0.7	0	0.0
	Sapling	30.1	0.8	0	0.0
	Immature	288.6	7.5	3.1	1.5
	Mature	298.8	7.8	2.8	1.3
	Old	0	0.0	0	0.0
Coniferous	Pre-sapling	1.6	<0.1	0	0.0
	Sapling	13.5	0.4	0	0.0
	Immature	97.4	2.5	4.7	2.2
	Mature	86.9	2.3	0	0.0
	Old	0	0.0	0	0.0
Total – All Forest Types Combined	Pre-sapling	30.9	0.8	0	0.0
	Sapling	52.8	1.4	0	0.0
	Immature	1,618.2	42.0	13.9	6.6
	Mature	1,069.9	27.8	67.6	32.2
	Old	0	0.0	0	0.0

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) Percentages based on total area of the RSA and LSA, respectively, inclusive of all other land cover types, not just forest (i.e., wetlands, flooded areas, unclassified (cleared) areas and aquatic habitat).

<= less than; RSA = Regional Study Area; LSA = Local Study Area.

Although ecosystem condition is primarily focused on native plant species, planted species can offer suitable surrogate habitat for wildlife, which often respond to habitat structure more so than species composition. For example, the somewhat naturalized coniferous tree plantations in the RSA may offer habitat for wildlife, including species at risk such as eastern whip-poor-wills.

Wetlands in the RSA provide important habitat for bat foraging and maternity roosting (if mature treed swamps) and for Blanding's turtle hibernation, mating, foraging, thermoregulation, staging prior to nesting and for movement. However, as described in Section 5.7.4.5, the East Swamp Wetland, which is adjacent to the SSA, has existing radioactive contamination associated with a shallow subsurface plume from the Chemical Pit and a second plume from Reactor Pit 2, thereby reducing the condition of this wetland. The surface contamination distribution in the East Swamp has been characterized with radiation field surveys, surface surveys and vegetation contamination surveys performed in 2002, 2007 and 2012. In 2002 and 2012, these surveys included wetland soil and vegetation sampling to determine the radionuclide concentrations in these media. These results are discussed in Section 5.7.4.7 Radioactivity in Soils.

According to a spatial query of the MNRF Make-a-Map system for natural heritage areas, there are no designated provincially significant natural features within the RSA (MNRF 2019d). Their small size and lack of provincially significant species occurrence precludes the sand barrens identified in the SSA and LSA from the provincially rare vegetation community designation (MNR 2000).

Detailed vegetation inventory was not available for the RSA; however, an invasive survey was conducted along roadways and other anthropogenic disturbances identified the presence of purple loosestrife (*Lythrum salicaria*), spotted knapweed (*Centaurea maculosa)*, Phragmites (*Phragmites sp.)*, reed canary grass (*Phalaris arundinacea)* and white sweet clover (*Melilotus albus)*. Although ingress into native forested areas where the soil has not been disturbed is poorly understood, invasive species have the potential to alter ecosystem condition, particularly in smaller patches where the edge-to-interior ratio is higher (Honnay et al. 2002).

Butternut (*Juglans cinerea*) is the only SARA-listed plant species that has been recorded in the RSA (see Figure 5.6.4-1). This species does not have a high likelihood of occurrence within the SSA based on the location of the RSA, which is beyond the known northern extent of the range of butternut in Ontario, and on site conditions. Surveys to date have not indicated the presence of butternut within the SSA, and suitable habitat is not common in this location. Suitable butternut habitat consists of a range of tolerable soil types, but the highest quality conditions are rich, moist, well-drained loams typically within streamside riparian areas and also well-drained gravely sites of limestone origin (Environment Canada 2010). Butternut is shade intolerant but can be a minor component of late-successional stage forests with openings in the canopy. Butternut within the RSA (but outside of the LSA) are associated with old homesteads. Some regeneration was noted in one patch during surveys, but it was always near the parent trees that were associated with the old homestead.

5.6.4.2 Migratory Birds

5.6.4.2.1 Habitat Availability

Given the large number of species of birds from various families that are classified as migratory birds, habitat preferences among migratory bird species are highly diverse and cover the range of available habitats in the RSA. A total of 117 migratory bird species are known to be present in the RSA or have the potential to be present in the RSA based on known distribution and presence of suitable habitat in the RSA (Appendix 5.6-3). Many of these are forest landbirds, but there are also several waterfowl and waterbirds.

The vegetation community data were used to map suitable habitat for migratory birds in the LSA and RSA. Migratory birds have the potential to occupy all natural habitat available in the RSA and, therefore, suitable habitat for migratory birds was evaluated as all age classes (if applicable) for all natural cover types. The potential exists for all of the natural cover types in the RSA and LSA to be occupied by various species of migratory birds at various times of the year (i.e., breeding season, during migration, winter).

Some migratory bird species will also occupy anthropogenic structures (e.g., buildings, bridges). This potential was considered qualitatively, but only natural cover types were considered in quantitative estimates of habitat availability for migratory birds. Table 5.6.4-3 presents habitat availability for migratory birds. Approximately 3,568 ha (92.6%) of the RSA and 177 ha (84.3%) of the LSA represent available habitat for migratory birds in the Base Case. The SSA comprises mostly mature mixed forest, but wetlands and aquatic habitat (Perch Lake) are also prominent habitat types in the LSA (Section 5.6.4.1.1).

Table 5.6.4-3: Habitat Availability for Migratory Birds (Base Case)

Habitat Suitability	Regional Study Area		Local Study Area	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Suitable	3,568	92.6	177	84.3
Unsuitable	285	7.4	33	15.7
Total	3,853	100.0	210	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.

Disturbances (e.g., fire, anthropogenic) have likely had both positive and negative effects on migratory bird habitat availability in the Base Case, depending on the habitat preferences of the species. For example, forest fire or logging may represent habitat loss for a forest species but habitat gain for an edge or early-successional species. The development of industrial infrastructure in the RSA represents a loss of habitat for most species of migratory birds, but other disturbances (e.g., fire, logging, farmsteading) would have had mixed effects on habitat availability for migratory birds as a group, with some species benefiting from these disturbances while others experience habitat loss.

Several forms of significant wildlife habitat (SWH) for migratory birds may be present in the RSA (MNR 2000). Although SWH is not a recognized designation on federal lands, it is nevertheless a useful indicator of the value of habitat to species of interest. The lakes and large wetlands in the RSA qualify as candidate waterfowl stopover and staging areas (aquatic). Seven of the waterfowl species identified as indicators for this SWH type have been observed in the RSA to date. Waterfowl surveys during the migration seasons have not been completed and would be required to confirm significance based on MNRF guidelines (MNR 2000). Nevertheless, CNL considers wetlands greater than 25 ha in area to be significant waterfowl stopover and staging areas based on the definition of a “waterfowl gathering area” in the Quebec Regulation Respecting Standards of Forest Management for Forests in the Domain of the State (chapter A-18.1, r. 7), as well as due to the proximity of the wetlands to the Ottawa River, which is a major migration corridor. The shorelines of lakes, rivers and wetlands in the RSA qualify as candidate shorebird migratory stopover areas, but surveys during the migration seasons have not been completed and would be required to confirm significance. None of the shorebird species identified as indicators for this SWH type have been observed in the RSA to date.

Great blue herons (*Ardea herodias*) have been confirmed breeding in the RSA; one nest with three young was observed in a swamp/marsh during surveys in 2012. However, only breeding colonies containing 10 or more active nests qualify as SWH in the form of colonially nesting bird breeding habitat (tree/shrub). Although suitable habitat is available in the LSA, no great blue heron colonies representing SWH have been observed during searches to date.

5.6.4.2.2 Habitat Distribution

Most of the RSA is under natural vegetative cover consisting primarily of mixed forest communities (Figure 5.6.4-3). Lakes and wetlands naturally fragment the forest cover and are themselves patchily distributed throughout the RSA. The RSA is likely less fragmented than it was in recent history because of fire suppression and cessation of logging and farmsteading, which have resulted in reforestation. Most of the current human disturbance in the RSA is concentrated in the southeastern two thirds of the RSA. Mattawa Road and a hydroelectric corridor run through the northern portion of the RSA and Plant Road runs from the CRL main campus through the western portion of the RSA to the rural village of Chalk River. The CRL main campus and WMAs are discrete, isolated disturbances that are not believed to represent major barriers to migratory bird movement since birds are highly mobile and can fly around or over these areas. Several local roads and two hydroelectric corridors cross the LSA, and a portion of the LDA is contained within the LSA, but the LSA remains mostly forested (Figure 5.6.4-4). Linear disturbances (roads, trails, hydroelectric corridors) in the LSA and RSA are generally less than 30 m wide and at most 45 m wide. Narrow linear disturbances generally do not represent barriers to bird movement (Desrochers and Hannon 1997; St. Clair et al. 1998), although they may influence territory establishment and delineation (Machtans 2006). Therefore, existing disturbances in the LSA and RSA are unlikely to function as dispersal barriers for migratory birds in the Base Case.

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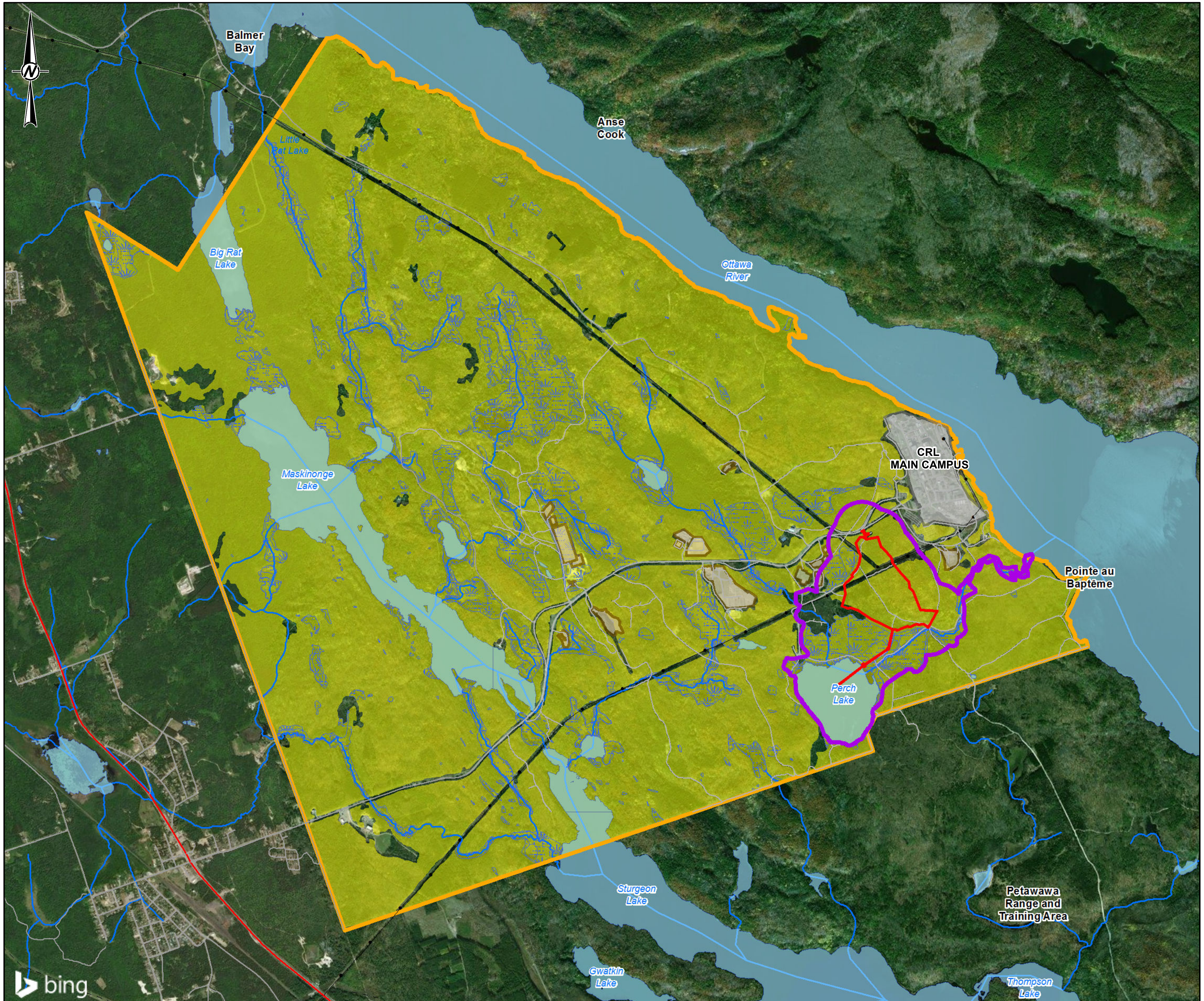

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- MIGRATORY BIRD HABITAT

1 0 1

1:35,000 KILOMETRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

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CLIENT

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PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

MIGRATORY BIRDS HABITAT AVAILABILITY AND DISTRIBUTION IN THE RSA – BASE CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.4-3

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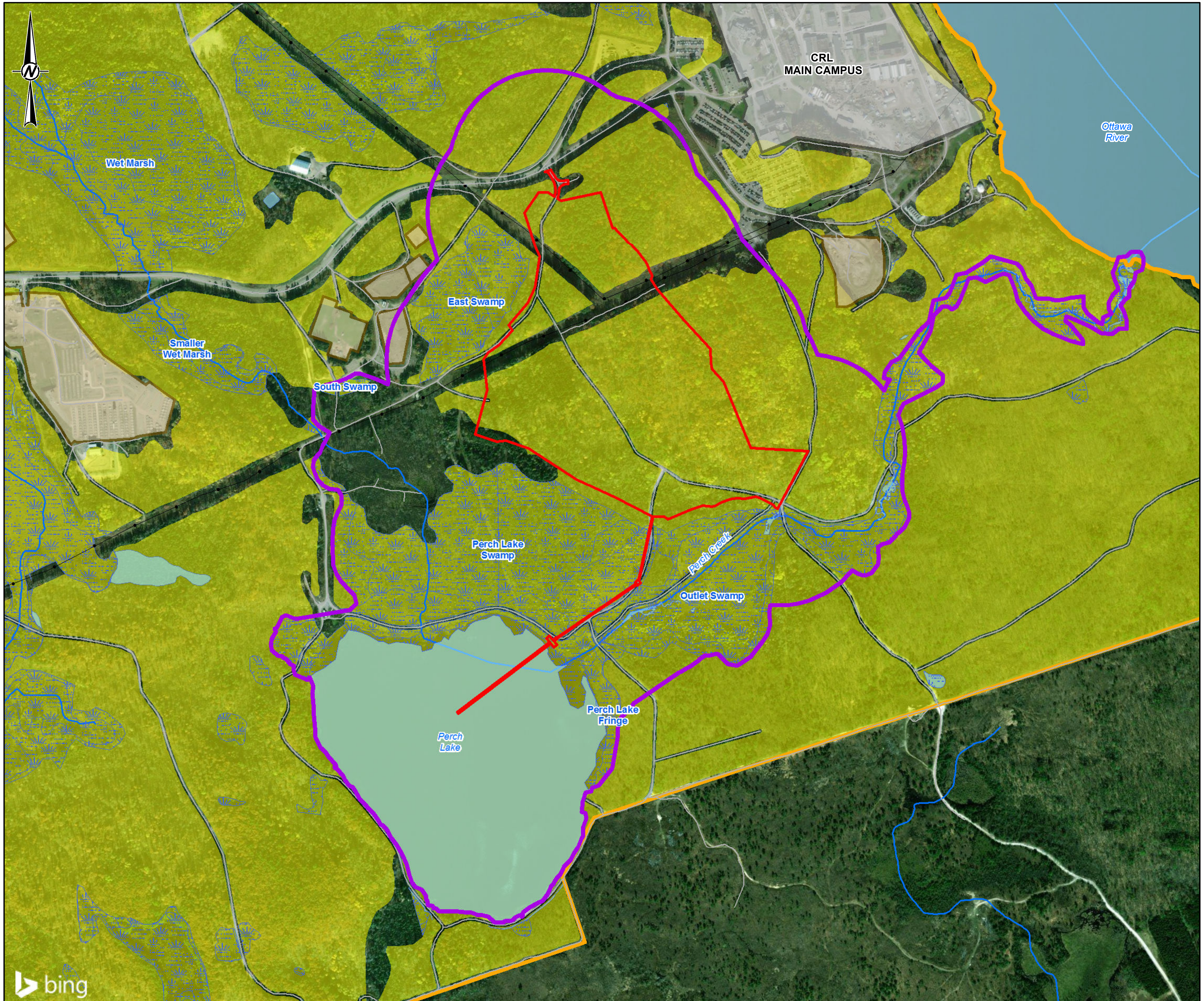

LEGEND

- HIGHWAY
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- SITE STUDY AREA
- MIGRATORY BIRD HABITAT

250 0 250

1:10,000 METRES

NOTE(S)

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5.6.4.2.3 Survival and Reproduction

Fifty-five migratory bird species have been recorded in the RSA during surveys, with chestnut-sided warbler (*Setophaga pensylvanica*), veery (*Catharus fuscescens*), white-throated sparrow (*Zonotrichia albicollis*) and black-throated blue warbler (*Setophaga caerulescens*) being the most commonly observed species. An additional 62 species are known to occur in the RSA or potentially occur in the RSA based on habitat availability. Based on the Ontario Breeding Bird Atlas (OBBA) and field observations (where available), 75 species are confirmed breeders, 17 are probable breeders and 24 are possible breeders in or within the vicinity of the RSA, which overlaps primarily with OBBA survey square 18US10 and slightly with OBBA survey squares 18US00 and 18UR19 (Cadman et al. 2007; Appendix 5.6-3). The breeding status of the remaining seven species is unknown in the vicinity of the RSA.

The *State of Canada's Birds 2012* report (NABCIC 2012) concluded that bird populations in the Southern Shield and Maritimes region, which includes the RSA, had declined by 13% on average across species groups and forest birds specifically by 10% since 1970. More broadly, the *State of North America's Birds 2016* report (NABCI 2016) concluded that one third of all North American bird species, many of which are migratory birds, are in urgent need of conservation action due to declining populations and/or severe threats to their sustainability. Although the results from these reports cover broad geographic areas and include species that would not occur in the RSA, they nevertheless demonstrate that migratory birds are of conservation concern and many species are in decline. The largely contiguous forested habitats in the RSA and LSA may be of local and regional benefit to forest-dwelling migratory birds in an increasingly fragmented landscape.

Anthropogenic threats to migratory bird survival and reproduction vary among species because of their diverse ecologies. However, some universal threats that may apply in the RSA are collisions with human infrastructure and collisions with vehicles. Buildings in the CRL main campus and WMAs may pose a collision risk to migratory birds that reside in or migrate through the RSA. Vehicular traffic volume and speed limits in the RSA are low, and therefore, risk of collision with vehicles is expected to be negligible in the Base Case.

5.6.4.3 Canada Warbler

5.6.4.3.1 Habitat Availability

The NSDF Project is in breeding habitat for Canada warblers (*Cardellina canadensis*). Throughout their breeding range, Canada warblers nest in a range of forest types, especially wet forests with a well-developed, dense shrub layer (COSEWIC 2008; Government of Ontario 2015a). This species is commonly found in shrub marshes, red maple stands, cedar (*Thuja* spp.) stands, swamps dominated by black spruce and tamarack (*Larix laricina*) and riparian woodlands (COSEWIC 2008). In the eastern portion of their range, Canada warblers are associated with wet mixed forests and early successional forests (6 to 30 years) created by forest harvesting or natural disturbance (Ball and Bayne 2014; ECCC 2016a). Critical habitat has not yet been defined for this species (ECCC 2016a). The vegetation community data were used to map suitable habitat for Canada warbler in the LSA and RSA as follows:

- all forest stands in the pre-sapling, sapling and mature age class; and
- wetlands.

A total of 128 ha (61.0%) and 1,701 ha (44.1%) of suitable habitat for Canada warbler is estimated to be present in the LSA and RSA, respectively, in the Base Case (Table 5.6.4-4).

Table 5.6.4-4: Breeding Habitat Availability for Canada Warbler in the Base Case

Habitat Suitability	Regional Study Area		Local Study Area	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Suitable	1,701	44.1	128	61.0
Unsuitable	2,152	55.9	82	39.0
Total	3,853	100.0	210	100.0

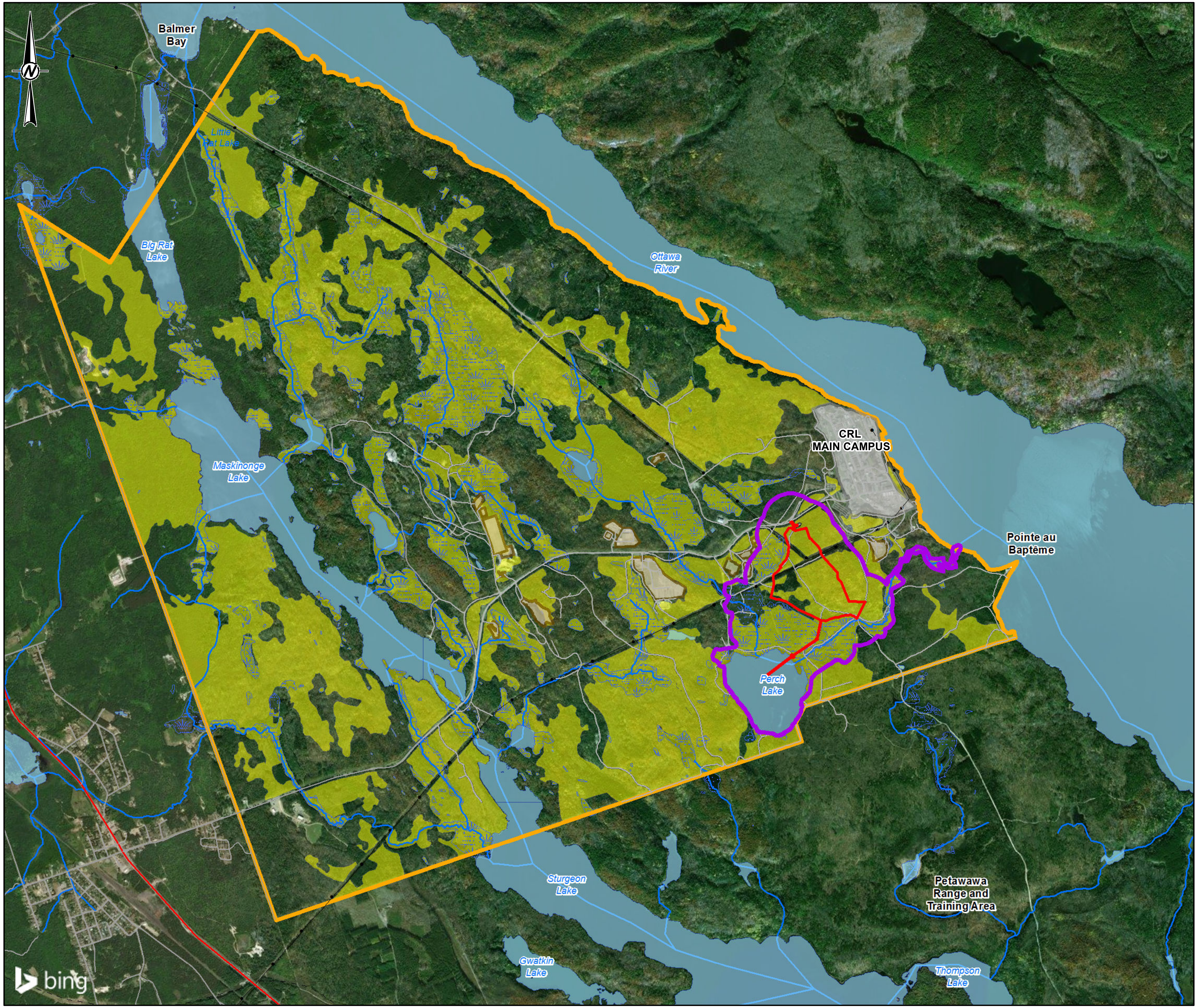
Disturbances can have both positive and negative effects on Canada warbler habitat availability. Disturbances result in the initial removal of habitat causing Canada warblers to be generally absent from recently disturbed areas (0 to 5 years post-disturbance; Norton et al. 2000; Schieck and Song 2006). However, vegetation clearing can improve habitat around the disturbance perimeter by creating shrubby edge habitats that are positively associated with Canada warbler abundance (Ball and Bayne 2014; Collins et al. 1982; ECCC 2016a). Firebreaks, utility corridors and road corridors may have created some suitable habitat for Canada warbler in the Base Case because forest edges generally have denser shrub layers than interior forests.

Fire suppression activities have likely had negative effects on Canada warbler habitat availability relative to what was historically available for this species in the RSA. Shrub density is highest in young regenerating (0 to 24 years) and mature forests because light levels are limited in closed-canopy stands characteristic of mid-seral stages (Alaback 1982; McKenzie et al. 2000). Most forested areas in the RSA are 60 to 80 years old and may not provide preferred habitat for Canada warbler; however, there is some uncertainty associated with the age of forests in the RSA (Section 5.6.4.1.3). Forest stands in the LSA are mostly mature (greater than 80 years old) and structurally complex (Section 5.6.4.1.1), and likely provide highly suitable habitat for Canada warbler in the Base Case.

5.6.4.3.2 Habitat Distribution

In the Base Case, suitable Canada warbler habitat is well distributed throughout the RSA (Figure 5.6.4-5) and LSA (Figure 5.6.4-6). Habitat does not appear to be a limiting factor for Canada warbler in the Base Case, as this species is highly mobile and can establish territories in new areas. Canada warblers are considered to have widespread, but clumped distribution in the Ottawa Valley Forest Management Unit (Van Dyke 2011).

Effects from habitat fragmentation on Canada warblers are unclear. Some studies suggest that fragmentation has negative effects on Canada warblers because they are an interior-forest nesting species that avoids edge habitat (Askins and Philbrick 1987; Hobson and Bayne 2000). Other studies suggest Canada warblers are resilient to habitat fragmentation because the species uses early successional and dense shrubby habitat that is often associated with habitat disturbance (Schmiegelow et al. 1997; Schmiegelow and Monkkonen 2002). Whether habitat fragmentation from linear disturbances in the LSA and RSA in the Base Case has had a positive or negative effect on the distribution of Canada warbler habitat in the RSA remains uncertain.



LEGEND

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- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- CANADA WARBLER HABITAT

1 0 1

1:35,000 KILOMETRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

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CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
CANADA WARBLER HABITAT AVAILABILITY AND DISTRIBUTION IN THE RSA – BASE CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.4-5

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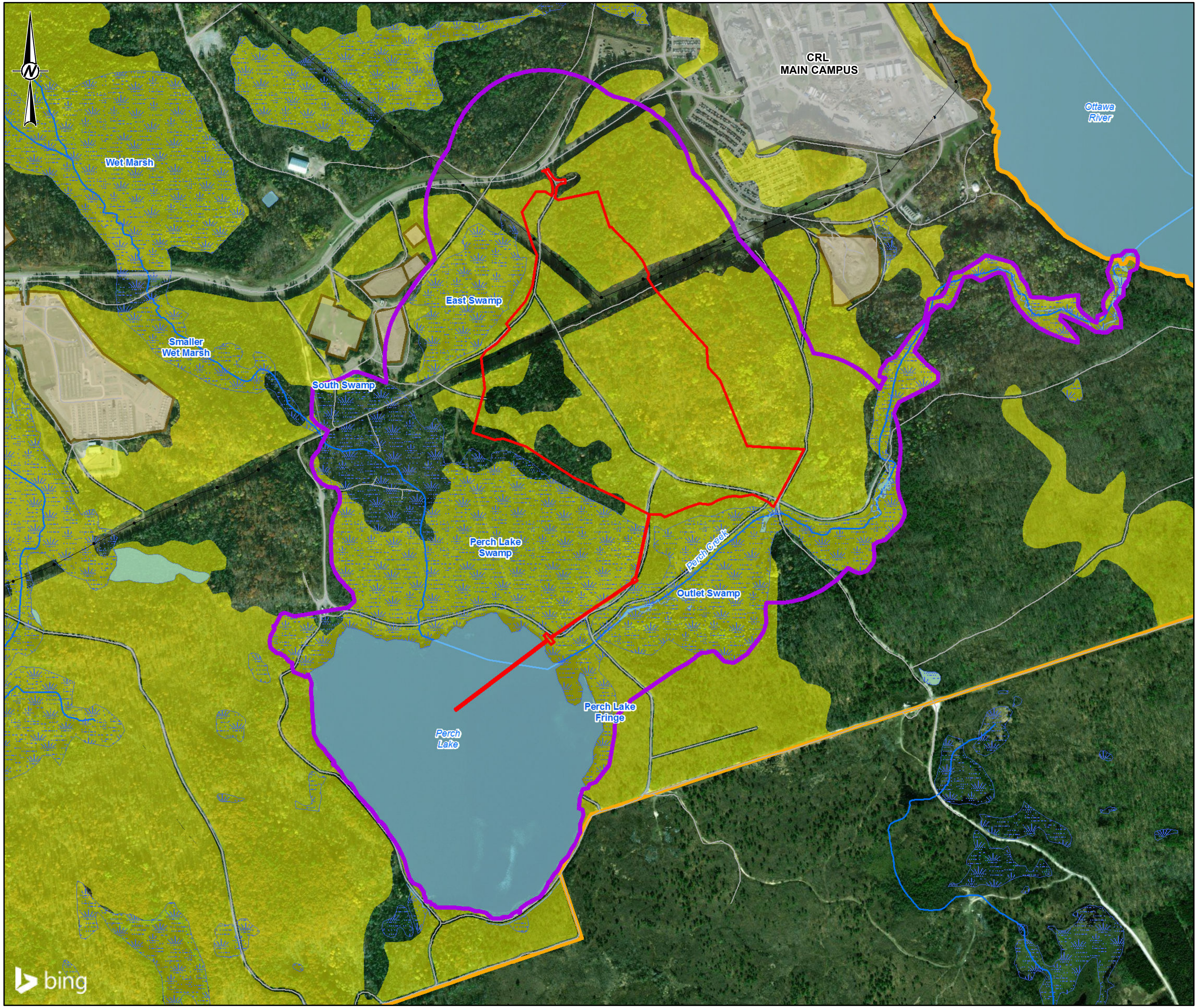

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- CANADA WABLAR HABITAT

250 0 250

1:10,000 METRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

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CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

CANADA WARBLER HABITAT AVAILABILITY AND DISTRIBUTION IN THE LSA AND SSA – BASE CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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Linear disturbances in the RSA are generally less than 30 m wide and the RSA is composed mostly of forested habitat in patches larger than 10 ha. Similarly, several local roads and two hydroelectric corridors cross the LSA, and a portion of the LDA is contained within the LSA, but the LSA remains mostly forested. Narrow linear disturbances generally do not represent barriers to bird movement (Desrochers and Hannon 1997). St. Clair et al. (1998) found that some forest birds were reluctant to cross gaps greater than 50 m, but would cross gaps of 200 m when no other choice existed. Existing disturbances in the RSA do not likely function as dispersal barriers for this species in the Base Case.

5.6.4.3.3 Survival and Reproduction

Approximately 82% of the Canada warbler breeding range occurs in Canada (ECCC 2016a). The Canadian population of this species is estimated to be 3,000,000 individuals (ECCC 2016a). Abundance estimates of Canada warbler in Ontario suggest a population of 900,000 individuals or approximately 33% of the Canadian population (COSEWIC 2008). In Ontario, results from the OBBA indicated an annual population decline of 0.8% between the first (1981 to 1985) and second (2001 to 2005) atlas periods (Cadman et al. 2007). Long-term Breeding Bird Survey (BBS) data show a decline of Canada warbler abundance of 4.5% per year from 1968 to 2007 (overall 83% decline; ECCC 2016a). Population trends for eastern Canada (Ontario, Quebec and the Maritimes) all show long-term (1968 to 2007) and short-term (1997 to 2007) declines (COSEWIC 2008).

Because the Canada warbler population in Canada has declined by 83% from 1968 to 2007, it is considered a priority species under the Bird Conservation Strategy for the region, which has the objective of doubling current abundance (Environment Canada 2014). The Canada warbler was designated as threatened by COSEWIC in 2008 and was given the same status under Schedule 1 of SARA in 2010. Despite concerning population trend data, the federal recovery strategy concluded that “there are currently adequate numbers of individuals to sustain the species in Canada or increase its abundance with the implementation of proper conservation actions” (ECCC 2016a). The population objective for Canada warbler, as identified in the final federal recovery strategy, is to halt the national decline by 2025, with no more than a 10% decline during this time and ensure a 10-year positive population trend thereafter (ECCC 2016a).

Site-specific surveys in the RSA recorded six Canada warblers in 2007 and seven in 2013. Canada warbler was identified as a confirmed breeder in the OBBA survey square 18US00 and as a possible breeder in the OBBA survey square 18UR19 (Cadman et al. 2007). Canada warblers have been regularly reported in the areas surrounding the RSA (COSEWIC 2008; eBird 2017). The presence of Canada warbler has been confirmed during baseline surveys in the LSA and RSA and is assumed to be breeding in suitable habitat throughout the RSA.

The abundance of Canada warblers is positively related to shrub density (Norton and Hannon 1997; Hallworth et al. 2008). The primary threats to Canada warbler habitat include conversion of land for agriculture, removal of the shrub layer (e.g., from forest harvesting or silviculture), forest harvesting and accidental mortality from collisions with infrastructure (ECCC 2016a). Several theories have been suggested as to the cause of Canada warbler population decline, including habitat loss and degradation (Ball and Bayne 2014), predation on breeding grounds (Bohning-Gaese et al. 1993) and spruce budworm declines (Sleep et al. 2009). A cause-effect relationship has not been established between loss and degradation of wintering habitat and Canada warbler population decline, but loss of primary forest on the wintering grounds is still considered to be a primary potential cause of this species’ decline (ECCC 2016a). It is currently unknown whether breeding habitat is a limiting factor for this species in Canada (ECCC 2016a).

The Canada warbler primarily feeds on flying insects and spiders. Although Canada warbler will feed on various species of insects, it has been found to feed heavily on spruce budworms during outbreaks. Insect populations are declining worldwide, and spruce budworm outbreaks in eastern forests have decreased since 1970; both factors may be contributing to Canada warbler decline (ECCC 2016a). Many aerial-foraging insectivorous birds, such as Canada warbler, have experienced large declines since the 1980s (Blancher et al. 2009; NABCIC 2012). The declines suggest a single cause related to insect abundance as both forest and non-forest aerial-foraging birds are declining (Blancher et al. 2009; Nebel et al. 2010; Nocera et al. 2012; Paquette et al. 2014). Potential causes of reduced availability of insects include habitat loss, changes to timing of peak food abundance from climate change and pesticide use (Nebel et al. 2010; Nocera et al. 2012; Paquette et al. 2014). Insect and bird populations in the RSA have likely been affected by all of these factors in the Base Case. Canada warblers may be susceptible to these factors because their residency on breeding grounds is brief compared to other warblers. Canada warblers are one of the last species to arrive on breeding grounds and one of the first species to leave in the fall (COSEWIC 2008). This behaviour reduces the possibility for raising more than one clutch per year, as well as limiting adaptive capability in regard to climate change (ECCC 2016a).

5.6.4.4 Eastern Whip-poor-will

5.6.4.4.1 Habitat Availability

The NSDF Project is located in breeding habitat for this species, which is the focus of this assessment. Whip-poor-wills (*Antrostomus vociferus*) breed in semi-open or patchy forests and wide-open spaces and avoid dense forest (COSEWIC 2009). Forest structure seems to be more important that forest composition, but whip-poor-wills are most commonly found in dry deciduous or mixed forests throughout most of the species' range (Cink et al. 2017; Beaudry et al. 2010). Whip-poor-wills are also commonly found in rock or sand barrens with scattered trees, old burns, other disturbed sites with early forest succession and pine plantations (Cink et al. 2017; COSEWIC 2009). This species prefers even-aged successional habitats and is uncommon in mature forests, although individuals may use openings in mature forest areas (Bushman and Therres 1988; Government of Ontario 2015b). Nests require tree cover, shade and sparse ground cover and need to be in close proximity to open areas for foraging (MNR 2012). Utility and road corridors may provide suitable habitat for this species (COSEWIC 2009). Critical habitat has been identified in the federal recovery strategy for this species to consider a combination of habitat suitability and habitat occupancy (ECCC 2018a). Suitable habitat is divided into nesting and foraging habitat, and these must be adjacent to one another to qualify for critical habitat designation (ECCC 2018a) and includes the following:

- Suitable nesting habitat includes most forest types, with a higher preference for those at early stages of succession, or edges of forests with a dense tree cover and similar structure types at the ground level. These suitable nesting habitats may also represent rock or sand barrens, savannahs, old burns and conifer plantations (Wilson 1985; Mills 2007; Wilson and Watts 2008).
- Suitable foraging habitat is forest with low tree cover or open habitats, dense shrub cover and poorly drained soils, or agricultural land with scattered shrubs or trees. Foraging activities generally occur within 500 m of the nest.

Vegetation community data were used to map suitable habitat for eastern whip-poor-will in the LSA and RSA as follows:

- all forest stands in the pre-sapling and sapling age class;
- all forest stands (any age class) within a 50 m buffer around wetlands and aquatic habitat; and
- all forest stands (any age class) within a 50 m buffer along the Ottawa River.

Suitable breeding habitat for eastern whip-poor-will consists of forests adjacent to open habitats. Availability of breeding habitat for eastern whip-poor-will was predicted in the Base Case using the vegetation community data (Section 5.6.4.1). Suitable habitats were mixed deciduous and coniferous forests 0 to 34 years of age (i.e., pre-sapling and sapling stages) and forests of any age within 50 m of wetland and aquatic habitats. A total of 13 ha (6.0%) and 769 ha (20.0%) of suitable habitat for eastern whip-poor-will is estimated to be present in the LSA and RSA, respectively, in the Base Case (Table 5.6.4-5).

Table 5.6.4-5: Breeding Habitat Availability for Eastern Whip poor will in the Base Case

Habitat Suitability	Regional Study Area		Local Study Area	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Suitable	769	20.0	13	6.0
Unsuitable	3,083	80.0	197	94.0
Total	3,852	100.0	210	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.

The RSA overlaps one 10 km by 10 km standardized Universal Transverse Mercator (UTM) grid square identified to contain critical habitat for this species (grid square 18TUS00; ECCC 2018a), but the area of overlap is small (28 ha). The exact location of critical habitat in grid squares is not identified in recovery strategies and, therefore, it is unknown whether critical habitat in grid square 18TUS00 overlaps with the RSA. Based on habitat mapping, approximately 3 ha of suitable habitat occurs in the grid square where it overlaps the RSA.

Rock barren habitat is uncommon in the RSA and is predominately found near the Ottawa River shoreline (AECL 2008). Sand barrens have been recorded in the Perch Lake and Maskinonge Lake basins (AECL 2008). Little development has occurred in areas with potential to contain rock and sand barren habitat.

Disturbances can have both positive and negative effects on whip-poor-will habitat availability. Fire suppression activities since the 1940s have likely increased nesting habitat availability relative to what was historically available for this species in the RSA by allowing natural forest succession. Shrub density is lowest in forests 25 to 100 years old because light levels are limited in these forest stands (Alaback 1982; McKenzie et al. 2000). Most forested areas in the RSA are 60 to 80 years old and may therefore provide suitable nesting habitat for whip-poor-will. On the contrary, fire suppression reduces the availability of open habitat and young forest used as foraging habitat by this species. Firebreaks and road and hydroelectric corridors in the RSA may provide suitable foraging habitat for whip-poor-wills (COSEWIC 2009). Larger disturbance areas, such as the WMAs, may provide suitable foraging habitat, especially areas surrounded by suitable nesting habitat (MNR 2012).

5.6.4.4.2 Habitat Distribution

In the Base Case, suitable eastern whip-poor-will habitat is well distributed throughout the RSA (Figure 5.6.4-7) and LSA (Figure 5.6.4-8). Habitat does not appear to be a limiting factor for whip-poor-will in the Base Case, and this species is highly mobile and can establish territories in new areas. The 10 km by 10 km standardized UTM grid square identified to contain critical habitat for this species (grid square 18TUS00; ECCC 2018a) overlaps the extreme northwestern tip of the RSA (Figure 5.6.4-7).

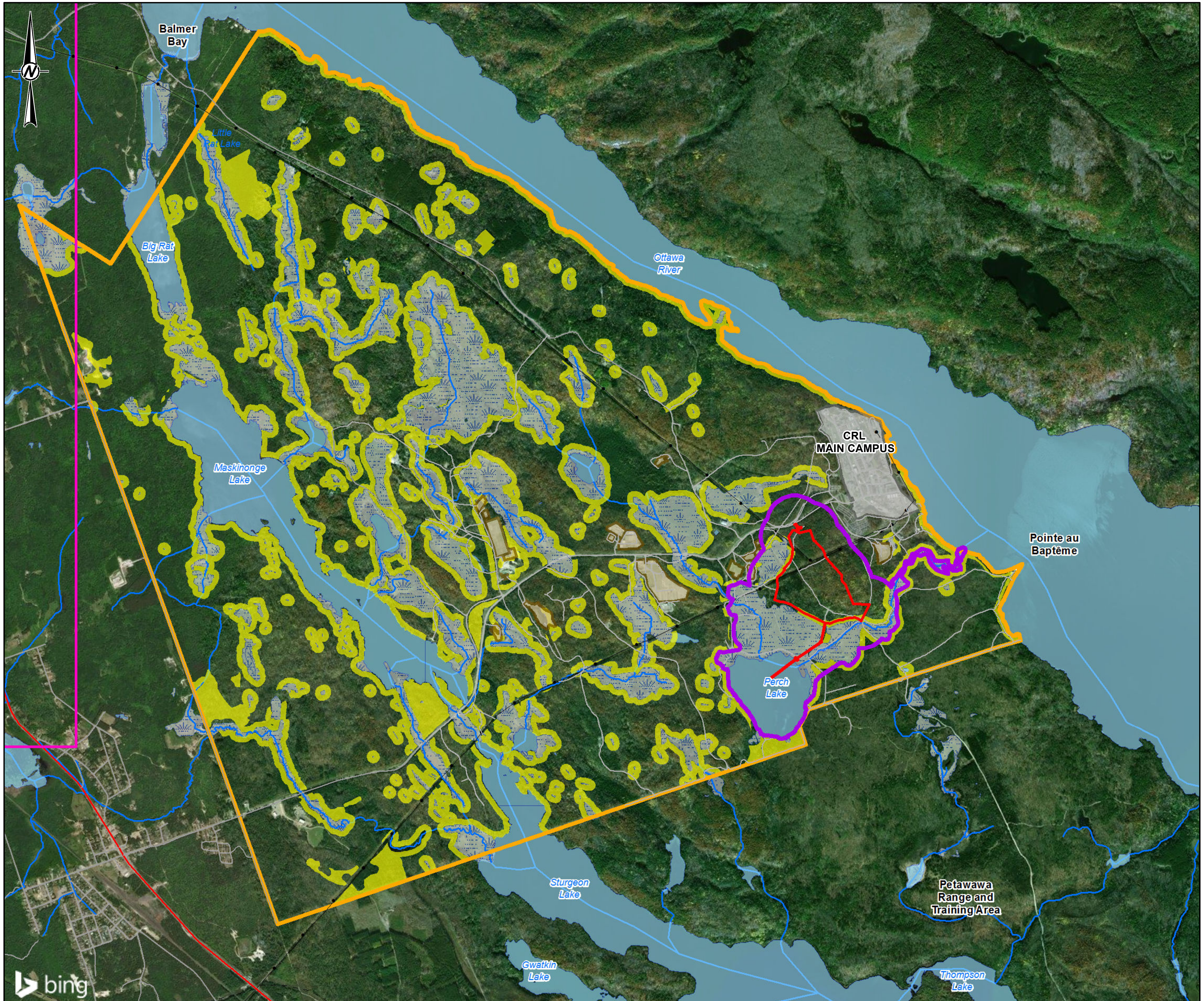
Studies suggest that habitat fragmentation may negatively affect this species because whip-poor-wills avoid small, isolated woodlands (Bushman and Therres 1988; COSEWIC 2009). Distance from large forest tract is an important factor influencing the presence of whip-poor-will (COSEWIC 2009). Fragmentation by roads and other linear disturbances is not anticipated to negatively affect whip-poor-will dispersal in the RSA because most linear disturbances are less than 30 m wide and the RSA is composed primarily of forested habitat.

5.6.4.4.3 Survival and Reproduction

Canada supports an estimated 6% of the global eastern whip-poor-will population (120,000 individuals; ECCC 2018a). Data from the BBS indicate a Canada-wide population decline of 3.19% per year from 2002 to 2012, or 75% loss of the population over this time period (ECCC 2018a). Between the first (1981 to 1985) and second (2001 to 2005) OBBA survey periods, whip-poor-wills declined by 37% (Cadman et al. 2007; ECCC 2018a).

Because the eastern whip-poor-will population in Canada has declined by 75% from 1970 to 2012, they are considered a priority species under the Bird Conservation Strategy for the region (Environment Canada 2014). The eastern whip-poor-will was designated as threatened by COSEWIC in 2009 and was listed under Schedule 1 of SARA as a threatened species in 2011. Despite the concerning population trend data, the federal recovery strategy concluded that individuals that are capable of reproduction are available to sustain the population and improve its abundance (ECCC 2018a). The population and distribution objectives for Canada as defined in the final federal recovery strategy are two-fold. In the short term, it aims to slow the decline of the species such that the population does not decrease by more than 10% (i.e., 12,000 individuals) over the 2018 to 2028 period, and maintain the area of occupancy at 3,000 km^2 or above. In the long term, the objective is to ensure a positive 10-year population trend starting in 2028 while favouring an increase in the area of occupancy, including the gradual recolonization of areas in the southern portion of the breeding range.

Species-specific surveys for whip-poor-will were completed in the RSA in 2013. Four individuals were recorded as using habitats in the RSA. An additional three birds were recorded using habitats outside the RSA. Eastern whip-poor-will was identified as a possible breeder in the OBBA survey square 18TUS00, but was not recorded in the other OBBA survey squares that overlap the RSA (i.e., 18TUR19 and 18TUS10; Cadman et al. 2007); however, whip-poor-wills have been regularly reported using habitats in areas surrounding the RSA (eBird 2017). A nest has been confirmed in 2019 at CRL 3 km northwest of the SSA.



LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- EASTERN WHIP-POOR-WILL HABITAT
- 10 km^2 GRID SQUARE CONTAINING CRITICAL HABITAT

1 0 1

1:35,000 KILOMETRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

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PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
EASTERN WHIP-POOR-WILL HABITAT AVAILABILITY AND DISTRIBUTION IN THE RSA – BASE CASE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
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REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.4-7

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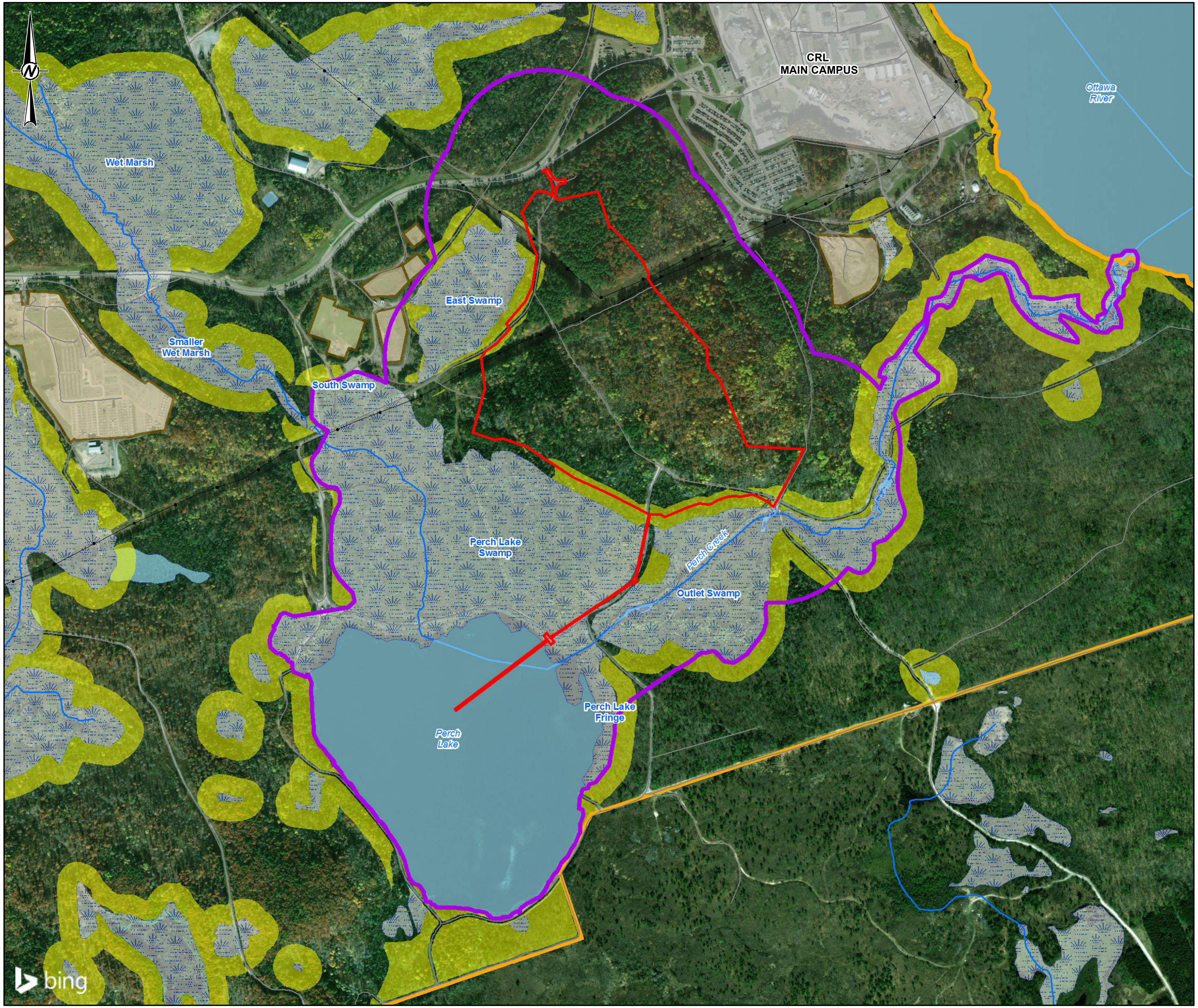

LEGEND
- HIGHWAY
- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- EASTERN WHIP-POOR-WILL HABITAT

250 0 250
1:10,000 METRES

NOTE(S)
1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

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1547525	0009	FINAL 2	5.6.4-8

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The primary threats to eastern whip-poor-wills are reduced availability of insect prey and habitat conversion for agriculture on wintering grounds (ECCC 2018a). Eastern whip-poor-wills feed on many types of flying insects (Cink et al. 2017). Insect populations are declining worldwide, and these declines may be a contributing factor to whip-poor-will population decline (COSEWIC 2009; ECCC 2018a). Many aerial-foraging insectivorous birds, such as whip-poor-will, have experienced large declines since the 1980s (Blancher et al. 2009; NABCIC 2012). Forest and non-forest aerial-foraging birds have experienced drastic population declines, which suggests the major cause of the declines is decreased insect availability (Blancher et al. 2009; Nebel et al. 2010; Nocera et al. 2012; Paquette et al. 2014). Wagner (2012) noted declines for many nocturnal moth species, which are the preferred prey for eastern whip-poor-will (Cink et al. 2017). Potential causes of reduced availability of insects include habitat loss, climate change resulting in a temporal mismatch between reproduction and peak food abundance and pesticide use, which can reduce the abundance and diversity of flying insects (ECCC 2018a; Nebel et al. 2010; Nocera et al. 2012; Paquette et al. 2014). Insect and bird populations in the RSA have likely been affected by all of these factors in the Base Case. Eastern whip-poor-will may be susceptible to these factors because they are primarily aerial insectivores and they have low annual reproductivity.

5.6.4.5 Eastern Wood-pewee

5.6.4.5.1 Habitat Availability

The NSDF Project is located in breeding habitat for this species and breeding habitat is the focus of the habitat availability assessment. Eastern wood-pewee (*Contopus virens*) breeds primarily in intermediate-aged to mature deciduous and mixed forests, typically near a clearing or forest edge (Peck and James 1987; COSEWIC 2012a; Watt et al. 2017). In one study, wood-pewees were most likely to be present in forest stands more than 24 years old (McDermott et al. 2011). Coniferous forests are rarely used by eastern wood-pewee in Ontario (Peck and James 1987). Distance to edge is not quantified in the literature for this species. In the absence of species-specific information, it is assumed a distance of 100 m into the forest reflects edge habitat as defined in provincial guidelines (MNR 2010) and supported by other literature and government sources (e.g., Environment Canada 2007; Terraube et al. 2016). The vegetation community data were used to map suitable habitat for eastern wood-pewee in the LSA and RSA as follows:

- Immature and mature forest stands (any forest type) within 100 m of the forest polygon edge where it abuts open habitat (wetland, aquatic habitat, flooded area, pre-sapling forest of any type, unclassified).

A total of 54 ha (25.5%) and 1,603 ha (41.6%) of suitable habitat for eastern wood-pewee is estimated to be present in the LSA and RSA, respectively, in the Base Case (Table 5.6.4-6).

Table 5.6.4-6: Breeding Habitat Availability for Eastern Wood-pewee in the Base Case

Habitat Suitability	Regional Study Area		Local Study Area	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Suitable	1,603	41.6	54	25.5
Unsuitable	2,250	58.4	156	74.5
Total	3,853	100.0	210	100.0

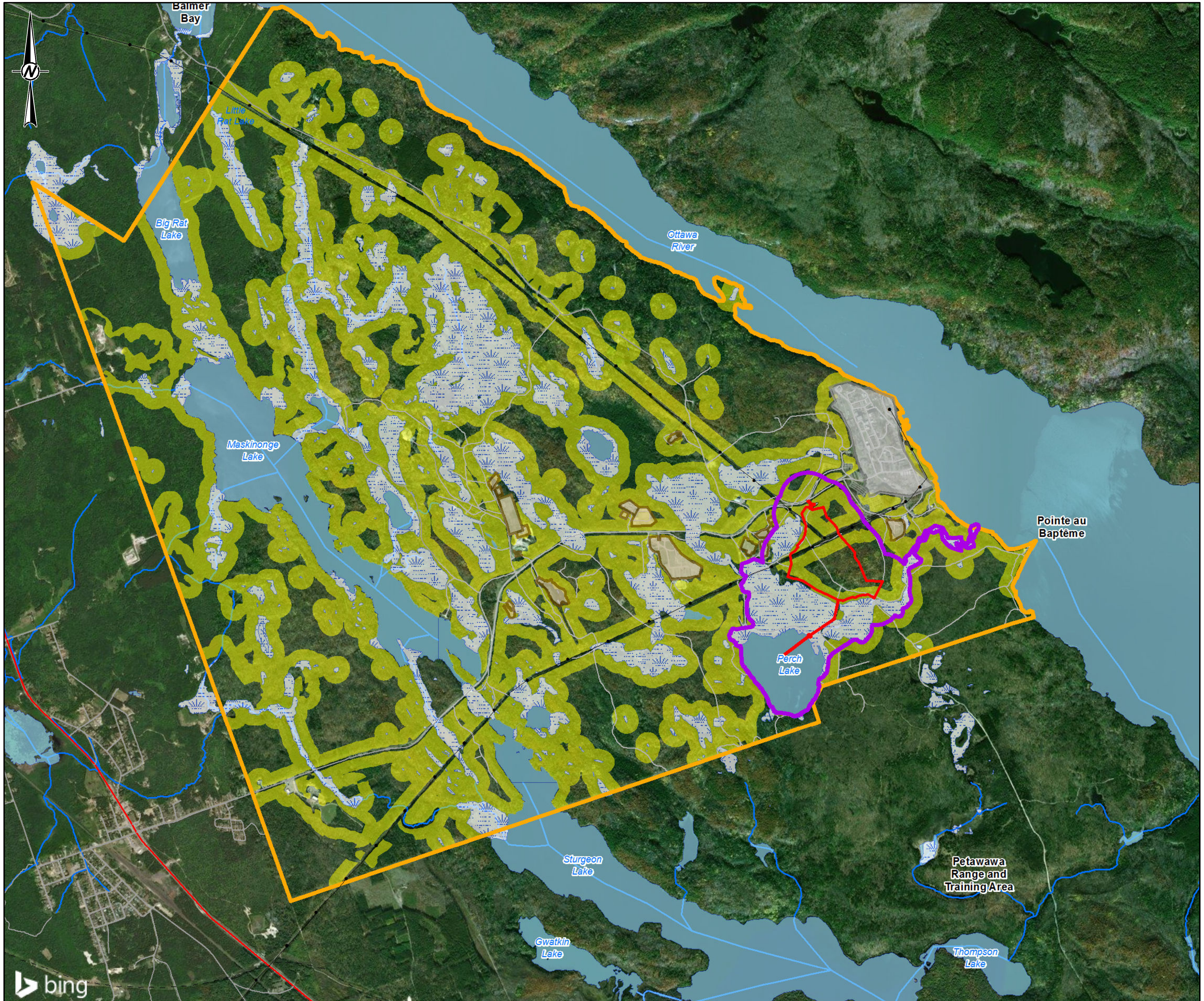
Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Disturbances can have both positive and negative effects on eastern wood-pewee habitat availability. Fire suppression activities since the 1940s have likely increased nesting habitat availability relative to what was historically available for this species in the RSA by allowing natural forest succession. Most of the forest stands in the RSA are of immature or mature structural stage and may therefore provide suitable nesting habitat for wood-pewees. However, on-going fire suppression reduces the opportunity for forest disturbance that would result in the creation of edge habitat favoured by this species. Forest edges along firebreaks, utility corridors and roads in the RSA may provide suitable habitat for eastern wood-pewee.

5.6.4.5.2 Habitat Distribution

In the Base Case, suitable eastern wood-pewee habitat is well distributed throughout the RSA (Figure 5.6.4-9) and LSA (Figure 5.6.4-10). Habitat does not appear to be a limiting factor for eastern wood-pewee in the Base Case, and this species is highly mobile and can establish territories in new areas. Fragmentation by roads and other linear disturbances is not anticipated to negatively affect wood-pewee dispersal in the RSA because most linear disturbances are less than 30 m wide and the RSA is composed primarily of forested habitat.

Eastern wood-pewees appear fairly tolerant of habitat fragmentation, given their preference for edge habitat, and forest patch size has not been found to be a strong determinant of occupancy (COSEWIC 2012a). The overall amount of forest on the landscape may be more important than local forest patch size (Perkins et al. 2003 in COSEWIC 2012a). However, large tracts of contiguous forest are likely to reduce habitat suitability for wood-pewees on the landscape due to the lack of edge habitat favoured by this species (COSEWIC 2012a). Habitat fragmentation from linear disturbances present in the LSA and RSA in the Base Case has likely had positive effects on wood-pewee habitat distribution by creating forest edge habitat.



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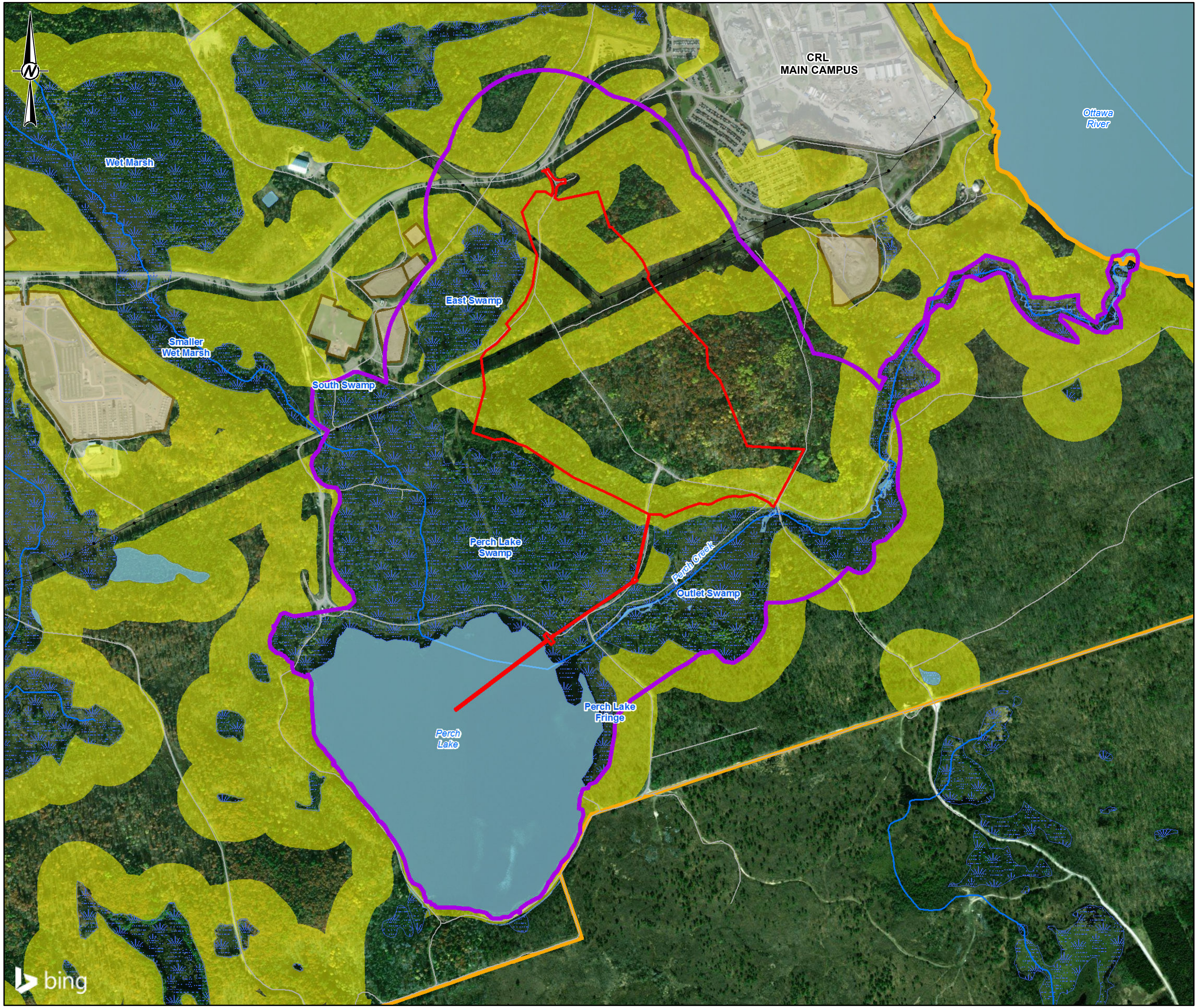

LEGEND
- HIGHWAY
- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
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- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- EASTERN WOOD-PEWEE HABITAT

250 0 250
1:10,000 METRES

NOTE(S)
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5.6.4.5.3 Survival and Reproduction

The Canadian population of eastern wood-pewee is estimated at 435,000 individuals, with the majority (69%) of the population concentrated in southern Ontario (COSEWIC 2012a). Population data are not available for the RSA, but the RSA falls within an area where population density is believed to be high (Cadman et al. 2007). Eastern wood-pewee has been recorded in the RSA eight times during site-specific surveys, including in the LSA. Several observations were made in the RSA and vicinity between 2002 and 2013 (eBird 2017) and the species was detected during monitoring surveys in the SSA in 2017 (CNL 2017d). Eastern wood-pewee was identified as a probable breeder in the OBBA survey square 18US10, and a possible breeder in the other OBBA survey squares that overlap the RSA (i.e., 18UR19 and 18US00; Cadman et al. 2007).

BBS data identify concerning long-term and short-term declines in Canadian and Ontario populations (COSEWIC 2012a). Eastern wood-pewee is considered a priority species under the Bird Conservation Strategy, with the objective of increasing abundance in Ontario (Environment Canada 2014). Eastern wood-pewee was designated as Special Concern by COSEWIC in 2012 and was listed under Schedule 1 of SARA as a Special Concern species in November 2017. Given the recent listing, a federal management plan has not yet been developed for this species, but it is expected that the population objective for Ontario will be to increase abundance consistent with the Bird Conservation Strategy objective.

Given the species' use of a variety of forest types including secondary growth forest (which is increasing in eastern Ontario) and affinity to forest edges, habitat loss and fragmentation on breeding grounds are not likely to explain the large population declines observed for eastern wood-pewee in Canada (COSEWIC 2012a). Change in flying insect prey availability is a suspected source of population decline for this and other aerial insectivorous bird species, which as a guild have experienced substantial population declines in recent decades (Nebel et al. 2010; COSEWIC 2012a).

5.6.4.6 Golden-winged Warbler

5.6.4.6.1 Habitat Availability

The NSDF Project is located in breeding habitat for this species, which is the focus of this assessment. Golden-winged warbler (*Vermivora chrysoptera*) is a habitat specialist that relies on early successional habitat (10 to 30 years after disturbance) (COSEWIC 2006). Suitable breeding habitat for golden-winged warbler consists of early successional habitat primarily at the interface of forest and open habitat (i.e., edge habitat). Forest type appears to be less important for this species than habitat structure (Confer et al. 2011), but most individuals are found in shrubby, deciduous habitats (Beaudry et al. 2010). Golden-winged warblers prefer habitats with low to moderate canopy cover and moderate shrub and herb cover (Confer et al. 2011). Critical habitat has been identified in the federal recovery strategy for this species to be a combination of habitat suitability and habitat occupancy, where suitable habitat has been identified as the interface (shared edge) between young forest and open habitat in a forest landscape (ECCC 2016a). Nests are often located within 200 m on either side of a forest edge (ECCC 2016a). Where the open habitat contains few shrubs or scattered trees, golden-winged warblers will use the habitat less extensively, outward to about 50 m (ECCC 2016a). Edges can be along roads, trails, cutblocks and other anthropogenic disturbances in addition to natural borders (ECCC 2016a). The vegetation community data were used to map suitable habitat for golden-winged warbler in the LSA and RSA as follows:

- deciduous forest stands (any age class) within 200 m of the forest polygon edge where it abuts open habitat (wetland, aquatic habitat, flooded area, pre-sapling forest of any type, unclassified);

- mixed forest stands (any age class) within 200 m of the forest polygon edge where it abuts open habitat (wetland, aquatic habitat, flooded area, pre-sapling forest of any type, unclassified); and
- 50 m buffer into the following polygon types where they abut deciduous or mixed forest stands (any age class):
  - wetland;
  - flooded area; and
  - pre-sapling forest of any type.

A total of 102 ha (48.6%) and 2,621 ha (68.0%) of suitable habitat for golden-winged warbler is estimated to be present in the LSA and RSA, respectively, in the Base Case (Table 5.6.4-7). The federal recovery strategy identified focal areas across the species' range that contain core populations that sustain the current breeding distribution and are important for expanding the population into adjacent areas (ECCC 2016a). The RSA falls within focal area GL10, but not in grid squares identified to contain critical habitat within the focal area (ECCC 2016a; Figure 5.6.4-11).

Table 5.6.4-7: Breeding Habitat Availability for Golden winged Warbler in the Base Case

Habitat Suitability	Regional Study Area		Local Study Area	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Suitable	2,621	68.0	102	48.6
Unsuitable	1,232	32.0	108	51.4
Total	3,853	100.0	210	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.

Disturbances can have both positive and negative effects on golden-winged warbler habitat availability. Fire suppression activities since the 1940s have likely had negative effects on golden-winged warbler habitat relative to what was historically available for this species in the RSA because golden-winged warblers are reliant on early successional habitat. Maturation of young forests is considered a threat to golden-winged warbler populations in Canada (ECCC 2016a). Vegetation clearing can improve habitat around the disturbance perimeter by creating early succession habitats that are positively associated with species abundance (Askins 1994; Beaudry et al. 2010; Confer et al. 2011). However, vegetation clearing can also result in a net loss of habitat. Disturbances with higher edge-to-interior ratios are more likely to have positive effects on golden-winged warbler habitat availability. Edge habitat along firebreaks, utility corridors and roads may provide suitable habitat for golden-winged warbler.

5.6.4.6.2 Habitat Distribution

In the Base Case, suitable golden-winged warbler habitat is well distributed throughout the RSA (Figure 5.6.4-11) and LSA (Figure 5.6.4-12). Habitat does not appear to be a limiting factor for golden-winged warbler in the Base Case, and this species is highly mobile and can establish territories in new areas. Habitat fragmentation from linear disturbances present in the LSA and RSA in the Base Case has likely had positive effects on golden-winged warbler habitat distribution. Golden-winged warblers are edge habitat specialists, and edge habitat is increased with linear developments. However, extensive habitat fragmentation that results in small forest patches may negatively affect this species; one study found golden-winged warblers did not use forest patches that are smaller than 10 ha (Confer and Knapp 1981). Linear disturbances in the RSA are generally less than 30 m wide and the RSA is composed mostly of forested habitat in patches larger than 10 ha. Similarly, several local roads and two hydroelectric corridors cross the LSA and a portion of the LDA is contained within the LSA, but the LSA remains mostly forested. Narrow linear disturbances generally do not represent barriers to bird movement (Desrochers and Hannon 1997). Further, linear disturbances are less likely to be perceived as movement barriers by edge species such as golden-winged warblers than by interior-forest species. Existing disturbances in the RSA do not likely function as dispersal barriers for this species in the Base Case.

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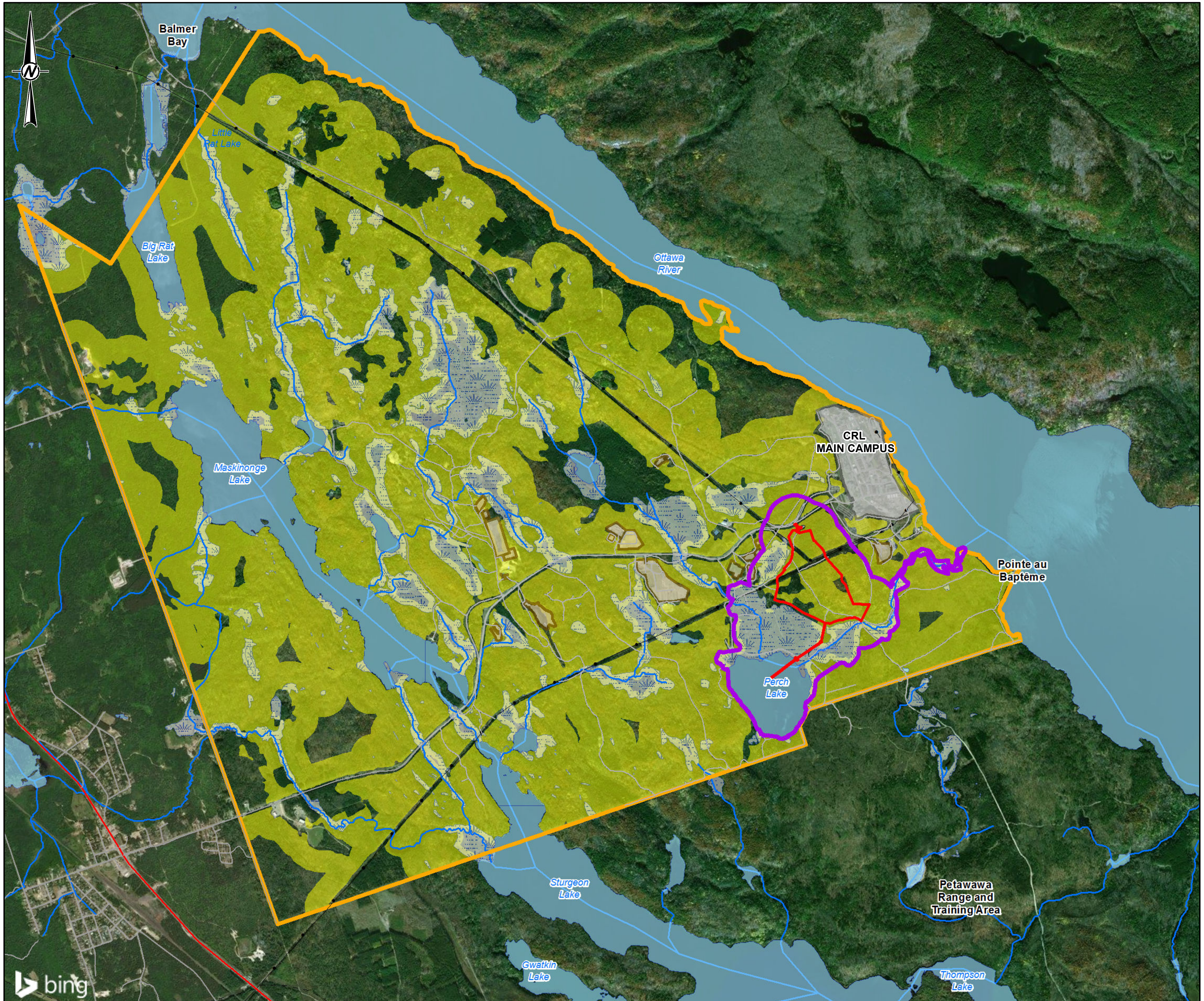

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- GOLDEN-WINGED WARBLER HABITAT

1 0 1

1:35,000 KILOMETRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
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CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

GOLDEN-WINGED WARBLER HABITAT AVAILABILITY AND DISTRIBUTION IN THE RSA – BASE CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- GOLDEN-WINGED WARBLER HABITAT

250 0 250

1:10,000 METRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

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CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

GOLDEN-WINGED WARBLER HABITAT AVAILABILITY AND DISTRIBUTION IN THE LSA AND SSA – BASE CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
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PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.4-12

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5.6.4.6.3 Survival and Reproduction

Canada is estimated to support 17% of the global population of golden-winged warblers, with most individuals occurring in Ontario (ECCC 2016a). Historical analysis of golden-winged warblers noted a dramatic population decline of 79% between 1993 and 2002; however, more recent analysis of BBS and OBBA data suggests that golden-winged warbler populations have been stable between 1970 and 2012 (ECCC 2016a).

Golden-winged warbler is considered a priority species under the Bird Conservation Strategy, with the objective of doubling current abundance (Environment Canada 2014). Golden-winged warbler was designated as threatened by COSEWIC in 2006 and was listed under Schedule 1 of SARA as a threatened species in 2007. The population objective for golden-winged warbler, as identified in the federal recovery strategy, is to maintain self-sustaining populations in the focal areas in Manitoba, Ontario and Quebec, while maintaining, at a minimum, the current abundance of approximately 35,000 pairs in Canada (ECCC 2016a).

Population data are not available for the RSA, but the RSA falls within one of the focal areas (GL10) identified in the federal recovery strategy to contain core populations that sustain the current breeding distribution and are important for expanding the population into adjacent areas (ECCC 2016a). There are occurrence records for golden-winged warbler throughout the Ottawa Valley Forest Management Unit (Van Dyke 2011). Golden-winged warblers have been recorded in the RSA two times during site-specific surveys (including in the LSA), and once during non-site-specific surveys (eBird 2017). Golden-winged warbler was identified as a confirmed breeder in the OBBA survey square 18US00, but was not recorded in the other OBBA survey squares that overlap the RSA (i.e., 18UR19 and 18US10; Cadman et al. 2007). Observations of golden-winged warbler were recorded in Chalk River in 1969 and 1970 (eBird 2017). In recent years, most observations of golden-winged warbler near the RSA have been reported south of Lac du Bois Dur (eBird 2017).

The primary threat to golden-winged warbler populations is considered to be hybridization with blue-winged warblers (*Vermivora cyanoptera*; ECCC 2016a); however, the current range of blue-winged warbler does not approach the vicinity of the RSA (Gill et al. 2001). Further, a recent study found that only six genomic regions differ between golden-winged and blue-winged warblers (Toews et al. 2016). This suggests golden-winged and blue-winged warblers are the same species, and therefore hybridization may not be a threat to the sustainability of golden-winged warbler populations.

5.6.4.7 Wood Thrush

5.6.4.7.1 Habitat Availability

The NSDF Project is located in breeding habitat for wood thrush (*Hylocichla mustelina*). In Ontario, wood thrush breeds in moist, deciduous hardwood or mixed forest stands that are often previously disturbed, with a dense deciduous understory, open forest floor with moist soil and decaying leaf litter, and tall trees for singing perches (COSEWIC 2012b). Due to its recent listing under SARA (November 2017), a federal recovery strategy has not yet been developed for wood thrush, and therefore critical habitat has not yet been defined for this species. The vegetation community data were used to map suitable habitat for wood thrush in the LSA and RSA as follows:

- mature deciduous and mixedwood forest stands; and
- mature treed swamps.

A total of 86 ha (41.0%) and 1,076 ha (27.9%) of suitable habitat for wood thrush is estimated to be present in the LSA and RSA, respectively, in the Base Case (Table 5.6.4-8).

Table 5.6.4-8: Breeding Habitat Availability for Wood Thrush in the Base Case

Habitat Suitability	Regional Study Area		Local Study Area	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Suitable	1,076	27.9	86	41.0
Unsuitable	2,777	72.1	124	59.0
Total	3,853	100.0	210	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.

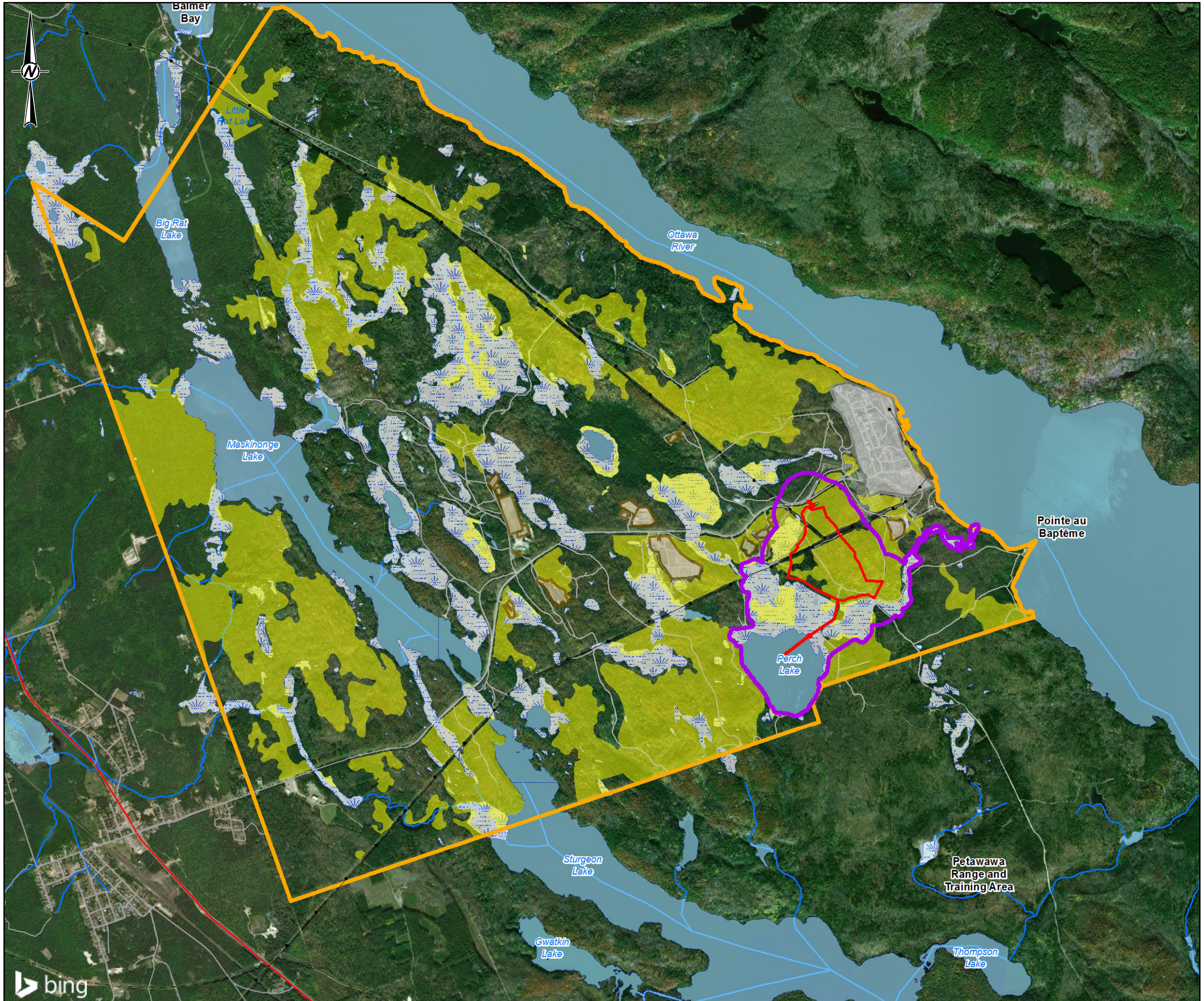
Wood thrushes in Ontario appear to prefer second-growth over mature forest (Peck and James 1987), suggesting that mid- to long-term effects of forestry are positive and wood thrushes in the RSA may have benefitted from historical logging, though initially this disturbance would have removed habitat. Similar observations of increased forest habitat use have been made following other disturbances, such as the major ice storm that affected much of southeastern Ontario in 1998 (COSEWIC 2012b). Periodic localized disturbances create openings in the forest that promote the development of a dense understory favoured by this species.

Most forested areas in the RSA are 60 to 80 years old and may not provide preferred habitat for wood thrush because these mid-seral stage forests typically have closed canopies that limit light penetration and development of the understory important for this species (Alaback 1982; McKenzie et al. 2000). However, there is some uncertainty associated with the age of forests in the RSA (Section 5.6.4.1.3). Forest stands in the LSA are mostly mature (greater than 80 years old) and structurally complex (Section 5.6.4.1.3), and likely provide highly suitable habitat for wood thrush in the Base Case.

5.6.4.7.2 Habitat Distribution

In the Base Case, suitable wood thrush habitat is well distributed throughout the RSA (Figure 5.6.4-13) and LSA (Figure 5.6.4-14). Habitats do not appear to be isolated from one another for wood thrush in the Base Case, and this species is highly mobile and can establish territories in new areas.

Wood thrushes appear tolerant of habitat fragmentation, nesting in woodlots as small as 0.4 ha (COSEWIC 2012b). The overall amount of forest on the landscape may be more important than local forest patch size; adverse effects of forest fragmentation on habitat use by wood thrush appear more pronounced in landscapes where overall forest cover is limited (Evans et al. 2011). Additionally, studies in forested landscapes in Ontario suggest populations in fragmented forests can be self-sustaining (COSEWIC 2012b).



LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- WOOD THRUSH HABITAT

1 0 1

1:35,000 KILOMETRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

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CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT CHALK RIVER, ONTARIO

TITLE
WOOD THRUSH HABITAT AVAILABILITY AND DISTRIBUTION IN THE RSA – BASE CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
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PREPARED	SO
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APPROVED	AB

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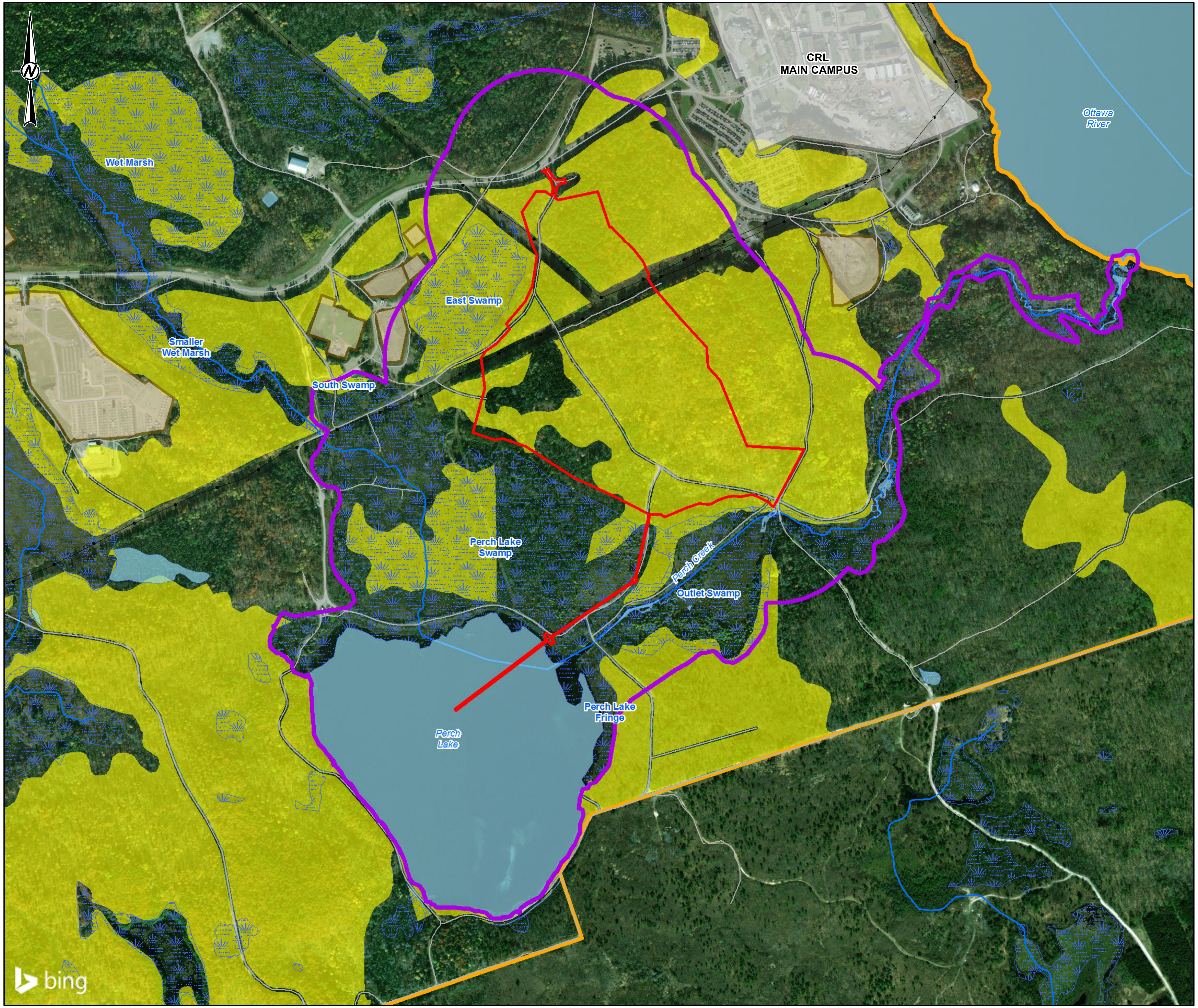

LEGEND

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- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
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- SITE STUDY AREA
- WOOD THRUSH HABITAT

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

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CHALK RIVER, ONTARIO

TITLE
WOOD THRUSH HABITAT AVAILABILITY AND DISTRIBUTION IN THE LSA AND SSA – BASE CASE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
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PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.4-14

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5.6.4.7.3 Survival and Reproduction

The Canadian population of wood thrush is estimated at 665,000 individuals, with highest densities in southeastern Ontario and southern Quebec (COSEWIC 2012b). Population data are not available for the RSA, but information at broader spatial scales suggests that the RSA falls within an area of moderate population density (COSEWIC 2012b). Wood thrush was identified as a probable breeder in the OBBA survey square 18US10, and a possible breeder in the other OBBA survey squares that overlap the RSA (i.e., 18UR19 and 18US00; Cadman et al. 2007). Two wood thrush individuals were recorded in the SSA during breeding bird surveys conducted for the NSDF Project in 2017 (CNL 2017d). One wood thrush was recorded in the RSA in 2003 and several other observations have been made in the vicinity of the RSA between 2001 and 2014 (eBird 2017).

Nest parasitism (i.e., laying eggs in the nests of other species) by brown-headed cowbirds (*Molothrus ater*) is considered a major threat to this species, with reported parasitism rates in Ontario averaging 33% and reaching as high as 60% (COSEWIC 2012b). Parasitism rates are markedly increased in suburban areas and other highly fragmented landscapes that contain open habitat preferred by cowbirds (Lowther 1993; COSEWIC 2012b), although consequences to reproductive success are not consistently observed (Phillips et al. 2005).

Wood thrush is considered a priority species under the Bird Conservation Strategy, with the objective of maintaining current abundance (Environment Canada 2014). Wood thrush was designated as threatened by COSEWIC in 2012 and was listed under Schedule 1 of SARA as a threatened species in November 2017. Given the recent listing, a federal recovery strategy has not yet been developed for this species, but the population objective for Ontario populations will likely be to maintain self-sustaining populations. Despite declines throughout the range of the wood thrush, Ontario populations appear to be currently self-sustaining (COSEWIC 2012b).

5.6.4.8 Bats

5.6.4.8.1 Habitat Availability

All Canadian bat species have four primary habitat requirements: hibernacula, swarming sites, roosts and foraging areas. Maternity roost sites and, especially, hibernacula are considered to be the main limiting habitat features for little brown myotis (*Myotis lucifugus*), northern myotis (*Myotis septentrionalis*) and tri-colored bat (*Perimyotis subflavus*) within their ranges (COSEWIC 2013). Critical habitat for the three SARA-listed bat species has only been partially identified for hibernacula. However, the majority of locations for maternity roosts are either unknown or undocumented (ECCC 2018c). As such, maternity roosts are not identified as critical habitat under the 2018 recovery strategy (ECCC 2018c).

Within the RSA, the potential for hibernacula in exposed bedrock that typically forms caves (i.e., karst topography with limestone, dolomite and gypsum-containing minerals) was coarsely assessed at an overview-level. Figure 5.3.1-3, which describes surficial geology in the RSA, indicates the potential for bat hibernacula is low across the RSA, because these mineral types are not present. CNL biologists have not conducted surveys to date that would confirm the presence or absence of hibernacula or potential hibernacula features within the RSA; however, the potential for hibernacula to be present within the RSA is considered to be low. Foraging habitat requirements are varied between the three species representing this VC and not likely limiting in the environment. As a result, the focus of this assessment is on potential maternity roost habitat.

Based on research conducted to date on maternity roosting behaviour in natural habitats, older forests are generally preferred by bats, including the three SARA-listed species represented by this VC, likely because of higher snag availability (in the case of little brown myotis and northern myotis; COSEWIC 2013). Snags contain cavities and loose bark required for sheltering roosting females and pups (ECCC 2018c). Two of the three species (little brown bat and northern myotis) show a preference for large-diameter (i.e., older) trees and little brown myotis and tri-colored bat females show evidence of philopatry in roost selection (the tendency to return to the same home area following hibernation; COSEWIC 2013; ECCC 2018c).

There is considerable variation in preferred roost tree species. Lacki et al. (2007) determined that little brown myotis most often roost in large trembling aspen (*Populus tremuloides*), but also in white spruce and red spruce (*Picea rubens*). Olson and Barclay (2013) found the majority of roosts to be located in trembling aspen or balsam poplar (*Populus balsamifera*). In Alberta's boreal forest, females are known to locate maternity roosts in tall trees of the genus *Populus* (i.e., balsam poplar, trembling aspen and cottonwood) with early stages of decay, located in old forest stands with moderate canopy cover (Crampton and Barclay 1998). Mature poplar-leading forest stands are common within the RSA. However, preferred roost tree species may vary by region and availability in the forest community.

As a conservative, coarse-scale estimation of potential maternity roost habitat within the RSA that applies to all three bat species, all of the oldest forest stands (i.e., mature age class) of all forest types within the RSA were included. The vegetation community data were used to determine the availability of forests or swamp wetland types with the following characteristics representing recorded maternity roost habitat preferences for little brown myotis and northern myotis:

- mature forest stands (all types; age of trees depending on tree species composition); and
- mature treed swamps (age of trees depending on tree species composition).

Anthropogenic structures such as buildings, bridges and bat boxes are used for maternity roosts by little brown myotis and less commonly by northern myotis (Whitaker et al. 2006). There are no such anthropogenic structures in the SSA.

A total of 1,149 ha (30.0%) and 86 ha (41.0%) of suitable maternity roost habitat for bats is estimated to occur in the RSA and LSA respectively, in the Base Case (Table 5.6.4-9). Within the SSA, most of the forested area is suitable, with the exception of the two coniferous forest stands, East Mattawa Road and two hydroelectric corridors.

Table 5.6.4-9: Maternity Roosting Habitat Availability for Bats in the Base Case

Habitat Suitability	Regional Study Area		Local Study Area	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Suitable	1,149	30.0	86	41.0
Unsuitable	2,704	70.0	124	59.0
Total	3,853	100.0	210	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.

CNL biologists have conducted acoustic monitoring surveys to determine the composition of the bat community at specific areas within the CRL site since 2014. The 2015 surveys focused on the CRL main campus, and 2016 to 2018 surveys covered a broader area, including the SSA and LSA. These surveys have determined the presence of all three SARA-listed species, little brown myotis, northern myotis and tri-colored bat, using habitats within the LSA.

Acoustic monitoring is not sufficient to determine the location of roosts or to confirm that habitat within the LSA is used for roosting by bats, because the bats recorded by acoustic monitors could fly several kilometres per night and roost in other areas. In order to provide appropriate protection it is necessary to understand where roosts are, the number of individuals using these roosts as well as specific habitat requirements. To address this issue, CNL has begun a research project in 2019 and will continue the project in 2020, which will involve netting for all three federally-listed bat species and affixing radio transmitters to select individuals. These individuals will be tracked to their maternity roosts and these roosts will be monitored for activity levels to determine the size and importance of each roost. In addition to determining the location of maternity roosts, the type of habitat being used for each roost will be assessed. The field work began in 2019 and resulted in 20 bats being captured and fitted with radio-transmitters. Those bats led to the identification of 15 different tree roosts composed mainly of large-tooth aspen (*Populus grandidendata*).

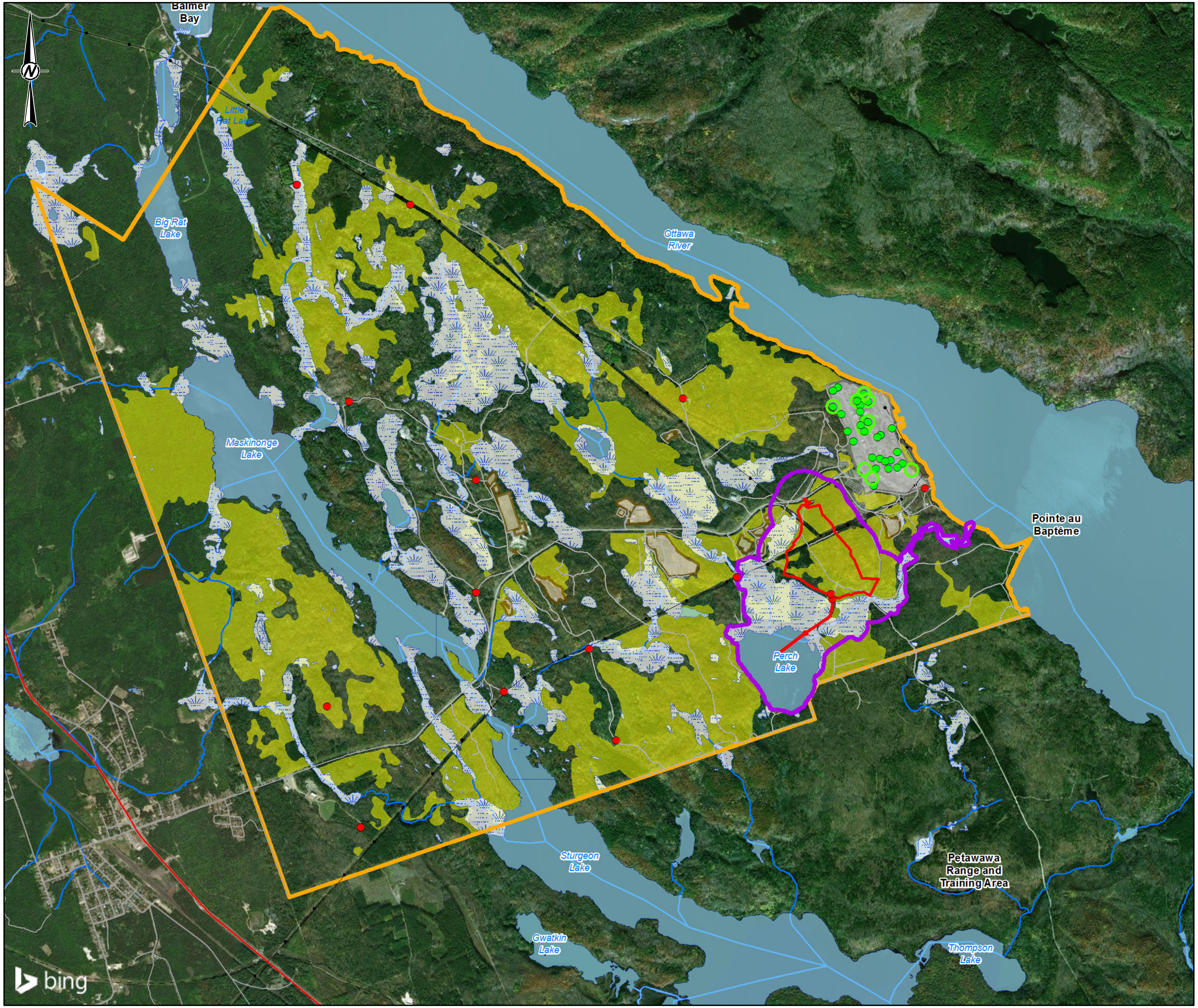
Information collected during the 2019-2020 telemetry study will allow for increased protection of maternity roosts on the CRL site, as well as aiding in protecting the species at a larger landscape level as the research conducted will increase the knowledge of local habitat requirements. With a greater understanding of important biophysical attributes for maternity roosts these elements can be protected. This information will be used for the development of a Sustainable Forest Management Plan at CRL. Currently, CRL is collaborating with Natural Resources Canada (NRCan) - Petawawa Research Forest (PRF) to develop a Sustainable Forest Management Plan for the CRL site and the PRF due to common elements for both organizations. The process will include establishing objectives (e.g., maintaining bat habitat and managing fuel load) as well as an advisory committee. Input will be solicited from stakeholders and Indigenous groups.

Because the forest types present in the LSA are consistent with roosting habitat preferences and because SARA-listed bats have been confirmed using this habitat, this assessment applies the precautionary principle and assumes that the habitat is used for maternity roosts. In both the RSA and LSA, stands of high-quality potential maternity roosting habitat for bats are relatively abundant. The majority of the RSA has been undisturbed for the last 75 years as a result of CNL activities. Fire suppression within the RSA has likely had a generally positive effect on the availability of maternity roost tree habitat for little brown myotis and northern myotis, because both species are more commonly found roosting in large diameter trees and snags that are present in mature forest stands. Maternity roost characteristics of tri-colored bats are less well known, but are also associated with forested stands (COSEWIC 2013). In addition, suitable foraging habitat in the form of wetlands and riparian areas around the numerous small lakes is also abundant in close proximity to potential roosting habitats.

The CRL main campus, roads and associated infrastructure have likely reduced maternity roosting habitat availability in the RSA in some locations. However, even these changes do not represent a complete loss of potential roosting habitat. Little brown myotis are considered to be habitat generalists and are well adapted to human disturbance and will use buildings, bat houses and bridges for maternity roosts. CNL installed eight bat boxes at CRL in 2017 and surveys conducted in 2018 confirmed that little brown myotis used five of these eight boxes (CNL 2018c). Availability of maternity roosting habitat is not likely a limiting factor for bats in the Base Case, within the boundaries of the RSA. Additionally, information collected during the 2019-2020 telemetry study will allow for increased protection of maternity roosts on the CRL site. The development of a Sustainable Forest Management Plan at CRL is expected to increase suitable bat maternity habitat over time.

5.6.4.8.2 Habitat Distribution

In the Base Case, potential maternity roost habitat is common and well distributed across the RSA (Figure 5.6.4-15) and LSA (Figure 5.6.4-16). Required foraging habitat features (wetlands, open water features such as Perch Lake) are also well distributed and commonly intersperse the potential maternity roosting habitat at both spatial scales. At the regional scale, highest-quality habitat distribution is roughly in a north–south gradient, with the least-disturbed areas at the north end of the RSA and most-disturbed areas in the south end of the RSA, closest to the CRL main campus. Throughout the RSA and LSA, linear features in the form of roads, two hydroelectric corridors and other gaps in forest cover create gaps and potential commuting corridors, if they are not too wide. All three species generally avoid large clear cuts in forested areas, as well as open areas (COSEWIC 2013; ECCC 2018c). Studies in Alberta found the centre of clear cuts greater than 30 m from the forest edge were completely avoided by northern myotis and that little brown myotis travelled 2 to 2.5 times less in the centre than through the forest edges or along retained stands of trees within the clear cut block (COSEWIC 2013). Tri-colored bats and northern myotis are generally forest associated and negatively affected by forest clearing activities (ECCC 2018c), but there is less information available about thresholds for maximum gap sizes.



LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- POTENTIAL BAT MATERNITY ROOSTING HABITAT [2]

CNL STAFF BAT MONITORING LOCATIONS

- 2016 NO SARA-LISTED SPECIES RECORDED
- 2016 - AT LEAST 1 OF 3 SARA-LISTED SPECIES RECORD
- 2015 NO SARA-LISTED SPECIES RECORDED [2]
- 2015 - AT LEAST 1 OF 3 SARA-LISTED SPECIES RECORD

1 0 1

1:35,000 KILOMETRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.
2. POTENTIAL BAT MATERNITY ROOSTING HABITAT IS BASED ON HABITAT CONDITIONS, MATERNITY ROOST PRESENCE AND BAT OCCUPANCY HAS NOT YET BEEN VERIFIED.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT CHALK RIVER, ONTARIO

TITLE

BAT HABITAT AVAILABILITY AND DISTRIBUTION IN THE RSA – BASE CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.4-15

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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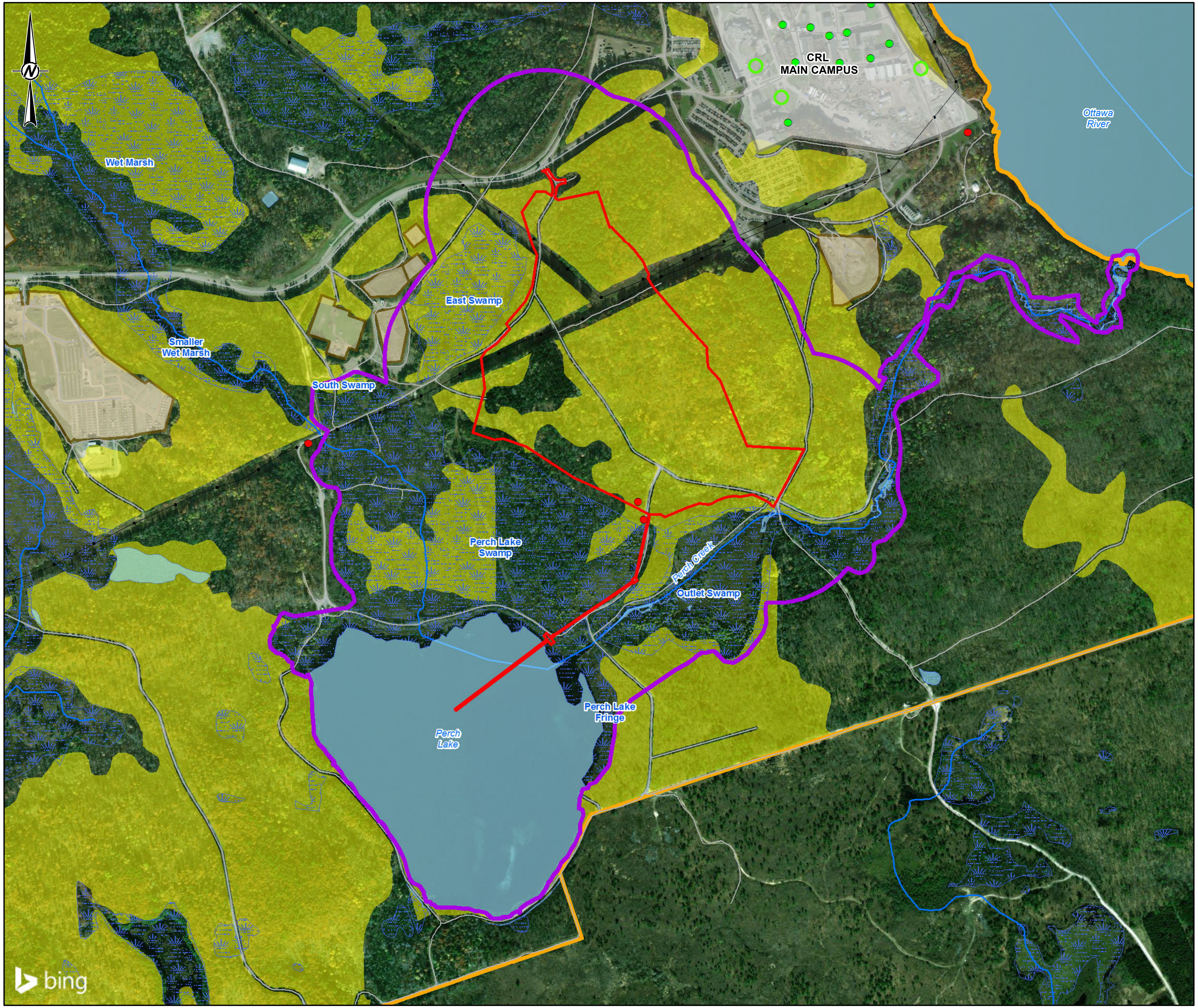

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
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CNL STAFF BAT MONITORING LOCATIONS

- 2016 NO SARA-LISTED SPECIES RECORDED
- 2016 - AT LEAST 1 OF 3 SARA-LISTED SPECIES RECORD
- 2015 NO SARA-LISTED SPECIES RECORDED [2]
- 2015 - AT LEAST 1 OF 3 SARA-LISTED SPECIES RECORD

250 0 250

1:10,000 METRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.
2. POTENTIAL BAT MATERNITY ROOSTING HABITAT IS BASED ON HABITAT CONDITIONS, MATERNITY ROOST PRESENCE AND BAT OCCUPANCY HAS NOT YET BEEN VERIFIED.

REFERENCE(S)

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2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
BAT HABITAT AVAILABILITY AND DISTRIBUTION IN THE LSA AND SSA – BASE CASE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.4-16

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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The effects of habitat edges and corridors around mature forest stands on little brown myotis, northern myotis and tri-colored bats are not well known, and there are inter-specific differences among them. A number of studies suggest that some degree of forest fragmentation may be beneficial for little brown myotis (Broders and Forbes 2004; Broders et al. 2006; Ethier and Fahrig 2011; Jantzen and Fenton 2013; Segers and Broders 2014). Other studies have found that little brown myotis prefer closed and cluttered canopy areas and avoid edges (Kalcounis and Brigham 1995; Jung et al. 1999; Morris et al. 2010). The forest structure preferred by northern myotis is not well characterized; however, edge habitat around the outer limits of mature forest stands, riparian and cleared corridors (from roads and hydroelectric lines) represent potential foraging and commuting corridors (COSEWIC 2013). Consequently, not only are maternity roost and foraging habitats common in the RSA and LSA in the Base Case, they are also well connected. Within the SSA, potential maternity roosting habitat covers most of the area, with travel corridors in the form of East Mattawa Road and the two hydroelectric corridors interspersed throughout.

CNL has initiated a research project in collaboration with Dr. Jeff Bowmann, adjunct professor with Trent University, to help CNL understand the habitat preference of bat species at risk using the CRL site. This will help to understand habitat quality, distribution and availability at CRL. This project is of a duration of two years.

5.6.4.8.3 Survival and Reproduction

Little brown myotis and northern myotis occur in every province and territory in Canada (except Nunavut) and approximately 50% and 40%, respectively, of their global range is within Canada. Tri-colored bat occur in Ontario, Quebec, New Brunswick and Nova Scotia, and 10% of their global range is within Canada (ECCC 2018c). These three bat species were listed as endangered on Schedule 1 of SARA through an emergency listing order in 2014. The urgency of this listing was due to dramatic population declines caused by white nose syndrome (WNS), which is a fungal disease caused by *Pseudogymnoascus destructans* that affects bats while they are hibernating.

WNS causes physical damage (erosion of the skin, as well as damage to sweat glands, muscles, hair follicles and other tissue) and results in white-grey blotches on the surface of wings and ears, and fuzzy white growth on the muzzle (ECCC 2018c). The physical damage causes bats to arouse from their state of torpor (i.e., sleep) and expend energy that is typically reserved until spring emergence. The change in activity levels and physical damage combined are what eventually causes death (ECCC 2018c). Canada is currently divided into WNS-affected and non WNS-affected areas. The province of Ontario, as well as Quebec, New Brunswick, Nova Scotia and Prince Edward Island are considered WNS affected, and all other provinces and territories are currently non-WNS-affected areas.

In general, the total population sizes of bats in Canada are not clearly known based on limitations in survey effort. However, prior to the introduction of WNS, little brown myotis was likely the most common bat species in Canada, with northern myotis also common, and populations of both species might have exceeded one million individuals (COSEWIC 2013). Canadian populations of tri-colored bats were likely less abundant, estimated to be under 20,000 individuals (ECCC 2018c). Since detection of WNS in 2010, the recorded population of myotis bats (which includes little brown and northern myotis) has been reduced by 94% in Nova Scotia, New Brunswick, Ontario and Quebec. For tri-colored bat, the estimated reduction in eastern Ontario, Quebec and Nova Scotia populations is also 94% (ECCC 2018c).

WNS has been estimated to travel at an average rate of 200 to 400 km per year (COSEWIC 2013). It is anticipated that the entire Canadian population of little brown myotis will be affected by WNS within 11 to 22 years, or possibly sooner based on the recent confirmation of WNS in Washington State (USGS 2016). Based on modelling, little brown myotis is predicted to be functionally extirpated (i.e., less than 1% of existing population or 65,000 individuals) in Canada and the United States by 2026 (COSEWIC 2013; ECCC 2018c); however, this modeling did not consider higher rates of WNS survival in the north portion of the species' range than originally expected. The northern myotis population is expected to have similar declines based on the similarity of their life history characteristics (ECCC 2018c). There is less information available about tri-colored bats; however, most of the Canadian range overlaps with the current WNS infection range, and further population declines are anticipated (ECCC 2018c).

Little brown myotis, northern myotis and tri-colored bat populations that overlap the RSA are within the WNS-affected area of Canada. Consequently, these populations are particularly susceptible to any additional sources of changes to survival or reproduction because the resilience and adaptability limits of these populations may have been exceeded in the Base Case. Declines of little brown myotis average 73% within two years of infection with WNS and 91% with more than two years of exposure (MECP 2018). In Ontario, little brown myotis populations are assumed to have declined by at least 30% (MECP 2018).

Beyond the devastating effects of WNS, other threats to the three species of bat comprising this VC have been recognized as habitat loss and degradation (at hibernacula, maternity roosts and foraging areas), disturbance or harm (through collision with or barotrauma from wind turbines, intentional harm from extermination, or unintentional harm from recreational [e.g., spelunking] or scientific disturbances and industrial disturbance), pollution and climate change (ECCC 2018c). Little brown myotis in particular are vulnerable to persecution and extermination efforts because of their tendency to roost in anthropogenic structures such as attics (ECCC 2018c). Extermination of large colonies can affect local populations, particularly in WNS-affected areas such as Ontario.

Regarding reproduction and lifespan, all three bat species are relatively long-lived and have low reproductive rates, making their populations sensitive to increases in adult mortality and slow to recover when the population size is already small. Individuals of little brown myotis have been recorded to live to over 30 years of age (Fenton and Barclay 1980), although the average lifespan is thought to be shorter (COSEWIC 2013). The lifespans of northern myotis and tri-colored bat are at least 15 years (COSEWIC 2013).

Survivorship of all three species is not well understood, and there is uncertainty based on deficiencies in study design and analysis used in studies that have reported survival rates. The mean annual survival of little brown myotis in Ontario was 0.82 for males and 0.71 for females (Keen and Hitchcock 1980). Survival rates are lowest in the first year of life because juveniles often lack sufficient fat reserves needed for hibernation (Fenton and Barclay 1980). Females of all three species start breeding after their first year and continue breeding annually (COSEWIC 2013). Females give birth to one pup per year (possibly two for tri-colored bat) after 44 to 60 days of gestation (COSEWIC 2013). For little brown myotis, which are more widely studied, reproductive rates seem to decline with increasing latitude; a reproductive rate of greater than 96% was recorded in the eastern United States, with lower rates of 33% to 74% in the Yukon (COSEWIC 2013).

In summary, because the RSA is within a WNS-affected area, survival and reproduction of bat populations overlapping the RSA is likely impaired in the Base Case (COSEWIC 2013).

5.6.4.9 Blanding's Turtle

5.6.4.9.1 Habitat Availability

Blanding's turtles (*Emydoidea blandingii*) are semi-aquatic reptiles that inhabit a variety of aquatic and wetland habitats such as marshes, ponds, swamps, bogs, fens, coastal wetlands, slow-flowing rivers and creeks, pools, lakes, bays, sloughs, marshy meadows, and artificial channels. They may also occupy wetlands maintained by beaver dams. They prefer aquatic habitats with soft muddy bottoms and abundant aquatic vegetation. They use these habitats for hibernating, mating, foraging, thermoregulation, summer inactivity (i.e., prolonged dormancy during hot or dry periods) and movement (ECCC 2018b).

Blanding's turtles hibernate from approximately October to April and partially bury themselves in soft substrates underwater. The typically overwinter in permanent wetlands such as bogs, fens, and marshes (ECCC 2018b). They emerge from the water to warm themselves or "bask" on available structures close to the water, such as logs, rocks, vegetation hummocks, sedge/grass tussocks, floating mats of aquatic vegetation, muskrat mounds and lodges, or up to 1 m from the water's edge on shorelines and channel banks. Fidelity to overwintering areas has been observed in this species (ECCC 2018b).

Although they spend most of their time in aquatic habitats and wetlands, Blanding's turtles also travel seasonally through upland terrestrial habitats to meet important life history requirements such as nesting (COSEWIC 2005). Terrestrial habitats also support thermoregulation, summer inactivity and movement functions (ECCC 2018b). In Ontario, Blanding's turtles typically nest from late May through to the second week of July, with a peak of nesting activity in June (ECCC 2018b). Nests are typically constructed in open areas such as beaches, shorelines, meadows, rocky outcrops and forest clearings, as well as in areas modified by human activity such as gardens, power line ROWs, fields, gravel roads and road shoulders, sand/gravel quarries, railway ROWs, cycling paths, hiking trails and all-terrain vehicle trails (ECCC 2018b). They require loose sandy substrates or organic soils to create nests. Nesting in open areas raises the mean temperature in the nest, resulting in an increased likelihood of nest success (COSEWIC 2005; ECCC 2018b). Females generally show high nest site fidelity (ECCC 2018b).

Blanding's turtles inhabit the RSA and have been the subject of field studies on the CRL site since 2009. Critical habitat for Blanding's turtles was partially defined in the draft recovery strategy (ECCC 2018b), and this definition was applied to the CNL baseline data for this VC. ECCC (2018b) identifies critical habitat based on two criteria: habitat occupancy and habitat suitability.

The following steps were undertaken to develop habitat mapping for Blanding's Turtle in the study areas:

1) Map all CNL observation records of Blanding's turtles in the study areas.
2) Within a 2 km radial distance from all observation records, identify and include all the permanent and seasonal wetlands and watercourses as critical habitat (based on average home range length observed in Ontario and Quebec; ECCC 2018b).
3) Apply a 240 m buffer to all those aquatic and wetland features to incorporate suitable terrestrial habitat into the critical habitat mapping (based on the average distance individuals moved between required resources within the home range; ECCC 2018b).

4) Remove all unsuitable habitats that fit the description in the recovery strategy (man-made structures, active sand and gravel pits, active agricultural fields and active roadways and shoulders) from the critical habitat mapping. Other anthropogenic features, such as powerlines that have low human activity may be used as nesting sites and were considered part of critical habitat. Additionally, large fast flowing rivers act as a barrier to the Blanding's turtle population connectivity, and thus critical habitat also is limited by the Ottawa River.

Overall, CNL's 2009 to 2018 field surveys were restricted to the southern portion of the RSA. Consequently, only using known observation records to map Blanding's turtle habitat in the RSA would underestimate the extent of critical habitat. Therefore, potential critical habitat was mapped as all remaining permanent and seasonal wetlands and watercourses in the RSA, plus a 240 m buffer around each aquatic or wetland feature.

A total of 179 ha (85.2%) and 2,788 ha (72.4%) of critical habitat for Blanding's turtle is estimated to be present in the LSA and RSA, respectively, in the Base Case (Table 5.6.4-10). An additional 571 ha (14.8%) of potential critical habitat is estimated to be present in the RSA (Table 5.6.4-10).

Table 5.6.4-10 Critical Habitat and Potential Habitat Availability for Blanding's Turtle in the Base Case

Habitat Suitability	Regional Study Area		Local Study Area	
	Area ha]	Percent (%)	Area (ha)	Percent (%)
Critical Habitat	2,788	72.4	179	85.2
Potential Critical Habitat	571	14.8	0	0.0
Unsuitable	493	12.8	31	14.8
Total	3,852	100.0	210	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.

The RSA contains 521.4 ha and the LSA contains 61 ha of wetlands. The SSA is bordered by wetlands to the north, west and south. A large wetland complex consisting of South Swamp and East Swamp abuts the northwest and southwest sides of the SSA. A riparian wetland associated with Perch Creek is located to the southeast of the SSA.

There are Blanding's turtle observation records congregated within various waterbodies and wetlands throughout the RSA and LSA. CNL baseline studies indicate that Blanding's turtles use the wetland habitats that surround the SSA. The closest observation records for Blanding's turtles are within the riparian corridor of Perch Creek, as well as a roadkill individual on Plant Road at the intersection with East Mattawa Road. CNL confirmed hibernation habitat at various location throughout the RSA, including the wetlands approximately 1 km east-southeast of the SSA and various wetlands northeast of the SSA (north of Plant Road; CNL 2015).

Perch Lake has the potential to be used as overwintering habitat for Blanding's turtles. This is a eutrophic lake of approximately 45 ha with a drainage area of 730 ha. The maximum depth of the lake is 3.5 m and the mean depth is 2 m (Robertson and Barry 1985). The majority of Perch Lake is open water except for the littoral zones, which are shallow wetlands composed of floating, emergent and submerged vegetation that amount to about 30% of the lake's surface (Yankovich et al. 2000). The outer fringe of this zone is known as Perch Lake Marsh.
This open marsh may be considered part of the lake, within which it is physically continuous. To the north, there are extensive wetlands, notably Perch Lake Swamp, South Swamp, East Swamp and West Swamp. The lake is confined in part by sand outcrops along the northern and southern shores, and by bedrock along the western

shores. These sandy areas around Perch Lake have potential as suitable nesting areas for Blanding's turtle; however, CNL's monitoring program did not include nesting surveys and this potential has not been confirmed.

Although the SSA is dominated by forest cover, the roads and hydroelectric corridors provide openings within which suitable turtle nesting habitat may be found. The surficial geology at the SSA consists primarily of sands, underlain by dense sandy silt till containing cobbles and boulders. Consequently, the SSA contains a suitable substrate for nest building. On steep slopes where there is bare ground and sparse vegetation cover, there are patches of exposed sand that have potential for Blanding's turtle nesting habitat. There are sand barrens identified through the SSA and LSA near WMA A (CH2M Gore and Storrie 1998). These sand barrens are near where a Blanding's turtle was found dead on the road in July 2013. These findings suggest there is the possibility of the sand barrens in this area being used during nesting (found in nesting period and in suitable habitat); however, this is an incidental sighting, and nesting locations for the local populations are undefined. Therefore, there has been no nesting habitat confirmed in the SSA to date.

CNL is committed to developing nesting habitat on the CRL site by building nesting mounds at five Priority 1 culverts (nesting mounds constructed in 2019/2020), and three Priority 3 culverts (nesting mounds to be created after culvert replacement, which will occur when culverts fail); Priority 2 culverts will be replaced when the NSDF Project is approved (see Section 5.6.7.8 for more details). Artificial nest mounds will be constructed on both sides of the culverts following guidelines developed by the Northeast Blanding's Turtle Working Group (NBTWG, no date). These artificial nesting mounds will be monitored for use by turtles during the nesting period using methods adapted from provincial protocols (MNR 2013b). Specifically, nesting surveys will be conducted at least once per week during the nesting period (May 15 to June 30); additional surveys will be completed after periods of rain to capture potential increases in nesting behaviour associated with even light rainfall (MNR 2013b; Golder 2019a). During nest mound inspections, maintenance of the nest mounds (e.g., vegetation removal) will occur if females are not present (Golder 2019a). More details on the locations of nesting mounds are presented in Section 5.6.4.9.3, below.

There are two cleared and maintained hydroelectric corridors for the 115 kV transmission lines through the RSA, one spanning most of the north–south length of the CRL site and the other spanning the southern east–west length of the RSA. These lines intersect in the SSA and thus, also span the width and length of the LSA. These open areas provide good opportunities for Blanding's turtle nesting because they are areas where eggs would incubate well, increasing the chance of successful hatchling development (COSEWIC 2016). Although these habitats could be suitable for nesting, they also represent ecological traps for the species because they are "active rights-of-way" maintained by Hydro One and CNL regularly to prevent a loss of Class IV power.

5.6.4.9.2 Habitat Distribution

Critical habitat for Blanding's turtles is well distributed throughout the RSA, and where observations of Blanding's turtles have precluded critical habitat mapping, potential critical habitat (wetlands and adjacent 240 m buffer) is well distributed (Figure 5.6.4-17). Shallow wetlands and waterbodies are distributed throughout the LSA and RSA and occupy 102 ha of the LSA and 797 ha of the RSA. Hydrologically connected wetlands in the RSA either drain to Maskinonge Lake or Perch Lake and eventually to the Ottawa River. The main wetland complex in proximity to the SSA is the Perch Lake Swamp complex. Perch Lake drains to the Ottawa River through Perch Creek, which contains a riparian wetland conducive to Blanding's turtle movement. Little, if anything, is known about the nesting habitat of Blanding's turtle in the study areas; however, based on the general nesting habitat requirements, there are likely nesting areas throughout the SSA, LSA and RSA.

CNL studies have provided some insights into Blanding's turtle movement in the three study areas. Wetlands are natural movement corridors for this species. It is likely that individuals move from the Perch Lake area, north through the wetlands that cross Plant Road, or east through the wetlands that extend along Perch Creek, which flows under ER-3 (Emergency Road), but the two-year telemetry study (2014 and 2015) did not record any Blanding's Turtle individuals crossing Plant Road. CNL has observation records that indicate the use of wetlands throughout the RSA and LSA during the active season. One particular observation of note is within the Perch Creek riparian corridor in the LSA. This riparian corridor connects Perch Lake to the Ottawa River (Figure 5.6-18) and outlets near a sand covered point of the Ottawa River known as Pointe au Baptême. Pointe au Baptême contains sand dunes and has the potential to be suitable nesting habitat for Blanding's turtles.

From 2009 to 2018, a total of 1,339 days have been surveyed in the RSA for Blanding's turtle using live traps and 113 live trap survey days have been completed in the LSA (Table 5.6.4-11). During the same time period, a total of 2,034 person-hours have been spent completing road searches in the RSA and LSA (Table 5.6.4-11). There were 32 individuals that were surveyed using telemetry in 2014 and 2015 (Table 5.6.4-11). There are no Blanding's turtle observation records within the SSA to date; search efforts by CNL did not incidentally locate Blanding's turtle nests. Based on CNL's extensive knowledge of the CRL site, there are numerous sandy outcrops throughout the LSA and RSA which have the potential to be nesting areas for Blanding's turtle (Figure 5.6.4-18). To highlight a few potential nesting areas within or in proximity to the SSA, the hydroelectric corridors that run through the study areas, particularly within the upland areas containing sandy soils and the sandy outcrop adjacent to Perch Lake both have the potential to be used as nesting habitat. Hibernation habitat has been confirmed in several wetlands/waterbodies in the RSA to the north, northeast and east of the SSA. Within the LSA, hibernation habitat for Blanding's turtle is likely in Perch Lake Swamp.

During the active season, many of CNL's observations of individuals were on roads and trails and along roadside shoulders. This is likely due to the intensive road surveys that CNL undertook (e.g., CNL 2017d, 2018b); however, this also may indicate that Blanding's turtles are using roads as travel corridors and as potential nesting areas. One Blanding's turtle nest was confirmed in 2019 on Plant Road over 2 km away from the SSA.

One new culvert is being installed in 2019 and five Priority 1 culverts are scheduled to be replaced in 2019/2020. Three additional Priority 3 culverts will be replaced during the Base Case; replacement will occur as the culverts fail. Priority 2 culverts will be replaced when the NSDF Project is approved (see Section 5.6.7.8 for more details). New and replaced culverts will be enhanced by having nesting mounds created nearby on both sides of the culvert, as well as by planting native vegetation around the culvert entrances, while maintaining a clear line of site through the culvert (Golder 2019a). The new culvert and Priority 1, Priority 2, and Priority 3 culverts are inspected weekly during the active turtle season (May to September) and after heavy rainfall events (≥7 millimetres per hour [mm/hr]) (Golder 2019a). During the inspections, barriers that can impede the passage of turtles through the culverts are removed or modified (Golder 2019a). These mitigations are anticipated to increase habitat connectivity for turtles at Base Case. More details on the new culvert and the replacement of Priority 1 and Priority 3 culverts are presented in Section 5.6.4.9.3, below.

Table 5.6.4-11: Survey Effort for Blanding's Turtles in the Local and Regional Study Areas, 2009 to 2018

Year	Regional Study Area			Local Study Area	
	Live Traps (Number of Survey Days)	Searches (Person-Hours)	Telemetry (Number of Individuals)	Live Traps (Number of Survey Days)	Searches (Person-Hours)
2009	150	0	0	20	Unknown
2010	484	360	0	93	Unknown
2011	194	270	0	0	Unknown
2012	247	675	0	0	Unknown
2013	165	620	0	0	Unknown
2014	0	0	32	0	0
2015	0	0	32	0	0
2016	0	0	0	0	72
2017	0	13	0	0	0
2018	99	39	0	0	0
Total	1,339	1,962	32	113	72

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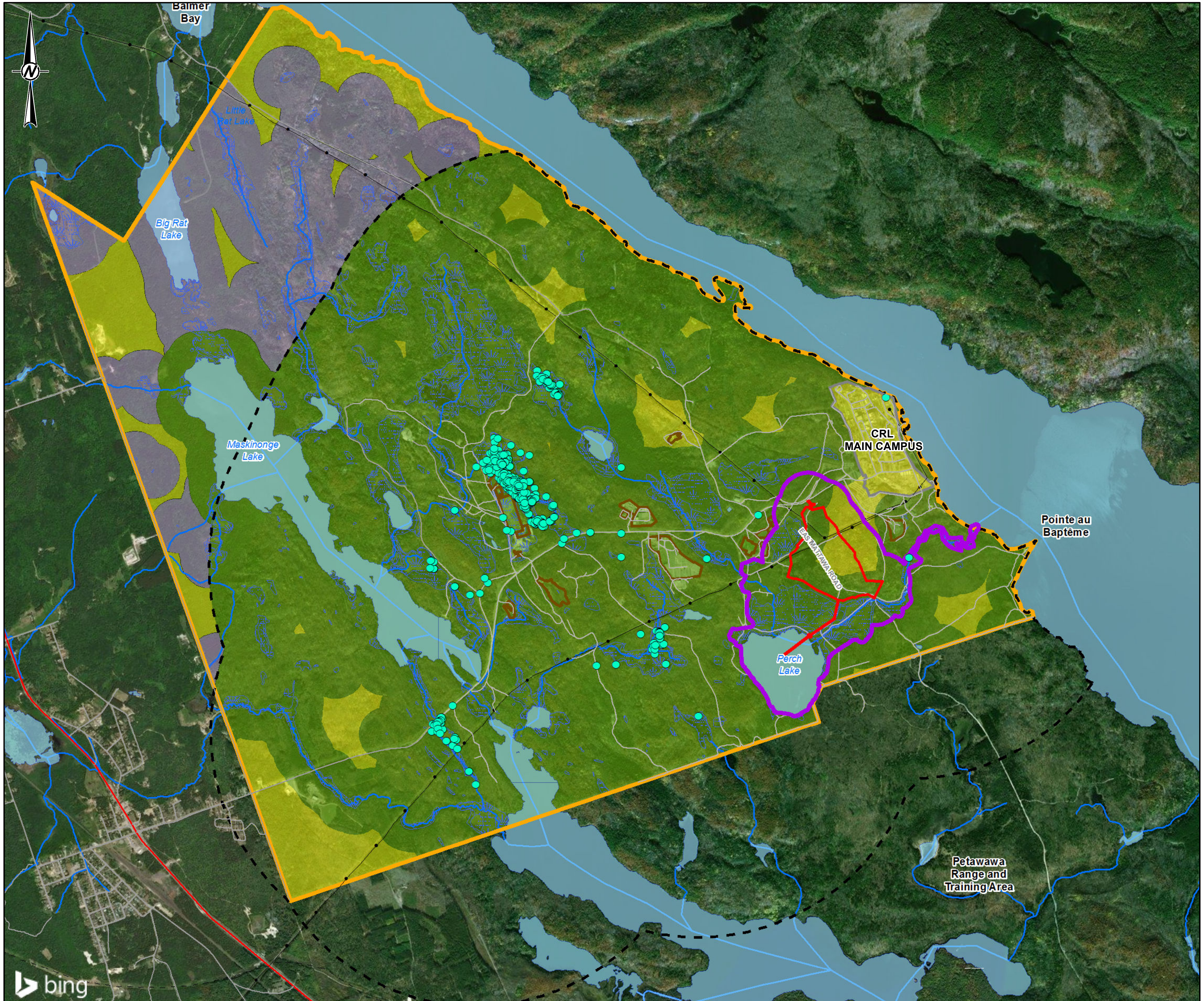

LEGEND

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- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT SITES (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- BLANDING'S TURTLE OBSERVATION
- BLANDING'S TURTLE CRITICAL HABITAT
- BLANDING'S TURTLE POTENTIAL CRITICAL HABITAT
- BLANDING'S TURTLE UNSUITABLE HABITAT
- BLANDING'S TURTLE OBSERVATION 2 km RADIUS

1 0 1

1:35,000 KILOMETRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
BLANDING'S TURTLE HABITAT AVAILABILITY AND DISTRIBUTION IN THE RSA – BASE CASE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.4-17

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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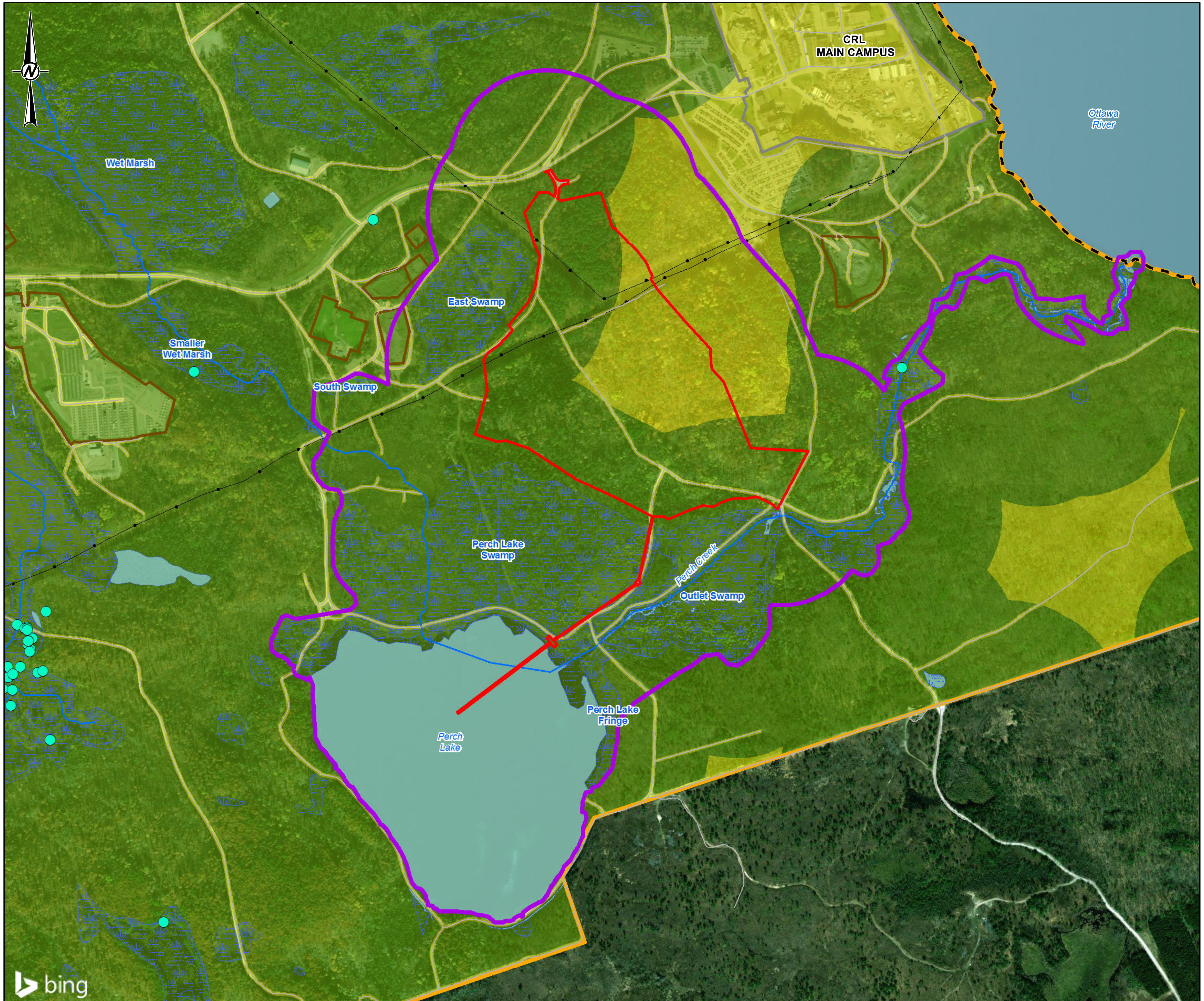

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- BLANDING'S TURTLE OBSERVATION
- BLANDING'S TURTLE CRITICAL HABITAT
- BLANDING'S TURTLE UNSUITABLE HABITAT
- BLANDING'S TURTLE OBSERVATION 2 km RADIUS

250 0 250

1:10,000 METRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

BLANDING'S TURTLE HABITAT AVAILABILITY AND DISTRIBUTION IN THE LSA AND SSA – BASE CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
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PREPARED	SO
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APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.4-18

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5.6.4.9.3 Survival and Reproduction

The Blanding's turtles in the RSA belong to the Great Lakes/St. Lawrence population, which is listed as threatened on Schedule 1 of SARA and under the Ontario *Endangered Species Act, 2007*. COSEWIC (2016) assessed the population as endangered. The Great Lakes / St. Lawrence population occurs in Ontario and Quebec and its size is roughly estimated at between 25,000 and 45,000 individuals (COSEWIC 2016).

Mean estimates of Blanding's turtle densities in Ontario were 0.78, 0.29 and 0.12 adults per hectare in the Lake Erie/Lake Ontario ecoregion, Lake Simcoe/Rideau ecoregion and Georgian Bay ecoregion, respectively (COSEWIC 2016). Based on CNL's mark-recapture studies in 2014 and 2015, an adult/sub-adult population of 25 ± 4 adults was determined to be within the portion of the RSA that was studied. In 2018, a total of seven Blanding's turtles were captured at five netting sites; two individuals were captured twice (SARA permit SARA-OR-2018-0434). No hibernating sites were observed and one nesting site was observed after it had been predated. Most (six) individuals were captured at Lake 233 N (313664 E 5102590 N).

According to the Ottawa Valley Forest Management Plan, the Ottawa Valley Forest, which encompasses the RSA, is one of the last remaining "strong holds" for Blanding's turtle in Ontario and Canada (Van Dyke 2011). There are occurrence records for this species throughout the Ottawa Valley Forest Management Unit. Available data suggest that Blanding's turtles survive and reproduce successfully in the RSA and that the RSA likely is important for the conservation of this species.

Habitats used by female Blanding's turtles for nesting within the RSA are likely present, including one confirmed nesting site on the Plant Road in 2019, but nest site records are uncommon. CNL's mark-recapture study did not include the capture or observation of any hatchlings; however, it should be noted that capture efforts were not expended in the hatchling emergence period (September and October), as trapping was not authorized by ECCC after August 31, and the mesh size of the hoop net may be larger than the hatchlings. CNL also noted that there was a relatively low number of juvenile/immature individuals captured during its studies. It is unknown whether this is an indication that juveniles are rare and reflects a low-level of recruitment in the population or whether juveniles eluded capture. It has been reported that high annual survivorship of juveniles is required to maintain a stable population of Blanding's turtles on the E. S. George Reserve in Michigan (Congdon et al. 1993).

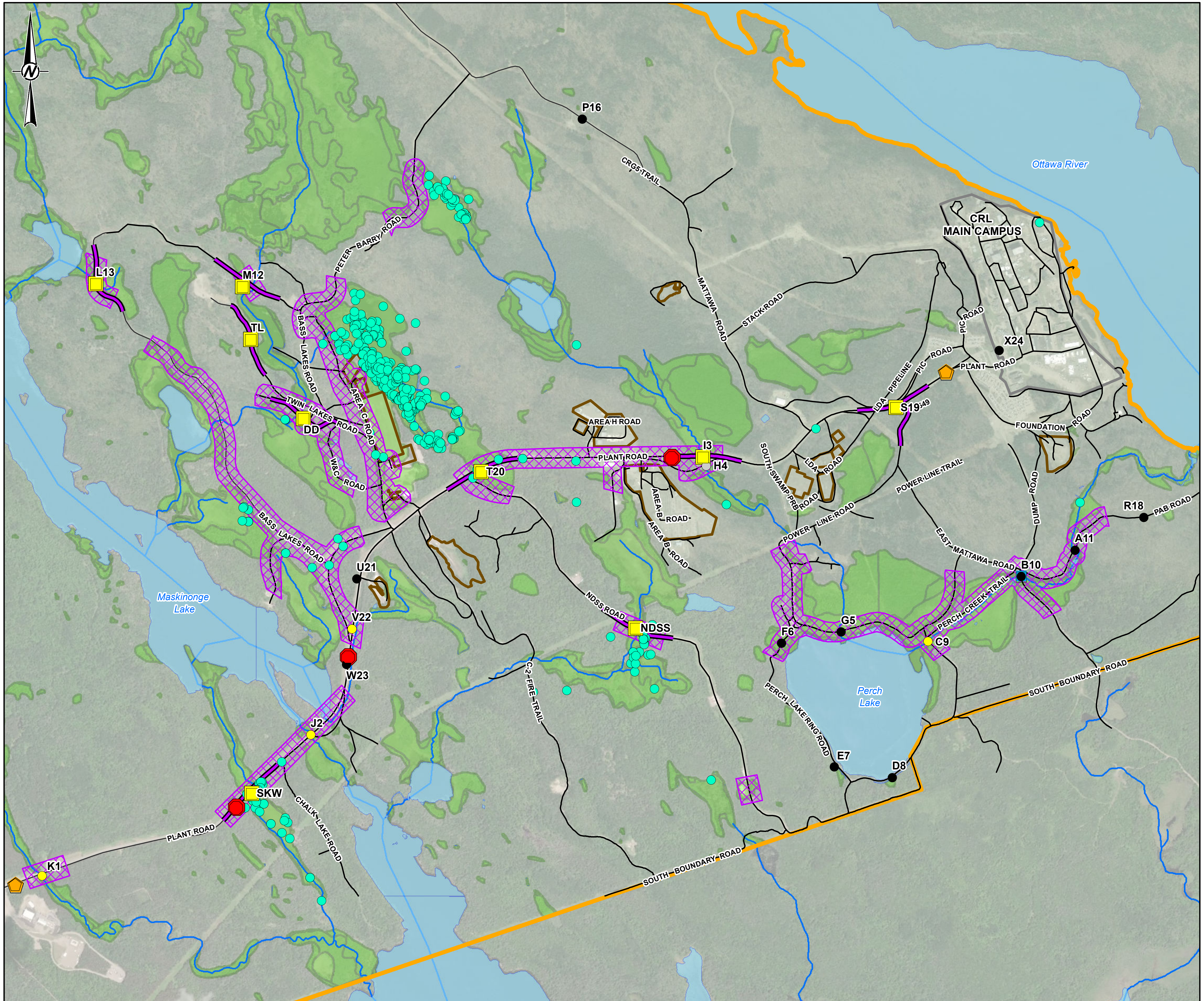
Mortality along roadways and railways has been identified as the most important threat to the Great Lakes / St. Lawrence Blanding's turtle population (ECCC 2018b). The risk of roadkill is a concern in the RSA. According to CNL's annual species at risk reports, two adult Blanding's turtle mortality events have been identified on the roads within the RSA in the last six years. One roadkill occurred on July 7, 2013, on Plant Road and the other occurred on Twin Lakes Road on June 6, 2014. Detection of roadkill events is unlikely to be 100% and other instances may have occurred, but were not recorded. CNL's observation records and road surveys, particularly during June and July, note a considerable number of turtles travelling on roadways (gravel roads) and near roadsides. This may indicate females in search of nesting sites, which makes them susceptible to roadkill.
Late maturity, low reproductive output and an extremely long life make this turtle highly vulnerable to adult mortality (Congdon et al. 1993; ECCC 2018b). Low reproductive success and low recruitment make this species especially vulnerable to extinction even with a very small increase of the annual mortality rate (less than 5%) from anthropogenic activities (Gibbs and Shriver 2002).

Because the RSA may act as a refuge for Blanding's turtles, road mortality on the CRL Site is a primary concern for the sustainability of the regional Blanding's turtle population. That is, there is concern that the RSA could function as a population sink because turtles are attracted to the abundant habitat on the CRL Site but may suffer high rates of road mortality. For this reason, CNL started implementing a detailed *Blanding's Turtle Road Mortality Mitigation Plan* (Golder 2019a) in 2019, and will continue to implement the plan moving forward. The *Blanding's Turtle Road Mortality Mitigation Plan* is designed to reduce or eliminate turtle road mortality at CRL and increase connectivity among habitats. This plan includes mitigation implemented in four key areas: driver awareness; installation of permanent exclusion fencing; creation of nesting mounds; and replacement of culverts in key areas. A key component of the *Blanding's Turtle Road Mortality Mitigation Plan* is the use of monitoring and adaptive management to determine the efficacy of mitigation and to develop and implement improvements to mitigation, as required (Golder 2019a).

Currently, temporary exclusion fencing is installed at Culvert J2 and Culvert SKW on both sides of Plant Road (Figure 5.6.4-19). Inspection of this temporary fencing is completed weekly during the active turtle season (May to September) and after heavy rainfall events (≥7 mm/hr) (Golder 2019a). Culverts in hotspots are also inspected during the exclusion fence inspections and barriers that can impede passage through the culverts are removed or modified (Golder 2019a).

One new culvert will be installed in November 2019 along the Twin Lakes Road at Dew Drop Lake (Culvert DD; Figure 5.6.4-19). Culvert H4 will be removed in November 2019 as the road that the culvert is located is will be closed. The remaining existing culverts that have identified for replacement are prioritized based on their proximity to a wetland, turtle observations, and potential for road mortality at the location (i.e., traffic levels). In the short-term (2019/2020), efforts are focused on Plant Road, as this is the road with the highest amount of traffic on the CRL Site. Five Priority 1 culverts will be replaced in November 2019 (Culverts T20, I3, S19, M12, and TL) and one Priority 1 culvert will be replaced in April 2020 (Culvert SKW) (Figure 5.6.4-19). Priority 2 culverts will be replaced after the NSDF Project has been approved and will mitigate effects from the NSDF Project (see Section 5.6.7.8.3 for more details). Remaining Priority 3 culverts (L13, M12, and NDSS) will be replaced as they fail (Figure 5.6.4-19). Not all culverts that are located in reptile hotspots are Priority 1, 2, or 3 because of barriers (e.g., a weir) that prevents turtles from accessing the culvert (see Appendix A in the *Blanding's Turtle Road Mortality Mitigation Plan* for more details). All new and replaced culverts will have appropriate permanent fencing for 200 m on either side of the culvert to guide turtles through the tunnel. Inspection of permanent fencing and culverts in hotspots will be undertaken similar to current inspections of temporary fencing at CRL. That is, inspections will occur weekly during the active turtle season (May to September) and after heavy rainfall events (≥7 mm/hr) (Golder 2019a).

Once culverts are installed or replaced, they will be enhanced by planting native vegetation around the culvert entrances, while maintaining a clear line of site through the culvert (Golder 2019a). Additionally, to help limit movement requirements for females to reach nesting areas, nesting mounds will be created in late 2019/early 2020 on both sides of culverts S19, I3, T20, and SKW (Figure 5.6.4-19). To improve the chance of successful nesting, starting in 2020, five wire-screen cages will be deployed over areas were eggs have been laid. An additional 25 cages will be constructed and deployed in 2021 and beyond. These nest cages will be designed according to guidelines adapted from Gillingwater (2008) and Ratnaswamy et al. (1997) (Golder 2019a). Nest cages will be deployed during the nesting season (May 15 to June 30) and weekly inspections of the cages will be completed from the end of the nesting period through to the end of the hatchling emergence period (July 1 to October 15). Cages will be retrieved prior to May 15 of the following year.



LEGEND

- ROAD
- RIVER/STREAM
- WATERBODY
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- CRL PROPERTY
- WETLANDS

DESCRIPTION

- CULVERT
- PRIORITY 1 CULVERT
- PRIORITY 2 CULVERT
- PRIORITY 3 CULVERT
- CULVERT TO BE INSTALLED IN 2019
- CULVERT TO BE REMOVED IN 2019
- BLANDING'S TURTLE OBSERVATION
- BOX TUNNEL CROSSING

MITIGATION MEASURES

- ARTIFICIAL NEST MOUNDS
- ELECTRONIC SLOW SPEED SIGN (MAY 15-JUNE 30)
- PERMANENT TURTLE CROSSING SIGN; SLOW SPEED LIMIT POSTING (MAY 15 - JUNE 30)
- EXCLUSION FENCING
- REPTILE HOTSPOT

0.5 0 0.5

1:20,000 KILOMETRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

BLANDING'S TURTLE MITIGATION TO BE IMPLEMENTED AT BASE CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	PR
PREPARED	PR
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.4-19

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To increase employee, contractor, and visitor awareness about the presence of turtles on the CRL site, the following mitigations have already been, and will continue to be, implemented at the site:

- Three permanent turtle crossing signs have been installed along Plant Road (Figure 5.6.4-19);
- Two electronic turtle crossing signs have been installed along Plant Road and are in use during the turtle terrestrial season (May 15 to September 30) (Figure 5.6.4-19);
- Detailed species at risk training (1-hour session) is provided to employees familiar with species at risk; and
- The presence of turtles on the CRL site is communicated using the following methods:
  - Information is included as a bulletin on the “My CNL” webpage;
  - Email notifications are regularly sent out to all employees;
  - Information is presented in the Contractor Safety Orientation training and specific contractor training; and
  - Employees are asked to fill out questionnaires each autumn to evaluate how familiar employees are with the mitigation program and objectives and to provide opportunities for employee feedback and suggestions.

Additionally, to avoid negative interactions with nesting turtles, road grading and levelling activities were not completed during the turtle terrestrial season (May 15 to September 30) in 2019 and these restrictions will remain in place during future years. Restrictions on vegetation removal during the terrestrial season will be in place in 2020 and beyond.

Formal turtle road mortality surveys were implemented at the CRL Site in 2019 (no Blanding’s turtle mortality was detected). These road mortality surveys will continue throughout the life of the CRL Site. Road mortality surveys are completed weekly along Plant Road and along hotspots on secondary roads during the active turtle terrestrial season (May 15 to September 30) (Figure 5.6.4-19; Golder 2019a). As part of the adaptive management component of the *Blanding’s Turtle Road Mortality Mitigation Plan*, results from the road mortality surveys will be used to consider the implementation of additional mitigation. For example, if there are road mortality hotspots, permanent exclusion fencing, crossing structures, and/or reduced speed limits during the nesting period may be implemented at these locations.

Adaptive management is an important part of the *Blanding’s Turtle Road Mortality Mitigation Plan*. Depending on results of monitoring, CNL is committed to taking additional actions, as required, to achieve a neutral or positive contribution to Blanding’s turtles. Potential additional actions would be developed as needed, but could including activities such as incubating Blanding’s turtle eggs in facilities that would located on the CRL Site, which would result in improved recruitment into the population. Eggs that are incubated would be those rescued from the CRL site and more broadly from Renfrew County and hatchlings would be released in the RSA or other areas where eggs were collected to support the local Blanding’s turtle population.

With the implementation of the comprehensive mitigation outlined above, CNL’s activities in the RSA are predicted to have a net neutral or positive effect on the local Blanding’s turtle population during the Base Case. That is, the mitigation that is or will be implemented on the CRL Site is considered sufficient to limit and offset mortality from previous and existing anthropogenic activities in the RSA. There is uncertainty regarding the effectiveness of mitigation, but monitoring and adaptive management will be implemented so that CNL achieves a net neutral or positive effect on the Blanding’s turtle population at CRL.

5.6.4.10 Eastern Milksnake

5.6.4.10.1 Habitat Availability

Eastern milksnakes (*Lampropeltis triangulum*) use a wide range of habitats including prairies, pastures, hayfields, wetlands and various forest types, and they occur regularly in rural areas where they frequent older buildings. Row and Blouin-Demers (2006a) report a strong preference for open habitats during their active period; however, eastern milksnakes require microhabitats for their critical life history stages of egg laying, hibernation and thermoregulation (COSEWIC 2014). This species lays eggs in late June / early July in rotting logs or under other suitable cover, and hibernation can take place in mammal burrows, hollow logs, gravel or soil banks, and old building foundations (COSEWIC 2014). Their hibernation sites can vary from well-drained sites at a distance from water or in areas close to water (COSEWIC 2014). They are known to display fidelity to their hibernation sites (Environment Canada 2015). Closed canopy forests may be less suitable for this species because the lack of available sunlight may limit their ability to thermoregulate (COSEWIC 2014). This is supported by a study from eastern Ontario (south of Ottawa) that found that milksnakes avoid forested habitat at both the home range and microhabitat scale (Row and Blouin-Demers 2006b).

The milksnake has adapted to rural areas in southern Ontario, suggesting it is resilient to low levels of anthropogenic disturbance. However, extensive changes in land use such as urbanization and intensive agriculture are reducing habitat availability across its range (COSEWIC 2014).

Because milksnakes are considered habitat generalists and microhabitat preferences cannot be determined from vegetation community mapping, a qualitative assessment of habitat availability was conducted for this species. The availability of natural habitat in the RSA and LSA, and its proximity to the Ottawa River and other wetlands, suggests that portions of the RSA and LSA may be suitable for eastern milksnake. The SSA is forested, with dense canopy in many places, and likely does not contain basking habitat that would be preferred by eastern milksnakes for thermoregulation. However, some microhabitats used for egg-laying by the species (e.g., rotting logs) may be present. These microhabitats are predicted to be of lower quality than similar features in areas with higher thermal quality than the SSA (i.e., open canopy or unforested habitats).

5.6.4.10.2 Habitat Distribution

The SSA is located within the known range of eastern milksnakes and the presence of individuals in the RSA has been confirmed (Figure 5.6.4-20). There are 11 occurrence records for this species in the RSA, most of which are located on the CRL main campus. The supporting information with the occurrence records note that individuals were often found inside buildings. This is typical for eastern milksnakes, which will often use buildings for hibernation. The timing of observation on the CRL main campus spanned from the late summer through to early winter period (late August through December) which generally corresponds with the hibernation period from October/November to April. A few of the observations were of individuals in the basements of buildings, which also might indicate hibernation sites.

No sightings of milksnakes have been recorded in the LSA or SSA. In addition, no road mortalities have been documented within the CRL site. However, given the secretive nature of this species and the use of microhabitats and cover objects, there is a strong likelihood that they may be using habitats within the LSA and SSA but have gone undetected. The CRL main campus, where the majority of observation records occur, borders the LSA to the north. Because home ranges of milksnakes in Ontario are typically between 5 and 29 ha (Row and Blouin-Demers 2006a), the home ranges of milksnakes using the CRL main campus could encompass the LSA and perhaps the SSA. Because eastern milksnakes prefer open habitats, the wetlands within the LSA may be used in the spring, summer and fall.

The road network within the RSA may limit movement and dispersal of this species in the Base Case if snakes are basking on roads in order to thermoregulate and being exposed to road mortality; however, no road mortalities have been documented within the RSA.

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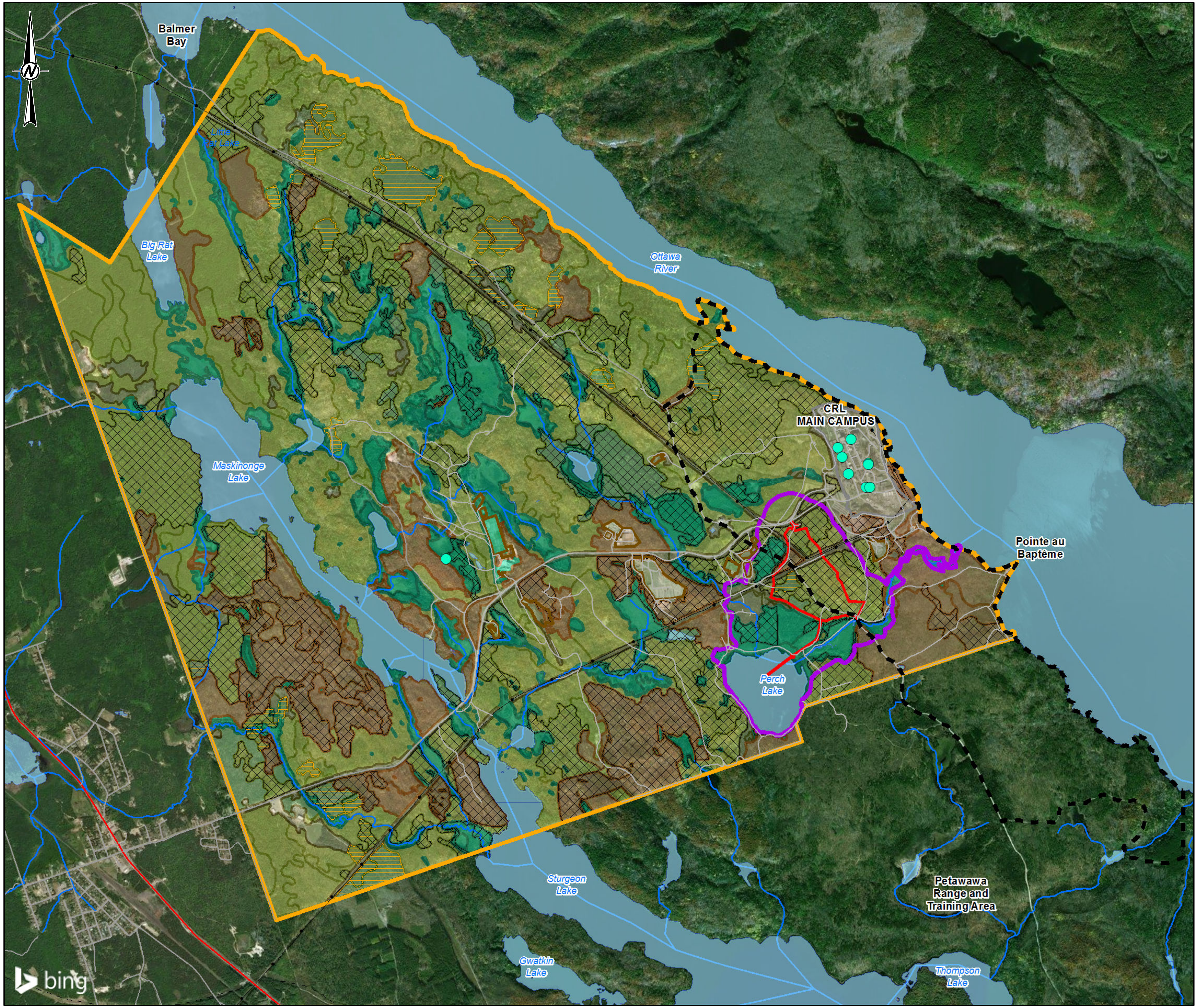

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- NORTH-SOUTH 2002 STUDY AREA
- EASTERN MILKSNAKE OBSERVATION

VEGETATION COMMUNITIES

- MIXED FOREST
- DECIDUOUS FOREST
- CONIFEROUS FOREST
- WETLANDS
- FLOODED AREA
- UNCLASSIFIED (CLEARED)
- MATURE FOREST STAND
- PLANTATION

1 0 1

1:35,000 KILOMETRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
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4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

EASTERN MILKSNAKE OCCURRENCE RECORDS IN THE RSA – BASE CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.4-20

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5.6.4.10.3 Survival and Reproduction

In Canada eastern milksnakes are mainly found in the Great Lakes / St. Lawrence region. These snakes are a species of Special Concern on Schedule 1 of the federal SARA. The main threats to the persistence of this species in Canada are road-related mortality, predation (from pets and other predators) and habitat loss (COSEWIC 2014). Other threats include intentional killing and collection for the pet trade. Because eastern milksnakes are a long-lived species with delayed maturity, this species is likely sensitive to changes in adult survival (Environment Canada 2015). Females are known to lay eggs only once every two years, which may make this species less resilient than more productive species (Environment Canada 2015).

Little is known about the abundance of this species nationally or provincially; however, the total adult population likely exceeds 10,000 and there are recent occurrence records in every jurisdiction (county or regional municipality) within their known range in Ontario (COSEWIC 2014). Consequently, this species was recently downlisted from Special Concern to Not at Risk by the Committee on the Status of Species at Risk in Ontario. The justification for downlisting is that while the species has exhibited declines in highly developed parts of Ontario (i.e., Toronto area), these areas represent a limited portion of the habitat available to this species in other parts of Ontario (i.e., eastern Ontario). The Committee on the Status of Species at Risk in Ontario also noted that the threats to this species are less severe in the part of its range on and near the Canadian Shield, where the CRL site is located.

Population estimates for eastern milksnakes are not available and density estimates are difficult to obtain due to their cryptic, fossorial (i.e., burrowing), behaviour and preference for hunting at night. A low detection rate for this species compared to other Ontario snakes suggests that eastern milksnakes occur at low density across the species' range (COSEWIC 2014). This is further supported by statistics on road mortality because the absolute numbers of milksnakes killed on roads and railroads is low compared to other species of snakes (COSEWIC 2014).

Most of the identified threats to milksnake populations are absent from the RSA. There have been no reported road mortalities on the CRL site, about 87% of the RSA consists of natural habitat (mostly forested) and predation from pets or intentional killing are highly unlikely given the CNL Employee Education Program, which prohibits pets and includes environmental awareness training. Predation during all life stages is likely the main factor affecting milksnake survival and reproduction in the RSA. Predators of milksnakes that may be present in the RSA include bullfrogs (*Rana catesbeiana*), brown thrashers (*Toxostoma rufum*), raccoons (*Procyon lotor*), hawks, owls, foxes, skunks, other snakes (Environment Canada 2015). Weasels and shrews may pose a threat to eggs and young hibernating milksnakes. With the exception of predation, other factors affecting milksnake survival and reproduction appear to be absent from the RSA, suggesting that the milksnake population that overlaps with the RSA may be more resilient to additional sources of mortality as compared to other populations within its range that are exposed to road-related mortality, habitat loss, intentional killing/collection and/or predation by domestic animals.

5.6.4.11 Monarch Butterfly

5.6.4.11.1 Habitat Availability

Monarch butterflies (*Danaus plexippus*) require milkweed (*Asclepius* spp.) for caterpillars and wildflowers that supply a nectar source for adults. Because the caterpillars feed solely on milkweed, breeding habitat suitability is defined by availability of milkweed, which grows in open habitats (ECCC 2016b). Consequently, monarch butterflies are often found on abandoned farmland, meadows, open wetlands, prairies and roadsides, but also in city gardens and parks where milkweed is planted (COSEWIC 2010). Monarch butterflies that breed in Ontario migrate south to overwinter in Mexico. Summer breeding habitat, which overlaps with the RSA, is the focus of this assessment.

Vegetation community data were used to map suitable summer breeding habitat for monarch butterflies in the LSA and RSA based on the likelihood of each vegetation community type to support milkweed plants. The following vegetation community types were identified as suitable monarch butterfly habitat:

- pre-sapling forest of any type;
- wetland;
- flooded area;
- 30 m buffer on aquatic habitat (i.e., each side of a river or around the perimeter of a lake);
- transmission line ROW; and
- 5 m buffer on roads (i.e., each side of a road).

A total of 80 ha (38.1%) and 805 ha (20.9%) of suitable habitat for monarch butterflies is estimated to be present in the LSA and RSA, respectively, in the Base Case (Table 5.6.4-12). Most of the suitable habitat (over 80%) in both the LSA and RSA is in the form of wetlands and shorelines. Road verges and transmission line ROWs represent about 15% of the suitable habitat in both the LSA and RSA. Flooded areas and pre-sapling forest represent a minor component (3%) of suitable habitat in the RSA only. The wetland community type includes swamps in addition to marsh and minor fen and bog elements. Swamps, other than thicket swamps or sunny openings in treed swamps, are generally not suitable habitats for monarch butterflies, so habitat availability in the study areas may be overestimated.

Table 5.6.4-12: Summer Habitat Availability for Monarch Butterfly in the Base Case

Habitat Suitability	Regional Study Area		Local Study Area	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Suitable	805	20.9	80	38.1
Unsuitable	3,047	79.1	130	61.9
Total	3,852	100.0	210	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.

Disturbance can have a positive effect on monarch butterfly habitat, particularly in predominantly forested landscapes such as the RSA. Fire suppression activities since the 1940s have likely had negative effects on monarch butterfly habitat relative to what was historically available for this species in the RSA because monarch butterflies occupy early successional habitat. Loss of breeding habitat in part due to reforestation of previously cleared land cover has been identified as a moderate threat to this species (ECCC 2016b). Regular vegetation maintenance in utility corridors and along roadsides maintains open land cover that provides suitable habitat for monarch butterflies due to the ability of milkweed to establish in these disturbed areas. However, excessive vegetation maintenance and herbicide use in road verges can be detrimental to milkweed establishment and growth (COSEWIC 2010). It is CNL's policy to minimize the use of all pesticides, including insecticides, herbicides and fungicides, on all its sites (CNL 2018c). The extent to which the quality of potential monarch butterfly habitat is reduced through the use of pesticides in the RSA and LSA in the Base Case is not known, but is presumably low given that approximately 15% of their suitable habitat is in areas that may require pesticide management by CNL (i.e., road verges and transmission line ROWs).

5.6.4.11.2 Habitat Distribution

In the Base Case, suitable monarch butterfly habitat is well distributed throughout the RSA (Figure 5.6.4-21) and LSA (Figure 5.6.4-22). Linear disturbances present in the LSA and RSA in the Base Case have likely had positive effects on monarch butterfly habitat distribution because these disturbances maintain open habitat suitable for the establishment and growth of milkweed and also provide movement corridors connecting patches of open habitat in a largely forested landscape. Adult monarch butterflies are highly mobile and not likely to be limited by habitat distribution in the study areas.

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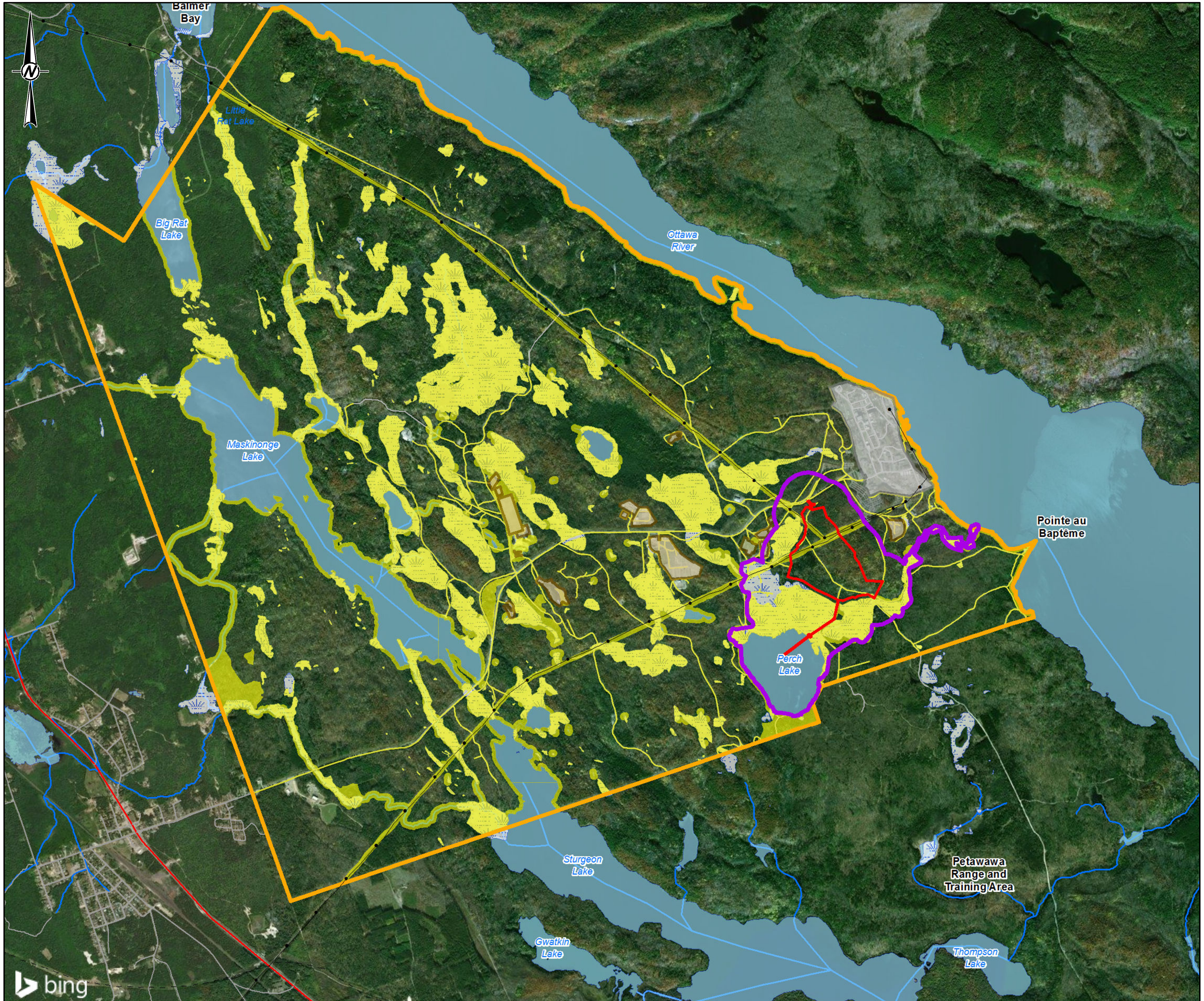

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- MONARCH BUTTERFLY HABITAT

1 0 1

1:35,000 KILOMETRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
MONARCH BUTTERFLY HABITAT AVAILABILITY AND DISTRIBUTION IN THE RSA – BASE CASE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.4-21

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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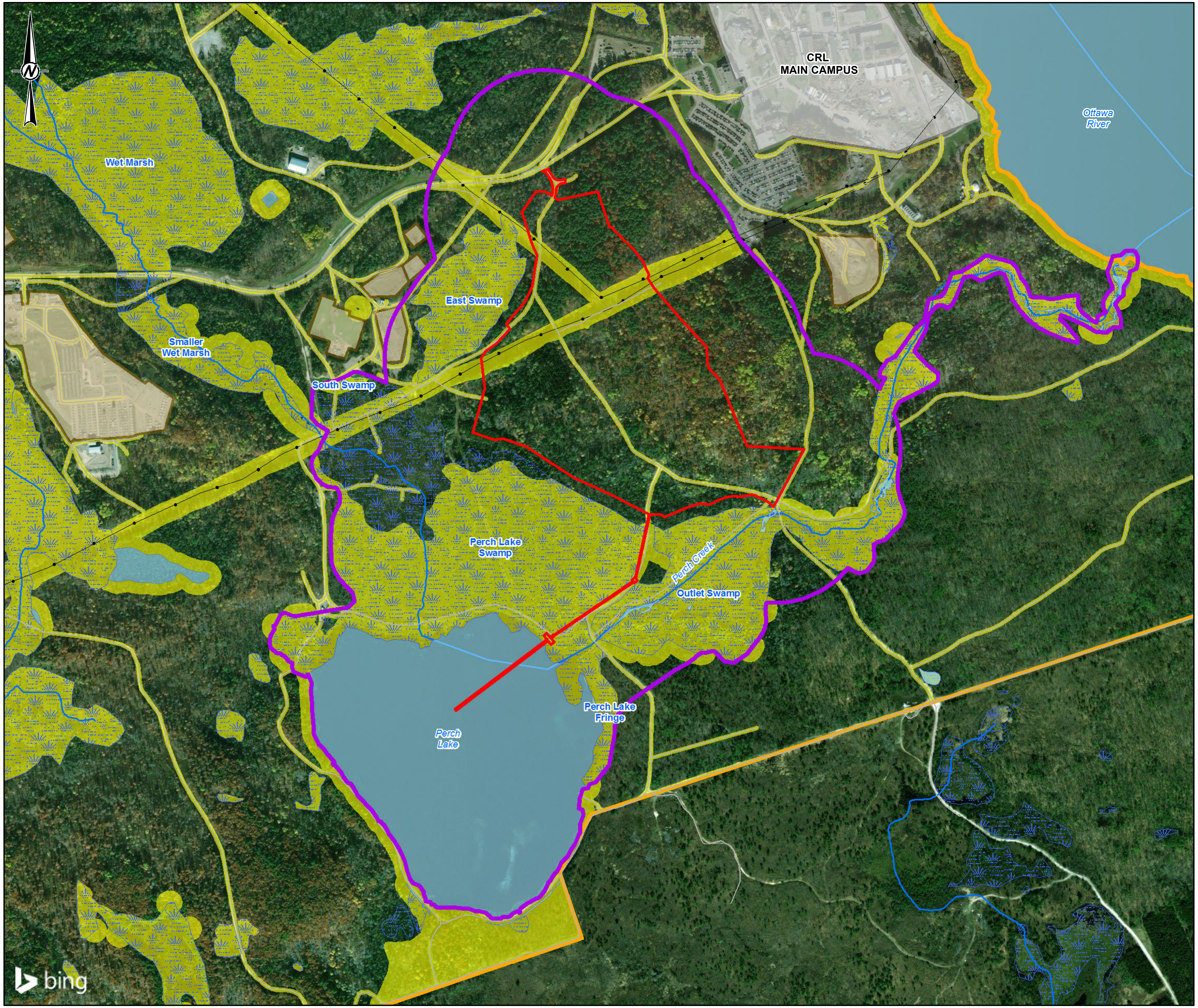

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- MONARCH BUTTERFLY HABITAT

250 0 250

1:10,000 METRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

MONARCH BUTTERFLY HABITAT AVAILABILITY AND DISTRIBUTION IN THE LSA AND SSA – BASE CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.4-22

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5.6.4.11.3 Survival and Reproduction

Population estimates for monarch butterflies in Ontario and more broadly in Canada are unavailable. Individuals numbering in the hundreds of thousands have been reported passing through Long Point and Point Pelee during fall migration, but what proportion of the Ontario population these numbers represent is unknown (COSEWIC 2010). The estimated population of monarch butterflies overwintering in Mexico is between 66 million to 200 million individuals; however, this includes American breeding populations, as well as those that breed in eastern Canada. Despite the large estimated overwintering population and year-to-year fluctuations, there is an annual declining trend in the overwintering population due to forest habitat loss in Mexico. Similar declining trends have not been consistently observed among breeding populations (COSEWIC 2010).

Overall, Canada supports about 10% of the global breeding range of the species, and southern Ontario and Quebec contain the most important breeding areas with highest concentrations of individuals in the country (COSEWIC 2010; ECCC 2016b). However, the RSA is unlikely to be an important breeding area for monarch butterflies given that it is mostly forested and approaching the northern limit of milkweed distribution in Ontario.

Road verges represent about 8.5% of the available habitat for monarch butterflies in both the LSA and RSA. These linear strips of vegetation maintained in early successional stages have been identified as important habitat for monarch butterflies as agricultural landscapes that formerly provided habitat continue to be lost due to agricultural intensification, urban development and reforestation, and it has been estimated that road verges support about 10% of the milkweed population (all species) in North America (Flockhart et al. 2014). However, mowing as part of roadside vegetation maintenance can cause direct mortality of eggs and caterpillars, and the use of herbicides in roadside vegetation maintenance can kill milkweed, reducing carrying capacity for monarch butterflies. Additionally, milkweed exposed to road salt runoff has been found to contain elevated concentrations of sodium, which have been linked to reduced monarch caterpillar survival rates and altered physiology in survivors with unknown implications for fitness (reviewed in COSEWIC 2010). CNL is committed to reducing the use of road salt in the RSA; however, more than 500 tonnes per year are required to maintain safety of operations and personnel (CNL 2018c).

Vehicle collisions have been identified as a threat to monarch butterflies given their tendency to occupy road verges (COSEWIC 2010). Risk of collision increases with road width and traffic speed (Skórkaa et al. 2013). Most of the roads in the RSA are secondary roads. Plant Road is the widest and most heavily used road in the RSA, posing the largest collision risk. However, due to existing traffic control measures enforced by CNL and the likelihood that monarch butterfly abundance in the RSA is relatively low, risk of collision is expected to be negligible.

5.6.5 Project Interactions and Mitigation

5.6.5.1 Methods

This section describes the process by which interactions between NSDF Project components and activities and terrestrial biodiversity VCs were identified and evaluated. Potential effects pathways are identified, and mitigation developed to eliminate and/or reduce effects is presented. A pathways analysis is then used to focus the assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects.
Where effects will be adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects after incorporation of mitigation measures are

further characterized in subsequent subsections of the assessment, as required. As such, the "Project Interactions and Mitigation" section helps to focus the remainder of the assessment on those interactions (effects pathways) likely to result in residual adverse effects.

The first part of the analysis was to identify the potential effects pathways for all phases of the NSDF Project. The next step in the analysis was the development of environmental design features and mitigation practices that could be incorporated into the NSDF Project to eliminate and/or reduce effects to terrestrial biodiversity VCs. Environmental design features included design elements, environmental best practices and management policies and procedures. These steps are widely recognized as the most important components of the mitigation hierarchy for biodiversity conservation (BBOP 2015). Environmental design features and mitigation were developed through an iterative process between the Project's engineering and environmental teams, combined with input from Project-specific or regional engagement with other interested parties. The environmental design features and/or mitigation were selected considering their effectiveness for implementation and maintenance, and their appropriateness within the context of the identified effects pathways.

Remediation was not incorporated into the pathway analysis as a means to eliminate interactions between the NSDF Project and the environment because the duration between the effect and remediation is long and because diverse vegetation communities supporting a range of terrestrial biodiversity features equivalent to that present in the Base Case are not expected on the reclaimed landscape. Upon completion of the installation of the final cover over the ECM, turf-grass will be established. The final cover will be maintained to deter wildlife and avoid the disruption of roots to the final cover. Consequently, the post-remediation state of the SSA will be highly modified and unlikely to support terrestrial biodiversity.

After incorporation of mitigation, potential pathways were evaluated into the following categories using scientific knowledge, logic, experience of the professionals conducting the assessment with similar developments and the demonstrated or expected effectiveness of mitigation:

- **No linkage**: The pathway is removed by environmental design features or mitigation so that the NSDF Project would not be expected to result in a measurable environmental change relative to Base Case values, and therefore would have no residual effect on terrestrial biodiversity.
- **Secondary pathway**: The pathway could result in a minor measurable change in the environment relative to the Base Case, but this change would have a negligible residual effect on terrestrial biodiversity and is not expected to contribute cumulatively to other NSDF Project effects or other previous, existing and reasonably foreseeable developments to cause a significant effect.
- **Primary pathway**: The pathway is likely to result in a measurable environmental change relative to the Base Case that could contribute to residual adverse effects on terrestrial biodiversity.

Environmental design features and mitigation that have been or could be incorporated into the NSDF Project to eliminate and/or reduce adverse effects to terrestrial biodiversity were considered. Potential pathways that were completely removed due to implementation of environmental design or mitigation were not assessed further. Pathways that were assessed to be secondary and demonstrated to have a negligible residual effect to terrestrial biodiversity through simple qualitative or semi-quantitative evaluation of the pathway were also not advanced for further assessment. Primary pathways were carried forward for more detailed quantitative and qualitative effects analysis to characterize the residual effects of the NSDF Project on terrestrial biodiversity. In some cases, there was uncertainty associated with the success of proposed mitigation, which contributes to uncertainty for the pathway analysis process. Where uncertainty about potential effect size after mitigation was high, pathways were considered primary.

5.6.5.2 Results

Potential interactions between the NSDF Project and terrestrial biodiversity are presented in Table 5.6.5-1. Mitigations identified to address and, if possible, remove potential interactions between the NSDF Project and terrestrial biodiversity are also integrated into the pathway analysis presented in Table 5.6.5-1. Following the table, assessments for each pathway considered secondary or having no linkage to terrestrial biodiversity are presented and primary pathways are summarized.

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Table 5.6.5-1: Pathways Analysis for the Terrestrial Biodiversity Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Project activities during the construction phase: - Site preparation - Construction of the ECM, - Blasting - Development of surface water management structures	Vegetation clearing and grubbing will result in the loss or alteration of existing vegetation and topographical features. This will cause losses of some vegetation communities and potentially change wildlife habitat availability, use and connectivity, and could influence wildlife abundance and distribution.	- The SSA has been designed to avoid wetlands, where possible, and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. - A 30 m buffer will be established along identified wetlands near the SSA; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion - A 5 m treeline buffer is established from all property lines on the SSA to limit disturbance to vegetation and large tree roots at the treeline. - Critical Blanding's turtle habitat will be assessed annually to ensure no significant loss at CRL and to determine compensation measures initiated at CRL or elsewhere.	Primary
	Vegetation clearing and grubbing will result in an increase in edge habitat, which could increase predation risk and nest parasitism risk for bird VCs.		Secondary

Table 5.6.5-1: Pathways Analysis for the Terrestrial Biodiversity Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
▪ Construction of the WWTP and other support facilities ▪ On-site road and access development ▪ Haulage of construction materials ▪ Installation of security and fencing around perimeter of ECM	Vegetation clearing and grubbing for the two temporary laydown and staging areas required for the installation of the transfer line to Perch Lake will result in the temporary loss or alteration of wetland habitat in the Perch Lake Swamp. This will cause temporary losses of a wetland vegetation community and potentially have a temporary effect on wildlife habitat availability, use and connectivity.	▪ Artificial nest mounds will be constructed on both sides of new and replaced culverts ▪ New and replaced culverts will be enhanced by planting native vegetation around the culvert entrances, while maintaining a clear line of site through the culvert ▪ The transfer line to Perch Lake will be installed using high-pressure horizontal directional drilling methods. This will limit surface disturbance within the wetland area of Perch Lake Swamp to two areas required for laydown and staging: one 400 m^2 area on the shoreline of Perch Lake, and one 100 m^2 area midway along Perch Lake Ring Road approach to the ECM. ▪ The mitigation described in the DFO Ontario Operational Statement – High-Pressure Directional Drilling (DFO 2007) will be followed, including siting of the transfer line and access to temporary laydown and staging areas largely within a previously established access road ROW (Perch Lake Ring Road), minimization of vegetation removal beyond previously disturbed areas, creation of, and adherence to an emergency Frac-out Response Plan and Spill Contingency Plan during installation, and full-time environmental monitoring during all phases of transfer line works within the Perch Lake Swamp to evaluate adherence to environmental protection measures and make observations on signs of surface frac-out of drilling mud (i.e., release through fractured bedrock drilling mud that travels toward the surface). Evidence of frac-out will trigger implementation of the Frac-out Response Plan. ▪ All in-water work will target the timing window of July 16 to October 1 to avoid critical fish spawning and egg/larval development periods for spring spawning fish species (DFO 2013, MNR 2013) while being protective of turtle overwintering habitats in and around Perch Lake. The construction duration is anticipated to be short term (i.e., <30 days). ▪ The Blanding's Turtle Road Mortality Mitigation Plan (Golder 2019a) includes provisions which will compensate for the removal of a portion of critical Blanding's turtles habitat near Perch Lake. The installation of nesting mounds as well as culverts are proposed to increase habitat connectivity and providing adequate nesting areas in close proximity to current habitat to limit movement requirements for nesting females. ▪ The disturbed portions of the two temporary laydown and staging areas beyond the edge of the Perch Lake Ring Road ROW (which will remain in place) will be restored to the natural wetland vegetation communities that were present prior to construction. ▪ Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site will be used during construction around disturbed areas, where appropriate. ▪ Bat boxes are relatively inexpensive and can be highly effective at providing habitat for roosting little brown myotis and possibly northern myotis. Tri colored bats are less likely to use bat boxes, but may use other forms of artificial roosting habitat; these options may be considered. Installation of bat boxes in suitable locations in the RSA is recommended to offset the incremental contribution of the NSDF Project to cumulative effects on SARA listed bats. ▪ In consultation with CNL biologists and in consideration of future losses of anthropogenic structures that may provide roosting habitat, offsetting in the form of 16 bat boxes was recommended. Bat boxes were installed in May 2017. Each two chambered box (Bat Conservation International approved design) was installed back to back on wooden poles in eight different locations around the proposed NSDF location. Occupancy was confirmed in July 2018 and has been increasing since then. This box design is suggested to have capacity for 350–400 individual bats per box, providing roosting habitat for a potential maximum of 6,400 individual bats (with 16 boxes). ▪ Criteria for appropriate siting included accessibility of box locations for installation and future monitoring of utilization/effectiveness, avoidance of areas with radiological contamination in surface water features and appropriate distance to anthropogenic disturbances to avoid sensory effects (i.e., noise). Immature forested areas adjacent to larger uncontaminated waterbodies and wetlands are high priority locations because these forest types do not currently provide high quality roosting habitat and would be most benefited by installation of bat roost boxes to expand the spatial coverage of potential roosting habitat within the RSA. Final site selection will be at the discretion of CNL biologists. ▪ Monitoring is being conducted at least weekly to determine if boxes are being used. Boxes not being used may be moved to an alternate location. ▪ A project in collaboration with Trent University is currently underway, where bats are being trapped and tracked back to the roost site (natural tree or bat box). Guano collection is being performed as well. This work has a duration of two years and will provide CNL with a better understanding of habitat occupancy by the bat species at risk, including bat boxes, and habitat preference. This work will support the objective of addressing knowledge gaps on the three bat species at risk ▪ A comprehensive Sustainable Forest Management Plan will be implemented to ensure the long-term retention of trees serving as maternity roosts for the bat species	Secondary

Table 5.6.5-1: Pathways Analysis for the Terrestrial Biodiversity Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment

Project activities during the construction phase (continued)	Vegetation clearing and grubbing may remove active migratory bird nests, bat maternity roosts and monarch butterflies (various life stages), which may influence reproduction and survival (incidental take).	▪ Vegetation clearing and grubbing in the majority of the SSA, and particularly in complex forested habitat, will occur before April 8 or after August 31 to avoid effects on nesting birds and bat maternity roosts.
		▪ CNL has a risk assessment checklist to determine if an area qualifies as a simple habitat, qualifying for nest searches and clearing in the absence of nests during the breeding season. The checklist has a series of risk factors and the total score provides whether the area qualifies. Examples of risk factors are:
		  ▪ knowledge of time periods of which migratory bird species are present;
		  ▪ ability to perform searches for evidence of nesting using non-intrusive search methods to prevent disturbance;
		  ▪ known breeding evidence of species at risk birds within 200 m (that reside in a similar habitat composition);
		  ▪ habitat size and complexity;
		  ▪ level of difficulty to locate and avoid the present nest types;
		  ▪ frequency of disturbance;
		  ▪ duration of disturbance;
		  ▪ intensity of disturbance;
		  ▪ extent of disturbance;
		  ▪ level of noise emissions generated from disturbances; and
		  ▪ birds' tolerance to disturbance.
		▪ If vegetation clearing in small areas with simple habitat (i.e., that can be effectively searched for nests) cannot be conducted outside the breeding bird nesting period (April 8 to August 28), or bat maternity roosting period (May 1 to August 31), pre-clearing bird and bat surveys will be completed to confirm no active nests/roosts are present in trees to be felled. Pre-clearing bird and bat surveys will be completed by CNL's Environmental Protection team to confirm no active nests/roosts are present in trees to be felled. This work must be approved by Environmental Protection prior to execution and can be denied if the risk to birds or bats is considered high.
		▪ Species-specific buffers will be put in place around active nests/roosts to avoid disturbance to wildlife caused by noise and other sensory disturbance caused by site preparation activities.
		▪ Implementation of a comprehensive Sustainable Forest Management Plan to ensure the long-term retention of trees serving as maternity roosts for the bat species. At CRL, harvesting has not been conducted in a consistent manner since CNL operations started back in the 1940s. In absence of natural disturbances such as forest fire, the CRL forest does not represent what the forest should look like under a natural disturbance regime. For this reason, the CRL site consists of more old forest stands than would exist in a natural environment offering more habitat to bat species than it would under natural regimes. Many bat species preferentially roost in older forest stands, compared to young forests. If the forest is not actively managed, the old trees will disappear from natural decay and will be replaced with species that do not represent a natural forest structure for this area and would not be suitable habitat for bats. For this reason, CNL is committing to implement a Sustainable Forest Management Plan to ensure a representative presence of roost trees in the landscape and through time.
		▪ Trees will not be felled until the nests/roosts are confirmed inactive and no longer occupied.
		▪ A 5 m treeline buffer is established from all property lines on the SSA to limit disturbance to vegetation and large tree roots at the treeline.
		▪ If vegetation clearing is scheduled in open habitat between late May and October, the habitat will be searched in advance of construction for the presence of milkweed. Areas of the footprint that contain milkweed will be cleared outside of late May to October to avoid effects on monarch butterflies.
			No Linkage

	Vegetation clearing and grubbing may remove active milksnake hibernacula, which may influence reproduction and survival (incidental take of hibernating snakes).	▪ None	Primary

Table 5.6.5-1: Pathways Analysis for the Terrestrial Biodiversity Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Project activities during the construction phase (continued)	The high-pressure horizontal directional drilling installation of the transfer line to Perch Lake may result in a release of drilling mud (i.e., frac-out), which may cause changes to surface water quality, which can cause changes to soils and vegetation communities (including wetlands), which in turn can affect wildlife survival and reproduction.	▪ The transfer line to Perch Lake will be installed using high-pressure horizontal directional drilling methods. The mitigation described in the DFO Ontario Operational Statement – High-Pressure Directional Drilling (DFO 2007) will be followed, including creation of, and adherence to a Frac-out Response Plan and Spill Contingency Plan during installation, and full-time environmental monitoring during all phases of transfer line works within the Perch Lake Swamp to evaluate adherence to environmental protection measures and make observations on signs of surface frac-out of drilling mud. Evidence of frac-out will trigger implementation of the Frac-out Response Plan.	Secondary
	Fly rock from blasting may result in injury or mortality to wildlife.	▪ A blasting plan, as part of the EPP, will be developed by the Contractor and implemented for the NSDF Project Blasting activities will follow industry standard best management practices and applicable federal regulations. ▪ Additional guidance for the NSDF Project blasting limits will be obtained from the Ontario Provincial Standard Specification (OPSS) in the document OPSS 120 – General Specification for the Use of Explosives (OPSS 2014). ▪ Set-back distances required for blasting will be identified in the Blasting Plan. ▪ Blasting activities will be temporarily suspended if wildlife are observed in the blasting area.	No Linkage
	Blasting residuals and metals may be released during construction of the ECM and surface water drainage features through the SSA may transport them directly into downstream waterbodies or adjacent wetlands, affecting surface water and sediment quality and causing changes to wetlands and riparian vegetation communities, which in turn can affect wildlife habitat availability and distribution.		No Linkage
	The construction of the NSDF Project may change downstream discharge, water levels and channel/bank stability in streams, which can cause changes to soils and vegetation communities (including adjacent wetlands), which in turn can affect wildlife habitat availability and distribution.	▪ Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site will be used during construction around disturbed areas, where appropriate. ▪ Where practical, natural drainage patterns will be used to reduce the use of ditches and diversion berms. ▪ Culverts will be installed or upgraded along site access roads, as necessary, to maintain drainage; all drainage features will be designed to safely convey the flows associated with the probable maximum precipitation event. ▪ The surface water pond designs will promote infiltration and suspended particulate settling, and will control discharge to the downstream receiving natural systems.	No Linkage

Table 5.6.5-1: Pathways Analysis for the Terrestrial Biodiversity Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Project activities during the construction phase: ▪ Site preparation ▪ Construction of the ECM ▪ Blasting (as required) ▪ Development of surface water management structures ▪ Construction of the WWTP and other support facilities ▪ On-site road and access development ▪ Construction of transfer line and Perch Lake diffuser ▪ Domestic waste (solid and liquid) management ▪ Soil spoils haulage to a soil storage area ▪ Installation of security and fencing around perimeter of ECM Project activities during the operations phase: ▪ Phased development of disposal cells in the ECM ▪ On-site transportation of waste and placement in the ECM ▪ Progressive closure of disposal cells and installation of final cover ▪ Operation of the WWTP ▪ Existing presence of fencing around perimeter of ECM ▪ Surface water management ▪ Domestic waste (solid and liquid) management; and, ▪ Routine operational management and monitoring activities.	Sensory disturbance (i.e., lights, smells, noise, human activity, alteration of viewscape) can change wildlife habitat availability, use and connectivity (movement and behaviour), which can lead to changes in wildlife abundance and distribution.	▪ Activities with highest levels of noise and habitat disturbance will be avoided during most sensitive life history phase (i.e., breeding and nesting for birds, maternity roosting for bats) by conducting vegetation clearing and grubbing before April 8, or after August 31 to avoid effects on nesting birds, bat maternity roosts and the active Blanding's turtle season, and to minimize effects on monarch butterfly and milksnake. ▪ Activities with a high noise level (e.g., rock crushing) will be completed during day light conditions. ▪ Work inside closed buildings may take place during non-daylight conditions.	Primary

	Potential introduction and spread of noxious weed species from trucks and other equipment can affect vegetation community species composition, which can affect wildlife habitat availability and distribution.	▪ An Invasive Species Management Plan in keeping with best management practices such as the MNR Forest Management Guide for Conserving Biodiversity at the Stand and Site Scales (MNRF 2019a) will be implemented to limit effects of noxious and invasive plants on natural vegetation, which includes:
		  ▪ cleaning and inspection of vehicles and equipment prior to SSA entry;
		  ▪ re-cleaning vehicles and equipment if an area of weed infestation is encountered, prior to advancing to a weed free area; and
		  ▪ locating and managing cleaning locations on the SSA.
			Secondary

	Attraction of wildlife to the NSDF Project (e.g., food waste, petroleum-based products) may increase human-wildlife interactions and change predator-prey relationships, which can affect wildlife survival and reproduction.	▪ All wastes that arise as a result of the construction, operations and closure phases will be safely managed and in accordance with CNL's Waste Management Program. ▪ Attractants (e.g., collection and storage in appropriate wildlife-resistant containers) will be managed to limit interactions between people and wildlife. ▪ As per CNL's Management of Land, Habitat and Wildlife procedure, (CNL 2018c) feeding of wildlife is prohibited to minimize habituation. ▪ Staff and contractors will be provided with training to reinforce the importance of not feeding wildlife and carrying out proper waste management practices.	Secondary
	Movement of heavy equipment and other vehicles on roads and through previously undeveloped / forested areas may cause injury or mortality to Blanding's turtle, milksnake and monarch butterfly.	▪ Reptile exclusion fencing will be installed around the perimeter of the SSA prior to initiating activities during the construction phase and prior to the active Blanding's turtle season (i.e., prior to April). This mitigation will also benefit milksnakes. ▪ Damaged or ineffective fencing and signage will be repaired. ▪ Road grading and levelling activities will not be completed during the turtle terrestrial season (May 15 to September 30). ▪ Temporary exclusion fencing will be installed around the NSDF EMR footprint during construction of the NSDF Project. This temporary exclusion fencing will be replaced by permanent fencing by the end of construction of the NSDF Project. Exclusion fencing will benefit both Blanding's turtles and milksnakes. ▪ A road mortality survey will be completed for turtles and milksnake in the species' active seasons of April 15 to September 30 ▪ After replacement, culverts will have appropriate permanent fencing installed for 200 m on either side of the culvert to guide turtles through the tunnel. ▪ Following approval of the NSDF Project, additional permanent exclusion fencing will be installed in reptile hotspots along Plant Road ▪ Drivers have standard safety training and are provided with environmental awareness training. ▪ Existing CRL site speed limits on access roads will be enforced. ▪ Signs warning drivers of high use wildlife areas will be posted and speed limits in these areas reduced. ▪ Employees in vehicles encountering wildlife of concern (e.g., Blanding's turtle, milksnake) on roads are required to communicate the presence of wildlife on the roads to other employees working in the area and to CNL's Environmental Protection team. ▪ The existing CNL Employee Education Program will be adapted to the NSDF Project prior to construction. All employees and contractors will be trained on the identification and safe handling of Blanding's turtle to help the turtles across the road. ▪ Per CNL's Management of Land, Habitat and Wildlife procedure (CNL 2018c), dead or wounded animals on roads must be reported to the environmental department. ▪ Wildlife collisions with vehicles will be monitored, which provides feedback for adaptive management.	Primary
	Installation and maintenance of perimeter fencing will potentially modify movement corridors for Blanding's turtle and milksnake in the LSA, which may increase their travel distances and thus increase the risk of injury/mortality on roads.		Primary

Table 5.6.5-1: Pathways Analysis for the Terrestrial Biodiversity Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Project activities during the construction phase (continued) Project activities during the operations phase (continued):	Attraction of wildlife to surface water management ponds may influence wildlife survival and reproduction.	▪ Reptile exclusion fencing will prevent Blanding's turtles and other reptiles (e.g., milksnake) and amphibians from entering the surface water management ponds. ▪ Migratory bird exclusion measures will be implemented at the surface water management ponds.	No Linkage

	Vegetation clearing and grubbing activities and hauling activities during operations use vehicles and equipment that combust fuel and emit criteria air contaminants. These activities involve material handling, vehicles travelling on paved and unpaved roads, and wind erosion of stockpiles that will result in fugitive dust emissions. Air and dust emissions and subsequent deposition may cause a change in soil quality and (directly affecting vegetation communities), which could in turn lead to indirect changes in wildlife habitat availability.	▪ CNL's procedure for Management and Monitoring of Emissions, (CNL 2018d) which includes operational control monitoring, verification monitoring and environmental monitoring, will be implemented.
		▪ The Dust Management Plan (AECOM 2018) for the NSDF Project will include:
		  ▪ restricting or suspending activities if unacceptable amounts of dust are generated due to winds or other site conditions;
		  ▪ use of water spraying or misting techniques (e.g., water trucks) as the primary dust control method;
		  ▪ use of fixatives (e.g., chemical suppressant) for dust control and for use as daily ECM cover;
		  ▪ suspension of excavating, loading, hauling and disposal operations when wind speeds exceed the specified criterion; and
		  ▪ vehicles that have come into contact with contamination will be required to pass through the vehicle decontamination facility.
		▪ On-site vehicles and equipment engines will meet Tier 2 emission standards and be maintained in good working order.
		▪ Idling of vehicles on site will be limited.
			Secondary

	Surface water runoff from the SSA (i.e., non-contact water) can contain contaminants and suspended solids, which can affect soil, water and vegetation quality, ultimately leading to changes to wildlife habitat availability, survival and reproduction.	▪ Procedures for surface water management will be developed and implemented for the NSDF Project. ▪ The target surface water quality objective for non-contact surface water is provided in the Stormwater Management Planning and Design Manual (MOE 2003). ▪ Non-contact surface water from all external areas will be conveyed by ditches, swales and culverts to surface water management ponds that will address water quality and water quantity criteria established for the wetland receiving waters and, ultimately, Perch Creek. ▪ The surface water management ponds are designed to address erosion and sediment control concerns during construction by providing interim sediment control and by providing water quality/quantity controls during the operations, closure and post-closure phases. ▪ The current surface water management pond footprints reflect the overall storage required to control post-closure flows to predevelopment levels for the 2-year through to 100-year rainfall events at the site. This volume also contains the storage required for sediment control during construction and water quality control during the operations phase. ▪ Where drainage crosses roadways, culverts are sized to convey the 25-year design event without road overtopping.	No Linkage

Table 5.6.5-1: Pathways Analysis for the Terrestrial Biodiversity Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment

Project activities during the operations and closure phases:
▪ Surface water management
▪ Operation of the WWTP
▪ Discharge of treated effluent from the WWTP
	Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) can cause changes to groundwater and surface water quality in the wetland and Perch Lake, as well as downstream surface water quality, which can affect wildlife survival and reproduction.	▪ The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses best available technology that is economically achievable and capable of meeting regulatory requirements.
		▪ Effluent discharge targets for wastewater discharges are protective of the environment and human health.
		  ▪ Discharge targets for non-radiological contaminants are sourced from federal and provincial guidelines for protection of aquatic biota.
		  ▪ Discharge targets for radionuclides are the Canadian Drinking Water Guidelines with the exception of tritium for which a site-specific target is developed (Section 3.4.2.5.1).
		▪ Treated effluent will be monitored and confirmed to meet the effluent discharge targets before release to the environment.
		▪ An exfiltration gallery is proposed at the discharge outlet to promote the exfiltration of treated effluent into the local groundwater regime.
		▪ The transfer line will release treated effluent via a diffuser to limit mobilization of sediment in Perch Lake.
		▪ Appropriate procedures to identify emergency spill occurrences and response, as well as appropriate response to non-contact surface water or leachate contamination, will also be implemented as described in the Operations and Maintenance Plan.
			Secondary

	Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch lake (via a transfer line) and the discharge of non-contact water to adjacent wetlands can cause changes to hydrology, resulting in scouring of the wetlands, which can affect wildlife habitat availability and distribution.	▪ Discharge of treated effluent to the exfiltration gallery area will help to reduce water loss from the hydrogeological system. ▪ Design consideration was given during the selection of the discharge location of treated effluent for environmental effects of scour on the receiving waterbodies. As such, the preferred design (i.e., discharge to the exfiltration gallery and Perch Lake diffuser) was chosen as the favourable alternative as they resulted in negligible scour potential. ▪ Outlet flows from all three SWMPs will be dispersed by level spreaders that will provide an even flow distribution to the adjacent wetlands with an appropriately wide dispersal pattern. ▪ The WWTP system's outlet utilizes a headwall which discharges to a level spreader for the purposes of preventing erosion and sedimentation at the outlet for the exfiltration gallery. ▪ The outlet locations of the SWMPs are limited by the site boundary (greater than 5 m separation required) so that there is no discharge from the spreader directly to a waterbody. ▪ Annual inspection and maintenance activities will identify any erosion problems. ▪ Inspections will be undertaken and maintenance activities completed, as required, after major storm events and after the annual spring melt to confirm there are no major erosion issues.	No Linkage
Project activities during the operations and closure phases: ▪ Surface water management ▪ Operation of the WWTP ▪ Discharge of treated effluent from the WWTP	Leakage of leachate from the ECM during the operations and closure phases may cause changes to groundwater quality in the wetland and downstream surface water quality, which can affect wildlife survival and reproduction.	▪ Design of the ECM includes base contours that have been developed using a herringbone pattern with ridges and valleys to promote leachate transport to the leachate collection system for removal. ▪ The base liner design include both primary and secondary liner systems that are designed to have redundancy in case of premature degradation and are a combination of natural and synthetic barrier systems. These include a compacted clay liner (CCL), two geosynthetic clay liners (GCL) and an HDPE geomembrane. ▪ Clay materials were selected for the CCL and GCL components of the liner system as these materials are anticipated to maintain their function as hydraulic barriers throughout and beyond the design life of the disposal facility (i.e., 550 years). ▪ The high-density polyethylene (HDPE) geomembrane for the liner was selected as it is compatible with the leachate generated by the waste and will achieve a long service life. ▪ The base liner system will include an underlying compacted clay liner to supplement the primary and secondary liner system. ▪ The leachate collection and monitoring system design will provide accessible access points for monitoring, inspections, maintenance, repairs and replacements. ▪ Appropriate responses to leachate leakage and contamination will be implemented as described in the Operations and Maintenance Plan and Contingency Plan	No Linkage

Table 5.6.5-1: Pathways Analysis for the Terrestrial Biodiversity Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Project activities during the closure and post-closure phases: ▪ Maintenance of fencing around perimeter of ECM ▪ Installation of final cover, remediation and grading of SSA ▪ On-going long-term performance monitoring, transfer of NSDF Project into institutional control	The installation of the final cover of the ECM and decommissioning of NSDF Project infrastructure may change downstream discharge, water levels and channel/bank stability in streams, which can cause changes to soils and vegetation communities (including adjacent wetlands), which in turn can affect wildlife habitat availability and distribution.	▪ The final cover will be designed to promote positive drainage from the SSA and reduce erosion or abrasion of the final cover. ▪ Environmental monitoring will be completed as required during the institutional control period for the NSDF Project to confirm that the final cover is functioning as intended	No Linkage
	Leakage of leachate from the ECM during the post-closure phase (i.e., after year 2400) from liner and final cover degradation as a result of normal evolution can cause changes to groundwater quality in the wetland and downstream surface water quality, which can affect wildlife survival and reproduction.	▪ The final cover is designed to promote positive drainage from the SSA and reduce erosion or abrasion of the final cover. ▪ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound and minimize leachate generation. ▪ The final cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity. ▪ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the final cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. ▪ The ECM Final Grading and Drainage Plan includes collection ditches along the top of the ECM berm road to collect side slope drainage. ▪ Environmental monitoring will be completed as required during the institutional control period for the NSDF Project to confirm that the final cover is functioning as intended	Secondary
	Potential introduction and spread of noxious weed species during closure and remediation can affect vegetation community species composition, which can affect wildlife habitat availability and distribution.	▪ Locally appropriate grass seed mixtures that are certified weed-free will be applied to any cleared and reclaimed areas as soon as practical following construction. ▪ Upon completion of the installation of the final cover over the ECM, turf grass will be established and maintained. Maintenance of the final cover includes restricting weed establishment and preventing surface erosion and abrasion.	Secondary

ECM = engineered containment mound; WWTP = Wastewater Treatment Plant; VC = Valued Component; SSA = Site Study Area; DFO = Fisheries and Oceans Canada; ROW = right-of-way; OPSS = Ontario Provincial Standard Specification; MNR = Ministry of Natural Resources; LSA = Local Study Area; MECP = Ministry of Environment, Conservation and Parks; MOECC = Ontario Ministry of the Environment and Climate Change.

5.6.5.2.1 No Linkage Pathways

The following pathways were assessed as having no measurable environmental change and hence, no linkage to residual effects on terrestrial biodiversity VCs.

- **Vegetation clearing and grubbing may remove active migratory bird nests, bat maternity roosts and monarch butterflies (various life stages), which may influence survival and reproduction.**

The MBCA prohibits the destruction of migratory bird nests during the breeding season. In the RSA, the migratory bird breeding season extends from April 8 to August 28. Little brown myotis, northern myotis and tri-colored bat are listed as endangered on the Ontario *Endangered Species Act, 2007,* and federal SARA. As such, there are prohibitions against killing or harming individuals or destroying a residence, including maternity roosting habitat. Female bats form maternity roost colonies to give birth and raise their young; most young are born in late-June or early-July and are weaned at 26 days of age (COSEWIC 2013). Roosts are also used during the pre-maternity roosting period and swarming period. Therefore, bat roosting period is assumed to be from May 1 to August 31.

Vegetation clearing in the majority of the SSA and particularly in complex forested habitat will be scheduled to occur outside of the migratory bird nesting period (April 8 to August 28) and out of the bat maternity roosting period (May 1 to August 31). Upland areas attractive to migratory birds carry a particularly high risk of disturbing or destroying migratory bird nests or eggs. Because the SSA contains upland areas known to support a diversity of migratory birds, the general use of nest searches as a form of mitigation is not recommended because it is unlikely that all nests would be successfully located. Furthermore, nest sweeps in complex forested habitat in the SSA would likely identify many active nests with overlapping setbacks where clearing could not take place until young have fledged, resulting in schedule delays and additional costs associated with monitoring nest activity. Therefore, every effort will be made to remove vegetation and topsoil prior to the nesting and roosting period to minimize nesting attempts and preclude bat roosting.

Pre-clearing bird and bat surveys will be completed by CNL’s Environmental Protection team to confirm no active nests/roosts are present in trees to be felled. This work must be approved by Environmental Protection prior to execution and can be denied if the risk to birds or bats is considered high. If vegetation clearing activities must be completed during the migratory bird nesting period or bat maternity roosting period, they will only occur in small areas and/or areas of simple habitat, where an active search for nests may be carried out successfully if undertaken by experienced observers using widely accepted protocols and including behaviour indicative of nesting (e.g., aggressive, territorial, defensive, distractive behaviour; carrying of faecal sacs, food or nesting material). CNL has a risk assessment checklist to determine if an area qualifies as a simple habitat, qualifying for nest searches and clearing in the absence of nests during the breeding season. The checklist has a series of risk factors and the total score provides whether the area qualifies. Examples of risk factors include the ability to perform searches for evidence of nesting using non-intrusive search methods to prevent disturbance and known breeding evidence of species at risk birds within 200 m (that reside in a similar habitat composition).

In addition, a 5 m treeline buffer is established from all property lines on the SSA to limit disturbance to vegetation and large tree roots at the treeline. Nest searches will be completed prior to any clearing or construction activities during the migratory bird nesting period, including in areas that were pre-cleared to account for ground nesting birds.

If vegetation clearing is scheduled in open habitat between late May and October, the habitat will be searched in advance of construction for the presence of milkweed. Areas of the footprint that contain milkweed will be cleared outside of late May to October to avoid effects on monarch butterflies.

These mitigation practices are anticipated to avoid any changes to the survival or reproductive success of birds, bats and monarch butterflies from the NSDF Project relative to baseline conditions. Therefore, this pathway was determined to have no linkage to effects on survival and reproduction of these species and is not predicted to affect the maintenance of self-sustaining and ecologically effective populations that overlap the RSA.

- **Blasting residuals and metals may be released during construction of the ECM and surface water drainage features through the SSA may transport them directly into downstream waterbodies adjacent wetlands, affecting surface water and sediment quality and causing changes to wetlands and riparian vegetation communities, which in turn can affect wildlife habitat availability and distribution.**

- **Fly rock from blasting may result in injury or mortality to wildlife.**

Use of explosives during the construction phase of the NSDF Project could cause changes in surface water and soil quality, which has potential to affect wildlife habitat. Explosives have the potential to release nitrogen residual substances (e.g., ammonium nitrate/fuel oil). Blasting activities and the removal of waste rock could increase dust deposition and could increase trace metal (e.g., aluminum, cadmium, chromium, copper, iron, mercury and silver) concentrations and nitrogen residual substances.

A Blasting Plan will be developed and implemented for the NSDF Project. The Blasting Plan will comply with Fisheries and Oceans Canada (DFO) *Guidelines for the Use of Explosives in or Near Canadian Waters* (Wright and Hopky 1998) to limit the potential for residual blasting interactions with downstream water quality. The Blasting Plan will also provide mitigation to limit the potential for effects on surface water quality from fugitive dust generation through excavation and material transport. Additional guidance will be obtained from *OPSS 120 – General Specification for the Use of Explosives* (OPSS 2014).

The anticipated quantities of blasted rock are approximately 170,000 m^3. There will also be an allowance made for additional trench blasting that may be required to facilitate utility runs. It is anticipated that the majority of blasted rock will be recycled for use within the construction of the ECM. Rock that cannot be recycled for reuse will either be stored at the CRL site or cleared for off-site use. Set-back distances required for blasting will be identified in the Blasting Plan. Any runoff in contact with blasting residues at the SSA will be managed according to the Surface Water Management Plan (e.g., directed to surface water management ponds and associated systems) during the construction phase. In addition, the potential for transporting blasting residuals into downstream waterbodies is minimized as blasting operations will be limited to a relatively short period of time during the construction phase. Blasting activities can also cause physical injury or mortality to wildlife. Surface blasting will be temporarily suspended if animals are observed within the danger zone identified by the blast supervisor.

The use of explosives for the development of the ECM in the proposed NSDF Project is considered to potentially influence runoff quality with respect to minor increases in nitrate and ammonia concentrations for a short period in the construction phase. As such, blasting activities are not predicted to affect the maintenance of self-sustaining and ecologically effective vegetation communities and wildlife populations that overlap the RSA.

- **The construction of the NSDF Project may change downstream discharge, water levels and channel/bank stability in streams, which can cause changes to soils and vegetation communities, which in turn can affect wildlife habitat availability and distribution, including sensitive species such as Blanding’s turtle.**

- **The installation of the final cover of the ECM and decommissioning of NSDF Project infrastructure may change downstream discharge, water levels and channel/bank stability in streams, which can cause changes to soils and vegetation communities (including adjacent wetlands), which in turn can affect wildlife habitat availability and distribution.**

Changes to surface flows, water levels and water quality from NSDF Project construction and decommissioning are expected to be limited using environmental design features and mitigation. The NSDF Project was designed to limit disturbance to the natural environment to the extent feasible and will avoid stream and wetland habitats. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. In addition, a 30 m buffer is established along all identified wetlands near the SSA. In addition to the wetlands buffer, a 5 m treeline buffer is established from all property lines on the SSA to limit disturbance to vegetation and large tree roots at the treeline. Buildings or structures will not be situated within 5 m of this buffer zone (i.e., 10 m from property line) to provide access for equipment around structures. A buffer zone will also be maintained between the waste and the boundary of the disposal site. This zone provides sufficient area surrounding the facility operations to allow environmental monitoring to be performed, facilitate maintenance and to allow implementation of contingency measure during an emergency.

All proposed physical works are located within the SSA, affecting a relatively small area (5.1%) of the total contributing basin area for Perch Creek (720 ha; Robertson and Barry 1985). Any changes to existing drainage patterns will largely be restricted to the Perch Creek and Perch Lake Watershed. The total annual volume of contact surface water to be treated is 11,000 m^3. The volume represents approximately 0.6% of the average total outflow from Perch Lake (1,700,000 m^3/yr), or 0.5% of the average total outflow from Perch Creek (2,200,000 m^3/yr). Operational treated effluent discharge is expected to be less than 11 m^3/hr. Flow rates within Perch Creek are approximately 252 m^3/hr; the effluent discharge rate is roughly 0.4% of the average Perch Creek flows and approximately 11.5% of East Swamp weir flows. Furthermore, the receiving wetlands are expected to buffer the discharge, further reducing flow rates into Perch Creek. Effects to the wetlands, including the East Swamp wetland, are expected to be minimal based on the NSDF Project’s anticipated change to flows in Perch Creek and East Swamp weir flows.

All non-contact and contact surface water will be managed within the SSA according to the Surface Water Management Plan that will be developed, reducing the potential for the NSDF Project to affect downstream discharge, water levels and channel/bank stability. Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site will be used during construction and decommissioning around disturbed areas, where appropriate.

Closure activities include the installation of a final cover over the ECM to limit ponding and water infiltration into the waste. Modification to the drainage ditches and conveyance channels will be made to promote positive drainage from the site and limit erosion or abrasion of the final cover. Runoff control for the final cover is designed to limit ponding and infiltration of water into the ECM, erosion of the final cover and waste material, and destabilization of the structure. The ECM design approach is to control the direction and velocity of the runoff to prevent erosion and abrasion of the final cover. Any surface water infiltrating the final cover will be collected by the leachate collection system and sent to the WWTP. The three surface water management ponds will remain to promote infiltration and settlement of suspended solids and restrict discharge rates to the nearby wetland. Decommissioning of the WWTP and all associated surface water management structures will be completed after the leachate quantity and quality no longer requires treatment. In the event that the WWTP is required beyond its design life, the unit would be refurbished to enable continued treatment of leachate or other treatment options investigated. Environmental monitoring will be completed throughout the post-closure phase for the NSDF Project to confirm that the final cover is functioning as intended.

Based on this information, effects to hydrology from changes in the Perch Creek and Perch Lake Watershed were determined to be negligible (Section 5.4.2.5.2.2). Consequently, these pathways were determined to have a no linkage to effects on vegetation and wildlife habitat availability and distribution. Changes to hydrology are not predicted to affect the maintenance of self-sustaining and ecologically effective vegetation communities and wildlife populations that overlap the RSA.

- **Attraction of wildlife to surface water management ponds may influence wildlife survival and reproduction.**

Surface water is categorized as contact or non-contact runoff. Contact runoff is considered to be contaminated and must be treated by the WWTP. Non-contact (i.e., non-contaminated) runoff is conveyed by ditches and culverts to the three surface water management ponds. All surface water management ponds are designed to address erosion and sediment control during construction (i.e., acting as interim sediment control ponds), and water quality/quantity concerns during the operations phase.

The surface water management ponds will be within the six-foot high chain link perimeter fence surrounding the NSDF Project, and therefore not accessible to ground-based wildlife species (e.g., most mammals, herpetofauna [i.e., reptiles and amphibians]). Birds and bats may be attracted to the surface water management ponds, especially during the spring if these ponds are the only open sources of water in the area (i.e., they are ice-free). These open surface water pond features are not predicted to contain any levels of contaminants that would be of concern to wildlife. In addition, the ponds will be small, and it is expected that the Ottawa River and other larger natural waterbodies in the RSA and LSA (Perch Lake, specifically) will be more attractive to wildlife than the ponds within the SSA. As such, this pathway was determined to have no linkage to effects on the survival and reproduction of wildlife and is not anticipated to affect the maintenance of self-sustaining and ecologically effective wildlife populations that overlap the RSA.

- **Surface water runoff from the NSDF Project can contain contaminants and suspended solids, which can affect soil, water and vegetation quality, ultimately leading to changes to wildlife habitat availability, survival and reproduction.**

The surface water management ponds are designed to address erosion and sediment control concerns during construction by providing interim sediment control and by providing water quality/quantity controls during the operations, closure and post-closure phases. The current surface water management pond footprints reflect the overall storage required to control post-closure flows to predevelopment levels for the 2-year through to 100-year rainfall events at the site. This volume also contains the storage required for sediment control during construction and water quality control during the operations phase. The target surface water quality objective is provided in the *Stormwater Management Planning and Design Manual* (MOE 2003), which reports a 60% total suspended solids removal that provides basic water quality treatment for discharge to the receiving wetland. The surface water management ponds 1 will meet 80% total suspended solids removal which will provide enhanced water quality treatment. surface water management ponds 2 will provide 76% TSS removal and surface water management ponds 3 will meet 60% total suspended solids removal during operations which will be sufficient because the receiving waterbody is a wetland and not a watercourse. The wetland functions as a sediment trap that will provide additional treatment prior to stormwater reaching any watercourses in wetlands.

During the construction phase, erosion and sediment control measures will be in place to mitigate the effects of soil erosion and sediment transport. The measures include the use of erosion control blankets, as needed, to control erosion on steep slopes, check dams in ditches and swales, and the three proposed surface water management ponds that will be constructed to serve as interim sediment control facilities during construction, and then as stormwater management facilities during the operations and post-closure phases. Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site (i.e., CNL's *Management of Land, Habitat and Wildlife* procedure; CNL 2018c) will be used around disturbed areas, where appropriate. Furthermore, an Environmental Management Plan has been developed as part of the design plan for the site outlining the erosion and sediment control measures and surface water management pond construction schedule discussed. It additionally outlines administrative protocols such as training, contractor document submissions and staffing required for effective surface water management throughout all phases of the NSDF Project.

Site operations include surface water management for the ECM and all external areas. Surface water from all external areas will be conveyed by ditches, swales and culverts to surface water management ponds that will address water quality and water quantity criteria established for the wetland receiving waters and, ultimately, Perch Creek. Contact water, which is exposed to waste within the ECM, will drain from the active cells of the ECM and be conveyed to the WWTP. Non-contact water drainage from completed cells and yet-to-be completed cells will be directed either by gravity to the external surface water management system or to temporary holding ponds within the ECM, then pumped to the three surface water management ponds.

Facility inspections will be completed on a defined schedule to confirm that inlets and outlets are clear of debris and to confirm that there are no major erosion issues at the inlet or outlet. As well, the integrity of berms and outlet structures will be confirmed by visual inspections (e.g., to identify any animal burrowing activity or active soil erosion). The transfer line will release treated effluent via a diffuser to limit mobilization of sediment in Perch Lake. Inspections will also include an annual sediment level monitoring component within each pond to identify sediment accumulation rates that may require clean-out. If necessary, pond sediment will be extracted by excavation equipment and will be disposed of based on sediment sampling, testing and classification according to MECP standards, or stockpiled, dewatered and reused on site for daily ECM cover operations. Sediment removal will follow procedures identified in the *Stormwater Management Planning and Design Manual* (MOE 2003).

Roadway, sidewalk and parking lot winter maintenance activities that may release road salt to the environment include snow plowing/shoveling and de-icing practices, salt and sand storage, and snow stockpiling, removal and disposal. The current winter maintenance practices outlined in the CRL Salt Management Plan provide for effective management of salt use, and will be applied to the NSDF Project, as necessary. Per the plan, the application of road salt on the SSA will be to be limited as salt residual within contact water and/or leachate may compromise the treatment effectiveness of the WWTP systems. Instead, alternative products in winter road management, such as a sand-stone mixtures, are currently being considered.

The implementation of this mitigation will reduce the potential for changes to soil, water and vegetation quality from surface water runoff from the SSA. As such, this pathway was determined to have no linkage to effects on the abundance of wildlife habitat, and survival and reproduction of wildlife and is not anticipated to affect the maintenance of self-sustaining and ecologically effective wildlife populations that overlap the RSA.

- **Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) and the discharge of non-contact water to adjacent wetlands can cause changes to hydrology, resulting in scouring of the wetlands, which can affect wildlife habitat availability and distribution.**

The NSDF Project will generate two water streams which will have the potential to impact water flows and levels in wetlands including:

- treated effluent from the WWTP which will be routed to the exfiltration gallery or Perch Lake; and
- non-contact water (i.e., water that has not been contaminated through contact with the ECM) which will be managed through a series of SWMPs.

A Surface Water Management Plan will be implemented to mitigate effects from wastewater discharges. Most of the wastewater flow will be generated from non-contact water produced during active filling of the ECM; contributions by leachate and decontamination activities represent a small fraction of the overall wastewater that will be treated by the WWTP. The total annual volume of water to be treated is 11,000 m^3. The volume represents approximately 0.6% of the average total outflow from Perch Lake (1,700,000 m^3/yr), or 0.5% of the average total outflow from Perch Creek (2,200,000 m^3/yr). Operational treated effluent discharge is expected to be a maximum of approximately 11 m^3/hr with an average effluent discharge rate below 1 m^3/hr. Flow rates within Perch Creek are approximately 252 m^3/hr; the maximum effluent discharge rate is roughly 0.4% of the average Perch Creek flows and approximately 11.5% of East Swamp weir flows. During the operations phase, the additional infiltration applied at the exfiltration gallery results in a localized increase in water table elevation of up to 1 m compared to the current conditions (see Section 5.3.2.6).

An exfiltration gallery is proposed at the discharge outlet for the treated effluent to promote the exfiltration of treated water into the local groundwater regime. Treated effluent will also be discharged directly to Perch Lake via a transfer line. The transfer line to Perch Lake has been designed to manage the full annual volume of treated effluent, if required, which will prevent the potential for overland flow at the exfiltration gallery.

The major flow system for all three SWMPs, which manage non-contact water, will outlet to adjacent wetlands and will be dispersed by level spreaders that will provide an even flow distribution to the wetlands with an appropriately wide dispersal pattern. Current SWMPs outlet locations are limited by the site boundary (greater than 5 m separation required) so that there is no discharge from the spreader directly to the wetlands. Local topography between the level spreader and the wetlands, as well as any setbacks, has influenced the location of the on-site level spreader.

Annual maintenance activities will identify any erosion problems. Facility inspections will be completed twice annually to confirm that inlets and outlets are clear of debris and to confirm that there are no major erosion issues at the inlet or outlet. In addition, a maintenance review will be completed after major storm events and after the annual spring melt to confirm there are no major erosion issues at the dispersion outlets. As a result of the design of the surface water management pond outlets and the proposed low discharge rates (i.e., 1 m^3/hr), the discharge of treated effluent and non-contact water to receiving wetlands is not predicted to result in changes to water levels, flows, and channel and bank stability, that would affect water quality at downstream locations. As a result, this pathway is not predicted to affect the maintenance of self-sustaining and ecologically effective vegetation communities and wildlife populations that overlap the RSA.

- **Leakage of leachate from the ECM during the operations and closure phases may cause changes to groundwater quality in the wetland and downstream surface water quality, which can affect wildlife survival and reproduction.**

Design of the ECM includes base contours that have been developed using a herringbone pattern with ridges and valleys to promote leachate transport to the leachate collection system for removal. The base liner design includes both primary and secondary liner systems that are designed to have redundancy in case of premature degradation and are a combination of natural and synthetic barrier systems. The primary liner will include a leachate collection system with the secondary liner housing a leak detection system. The composite base liner will contain perforated high-density polyethylene (HDPE) collection and monitoring pipes. The HDPE geomembrane was selected as it is compatible with the leachate generated by the waste and will achieve a long service life. The HDPE geomembrane was selected as it is compatible with the leachate generated by the waste and is expected to perform as an effective hydraulic and diffusion barrier over the 550-year design life (see Section 3.4.1.4). The base liner system will include an underlying compacted clay liner to supplement the primary and secondary liner system. The leachate collection and monitoring system design will provide accessible access points for monitoring, inspections, maintenance, repairs and replacements.

The primary liner system will contain the leachate collection system and will convey leachate to a single collection point for removal from the mound, and ultimately to the WWTP for treatment. The primary liner system will also protect the natural environment below the mound from leachate migration and will maintain a maximum depth of leachate on the geomembrane liner of less than or equal to 300 mm. The secondary liner system will contain the leak detection system, which will be used to detect leaks in the unlikely event that the primary liner system fails. The secondary liner will also protect the natural environment from leachate migration if the primary liner system fails. Leachate collected by the leachate collection system will be pumped to the on-site WWTP for treatment.

Perimeter berms consist of three main geotechnical elements, or layers, each contributing to the soundness and integrity of the berm itself and the whole ECM. A slope stability analysis was completed to provide the information needed to support the design of the base slopes, sidewalls and side slopes of the ECM. The slope stability analysis addresses the range of anticipated loading conditions, under both short-term and long-term scenarios, to confirm that the slope designs will satisfy minimum factor-of-safety requirements for stability. Size and shape of the berms and each of the elements and layers were determined using a seismic design basis.

The implementation of this mitigation will reduce the potential for changes to groundwater and surface water quality from the NSDF Project. As such, this pathway was determined to have no linkage to effects on the abundance of wildlife habitat, and survival and reproduction of wildlife and is not anticipated to affect the maintenance of self-sustaining and ecologically effective wildlife populations that overlap the RSA.

5.6.5.2.2 Secondary Pathways

The following pathways were assessed as potentially having a measurable minor environmental change, but negligible residual effect on the terrestrial biodiversity VCs relative to Base Case.

- **Vegetation clearing and grubbing will result in an increase in edge habitat, which could increase predation risk and nest parasitism risk for bird VCs.**

The NSDF Project may increase predation risk by increasing the amount of edge habitat in the LSA. Ground-nesting bird species are particularly vulnerable to nest predation (Cink et al. 2017) and many predators will use habitat edges as movement corridors (Chalfoun et al. 2002). An increase in edge habitat may also increase the risk of nest parasitism. Fragmentation of forests has increased accessibility for brown-headed cowbirds, which prefer more open habitats (Lowther 1993). However, cowbirds are generally more dispersed and have lower densities in forested areas in the Canadian Shield than south of the Canadian Shield where agricultural land is more common (Lowther 1993). Therefore, nest parasitism risk to bird VCs is not anticipated to increase with construction of the NSDF Project. Increases in edge habitat are not predicted to affect the maintenance of self-sustaining and ecologically effective bird populations that overlap the RSA.

- **Vegetation clearing and grubbing for the two temporary laydown and staging areas required for the installation of the transfer line to Perch Lake will result in the temporary loss or alteration of wetland habitat in the Perch Lake Swamp. This will cause temporary losses of a wetland vegetation community and potentially have a temporary effect on wildlife habitat availability, use and connectivity.**

The construction phase of the NSDF Project has the potential to affect wetland habitat in the Perch Lake Swamp as a result of the installation of a transfer line from the WWTP to Perch Lake. The method of installation of this transfer line is mitigation in itself, as high-pressure directional drilling reduces the extent of surface disturbance within the alignment of the line route to the entry and exit points of the line. The DFO *Ontario Operational Statement – High-Pressure Directional Drilling* (DFO 2007) was created to provide a standard set of regionally appropriate mitigation that, if followed, avoid effects on fish habitat, and more broadly, any habitat potentially affected by these works. The use of horizontal directional drilling will limit surface disturbance within the Perch Lake Swamp wetland to two areas required for laydown and staging: one 300 m^2 area on the shoreline of Perch Lake, and one 100 m^2 area midway along the Perch Lake Ring Road approach to the ECM. An additional shallow trench (2 m deep and 30 m long) will be excavated within the riparian area of Perch Lake for the installation of the discharge transfer line (effects described in the Section 5.5.5.2.2). The disturbed portions of the two laydown and staging areas beyond the edge of the Perch Lake Ring Road ROW (which will remain in place) and the trenched area will be restored to the natural vegetation communities that were present prior to construction. Disturbed areas should be re-vegetated immediately upon completion of the Project to prevent erosion or colonization of noxious weed species (mitigation described below).

The construction of the transfer line may result in minor, temporary changes to the abundance and distribution of plant populations and communities relative to baseline conditions. Therefore, this interaction was determined to have a negligible residual effect on vegetation and wildlife habitat availability and distribution. The clearing of small areas required for construction of the transfer line is not predicted to affect the maintenance of self-sustaining and ecologically effective vegetation communities and wildlife populations in the RSA.

- **The high-pressure horizontal directional drilling installation of the transfer line to Perch Lake may result in a release of drilling mud (i.e., frac-out), which may cause changes to surface water quality, which can cause changes to soils and vegetation communities (including wetlands), which in turn can affect wildlife survival and reproduction.**

With high pressure drilling operations, there is a risk of the drilling mud entering the environment through tunnel collapse, spills or frac-out (the rupture of mud to the ground surface). On-going environmental monitoring during drilling works can limit the effects of a frac-out, and having an appropriate response plan in place can reduce the environmental effects of frac-out. Drilling mud is considered a deleterious substance that can adversely affect aquatic organisms and habitat. Specifically, introductions of this substance to aquatic habitat can result in adverse effects such as fish egg suffocation and reduction of plant and insect productivity (Falk and Lawrence 1973; Land 1974; Ferrante 1981).

The mitigation described in the DFO *Ontario Operational Statement – High-Pressure Directional Drilling* (DFO 2007) will be followed, including siting of the transfer line and access to temporary laydown and staging areas largely within a previously established access road ROW (Perch Lake Ring Road); minimization of vegetation removal beyond previously disturbed areas; creation of, and adherence to an emergency Frac-out Response Plan and Spill Contingency Plan during installation; and full-time environmental monitoring during all phases of transfer line works within the Perch Lake Swamp to evaluate adherence to environmental protection measures and make observations on signs of surface frac-out of drilling mud. Evidence of frac-out will trigger implementation of the Frac-out Response Plan. The following measures will be enacted to allow the NSDF Project to meet relevant provincial and federal legislation (particularly the *Fisheries Act*):

- Machine operation will take place on land above the high water mark of Perch Lake. Drilling machinery will kept be clean and leak free. Service, washing or refuel and storage of these substances for the machinery will be away from surface water features. Emergency spill kits will be kept on site in the event of a fluid leak or spill. Potential pathways for spilled products (e.g., storm drains) will be mapped and plans put in place to prevent entry of deleterious products into the storm drain system.
- Where possible, drilling will occur during daylight hours, which will increase the probability of visually identifying a frac-out (i.e., a condition where drilling mud from a directional drilling operation is released through fractured bedrock and travels to the surface through surrounding porous materials).
- Drilling mud, cuttings and all waste will be disposed of at appropriate disposal facility. All waste materials will be contained in a dugout or holding basin away from wetlands or other surface water features, or storm drains, to avoid entering natural surface water features, until the waste can be transported for disposal.
- Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site will be used during construction of the transfer line to Perch Lake as the exit point for drilling will be within the Perch Lake riparian area.
- On-going monitoring will be in effect during all phases of drilling works to assess fluid pressure (by drillers) and changes in turbidity in local surface water features (by environmental monitors) that would indicate surface migration (frac-out) of drilling mud.
- All material and equipment required to contain and clean up a frac-out event will be available on site.
- In the event of frac-out:
  - Work will be stopped and drilling mud will be contained. Care will be taken that cleanup effort does not result in damage to Perch Lake Swamp or Perch Lake.
  - Containment booms, silt fences and other appropriate erosion control measures will be deployed to prevent further migration to surrounding areas. Erosion control equipment will be on site and ready for deployment.
  - The CNL facilities representative on site will be notified.
  - Drillers are to evaluate data and circumstances leading to the loss of circulation and, if possible, implement methods to seal the fracture.

- All spills will be evaluated and work will cease if frac-out cannot be stopped and/or thresholds of environmental regulations are exceeded (i.e., relevant water quality guidelines). A Directional Drilling Contingency Plan will be implemented if drilling is unsuccessful along the designated corridor. Enactment of this contingency plan will require review by the responsible parties with CNL prior to initiation.

The implementation of mitigation will reduce the potential for a frac-out to occur during drilling of the transfer line. Some localized effects may occur, but the mitigation to address these identified above would result in small and temporary changes to surface water, soils and vegetation community quality. Therefore, this interaction was determined to have a negligible residual effect on terrestrial biodiversity. The accidental release of drilling mud during installation of the transfer line to Perch Lake is not predicted to affect the maintenance of self-sustaining and ecologically effective vegetation communities and wildlife populations in the RSA.

- **Potential introduction and spread of noxious weed species from trucks and other equipment can affect vegetation community species composition, which can affect wildlife habitat availability and distribution.**
- **Potential introduction and spread of noxious weed species during closure and remediation can affect vegetation community species composition, which can affect wildlife habitat availability and distribution.**

The construction, operations and closure phases of the NSDF Project have potential to introduce noxious weed species listed under the provincial *Weed Control Act*. There is also potential to introduce invasive plant species into new areas, which can disrupt plant communities and decrease habitat quality (Mack et al. 2000; Carlson and Shephard 2007; Truscott et al. 2008). Weed species introduced into natural areas have the potential to affect plant community structure and species diversity directly through competition and indirectly through alterations to soil microorganisms, nutrients and soil moisture (Mack et al. 2000; Truscott et al. 2008).

The majority of weed species introductions arise from human transport (Mack et al. 2000; Reichard and White 2001), and roads also act as dispersal route and habitat for weed establishment (Parendes and Jones 2000). Transportation corridors to and from construction areas provide a means of ingress for noxious weed species through direct dispersion of plant propagules (seeds and/or vegetative parts) from vehicles and machinery, and indirectly through the formation of suitable sites for weeds, in the form of disturbed road edges. Many weed species are able to spread more easily in landscapes that have been fragmented, often becoming established along edge habitats such as disturbed road edges associated with transportation corridors (Lafortezza et al. 2010).

Preventing weed species from entering an area is often more efficient and cost effective than dealing with their removal once established (Clark 2003; Polster 2005; Carlson and Shephard 2007). An Invasive Species Management Plan, in keeping with best management practices outlined in the MNR *Forest Management Guide for Conserving Biodiversity at the Stand and Site Scales* (MNRF 2019a), will be developed and implemented to limit effects of noxious and invasive plants on natural vegetation. For example, to mitigate the transport and introduction of prohibited, noxious, nuisance and invasive plant species into new areas, construction equipment will be regularly cleaned on site.

Locally appropriate grass seed mixtures that are certified weed-free will be applied to any cleared and reclaimed areas as soon as practical following construction. This will reduce the potential for the establishment and spread of invasive plant and weed species. Upon completion of the installation of the final cover over the ECM, turf-grass will be established and maintained. Maintenance of the final cover includes restricting weed establishment and preventing surface erosion and abrasion.

The implementation of this mitigation will reduce the potential for introduction of weed species during activities of the construction and operations phases. Some localized introduction of weed and invasive species may occur, but the mitigation to address these identified in Table 5.6.5-1 would result in minor changes to the abundance and distribution of plant populations and communities relative to Base Case conditions. Therefore, this interaction was determined to have a negligible residual effect on vegetation and wildlife habitat availability and distribution. Introduction of weed species is not predicted to affect the maintenance of self-sustaining and ecologically effective vegetation communities and wildlife populations in the RSA.

- **Attraction of wildlife to the NSDF Project (e.g., food waste, petroleum based products) may increase human-wildlife interactions and change predator-prey relationships, which can affect wildlife survival and reproduction.**

Food smells and other aromatic compounds such as petroleum-based chemicals can attract carnivores to human developments (Benn and Herrero 2002; Peirce and Van Daele 2006; CWS 2007; Beckmann and Lackey 2008). In addition, infrastructure such as buildings (e.g., the administration office building, which will be installed and used during the construction phase and remain through the operations phase) may also attract carnivores as it can serve as a refuge to escape extreme heat or cold (CWS 2007). Corvids (e.g., crows and ravens) and raptors (e.g., hawks, eagles, and owls) may also be attracted to infrastructure and anthropogenic food sources (Restani et al. 2001; Marzluff and Neatherlin 2006; CWS 2007; Kristan and Boarman 2007; Baxter and Allan 2008). Attraction of carnivores and predatory birds (e.g., ravens and gulls) to the NSDF Project can increase predation pressure on VC prey species (e.g., passerines [sparrows, warblers] and waterfowl [ducks, geese, grebes]), and may cause local declines in abundance in these prey species (Monda et al. 1994; CWS 2007; Liebezeit et al. 2009).

The attraction of wildlife to the NSDF Project also has the potential to increase human-wildlife interactions, which may result in the removal of wildlife by mortality or relocation. The implementation of the mitigation summarized in Table 5.6.5-1 and in the CNL's Waste Management Program and Management of Land, Habitat and Wildlife Procedure is anticipated to limit the attraction of wildlife to the site and result in minor changes in survival and reproduction from problem wildlife and altered predator-prey relationships relative to Base Case conditions. Subsequently, this pathway is expected to have a negligible net effect on wildlife abundance, and is not predicted to affect the maintenance of self-sustaining and ecologically effective populations that overlap the RSA.

- **Movement of heavy equipment and other vehicles on roads and through previously undeveloped/ forested areas may cause injury or mortality to bird VCs and monarch butterfly.**

The NSDF Project will increase vehicle traffic during construction, which could result in increased injury and mortality to bird VCs and monarch butterfly. The risk of vehicle-wildlife collisions is not uniform among species; highly mobile species such as birds and butterflies have a lower mortality risk from crossing roads than slower species such as amphibians and reptiles because they are more capable of avoiding collision (Hels and Buchwald 2001; Fahrig and Rytwinksi 2009).

Traffic speed and volume are the primary factors that contribute to road-related wildlife mortality. Speed limits will be clearly posted on access roads and enforced to mitigate against potential wildlife mortalities during the construction, operations and closure phases. In addition, drivers will have standard safety training and are provided with environmental awareness training. Because of the mitigation that will be applied, increases in vehicle traffic during NSDF Project construction, operations and closure are expected to result in minor changes to avian and monarch butterfly populations as compared to Base Case conditions. Therefore, collisions with NSDF Project vehicles are expected to have negligible residual effects on avian and monarch butterfly populations and are not predicted to affect the maintenance of self-sustaining and ecologically effective avian or monarch butterfly populations that overlap the RSA.

- **Vegetation clearing and grubbing activities and hauling activities during operations use vehicles and equipment that combust fuel and emit Criteria Air Contaminants. These activities involve material handling, vehicles travelling on paved and unpaved roads, and wind erosion of stockpiles that will result in fugitive dust emissions. Air and dust emissions and subsequent deposition may cause a change in soil quality and (directly affecting vegetation communities), which could in turn lead to indirect changes in wildlife habitat availability.**

The construction and operations phases of the NSDF Project will generate air and dust emissions such as carbon monoxide (CO), oxides of sulphur (SOx includes sulphur dioxide [SO_2]), oxides of nitrogen (NOx includes nitrogen dioxide NO_2), particulate matter ($PM_{2.5}$ [particulate matter with a diameter less than 2.5 microns]) and suspended particulate matter (SPM). Air emissions such as SOx and NOx can result from the use of fossil fuels in generators, vehicles and machinery. Vehicle exhaust and fugitive dust from unpaved and paved roads is the largest contributor to particulate matter (SPM, PM_{10} and $PM_{2.5}$) during both the construction and operations phases (Section 5.2.1.6.2).

Air and dust emissions and subsequent deposition can change soil quality and alter vegetation and wetlands, which can adversely influence wildlife habitat availability and distribution. SO_2 and NO_x from combustion of fossil fuels and dust deposition can affect soil pH and nutrient content, and soil fauna composition (Rusek and Marshall 2000). Changes in soil quality (physical, chemical and biological properties) can affect plant community composition, structure and diversity (Grantz et al. 2003; Peachey et al. 2009). Dust that falls directly on plants also can have a physical effect by smothering plant leaves or blocking stomata openings (Farmer 1993; Grantz et al. 2003). Plant species have different levels of tolerance to dust deposition, which can result in changes to above-ground biomass and species composition. For example, bryophytes (e.g., mosses) and lichens can be sensitive to the chemical effects of dust because they obtain moisture and nutrients from the atmosphere and immediate surroundings, including substances that are trapped or deposited directly on the surface of the bryophyte leaf or lichen thalli (Farmer 1993). Bryophytes and lichens may experience the largest effects close to roads where the greatest amount of deposition frequently occurs (Auerbach et al. 1997). Rates of dust deposition and accumulation are dependent on the rate of supply from the source, wind speed, precipitation events, topography and vegetation cover. Mitigation to be implemented to limit predicted residual effects from NSDF Project emissions to air quality (and subsequently to aquatic biodiversity VCs) includes: meeting Tier 2 emission standards for on-site vehicles and equipment engines, use of vehicles that are maintained in good working order and idling of vehicles on site will be limited.

Dust control will be conducted to support waste placement operations in accordance with the *Dust Management Plan* (AECOM 2018) during loading, transportation, placement, and compaction operations. Work areas that have the potential for generating dust will require implementation of dust suppression applications. The primary dust control method will include water spraying or misting techniques (e.g., water trucks). Fixatives (e.g., chemical suppressant) may also be used for dust control and for use as daily ECM cover. Water application and the use of fixatives will be controlled to limit potential effects on leachate and surface water runoff generated by the ECM.

Predicted concentrations for the Application Case during both construction and operations phases are below applicable air quality guidelines and/or standards with the exception of nitrogen dioxide, that will not meet the 2020 1-hour Canadian Ambient Air Quality Standards (Section 5.2.1.6.2, Table 5.2.1-14). The contributing factor to the high magnitude nitrogen dioxide emissions is the heavy-duty construction equipment and the conservative assumption that all equipment will run simultaneously and continuously during working hours. In reality, individual equipment will be idling or off for varying parts of the workday that can not be predicted but will result in lower emissions than currently estimated. The likelihood that all equipment operates simultaneously for an hour or more along with unfavourable weather conditions to produce the maximum concentrations modelled is very low. The World Health Organization (WHO) has established annual critical levels at which vegetation growth and community composition characteristics may be altered due to SO_2 and NO_x emissions (WHO 2000). The maximum modelled annual SO_2 (1.05 micrograms per cubic metre [µg/m^3]) and NO_2 (15.48 µg/m^3) concentrations at the LSA boundary are also below the WHO critical levels of 20 µg/m^3 and 30 µg/m^3, respectively (WHO 2000).

With the implementation of the mitigation summarized in Table 5.6.5-1 and in CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018d) and through the implementation of the *Dust Management Plan* (AECOM 2018) for the NSDF Project, air and dust emissions and subsequent deposition are expected to result in minor and local changes to soil quality and vegetation communities relative to Base Case conditions. Therefore, this pathway was determined to have a negligible net effect on wildlife habitat availability and distribution. Air and dust emissions are not predicted to affect the maintenance of self-sustaining and ecologically effective vegetation communities and wildlife populations that overlap the RSA.

- **Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) can cause changes to groundwater quality in the wetland and Perch Lake as well as downstream surface water quality, which can affect wildlife survival and reproduction.**

The WWTP for the NSDF Project will be a new, stand-alone facility with a new discharge point. The WWTP will treat leachate generated in the ECM during the operations and closure phases. The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses best available technology that is economically achievable and capable of meeting regulatory requirements.

The radionuclide concentrations in wastewater will be a combination of the leachate concentrations and the leachate volume, combined with the contact water and decontamination volumes. The contact water is assumed to have very low radionuclide concentrations because of the effects of daily ECM cover and water management practices within the disposal cell. Decontamination water is assumed to have the same radiological and chemical characteristics as the wastewater from the ECM. In the absence of quantitative information, non-radiological waste constituents were developed from information gathered from other sites and the expected characteristics of wastes to be disposed of in the NSDF. These values present a reasonable and conservative estimate of concentrations in wastewater such that the WWTP design is capable of treating wastewater to meet effluent discharge targets (as described in Section 3.4.2.2, Tables 3.5.3-2 and 3.5.3-3).

Treated effluent will be sampled and confirmed that it meets effluent discharge targets before release to the environment. A portion of the treated effluent from the WWTP will be released to an exfiltration gallery to promote the exfiltration of treated water into the local groundwater regime; from here, small quantities of residual contaminants will migrate from the East Swamp Wetland to East Swamp Stream. The remaining treated effluent will be released into Perch Lake using a submerged diffuser. It is anticipated that the diffuser placement will result in a ten-fold dilution of any treated effluent discharge to Perch Lake within 100 m of the discharge (Golder 2019b). The East Swamp Stream flows into Main Stream and then Perch Lake, which is connected to the Ottawa River through Perch Creek.

Both aquatic and terrestrial species will be exposed to contaminated surface water and sediment in the East Swamp Stream, Perch Lake, Perch Creek, and possibly the Ottawa River. Doses to non-human biota were calculated based on water concentrations from East Swamp Stream. Although dilution will occur in Perch Lake, Perch Creek and the Ottawa River, the exposure limits within the aquatic environment was conservatively assessed to match that of East Swamp Stream during the period of leachate management system and WWTP operations. Doses to non-human biota were calculated based on the waterborne and airborne emissions from the ECM and assessed against the most conservative criteria available such as Environmental Quality Guidelines (CCME 2019) for non-radiological contaminants, No-Effect Concentrations for non-human biota derived for the boreal Canadian Shield forest ecosystem (SENES 2010) for radiological contaminants. The NSDF Project is confident that there will be no adverse effects to biota during operations phase by ensuring that releases and subsequent environmental concentrations are below the relevant guidelines or are below levels that would result in potential adverse effects on aquatic life as summarized in Section 5.7.6.2.1.

Many of the site's existing WMAs, including WMAs A and B and the Liquid Dispersal Area (which includes Reactor Pit 1, Reactor Pit 2 and the Chemical Pit) may also affect the Perch Creek and Perch Lake Watershed. Contaminants are transported by groundwater to nearby wetlands, including East Swamp and via the transfer discharge line directly into Perch Lake, which will be the recipient waterbodies for the NSDF Project wastewater. Contaminants released into the Perch Lake then migrate to Perch Creek from where they reach the Ottawa River, which is the ultimate receptor for all CRL discharges. The NSDF Project's contribution to potential effects on populations of non-human biota in the Perch Creek and Perch Lake Watershed does not result in unacceptable cumulative effects. Estimated doses resulting from historic contamination, due to releases from WMAs and Liquid Dispersal Areas, fall below benchmark values for Perch Lake and Perch Creek. Potential contribution from the NSDF to exposure of aquatic species in East Swamp is less than 1% of the current levels of exposures.

For non-radiological and radiological constituents, two surface water model scenarios were completed for a select group of constituents of potential concern (COPCs) as defined in Section 5.4.2.6.1.4 and Section 5.7.6.2.1. Key elements of the COPCs selection process included identifying those COPCs that were expected to change as a result of the NSDF Project, those with available guidelines, treatment requirements, high existing environmental conditions, potential for nutrient effects, water properties and those that were expected to be toxic to aquatic organisms. The selected non-radiological COPCs included: aluminum, ammonia, antimony, boron, barium, calcium, cadmium, chloride, chromium, cobalt, copper, fluoride, iron, lead, manganese, magnesium, mercury, molybdenum, nickel, phosphorus, potassium, selenium, silver, sodium, strontium, sulfate, thallium, tin, uranium, vanadium and zinc. Radiological COPCs included: carbon-14, caesium-137, cobalt-60, gross beta and tritium.

The predicted radiological and non-radiological concentrations for the COPCs were compared to effluent discharge targets[1] and to local background at the six water quality nodes (i.e., East Swamp weir, Perch Lake Inlet 2, Perch Lake, Perch Creek weir, Perch Creek Outlet and the Ottawa River; Section 5.4.2.6.2 and Tables 5.4.2-9 to 5.4.2-18). The predicted concentrations for most COPCs met the effluent targets at all sampling nodes, with the exception of aluminum, barium, copper, iron, lead, manganese, phosphorus, selenium and silver. However, predicted concentrations were generally similar to local background concentrations at these nodes with the exception of selenium concentrations that were predicted to exceed local ambient concentrations. Predicted selenium concentrations were less than the United States Environmental Protection Agency guidelines for protection of aquatic life and therefore are predicted to not result in adverse effects on aquatic life.

For most COPCs, the incremental changes in concentration as a result of the NSDF Project are expected not to be measurable in the Ottawa River. COPCs that increase above background in the Ottawa River included only Tritium. However, results of the radiological dose assessment for the operations phase and post-closure phase also indicates that doses to ecological health VCs are below their respective No Effect Concentrations (see Section 5.7.8). As such, changes to surface water quality (and habitat quality) from the discharge of treated effluent are expected to have negligible residual effects on wildlife VCs.

- **Leakage of leachate from the ECM during the post-closure phase (i.e., after year 2400) from liner and final cover degradation as a result of normal evolution can cause changes to groundwater quality in the wetland and downstream surface water quality, which can affect wildlife survival and reproduction.**

Potential impacts on terrestrial biota from failure of cover and liner as a result of normal evolution are assessed in Section 5.7.6.3.2.1. No adverse effects are predicted to terrestrial biodiversity VCs.

5.6.5.2.3 Primary Pathways

Primary pathways advanced for further residual effects assessment and determination of significance are summarized by VC in Table 5.6.5-2. As a result of mitigation, the migratory bird VC will not be affected by any mortality-related pathways. Because several other VCs are migratory birds and changes in habitat availability and distribution will be addressed for these VCs, migratory birds as a group were not carried forward for further assessment.

[1] Effluent discharge targets for radiological COPCs were composed of No Effect Concentrations for the protection of aquatic biota (See Section 5.4.2.6.1).

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Table 5.6.5-2: Interaction between Primary Pathways and Terrestrial Biodiversity Valued Components

Primary Pathway	Vegetation Communities	Migratory Birds	Canada Warbler	Eastern Whip-poor-will	Eastern Wood-pewee	Golden-winged Warbler	Wood Thrush	Bats	Blanding's Turtle	Eastern Milksnake	Monarch Butterfly
Vegetation clearing and grubbing during construction will result in the loss or alteration of existing vegetation and topographical features. This will cause losses of some vegetation communities, and potentially change wildlife habitat availability, use and connectivity, and could influence wildlife abundance and distribution.	+	+	+	+	+	+	+	+	+	+	+
Vegetation clearing and grubbing may remove active milksnake hibernacula, which may influence survival and reproduction.	-	-	-	-	-	-	-	-	-	+	-
Sensory disturbance (i.e., lights, smells, noise, human activity, alteration of viewscape) can change wildlife habitat availability, use and connectivity (movement and behaviour), which can lead to changes in wildlife abundance and distribution.	-	+	+	+	+	+	+	+	+	+	+

Table 5.6.5-2: Interaction between Primary Pathways and Terrestrial Biodiversity Valued Components

Primary Pathway	Vegetation Communities	Migratory Birds	Canada Warbler	Eastern Whip-poor-will	Eastern Wood-pewee	Golden-winged Warbler	Wood Thrush	Bats	Blanding's Turtle	Eastern Milksnake	Monarch Butterfly
Movement of heavy equipment and other vehicles on roads and through previously undeveloped / forested areas may cause injury or mortality to Blanding's turtle and milksnake.	-	-	-	-	-	-	-	-	+	+	-
Installation and maintenance of perimeter fencing will potentially modify movement corridors for Blanding's turtle and milksnake in the LSA which may increase their travel distances and thus increase the risk of injury/mortality on roads.	-	-	-	-	-	-	-	-	+	+	-

+ = primary pathway for this valued component; **-** = no interaction or secondary pathway for this valued component; LSA = Local Study Area

5.6.6 Residual Effects Assessment Methods

5.6.6.1 Residual Effects Analysis

The residual effects analysis for the Application Case describes the incremental changes caused by the NSDF Project from existing conditions. Residual effects are described for each of the measurement indicators identified in Section 5.6.2 for the primary pathways identified for each terrestrial biodiversity VC (Section 5.6.6.3), as follows:

- Changes in ecosystem availability were estimated quantitatively by calculating differences in the amount of different types of vegetation communities. For wildlife VCs, changes in habitat availability were estimated quantitatively by calculating differences in the amount of suitably habitat and qualitatively by considering potential changes in habitat use by wildlife (e.g., avoidance due to sensory disturbance).
- Changes in ecosystem distribution were estimated for the vegetation community VC by qualitatively examining changes to the size and distribution of vegetation communities within the RSA and LSA. For wildlife VCs, changes in habitat distribution in the RSA and LSA were estimated by qualitatively evaluating the distribution of suitable wildlife habitat and considering wildlife VC movement, habitat connectivity and potential barriers to their dispersal.
- Changes in ecosystem condition (vegetation community VC) or survival and reproduction (wildlife VCs) were identified qualitatively and quantitatively using the results from changes in vegetation communities and knowledge of potential changes in abundance from other NSDF Project components and activities (e.g., wildlife strikes with vehicles). Predictions of change were made using data collected in the RSA and the LSA, where possible, and supported by scientific literature.

The residual effects analysis uses a logical reasoning to describe anticipated changes to each measurement indicator caused by the NSDF Project. This narrative description of anticipated effects is the foundation for the residual effects classification presented in Section 5.6.6.3.

5.6.6.2 Prediction Confidence

The predicted residual effects are based on scientific inference and logical reasoning, which are associated with uncertainty. Consequently, a description of the level of confidence that can be assigned to the residual effect analysis was presented for each terrestrial biodiversity VC.

Primary factors affecting confidence in the predictions made in the terrestrial biodiversity assessment include:

- availability and accuracy of baseline data;
- efficacy of mitigation applied at CNL during the Base Case;
- accuracy of vegetation spatial data and inferences on habitat associations;
- level of understanding of the strength of primary pathways (i.e., mechanisms) in terms of the effects they are likely to have on each VC;
- level of certainty associated with the effectiveness of proposed mitigation specific to the NSDF Project, where applicable; and
- level of understanding of the cumulative drivers of change in measurement indicators and associated effects on assessment endpoints.

Uncertainty in the assessment was managed by:

- reviewing historical and current data and relevant studies conducted in the study areas;
- conducting desktop studies to understand potential interactions between the proposed NSDF Project and terrestrial biodiversity, and supplementing with local and regional data to the extent possible; and
- comparing assessment results with relevant published literature to make inferences about ecological interactions and mechanisms of change.

Remaining uncertainty was primarily addressed by making assumptions that overestimated rather than underestimated potential effects of the NSDF Project (i.e., a precautionary assessment). This approach meant that when uncertainty was identified, the assessment was likely to overestimate predicted residual effects. For example, East Mattawa Road is an existing road that will be used as the main access road for the NSDF Project. The north and south ends of East Mattawa Road require upgrading, but no or little additional clearing to widen and have sufficient clearance for operational needs is needed. East Mattawa Road was not mapped as "unclassified" in the FRI dataset; it was considered to be part of the forested polygon. Consequently, the amount of physical disturbance to vegetation communities from the NSDF Project was overestimated in these areas (as the FRI dataset used for calculating changes to vegetation communities would make it appear that the entire segment of East Mattawa Road within the SSA is a "new" disturbance to the forested land cover), providing a precautionary assessment.

5.6.6.3 Residual Effects Classification

Residual effects from the NSDF Project on each measurement indicator for each VC were classified according to the standard effects criteria described by Canadian Environmental Assessment Agency (The Agency 2015) and presented in Table 5.6.6-1.

Magnitude was not classified categorically because narrative or numeric quantification is more useful for unambiguously describing the effects of the NSDF Project for these VCs. Integrating context to understand the point at which an effect size is large enough to be important for a VC is directly linked to the self-sustaining and ecologically effective status of the population, and is therefore considered as part of the significance evaluation.

Table 5.6.6-1: Definitions of Effects Categories Used to Classify Predicted Residual Effects Terrestrial Biodiversity Valued Components

Criteria	Definition	Description
Direction	Direction relates to the "value" of the effect in relation to the environment.	▪ Positive – net gain or benefit; effect is desirable ▪ Neutral – no change compared with baseline conditions and trends ▪ Negative – net loss or adverse effect; effect is undesirable
Magnitude	Magnitude is the intensity of the effect or a measure of the degree of change from existing (baseline) conditions expected to occur in the criterion.	▪ Magnitude will be defined for each measurement indicator to reflect VC-specific characteristics

Table 5.6.6-1: Definitions of Effects Categories Used to Classify Predicted Residual Effects Terrestrial Biodiversity Valued Components

Criteria	Definition	Description
Geographic extent	Geographic extent refers to the spatial area over which an effect will occur/can be detected (distance covered or range).	▪ SSA – effect is limited to the direct physical disturbance from the NSDF Project ▪ Local – the effect is confined to the LSA ▪ Regional – the effect extends beyond the LSA boundary, but is confined within the RSA ▪ Beyond regional – the effect extends beyond the RSA boundary
Duration/ reversibility	▪ Duration is the period of time over which the environmental effect will be present—the amount of time between the start and end of an activity or stressor (which relates to project development phases), plus the time required for the effect to be reversed. Duration and reversibility are functions of the length of time a criterion is exposed to activities. ▪ Reversibility is an indicator of the potential for recovery of the criterion from an effect. Reversible implies that the effect will not influence the criterion at a future predicted period in time. For effects that are permanent, the effect is determined to be irreversible.	▪ Short-term – the effect is reversible before the end of construction ▪ Medium-term – the effect occurs during the construction and/or operations phase and is reversible soon after the operations phase begins ▪ Long-term – the effect occurs during the construction and/or operations phase and persists into the closure phase, but is reversible ▪ Permanent – the effect occurs during construction and/or operations phases and is irreversible
Frequency	Frequency refers to the occurrence of the environmental effect over the duration of the assessment. Discussions on seasonal considerations are made when they are important in the evaluation of the effect.	▪ Infrequent – the effect is expected to occur rarely ▪ Frequent – the effect is expected to occur intermittently ▪ Continuous – the effect is expected to occur continually
Likelihood	Likelihood is a measure of the probability that an activity will result in an environmental effect.	▪ Unlikely – the effect is not likely to occur ▪ Possible – the effect may occur, but is not likely ▪ Probable – the effect is likely to occur ▪ Certain – the effect will occur

VC = valued component; SSA = Site Study Area; LSA = Local Study Area; RSA = Regional Study Area.

5.6.6.4 Determination of Significance

For each terrestrial biodiversity VC, a determination of significance was made based on an assessment of existing cumulative effects of previous and existing developments described in the Base Case. This classification provides context from the Base Case to which incremental changes in the Application Case are added.

The addition of the incremental effects of the NSDF Project are described and classified according to the methods outlined in Sections 5.6.6.1 and 5.6.6.3, respectively.

Future beyond regional disturbance factors such as climate change have the potential to adversely affect vegetation communities and populations of wildlife VCs that overlap with the RSA. Therefore, a determination of significance was also made based on the cumulative effects of previous and existing developments, the incremental effect of the NSDF Project, and a qualitative consideration of future, beyond regional disturbance factors.

Overall significance determination based on cumulative effects provides important context because the effects of a single project infrequently cause an ecologically significant effect on their own (McCold and Saulsbury 1996) and many environmental effects of primary concern are cumulative (Canter and Ross 2010). Therefore, whether vegetation communities or populations of wildlife VCs would remain self-sustaining and ecologically effective was assessed considering the cumulative effects of previous and existing developments in combination with the NSDF Project (i.e., Application Case). If a significant effect was identified for the Application Case, the incremental contribution of the NSDF Project to the significant effect is clearly described.

Significance of cumulative effects was predicted as a binary response, with effects classified as significant or not significant. Residual effects were determined to be significant if a VC is expected to no longer be 1) self-sustaining, or 2) ecologically effective. Specifically:

- A vegetation community or wildlife VC population was considered to be no longer self-sustaining where residual effects were expected to place the vegetation community or abundance of a wildlife VC, whether an open or closed population, on a declining trajectory that is not predicted to recover or stabilize. Part of being self-sustaining, in this context, was that a vegetation community or wildlife VC population that stabilizes at a lower abundance is not expected to be extirpated because of unrelated stochastic events (e.g., wildfires). Another part of being considered self-sustaining was the assumption that no additional mitigation or management actions beyond the proposed NSDF Project mitigation strategies and existing management strategies in the region would be required. Residual effects that are considered to be not significant could result in either no change, stabilization at lower abundance, stabilization at higher abundance, or a temporary decline followed by recovery. Where vegetation communities or wildlife populations remain stable, fragmentation effects that cause vegetation communities or wildlife populations to become isolated or substantially disconnected (e.g., severely reducing or eliminating gene flow and/or immigration within one regional or local populations) may also be considered significant.
- A vegetation community or wildlife VC population that has lost important ecological function would also result in determination of a significant adverse effect, regardless of its self-sustaining status. Ecological function can be lost, even when a vegetation community remains abundant, if the composition of that community is altered. For wildlife VCs, loss of ecological function occurs when a population can no longer perform its ecological role, such that it might trigger ecological changes that result in degraded or simplified ecosystems (Soulé et al. 2003). The potential to lose ecological function is more common for highly interactive wildlife VCs that have important ecological effects on other species, such as predators or ecosystem engineers (i.e., organism that creates, considerably modifies, maintains or destroys a habitat; Soulé et al. 2003).

The approach to determining the significance of residual effects for each VC incorporated the concepts of resilience and adaptability using the reasoned narrative provided in the residual effects assessment. Although the determination of significance was informed by the VC for characterizing residual effects, the interaction between ecological context from the Base Case and the magnitude, duration and geographic extent of the interacting residual effects were the most important factors. Provincial and federal standards, guidelines and objectives were considered, where available, and integrated into the reasoned narrative.

If uncertainty was high about where a threshold for a significant cumulative effect would occur in the range of cumulative change for the Application Case, and if the residual effect could be assessed as either 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. Effects determined significant because of high uncertainty around undefined true thresholds were clearly identified as such, and additional follow-up actions to reduce uncertainty were proposed (Section 5.6.8).

Adding to the challenges of understanding complex systems is the difficulty of forecasting a future that may be outside the range of observable baseline environmental conditions (Walther et al. 2002). For example, climate change models predict an increase in average global temperatures (Huff and Thomas 2014); however, the effect of these changes on ecosystem processes is uncertain (Deser et al. 2010; Walther 2010). Predicting how an ecosystem or an individual species will cope with climate change is difficult and many scenarios are possible (Dawson et al. 2011).

Climate change was addressed in this assessment using a precautionary approach. For example, climate change may have different effects on plant species abundance and distribution through shifts in temperature, precipitation, fire and insects, which can alter wildlife populations (Huff and Thomas 2014). If one scenario was much more likely than another, the assessment considered the most likely scenario. However, if uncertainty was high, the assessment considered a precautionary outcome for each VC.

Effects of the NSDF Project were considered significant if they contributed in a meaningful way to a significant adverse cumulative effect (i.e., a change that would contribute to jeopardizing the survival of the regional population).

5.6.7 Residual Effects Assessment Results

5.6.7.1 Vegetation Communities

5.6.7.1.1 Residual Effects Analysis

Ecosystem Availability

The incremental effect of the NSDF Project on ecosystem availability is summarized in Table 5.6.7-1. At the RSA scale, the changes to ecosystem availability represents a total permanent loss of 0.8% of forested ecosystems, primarily of second-growth, mature, mixed forest with high poplar content and snag presence. A somewhat greater proportional loss of the total coniferous forest coverage in the RSA (at 2%) is predicted. Coniferous forest stands are relatively rare in the RSA and the effects of the NSDF Project on coniferous forests is due to the predicted loss of one Norway spruce plantation stand and a portion of another coniferous forest stand.

There will be a total loss of 33 ha of forested ecosystems as a result of the NSDF Project (i.e., in the SSA), which will be converted to unclassified (cleared) land cover. A minor amount of wetland habitat (less than 1 ha) will be affected temporarily by the laydown and staging areas required for the installation of the Perch Lake transfer line (assessed as a secondary pathway). The remaining 4 ha within the SSA is unclassified / already anthropogenically altered land cover that will permanently retain the same classification once the NSDF Project has been constructed. Avoidance undertaken during the NSDF Project design means that wetland ecosystems availability is largely unchanged, with the exception of the wetland area to be temporarily affected by the laydown and staging areas required for the installation of the Perch Lake transfer line. At the LSA scale, the permanent conversion of 33 ha of forest to cleared land cover translates to a loss of 53.0% of forested ecosystems.

Table 5.6.7-1: Changes to Availability of Vegetation Communities in the Application Case

Vegetation Community	Regional Study Area				Local Study Area			
	Base Case (ha)	Application Case (ha)	Change in Area[(a)] (ha)	Percent Change[(a)] (%)	Base Case (ha)	Application Case (ha)	Change in Area[(a)] (ha)	Percent Change[(b)] (%)
Mixed Forest	1,930	1,903	-27	-1.4	70	42	-27	-39.1
Deciduous Forest	643	641	-2	-0.3	6	4	-2	-33.3
Coniferous Forest	199	195	-4	-2.0	5	1	-4	-80.0
Wetland	522	522	<1	<1.0	61	61	<1	<1.0
Flooded	1	1	0	0	0	0	0	0
Unclassified (cleared)	268	301	33(a)	12.3	27	60	33[(a)]	126.2
Total Aquatic Habitat:	274	274	0	0	41	41	0	0
Gaps/Slivers:	16	16	0	0	0	0	0	0
Total	3,853	3,853	0	0	210	210	0	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) A total of 3.81 ha of the SSA is “Unclassified (cleared)” in the Base Case and will remain in this vegetation community in the Application Case. Therefore, the change in area in the RSA and LSA in the Application Case does not equal the total SSA of 38 ha.

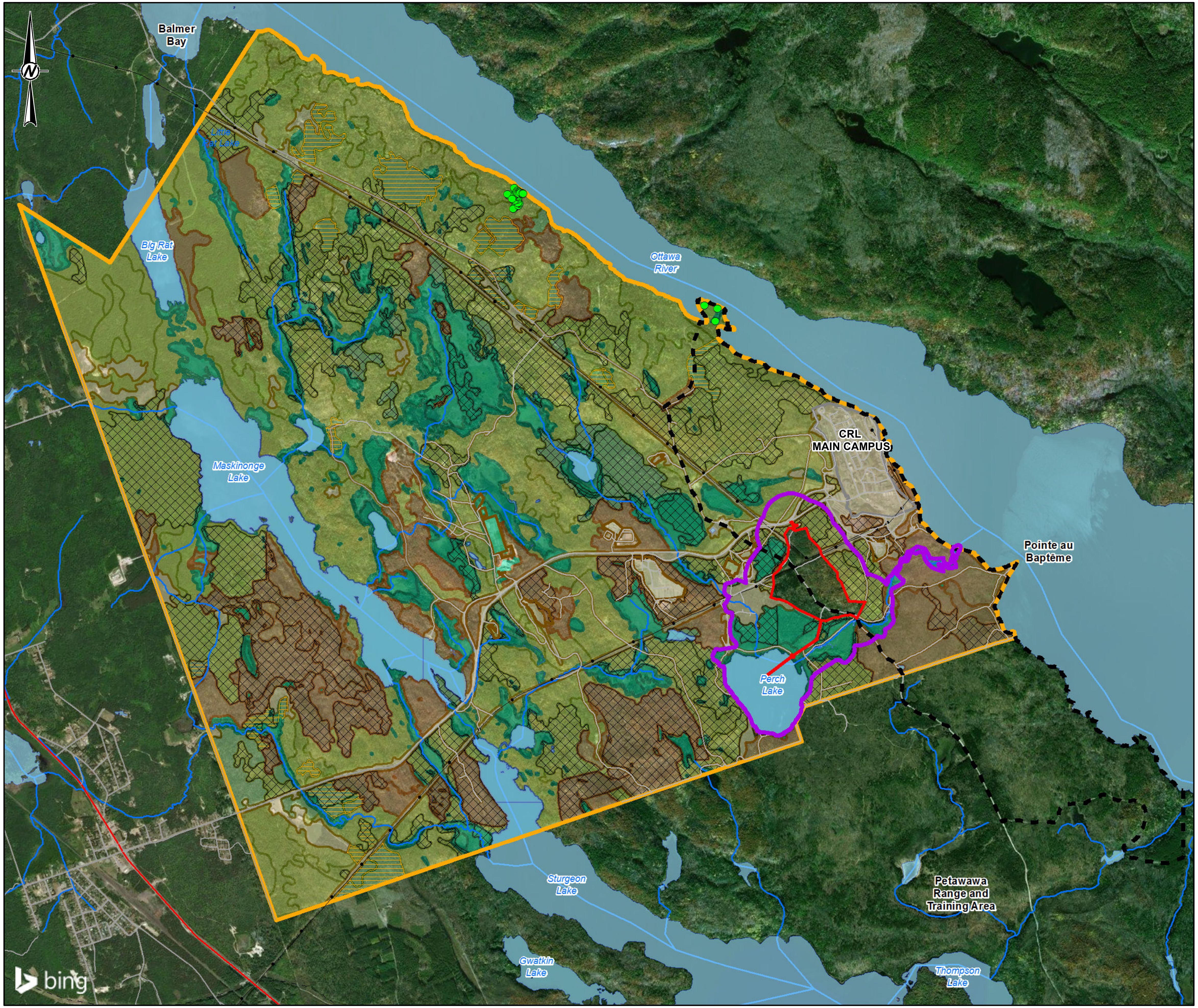
b) The total percent change is calculated relative to the total area and therefore this value will not equal the sum of the individual values.

SSA = Site Study Area; RSA = Regional Study Area; LSA = Local Study Area.

Ecosystem Distribution

At the RSA scale, the NSDF Project creates a relatively minor gap in existing forest coverage (0.8% change in coverage with a corresponding small degree of change to distribution). This disturbance is primarily associated with the distribution of vegetation communities within the RSA in the Application Case are presented on Figure 5.6.7-1. The location of the NSDF Project is within the southeast corner of the RSA, which already contains the highest level of anthropogenic disturbance and activity, leaving the northern two-thirds of the RSA still largely undisturbed.

Distribution of vegetation communities within the LSA and SSA in the Application Case are presented on Figure 5.6.7-2. At a local level, the SSA represents a relatively larger gap in forested ecosystems, a span of approximately 1,021 m north–south and 645 m east–west (53.0% change in coverage). Ecosystem processes, and in particular, the use of ecosystems by the wildlife VCs considered, are at a broader scale and are less likely to be disturbed as a whole, at this local scale. The range of these species is beyond the LSA boundary—which does not have an ecologically functional basis and is primarily defined by the footprint of the NSDF Project. Fragmentation of forested ecosystems is a concern if it reaches a threshold beyond what interior and area-sensitive species can tolerate. With the high degree of forest cover remaining on the CRL site, it is highly unlikely the forest clearing associated with the NSDF Project will represent a level of fragmentation that goes beyond this threshold. The forested ecosystems within the SSA were already fragmented by East Mattawa Road, which bisects the forested area, and two transmission corridors that criss-cross the northern portion of the forested area; therefore, the actual “new” edge creation is limited, but the size of the gap between the edges is increased.



LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- NORTH-SOUTH 2002 STUDY AREA

VEGETATION COMMUNITIES

- MIXED FOREST
- DECIDUOUS FOREST
- CONIFEROUS FOREST
- WETLANDS
- FLOODED AREA
- UNCLASSIFIED (CLEARED)
- MATURE FOREST STAND
- PLANTATION
- UNCLASSIFIED (CLEARED)

SARA LISTED PLANT SPECIES OBSERVATION

- BUTTERNUT OBSERVATION

1 0 1

1:35,000 KILOMETRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

VEGETATION COMMUNITIES AVAILABILITY AND DISTRIBUTION IN THE RSA – APPLICATION CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.7-1

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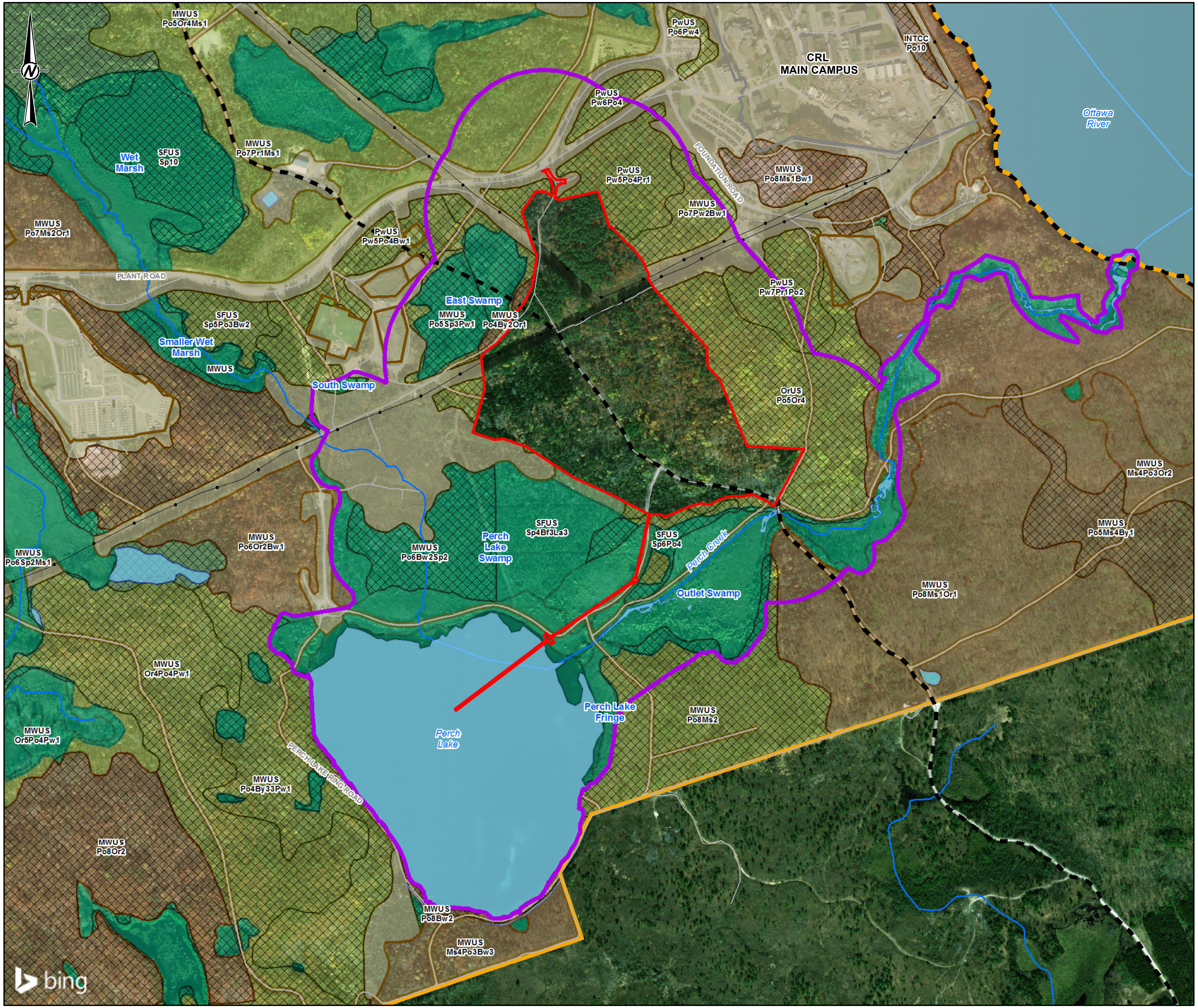

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- FENCE
- INFRASTRUCTURE
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- NORTH-SOUTH 2002 STUDY AREA

VEGETATION COMMUNITIES

- MIXED FOREST
- DECIDUOUS FOREST
- CONIFEROUS FOREST
- WETLANDS
- FLOODED AREA
- UNCLASSIFIED (CLEARED)
- MATURE FOREST STAND
- PLANTATION
- UNCLASSIFIED (CLEARED)

FOREST UNIT CODES:

Forest Unit	Description
MWUS	Mixed Uniform Shelterwood
PWUS	White Pine Uniform Shelterwood
SFUS	Spruce - Fir Uniform Shelterwood
INTCC	Intolerants Clear Cut
ORUS	Red Oak

FOREST COVER SPECIES CODES:

FRI Code	Tree Species	Coniferous (C) or Deciduous Species (D)
Bf	Balsam Fir (*Abies balsamea*)	C
Bw	Dwarf White Birch (*Betula minor*) or Paper Birch (*B. papyrifera*)	D
By	Yellow Birch (*B. alleghaniensis*)	D
La	American Larch (Tamarack) (*Larix laricina*)	C
Ms	Red Maple (Soft Maple) (*Acer rubrum*)	D
Or	Northern Red Oak (*Quercus rubra*)	D
Po	Poplar species (*Populus* sp.)	D
Pr	Red Pine (*Picea resinosa*)	C
Pw	Eastern White Pine (*Pinus strobus*)	C
Sp	Spruce species (*Picea* sp.)	C

250 0 250

1:10,000 METRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND JANUARY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
VEGETATION COMMUNITIES AVAILABILITY AND DISTRIBUTION IN THE LSA AND SSA – APPLICATION CASE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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Ecosystem Condition

The SSA is approximately 38 ha and consists primarily of mature forest, dominated by poplar species, red oak, eastern white pine and spruce species. It also contains a 1.2 km long segment of East Mattawa Road and two linear areas cleared as 30 to 45 m wide ROW for overhead hydroelectric lines. The area of the SSA associated with the Perch Lake transfer line is within Perch Lake Swamp and largely within the previously disturbed area of the wetland feature along the Perch Lake Ring Road right of way. Although the entire length of the transfer line is mapped, the surface disturbance in Perch Lake Swamp associated with this project component will be limited to two temporary laydown and staging areas, one 300 m^2 area (on the Perch Lake shoreline) and one 100 m^2 area (along the Perch Lake Ring Road segment that approaches the ECM). The East Mattawa Road corridor and Perch Lake Ring Road corridor were not captured in the FRI data, but the hydroelectric corridors were. Inclusion of the true extent of East Mattawa Road and Perch Lake Ring Road would result in a minor decrease to the mixed forest total coverage of the SSA and the wetland total coverage of the SSA, respectively, because the East Mattawa Road bisects a mixed forest stand and Perch Lake Ring Road bisects the Perch Lake Swamp wetland feature.

There are two areas of immature coniferous forest stands in the SSA: one is a tree research plantation containing 100% Norway spruce and the other is a portion of a stand of spruce, balsam fir and larch species. The Norway spruce research plantation is within the western portion of the SSA and was planted in the 1950s. Personnel with the Petawawa Research Forest have confirmed this plantation is no longer required for research purposes. There is also a portion of one deciduous forest stand, within the northwest end of the SSA, which contains poplar species, yellow birch and red oak.

There are no flooded areas within the SSA. The surficial geology around the SSA consists primarily of sands underlain by dense sandy silt till containing cobbles and boulders. Organic soils (e.g., peat) have deposited in the low-lying areas. The overburden thickness at the site typically ranges from approximately 0 to 10 m, depending on bedrock topography. The vegetation communities present within the SSA reflect these soil conditions.

At the regional scale, the NSDF Project will create a minor change in ecosystem condition with regard to mature forest cover (a loss of 3%; Table 5.6.7-2) but negligible change to ecosystem condition with regard to wetland cover (temporary loss of two areas for laydown and staging within Perch Lake Swamp, totalling 400 m^2, addressed as a secondary pathway above, with the assumption that all mitigation is followed). At the local scale, the NSDF Project will have a larger relative effect (reduction in 43% of available mature forest cover) and result in a permanent conversion of primarily mature forest to road and/or turf-grass. The temporary loss, for the duration of the construction period, of 400 m^2 wetland cover will also be negligible at the local scale (addressed as a secondary pathway above). The NSDF Project will create a permanent change to ecosystem condition from forested habitat to turf-grass habitat, with low value for terrestrial biodiversity. Moreover, terrestrial wildlife will be excluded from the SSA by a six foot high chain link perimeter fence that will remain through post-closure.

Table 5.6.7-2: Changes to Ecosystem Condition (as measured by Mature Forest Cover) in the Application Case

Ecosystem Condition Measures	Regional Study Area				Local Study Area			
	Base Case (ha)	NSDF Project Case (ha)	Change in Area (ha)	Percent Change (%)	Base Case (ha)	NSDF Project Case (ha)	Change in Area (ha)	Percent Change (%)
Mature Forest Cover	1,070	1,041	-29	-2.7	68	39	-29	-42.6

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

5.6.7.1.2 Prediction Confidence

Confidence in description of Base Case ecosystem availability, distribution and condition is tempered by reliance on primarily air-photo interpreted mapping—this potential for error is highlighted by the discrepancy in classification of a stand of one forest ecosystem type from the North-South (2002) survey work in one portion of the SSA. The North-South survey classified the forested area within the north portion of the SSA, north of the east–west transmission line ROW, and straddling the north–south transmission line ROW, as white pine / red pine forest. The FRI data for the site have this area mapped as a poplar / yellow birch / red oak deciduous forest stand on the west side of the north–south transmission line ROW (which is inconsistent with the North-South 2002 report) but white pine / poplar / red pine on the east side of that ROW (which is consistent; Figure 5.6.7-2).

In addition, the FRI dataset did not contain some common attributes that are used to assign ecosystem condition, including the year of origin for forest stands. The dataset used only provided the attribute of “age,” and no date for the GIS spatial dataset was available, meaning there may be some discrepancy in true forest stand ages relative to what was used in the assessment—with the degree of discrepancy widening depending on the age of the FRI dataset used.

Because of the lack of recent, ground-based surveys, the presence or absence of regionally or provincially rare vegetation species within areas to be disturbed cannot be determined. There is only one SARA-listed plant species that has been recorded in the RSA and could occur within the SSA: butternut (see Figure 5.6.4-1). However, this species does not have a high likelihood of occurrence within the SSA due to the lack of suitable habitat and location of the RSA, which is north of the current northern range extent (Appendix 5.6-1). Butternut located at CRL are associated with an old homestead. Some regeneration was noted in one patch during surveys, but it was always near the parent trees that were associated with the old homestead.

In all cases where there was the opportunity to be more conservative/precautionary in the assessment of effects on vegetation communities, decisions were made to achieve conservatism (e.g., use of modified age categories for forest unit structural age class definition so that stands that should be identified as mature or old based on leading tree species, specifically poplar, were identified as such).

Despite acknowledged deficiencies in reliance on desktop-derived data, the vegetation communities to be removed as a result of the NSDF Project are not unique on the regional landscape. The FRI data for the SSA also generally aligns with the observations of the reconnaissance-level site visit in 2016. Overview level review of Google Earth imagery has also confirmed general agreement with existing levels of forest cover and general composition.

Regardless of some level of uncertainty on exact stand composition, particularly in other areas of the RSA that were not visited during the site reconnaissance, the prediction of effects on the physical losses of vegetation communities has high confidence as the significance determination is primarily based on accurately quantifiable spatial changes to the landscape.

5.6.7.1.3 Residual Effects Classification

Vegetation communities in the RSA in the Base Case are considered to be within the limits of resilience and adaptive capacity to changes in availability, distribution and composition. After calculating changes from the NSDF Project, the composition of vegetation communities remain common and well distributed in the RSA. An estimated 99% of non-disturbed vegetation communities (i.e., the forested stands and wetlands) present in the Base Case will remain intact in the Application Case. Moreover, the implementation of appropriate invasive species control in keeping with best management practices such as the MNR *Forest Management Guide for Conserving Biodiversity at the Stand and Site Scales* (MNRF 2019a) will reduce the potential for invasive species to colonize vegetation communities adjacent to the NSDF Project. The most sensitive vegetation communities in the RSA (wetlands) will be largely avoided by the NSDF Project. With the implementation of mitigation described and adherence to the DFO *Ontario Operational Statement – High-Pressure Directional Drilling* (DFO 2007), there will be a temporary and minor effect on a small portion of Perch Lake Swamp, and no permanent loss of wetland habitat will occur within the SSA.

A summary of the classification of incremental adverse effects of the NSDF Project on vegetation communities in the Application Case is provided for each measurement indicator in Table 5.6.7-3. Residual effects after the implementation of effective mitigation are described, and are summarized according to direction, magnitude, geographic extent, duration/reversibility, frequency/timing and likelihood of the effect occurring following the methods described in Section 5.6.6.1. Effective implementation of mitigation summarized in Section 5.6.5.1 is expected to reduce the magnitude and duration of residual effects on vegetation communities.

Residual effects on the availability and distribution of vegetation communities resulting from the NSDF Project are predicted to be negative, resulting in a loss of 0.8% of forested communities in the RSA and 15.9% in the LSA. Construction of the NSDF Project will permanently remove forested vegetation communities and the direct effects of the changes will be confined to the SSA. Effects on vegetation community condition (e.g., species abundance and richness) are certain with regard to the permanent change in composition from largely undisturbed mature forest to heavily maintained turf-grass, but less certain due to the effectiveness of mitigation to avoid intrusion into adjacent forest and wetland edges by invasive species. For the purposes of this assessment, changes to all three indicators are assumed to be irreversible for vegetation communities affected by the SSA. Although remediation of the SSA will be completed, for the purposes of terrestrial biodiversity and vegetation communities specifically, conversion of a largely undisturbed, mature forested area to a permanently fenced, turf-grass habitat that is highly modified (i.e., mown, fertilized and maintained as tree-free to avoid the disruption of roots to the cover structure) eliminates the applicability of remediation as a means to reduce the level of residual effects.

Table 5.6.7-3: Classification of Residual Effects on Vegetation Community Indicators in the Application Case

Indicator	Characteristic	Rating/Effect Size
Ecosystem Availability	Direction	Negative
	Magnitude	Loss of 33 ha of ecosystems (0.8% of the RSA Base Case; 15.9% of the LSA Base Case). All ecosystem losses that would be caused by the Project are forested ecosystems.
	Geographic Extent	SSA
	Duration/Reversibility	Permanent/Irreversible
	Frequency/Timing	Continuous
	Likelihood	Certain
Ecosystem Distribution	Direction	Negative
	Magnitude	Changes to the distribution of vegetation communities primarily affects mixed forests and creates a localized fragmentation and distribution of this community type. However, East Mattawa Road and the two hydroelectric corridors already create three linear breaks in the distribution of forested communities in the SSA. The existing Perch Lake Ring Road through the Perch Lake Swamp is another existing linear break in the distribution of wetland habitat in the SSA. These mixed forest communities and wetlands remain well connected in the majority of the RSA; this change in distribution only occurs within the southeast corner of the RSA that is already affected by anthropogenic activity and disturbance, and the remaining largely undisturbed areas are left unmodified by the NSDF Project. Permanent fragmentation of wetlands, which are the most sensitive vegetation community, will not occur as a result of the Project, following implementation of mitigation during installation of the Perch Lake transfer line.
	Geographic Extent	SSA
	Duration/Reversibility	Permanent/Irreversible
	Frequency/Timing	Continuous
	Likelihood	Certain
Ecosystem Condition	Direction	Negative
	Magnitude	Conversion of the Base Case vegetation community composition from largely forested to turf-grass or unvegetated. Permanently affects the condition of a 38 ha SSA area that is comprised primarily of mature forest under existing conditions. Edge effects during the operations phase may alter adjacent vegetation community richness.
	Geographic Extent	Local
	Duration/Reversibility	Permanent /Irreversible
	Frequency/Timing	Continuous
	Likelihood	Certain (change to ecosystem condition) / Possible (introduction of invasive species)

RSA = Regional Study Area; SSA = Site Study Area.

5.6.7.1.4 Determination of Significance

The combined effects of past and present activity have altered vegetation communities in the RSA. Historically, forest composition and structure in the Georgian Bay Ecoregion was primarily driven by wildfire, insect outbreaks and disease. Within the RSA, active fire suppression combined with a lack of timber harvest since the 1940s has resulted in a high concentration of forested habitats, including mature forests (Section 5.6.4.1). The forest age class with highest coverage in the RSA in the Base Case is the immature seral stage at 1,618 ha (42%), with mature forest having second highest coverage, at 1,070 ha (28%). The LSA has the reverse, with mature forest at higher coverage (66 ha and 31.6% total area coverage) than immature forest (14 ha or 6.7%).

The relatively high coverage of older seral stages of forest cover within the RSA, as well as relatively high spatial coverage of wetlands and other aquatic habitat types, combines to create an area of high value for terrestrial biodiversity. This is especially true relative to areas surrounding the RSA that are more affected by forestry, farming and industrial disturbance. These forested ecosystems are interspersed and relatively abundant, and wetlands and natural vegetation communities are well distributed and connected in the RSA in the Base Case. Therefore, the combined evidence considered for ecosystem availability, distribution and condition indicates vegetation communities are currently self-sustaining and ecologically effective in the Base Case.

Because vegetation communities in the RSA are abundant, well connected and in good condition, they are expected to have the capacity to adapt and be resilient to existing natural and human-related disturbances. The NSDF Project will result in a permanent loss of 33 ha of forest, most of which is mature (3.0% of the Base Case RSA; 43% of the Base Case LSA). This is predicted to create small, negative changes to vegetation community availability, distribution and condition. However, although the loss of forest is permanent, these forest types are abundant in the RSA. The permanent incremental loss of forested vegetation communities and temporary, but replaced, loss of 400 m^2 of wetland habitat, from the NSDF Project is predicted to have little influence on ecological structure and function; 99% of undisturbed forested and wetland ecosystems present in the Base Case are predicted to remain in the Application Case. The NSDF Project will not permanently alter or fragment wetlands, which are the most sensitive vegetation community.

With effective implementation of the mitigation summarized in Table 5.6.5-1, the incremental contribution of the NSDF Project to combined effects from previous and existing development on vegetation communities in the RSA is not expected to change the self-sustaining and ecologically effective status of this VC. Consequently, effects on vegetation communities in the Application Case are predicted to be not significant.

On-going fire suppression in the RSA is anticipated to continue to promote succession of open habitat to forested habitat and young forest to old forest. However, climate change is predicted to increase the frequency and intensity of extreme weather events, including droughts, forest fires and heavy precipitation (Huff and Thomas 2014).

Overall, the weight of evidence from the analysis of the primary pathways predicts that changes to vegetation community ecosystem availability, ecosystem distribution and ecosystem condition in the RSA as a result of the NSDF Project are within the resilience and adaptability limits of this ecosystem. Continued fire suppression in the RSA and climate change are expected to affect vegetation community ecosystem availability, ecosystem distribution and ecosystem condition in the RSA. However, vegetation communities are expected to have the capacity to adapt and be resilient to natural and human-related disturbance, and fire suppression and effects of climate change are predicted to act together to continue to maintain a heterogeneous vegetative landscape in the RSA that provides habitat for a diversity of terrestrial flora and fauna. Therefore, effects from continued fire suppression and climate change in conjunction with the effects of the NSDF Project and past and present activities and developments in the RSA are not predicted to exceed the resilience and adaptability limits of vegetation communities in the RSA. Consequently, cumulative effects of previous and existing developments, the incremental effect of the NSDF Project and future, beyond regional disturbance factors (e.g., climate change) on vegetation communities in the RSA, are predicted to be not significant. The contributions of the NSDF Project are therefore also considered not significant.

5.6.7.2 Canada Warbler

5.6.7.2.1 Residual Effects Analysis

Habitat Availability

The NSDF Project is estimated to remove 28 ha of suitable breeding habitat for Canada warbler, which is 21.9% of suitable habitat in the LSA and 1.6% of suitable habitat in the RSA (Table 5.6.7-4). Sensory disturbance during the construction, operations and closure phases may indirectly reduce Canada warbler habitat availability in the LSA through avoidance. Noise levels greater than 50 dB can negatively affect birds (ECCC 2019). Canada warblers may avoid otherwise suitable habitat in areas where NSDF Project activities create noise levels greater than 50 dB.

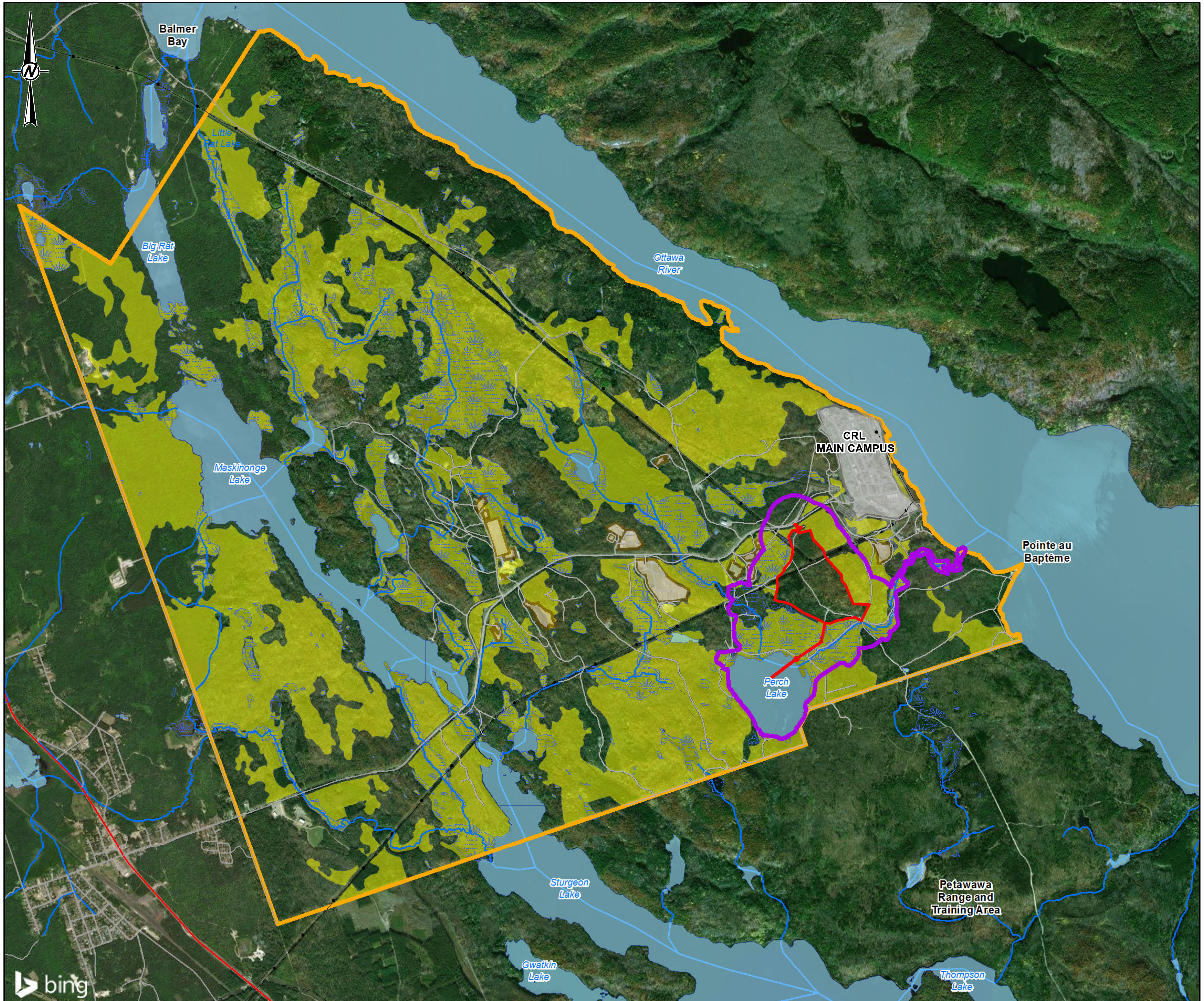
Table 5.6.7-4: Changes to Canada Warbler Breeding Habitat Availability in the Application Case

Habitat Suitability	Regional Study Area				Local Study Area			
	Base Case (ha)	Application Case (ha)	Change in Area (ha)	Percent Change (%)	Base Case (ha)	Application Case (ha)	Change in Area (ha)	Percent Change (%)
Suitable	1,701	1,673	-28	-1.6	128	100	-28	-21.9
Unsuitable	2,152	2,180	28	1.3	82	110	28	34.1

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Habitat Distribution

The development of the NSDF Project is unlikely to have a measurable effect on Canada warbler habitat distribution and movement in the RSA given the small size of the SSA and its location in the southeastern portion of the RSA where most existing human disturbance is concentrated (Figure 5.6.7-3). Canada warblers are highly mobile and capable of moving around or over the NSDF Project infrastructure. Forest clearing in the SSA is approximately 33 ha. Canada warblers may perceive this area of forest clearing as a barrier to movement (Desrochers and Hannon 1997; St. Clair et al. 1998); however, the land around the SSA will remain in natural cover, which is primarily forest, allowing individuals to move around the NSDF Project during transit. The SSA represents a large portion of the LSA (17.9%) and is expected to affect Canada warbler movement, with individuals travelling along the perimeter of the LSA more frequently in the Application Case than in the Base Case, as a result of the SSA being located in the centre of the LSA (Figure 5.6.7-4).



LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT SITES (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- CANADA WARBLER HABITAT

1 0 1
1:35,000 KILOMETRES

NOTE(S)
1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)
1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
CANADA WARBLER HABITAT AVAILABILITY AND DISTRIBUTION IN THE RSA – APPLICATION CASE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- FENCE
- INFRASTRUCTURE
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- CANADA WARBLER HABITAT

250 0 250

1:10,000 METRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
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3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

CANADA WARBLER HABITAT AVAILABILITY AND DISTRIBUTION IN THE LSA AND SSA – APPLICATION CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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Survival and Reproduction

Site clearing for the NSDF Project is not predicted to cause Canada warbler mortality. Adult Canada warblers are mobile and can avoid interactions with activities that could result in direct mortality, and mitigation will be implemented to avoid nest loss (Section 5.6.5.2.1).

The loss of breeding habitat may affect reproductive success if individuals are displaced or return to breeding grounds to find habitat removed, and subsequently are unable to establish a new territory or establish a territory in lower quality habitat. However, potentially suitable nesting habitat is broadly available in the RSA.

Sensory disturbance, such as noise from construction of the NSDF Project, may potentially reduce reproductive success and survival in the LSA by raising stress levels and interfering with communications (e.g., reducing ability to hear approaching predators or vocalizations by others of the same species; Ortega 2012). Thus, the carrying capacity of the LSA and RSA during the Application Case may be reduced relative to conditions in the Base Case.

5.6.7.2.2 Prediction Confidence

The residual effects assessment for Canada warbler is based on a good understanding of this species' ecology and tolerance to anthropogenic activities and a moderate understanding of threats to the persistence of the species.

There is some uncertainty concerning the Canada warbler population in the RSA because few quantitative data are available. Some uncertainty also exists in the accuracy of the mapping layer used to predict habitat availability, which was defined by relatively coarse vegetation community categories that did not always capture detailed habitat preferences. Moreover, the mapping could not be validated due to the limited amount of ground-truthing data available. This assessment dealt with uncertainty in map accuracy by making precautionary assumptions about habitat availability and occupancy in the study areas, and most likely overestimated the amount of habitat loss and reduction in carrying capacity.

There is a high level of uncertainty associated with the future population status of Canada warbler in Canada. Evidence suggests that populations are declining across the species' range, including in Ontario. If the declining population trend is not reversed or accelerates over the next decade, then Canada warbler may be up-listed from Threatened to Endangered. Critical habitat for Canada warbler is anticipated to be identified and one or more action plans will be developed for this species by 2021 (ECCC 2016a).

5.6.7.2.3 Residual Effects Classification

A summary of the classification of incremental adverse residual effects of the NSDF Project on Canada warbler in the Application Case is provided for each measurement indicator in Table 5.6.7-5. Residual effects after the implementation of effective mitigation are described, and are summarized according to direction, magnitude, geographic extent, duration/reversibility, frequency/timing and likelihood of the effect occurring following the methods described in Section 5.6.6.3 and the definitions provided in Table 5.6.6-1.

Table 5.6.7-5: Classification of Residual Effects on Canada Warbler in the Application Case

Indicator	Characteristic	Rating/Effect Size
Habitat Availability	Direction	Negative
	Magnitude	Direct loss of 28 ha of suitable habitat; reduced quality of nesting habitat and possible avoidance in the LSA from sensory disturbance during the construction and operations phases
	Geographic Extent	SSA (direct habitat loss); Local (sensory disturbance)
	Duration/Reversibility	Permanent/Irreversible (direct habitat loss); Long-term (sensory disturbance)
	Frequency/Timing	Continuous
	Likelihood	Certain (direct habitat loss); Probable (sensory disturbance)
Habitat Distribution	Direction	Negative
	Magnitude	Small change in movement in the LSA, with individuals travelling along the perimeter of the LSA more frequently as a result of the NSDF Project
	Geographic Extent	Local
	Duration/Reversibility	Permanent/Irreversible
	Frequency/Timing	Continuous
	Likelihood	Probable
Survival and Reproduction	Direction	Negative
	Magnitude	Small reduction in carrying capacity from habitat loss and sensory disturbance
	Geographic Extent	Local
	Duration/Reversibility	Long-term (sensory disturbance)
	Frequency/Timing	Continuous
	Likelihood	Probable

LSA = Local Study Area; SSA = Site Study Area.

5.6.7.2.4 Determination of Significance

The loss/degradation of overwintering habitat may be the most important factor affecting the Canada warbler population that overlaps the RSA in the Base Case (ECCC 2016a). The loss/degradation of breeding habitat is also considered a primary threat, but its relative importance varies across the species' geographic range (ECCC 2016a). Ontario may support 50% of Canada's breeding population of this VC and 44.1% of the RSA comprises suitable habitat for this species. Habitat availability for the population of Canada warbler that overlaps with the RSA is not considered a limiting factor in the Base Case and changes to this indicator have not exceeded its resilience or adaptability limits. Existing disturbance in the RSA and LSA do not likely function as dispersal barriers for this species in the Base Case because it is highly mobile.

Other threats affecting this VC in the Base Case include accidental mortality (e.g., collision with anthropogenic structures) and changes in the availability of insect prey (ECCC 2016a). Canada warblers may have a low ability to adapt to changes because they are a single-brooded species that arrives late on the breeding grounds and leaves early. However, Canada warblers also have the ability to produce many young, which increases the species' resilience to changes in survival and reproduction. The federal recovery strategy states that "there are currently adequate numbers of individuals to sustain the species in Canada or increase its abundance with the implementation of proper conservation actions" (ECCC 2016a). Therefore, changes to Canada warbler survival and reproduction in the Base Case are considered to be within the resilience and adaptability limits of this species.

For the primary pathways influencing habitat availability, habitat distribution, and survival and reproduction, the residual effects of the NSDF Project are predicted to be negative in direction and restricted to the SSA or LSA in geographic extent, which implies that at least a portion of the population is affected during any given year, but likely not the entire population every year. In the Application Case, the SSA is predicted to remove 28 ha of suitable Canada warbler habitat in the RSA. In addition, there may be changes to Canada warbler movement in the LSA as Canada warblers may not be willing to cross the gap in the forest created by the SSA. Suitable habitat in the LSA may be avoided by Canada warbler due to sensory disturbance during the construction and operations phases. Effects from habitat loss are expected to be permanent because the development of the NSDF Project will result in the permanent reconfiguration of habitat on the landscape. Conversely, effects from sensory disturbance during the construction and operations phases of the NSDF Project are expected to be continuous, but reversible at the end of the operations phase (long-term), although some individuals may adapt to sensory disturbance during construction and operations. Although these changes are negative, they are relatively small in a population context. After implementation of mitigation, the incremental changes due to the NSDF Project are not predicted to adversely affect populations of Canada warbler that overlap with the RSA. Consequently, cumulative effects from the NSDF Project and previous and existing activities and developments in the RSA on the Canada warbler population that overlaps with the RSA are predicted to be not significant in the Application Case.

On-going fire suppression in the RSA may reduce Canada warbler habitat availability as fire creates natural forest gaps with complex and dense shrubby cover required by this species (ECCC 2016a). Climate change is also likely to affect the Canada warbler population for the foreseeable future, although the direction and magnitude of changes are uncertain because predictions are based on simulations that can be highly variable and many scenarios are possible. Warmer and drier conditions in Ontario due to climate change may alter the onset of spring and summer and the timing of insect hatches (Nituch and Bowman 2013). Insectivorous long-distance migrants, such as Canada warblers, often exhibit a strong synchronization between breeding and peak food abundance, and climate change may affect this timing by creating a temporal mismatch between reproduction and optimal foraging conditions for prey (Both et al. 2009). A longer growing season may allow for Canada warblers to raise more than one brood per year, which is currently not possible with the timing of this species migration patterns (COSEWIC 2008). Climate change is also predicted to increase the frequency and intensity of extreme weather events, including droughts, forest fires and heavy precipitation (Huff and Thomas 2014). Extreme weather events during the breeding season can result in reduced fecundity and nest success. Forest fires may increase habitat availability by creating nesting habitat through the creation of gaps in the forest that contain a dense shrub layer. Individuals may also be susceptible to extreme weather events outside of the breeding season. The frequency and intensity of hurricanes are predicted to increase as a result of climate change, which may negatively affect individuals during fall migration and on wintering grounds.

Overall, the weight of evidence from the analysis of the primary pathways predicts that changes to Canada warbler habitat availability, habitat distribution, and survival and reproduction in the RSA as a result of the NSDF Project are within the resilience and adaptability limits of the species. Continued fire suppression in the RSA and climate change are expected to also affect Canada warbler habitat availability, habitat distribution, and survival and reproduction in the RSA. However, neither of these threats has been identified as being of high concern to the persistence of the species (ECCC 2016a). Therefore, effects from continued fire suppression and climate change in conjunction with the effects of the NSDF Project and past and present activities and developments in the RSA are not predicted to exceed the resilience and adaptability limits of the Canada warbler population that overlaps with the RSA. Consequently, cumulative effects of previous and existing developments, the incremental effect of the NSDF Project and consideration of future, beyond regional disturbance factors (e.g., climate change) on the Canada warbler population that overlaps with the RSA, are predicted to be not significant.
The contributions of the NSDF Project are therefore also considered not significant.

5.6.7.3 Eastern Whip-poor-will

5.6.7.3.1 Residual Effects Analysis

Habitat Availability

The NSDF Project is estimated to remove approximately 2 ha of suitable breeding habitat for eastern whip-poor-will, which is 15.4% of suitable habitat in the LSA and 0.3% of suitable habitat in the RSA (Table 5.6.7-6). Sensory disturbance during the construction, operations and closure phases may indirectly reduce eastern whip-poor-will habitat availability in the LSA through avoidance. Noise levels greater than 50 dB can negatively affect birds (ECCC 2019). Eastern whip-poor-will may avoid otherwise suitable habitat in areas where NSDF Project activities create noise levels greater than 50 dB.

Table 5.6.7-6: Changes to Eastern Whip poor will Breeding Habitat Availability in the Application Case

Habitat Suitability	Regional Study Area				Local Study Area			
	Base Case (ha)	Application Case (ha)	Change in Area (ha)	Percent Change (%)	Base Case (ha)	Application Case (ha)	Change in Area (ha)	Percent Change (%)
Suitable	769	767	-2	-0.3	13	11	-2	-15.4
Unsuitable	3,083	3,085	2	<0.1	197	199	2	1.0

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Effects on whip-poor-will from changes to habitat availability are expected because there is anticipated to be a direct loss of suitable breeding habitat; indirect habitat loss from avoidance due to sensory disturbance is also probable. Although effects are assumed to cease after the completion of closure activities, some individuals may adapt to sensory disturbance and may use suitable habitat within one to three years after NSDF Project construction is complete.

Habitat Distribution

The development of the NSDF Project is unlikely to have a measurable effect on eastern whip-poor-will habitat distribution and movement in the RSA given the small size of the SSA and its location in the southeastern portion of the RSA, where most existing human disturbance is concentrated (Figure 5.6.7-5). Whip-poor-wills are highly mobile and capable of moving around or over the NSDF Project infrastructure. Forest clearing in the SSA is approximately 33 ha. Whip-poor-wills may perceive this area of forest clearing as a barrier to movement (Desrochers and Hannon 1997; St. Clair et al. 1998); however, the land around the SSA will remain in natural cover, which is primarily forest, allowing individuals to move around the NSDF Project during transit. The SSA represents a large portion of the LSA (17.9%) and is expected to affect whip-poor-will movement locally, with individuals travelling along the perimeter of the LSA more frequently in the Application Case than in the Base Case, as a result of the SSA being located in the centre of the LSA (Figure 5.6.7-6). However, the SSA is less likely to be perceived as a movement barrier by species that use earlier successional habitats, such as eastern whip-poor-wills, than by interior-forest species.

Survival and Reproduction

Site clearing for the NSDF Project is not predicted to cause whip-poor-will mortality. Adult whip-poor-wills are mobile and can avoid interactions with activities that could result in direct mortality, and mitigation will be implemented to avoid nest loss (Section 5.6.5.2.1). The loss of breeding habitat may affect reproductive success if individuals are displaced or return to breeding grounds to find habitat removed, and subsequently are unable to establish a new territory or establish a territory in lower quality habitat. The loss of suitable breeding habitat due to the NSDF Project is predicted to result in a small reduction in the carrying capacity of the LSA and RSA. However, this is unlikely to have a measurable effect on the eastern whip-poor-will population in the RSA given the small area of predicted habitat loss (0.3% of suitable habitat in the RSA) and good representation of suitable habitat in the RSA (19.9% of RSA). Sensory disturbance may affect reproductive success and survival in the LSA by raising stress levels and interfering with communications (e.g., reducing ability to hear approaching predators or vocalizations by others of the same species; Ortega 2012). Thus, the carrying capacity of the LSA and RSA may be reduced in the Application Case relative to conditions in the Base Case.

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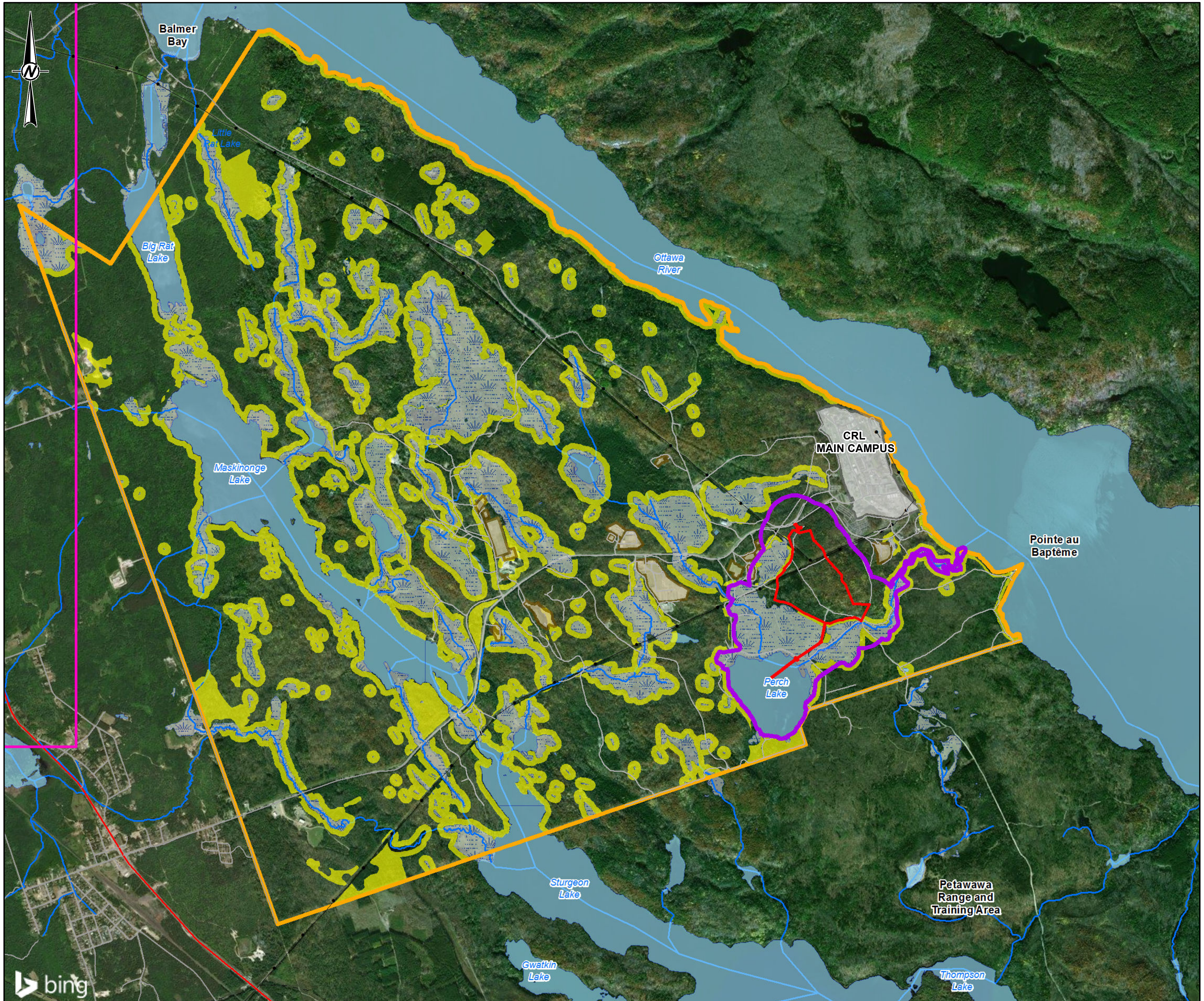

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- EASTERN WHIP-POOR-WILL HABITAT
- 10 km^2 GRID SQUARE CONTAINING CRITICAL HABITAT

1 0 1

1:35,000 KILOMETRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
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4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

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PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

EASTERN WHIP-POOR-WILL HABITAT AVAILABILITY AND DISTRIBUTION IN THE RSA – APPLICATION CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
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APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.7-5

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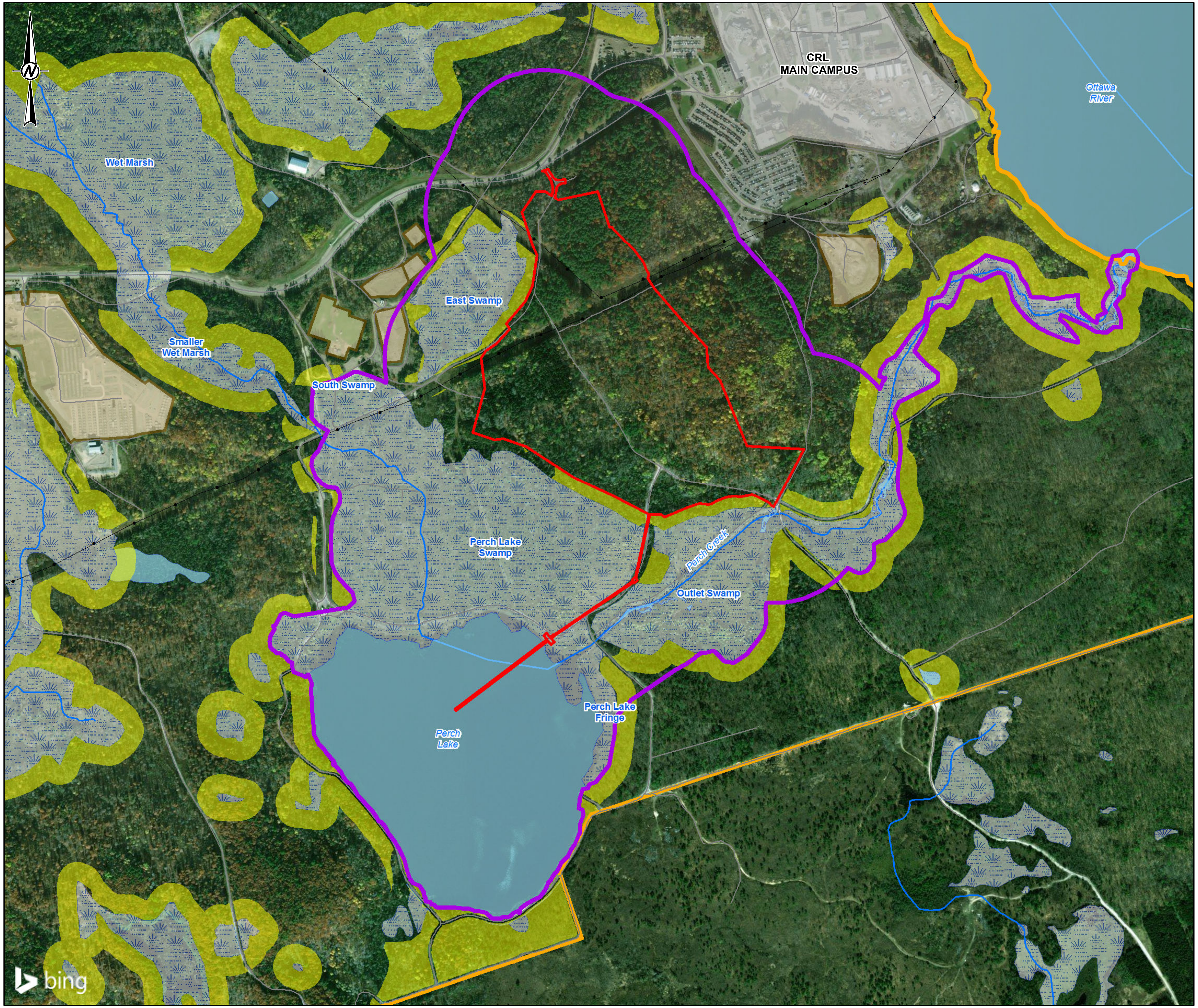

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- FENCE
- INFRASTRUCTURE
- STOCKPILE AREA
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- EASTERN WHIP-POOR-WILL HABITAT

250 0 250

1:10,000 METRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

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3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
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CHALK RIVER, ONTARIO

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DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.7-6

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5.6.7.3.2 Prediction Confidence

The residual effects assessment for eastern whip-poor-will is based on a good understanding of whip-poor-will ecology and the species' tolerance to anthropogenic activities and a moderate understanding of threats to the persistence of the species.

There is moderate uncertainty concerning the whip-poor-will population in the RSA because few quantitative datasets are available. There is moderate confidence in the habitat mapping. Some uncertainty exists in the accuracy of the mapping layer used to predict habitat availability, which was defined by relatively coarse vegetation community categories that did not always capture detailed habitat preferences. Moreover, the mapping could not be validated due to the limited amount of ground-truthing data available. This assessment dealt with uncertainty in map accuracy by making precautionary assumptions about habitat availability and occupancy in the study areas and most likely overestimating the amount of habitat loss and reduction in carrying capacity.

There is a high level of uncertainty associated with the future population status of whip-poor-will in Canada. Evidence suggests that populations are declining across the species' range, including in Ontario. If the declining population trend is not reversed or accelerates over the next decade, then whip-poor-will may be up-listed from Threatened to Endangered. The federal recovery strategy has partially identified critical habitat for the species and outlines a schedule to further identify critical habitat by 2035; and one or more action plans will be developed for this species by 2020 (ECCC 2018a).

5.6.7.3.3 Residual Effects Classification

A summary of the classification of incremental adverse residual effects of the NSDF Project on eastern whip-poor-will in the Application Case is provided for each measurement indicator in Table 5.6.7-7. Residual effects after the implementation of effective mitigation are described, and are summarized according to direction, magnitude, geographic extent, duration/reversibility, frequency/timing and likelihood of the effect occurring following the methods described in Section 5.6.6.3 and the definitions provided in Table 5.6.6-1.

Table 5.6.7-7: Description of Residual Effects on Eastern Whip poor will in the Application Case

Indicator	Characteristic	Rating/Effect Size
Habitat Availability	Direction	Negative
	Magnitude	Direct loss of 2 ha of suitable habitat (15.4% in LSA; 0.3% in RSA); reduced quality of nesting habitat and possible avoidance in the LSA from sensory disturbance during the construction and operations phases
	Geographic Extent	SSA (direct habitat loss); Local (sensory disturbance)
	Duration/Reversibility	Permanent /Irreversible (direct habitat loss); Long-term (sensory disturbance)
	Frequency/Timing	Continuous
	Likelihood	Certain (direct habitat loss); Probable (sensory disturbance)
Habitat Distribution	Direction	Negative
	Magnitude	Small change in movement in the LSA, with individuals travelling along the perimeter of the LSA more frequently as a result of the NSDF Project
	Geographic Extent	Local
	Duration/Reversibility	Permanent/Irreversible
	Frequency/Timing	Continuous
	Likelihood	Probable

Table 5.6.7-7: Description of Residual Effects on Eastern Whip poor will in the Application Case

Indicator	Characteristic	Rating/Effect Size
Survival and Reproduction	Direction	Negative
	Magnitude	Small reduction in reproductivity from habitat loss and sensory disturbance
	Geographic Extent	Local
	Duration/Reversibility	Permanent/Irreversible (direct habitat loss); Long-term (sensory disturbance)
	Frequency/Timing	Continuous
	Likelihood	Probable

LSA = Local Study Area; RSA = Regional Study Area.

5.6.7.3.4 Determination of Significance

The population of eastern whip-poor-will that overlaps with the RSA is not considered sensitive to changes in habitat availability or distribution because breeding habitat is not considered a limiting factor for this VC in the RSA, and suitable habitat is well represented (19.9% of RSA) and well distributed in the RSA. The RSA overlaps one 10 km by 10 km standardized UTM grid square identified to contain critical habitat for this species (grid square 18US00; ECCC 2018a). However, the area of overlap is small (28 ha) and is located in the extreme northwestern tip of the RSA (Figure 5.6.7-5). The exact location of critical habitat in grid squares is not identified in recovery strategies. Based on habitat mapping, approximately 3 ha of suitable habitat occurs in the grid square where it overlaps with the RSA. Whip-poor-wills are highly mobile and they demonstrate flexibility in habitat selection, including use of human disturbance, such as clear cuts and utility corridors. These characteristics suggest resilience and adaptability to changes in habitat availability and distribution. Whip-poor-wills have been regularly reported using habitats in areas surrounding the RSA (eBird 2017), and seven individuals were observed in and around the RSA during species-specific surveys. Despite concerning population trend data, the federal recovery strategy concluded that individuals that are capable of reproduction are available to sustain the population and improve its abundance (ECCC 2018a). Therefore, changes to whip-poor-will survival and reproduction in the Base Case are considered to be within the resilience and adaptability limits of this species. Overall, there is no evidence to suggest the population that overlaps the RSA is not self-sustaining and ecologically effective in the Base Case.

In the Application Case, the SSA would permanently remove approximately 2 ha of suitable breeding habitat during construction. Additional suitable breeding habitat in the LSA may be avoided due to sensory disturbance. The NSDF Project would result in a change in movement patterns at the local scale, but this change is not expected to alter the extent of occurrence of the population that overlaps with the RSA because the area of disturbance is small and localized, and whip-poor-wills are highly mobile and capable of using anthropogenic disturbances for breeding. With effective implementation of mitigation, the incremental changes due to the NSDF Project are not predicted to adversely affect the population of whip-poor-wills that overlaps with the RSA because habitat is unlikely to be a limiting factor in the RSA and direct mortality of individuals will be avoided by implementing appropriate mitigation. Therefore, effects from the NSDF Project are not predicted to exceed the resilience and adaptability limits of the whip-poor-will population that overlaps with the RSA. Consequently, cumulative effects from the NSDF Project and previous and existing activities and developments in the RSA on the eastern whip-poor-will population that overlaps with the RSA are predicted to be not significant in the Application Case.

On-going fire suppression in the RSA may reduce whip-poor-will habitat availability as forests progress towards old growth age and lose preferred attributes of nesting and foraging habitat (ECCC 2018a). Climate change is also likely to affect the whip-poor-will population for the foreseeable future, although the direction and magnitude of changes are uncertain because predictions are based on simulations that can be highly variable and many scenarios are possible. Warmer and drier conditions in Ontario due to climate change may alter the onset of spring and summer and the timing of insect hatches (Nituch and Bowman 2013). Insectivorous, long-distance migrants such as eastern whip-poor-wills often exhibit a strong synchronization between breeding and peak food abundance, and climate change may affect this timing by creating a temporal mismatch between reproduction and optimal foraging conditions for prey (Both et al. 2009; COSEWIC 2009). On the contrary, an anticipated longer growing season may have a positive effect on eastern whip-poor-will by allowing for this species to increasingly raise more than one brood per year. However, climate change is also predicted to increase the frequency and intensity of extreme weather events, including droughts, forest fires and heavy precipitation (ECCC 2018a; Huff and Thomas 2014). Extreme weather events during the breeding season can result in reduced fecundity and nest success. Forest fires may increase habitat availability by creating foraging habitat and eventually nesting habitat through succession. Individuals may also be susceptible to extreme weather events outside of the breeding season. The frequency and intensity of hurricanes are predicted to increase as a result of climate change, which may negatively affect individuals during fall migration and on wintering grounds.

Overall, the weight of evidence from the analysis of the primary pathways predicts that changes to eastern whip-poor-will habitat availability, habitat distribution, and survival and reproduction in the RSA as a result of the NSDF Project are within the resilience and adaptability limits of the species. Continued fire suppression in the RSA and climate change are expected to also affect whip-poor-will habitat availability, habitat distribution, and survival and reproduction in the RSA. However, neither of these threats has been identified as being of high concern to the persistence of the species (ECCC 2018a). Therefore, effects from continued fire suppression and climate change in conjunction with the effects of the NSDF Project and past and present activities and developments in the RSA are not predicted to exceed the resilience and adaptability limits of the whip-poor-will population that overlaps with the RSA. Consequently, cumulative effects of previous and existing developments, the incremental effect of the NSDF Project, and consideration of future, beyond regional disturbance factors (e.g., climate change) on the eastern whip-poor-will population that overlaps the RSA are predicted to be not significant. The contributions of the NSDF Project are therefore also considered not significant.

5.6.7.4 Eastern Wood-pewee

5.6.7.4.1 Residual Effects Analysis

Habitat Availability

The NSDF Project is estimated to remove 18 ha of suitable breeding habitat for eastern wood-pewee, which is 33.3% of suitable habitat in the LSA and 1.1% of suitable habitat in the RSA (Table 5.6.7-8). Sensory disturbance during the construction, operations and closure phases may reduce eastern wood-pewee habitat availability in the LSA through avoidance. Noise levels greater than 50 dB can negatively affect birds (ECCC 2019). Eastern wood-pewee may avoid otherwise suitable habitat in areas where NSDF Project activities create noise levels greater than 50 dB.

Table 5.6.7-8: Changes to Eastern Wood-pewee Breeding Habitat Availability in the Application Case

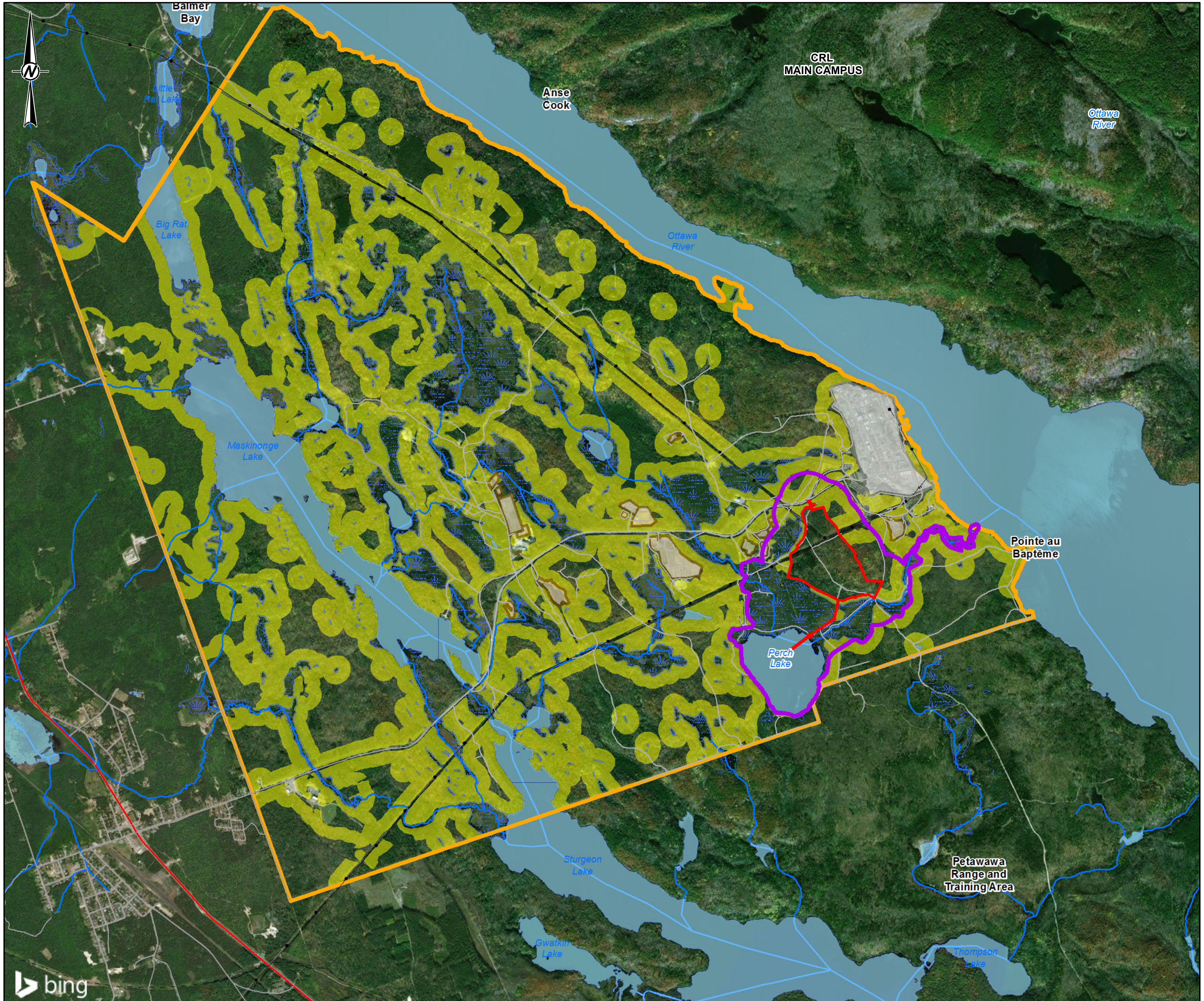
Habitat Suitability	Regional Study Area				Local Study Area			
	Base Case (ha)	Application Case (ha)	Change in Area (ha)	Percent Change (%)	Base Case (ha)	Application Case (ha)	Change in Area (ha)	Percent Change (%)
Suitable	1,603	1,584	-18	-1.1	54	36	-18	-33.3
Unsuitable	2,250	2,268	18	0.8	156	174	18	11.5

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Effects on eastern wood-pewee from changes to habitat availability are expected because there will be a direct loss of suitable breeding habitat, and indirect habitat loss from avoidance due to sensory disturbance is also probable. Changes to habitat availability from habitat loss are permanent because the ECM will remain deforested in perpetuity. Effects from sensory disturbance are conservatively assumed to cease after completion of closure activities; however, some individuals may adapt to sensory disturbance and may use suitable habitat within one to three years after construction is complete.

Habitat Distribution

The development of the NSDF Project is unlikely to have a measurable effect on eastern wood-pewee habitat distribution and movement in the RSA given the small size of the SSA and its location in the southeastern portion of the RSA where most existing human disturbance is concentrated (Figure 5.6.7-7). Eastern wood-pewees are highly mobile and capable of moving around or over the NSDF Project infrastructure. Forest clearing in the SSA is approximately 33 ha. Eastern wood-pewees may perceive this area of forest clearing as a barrier to movement (Desrochers and Hannon 1997; St. Clair et al. 1998); however, the land around the SSA will remain in natural cover, which is primarily forest, allowing individuals to move around the NSDF Project during transit. The SSA represents a large portion of the LSA (17.9%) and is expected to affect eastern wood-pewee movement, with individuals travelling along the perimeter of the LSA more frequently in the Application Case than in the Base Case, as a result of the SSA being located in the centre of the LSA (Figure 5.6.7-8).



LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- EASTERN WOOD-PEWEE HABITAT

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1:35,000 KILOMETRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
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PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

EASTERN WOOD-PEWEE HABITAT AVAILABILITY AND DISTRIBUTION IN THE RSA – APPLICATION CASE

CONSULTANT

GOLDER

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LEGEND

- HIGHWAY
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- WATERBODY
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- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- EASTERN WOOD-PEWEE HABITAT

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

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CONSULTANT
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PROJECT NO.	CONTROL	REV.	FIGURE
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Survival and Reproduction

Site clearing for the NSDF Project is not predicted to cause eastern wood-pewee mortality. Adult wood-pewees are mobile and can avoid interactions with activities that could result in direct mortality, and mitigation will be implemented to avoid nest loss (Section 5.6.5.2.1). The loss of breeding habitat may affect reproductive success if individuals are displaced or return to breeding grounds to find habitat removed, and subsequently are unable to establish a new territory or establish a territory in lower quality habitat. The loss of suitable breeding habitat due to the NSDF Project is predicted to result in a small reduction in the carrying capacity of the LSA and RSA. However, this is unlikely to have a measurable effect on the eastern wood-pewee population in the RSA since suitable nesting habitat is broadly available in the RSA.

Sensory disturbance, such as noise from construction of the NSDF Project, may potentially reduce reproductive success and survival in the LSA by raising stress levels and interfering with communications (e.g., reducing ability to hear approaching predators or vocalizations by others of the same species; Ortega 2012). Thus, the carrying capacity of the LSA and RSA during the Application Case may be reduced relative to conditions in the Base Case.

5.6.7.4.2 Prediction Confidence

The residual effects assessment for eastern wood-pewee is based on a good understanding of this species ecology and tolerance to anthropogenic activities and a moderate understanding of threats to the persistence of the species.

There is some uncertainty concerning the eastern wood-pewee population in the RSA because few quantitative data are available. There is moderate confidence in the habitat mapping. Some uncertainty exists in the accuracy of the mapping layer used to predict habitat availability, which was defined by relatively coarse vegetation community categories that did not always capture detailed habitat preferences. Moreover, the mapping could not be validated due to the limited amount of ground-truthing data available. This assessment dealt with uncertainty in map accuracy by making precautionary assumptions about habitat availability and occupancy in the study areas and most likely overestimating the amount of habitat loss and reduction in carrying capacity.

There is some uncertainty about the future population status of eastern wood-pewee in Canada. Discrepancies exist among population trend estimates from different bird population monitoring programs, although it was determined through expert panel review that BBS results were most reliable and demonstrate consistent long- and short-term declines in Canada and Ontario (COSEWIC 2012a).

5.6.7.4.3 Residual Effects Classification

A summary of the classification of incremental adverse residual effects of the NSDF Project on eastern wood-pewee in the Application Case is provided for each measurement indicator in Table 5.6.7-9. Residual effects after the implementation of effective mitigation are described, and are summarized according to direction, magnitude, geographic extent, duration/reversibility, frequency/timing and likelihood of the effect occurring following the methods described in Section 5.6.6.3 and the definitions provided in Table 5.6.6-1.

Table 5.6.7-9: Classification of Residual Effects on Eastern Wood-pewee in the Application Case

Indicator	Characteristic	Rating/Effect Size
Habitat Availability	Direction	Negative
	Magnitude	Direct loss of 18 ha of suitable habitat; reduced quality of nesting habitat and possible avoidance in the LSA from sensory disturbance during the construction and operations phases
	Geographic Extent	SSA (direct habitat loss); Local (sensory disturbance)
	Duration/Reversibility	Permanent /Irreversible (direct habitat loss); Long-term (sensory disturbance)
	Frequency/Timing	Continuous
	Likelihood	Certain (direct habitat loss); Probable (sensory disturbance)
Habitat Distribution	Direction	Negative
	Magnitude	Small change in movement in the LSA, with individuals travelling along the perimeter of the LSA more frequently as a result of the NSDF Project
	Geographic Extent	Local
	Duration/Reversibility	Permanent/Irreversible
	Frequency/Timing	Continuous
	Likelihood	Probable
Survival and Reproduction Indicator	Direction	Negative
	Magnitude	Small reduction in carrying capacity from habitat loss and sensory disturbance
	Geographic Extent	Local
	Duration/Reversibility	Permanent (direct habitat loss); Long-term (sensory disturbance)
	Frequency/Timing	Continuous
	Characteristic	Rating/Effect Size

LSA = Local Study Area; SSA = Site Study Area.

5.6.7.4.4 Determination of Significance

The population of eastern wood-pewee that overlaps with the RSA is not considered sensitive to changes in habitat availability or distribution because breeding habitat is not considered a limiting factor for this VC in the RSA, and suitable habitat is well represented (41.6% of RSA) and well distributed in the RSA. Wood-pewees are highly mobile, use a wide variety of forest types and appear relatively insensitive to habitat fragmentation (COSEWIC 2012a). These characteristics suggest resilience and adaptability to changes in habitat availability and distribution. Eastern wood-pewees have been observed using habitats in the RSA and surrounding areas in recent years (eBird 2017). Although population trends indicate short- and long-term declines in Canada and Ontario, Ontario supports the greatest densities of the species in the country and individuals that are capable of reproduction are available to sustain the population and improve its abundance. Therefore, changes to wood-pewee survival and reproduction in the Base Case are considered to be within the resilience and adaptability limits of this species. Overall, there is no evidence to suggest the population that overlaps the RSA is not self-sustaining and ecologically effective in the Base Case.

In the Application Case, the SSA is predicted to remove 18 ha of suitable eastern wood-pewee habitat in the RSA. In addition, there may be changes to wood-pewee movement in the LSA as wood-pewees may not be willing to cross the gap in the forest created by the SSA. Suitable habitat in the LSA may be avoided by wood-pewees due to sensory disturbance during the construction and operations phases. Effects from habitat loss are expected to be permanent because the development of the NSDF Project will result in the permanent reconfiguration of habitat on the landscape. Conversely, effects from sensory disturbance during the construction and operations phases of the NSDF Project are expected to be continuous, but reversible at the end of the operations phase (long-term), although some individuals may adapt to sensory disturbance over the medium-term. Although these changes are negative, they are relatively small in a population context. After implementation of mitigation, the incremental changes due to the NSDF Project are not predicted to adversely affect the population of wood-pewee that overlaps with the RSA. Consequently, cumulative effects from the NSDF Project and previous and existing activities and developments in the RSA on the eastern wood-pewee population that overlaps with the RSA are predicted to be not significant in the Application Case.

On-going fire suppression in the RSA may reduce wood-pewee habitat availability as forests progress towards old growth age and habitat edge attributes preferred by this species are lost. Climate change is also likely to affect the wood-pewee population for the foreseeable future, although the direction and magnitude of changes are uncertain because predictions are based on simulations that can be highly variable and many scenarios are possible. Warmer and drier conditions in Ontario due to climate change may alter the onset of spring and summer and the timing of insect hatches (Nituch and Bowman 2013). Insectivorous, long-distance migrants such as eastern wood-pewees often exhibit a strong synchronization between breeding and peak food abundance, and climate change may affect this timing by creating a temporal mismatch between reproduction and optimal foraging conditions for prey (Both et al. 2009; COSEWIC 2012a). On the contrary, an anticipated longer growing season may have a positive effect on eastern wood-pewee by allowing this species to increasingly raise more than one brood per year. Climate change is also predicted to increase the frequency and intensity of extreme weather events, including droughts, forest fires and heavy precipitation (ECCC 2018a; Huff and Thomas 2014). Forest fires and other extreme weather events that cause forest disturbance may increase habitat availability by creating edge habitat. However, extreme weather events during the breeding season can result in reduced fecundity and nest success. Individuals may also be susceptible to extreme weather events outside of the breeding season. The frequency and intensity of hurricanes are predicted to increase as a result of climate change, which may negatively affect individuals during fall migration and on wintering grounds.

Overall, the weight of evidence from the analysis of the primary pathways predicts that changes to eastern wood-pewee habitat availability, habitat distribution, and survival and reproduction in the RSA as a result of the NSDF Project are within the resilience and adaptability limits of the species. Continued fire suppression in the RSA and climate change are expected to also affect wood-pewee habitat availability, habitat distribution, and survival and reproduction in the RSA. Neither has been identified as a major threat to the persistence of the species, though climate change may factor in changes to prey availability, which itself has been identified as a potential serious threat requiring more study (COSEWIC 2012a). Therefore, effects from continued fire suppression and climate change in conjunction with the effects of the NSDF Project and past and present activities and developments in the RSA are not predicted to exceed the resilience and adaptability limits of the wood-pewee population that overlaps with the RSA. Consequently, cumulative effects of previous and existing developments, the incremental effect of the NSDF Project, and consideration of future, beyond regional disturbance factors (e.g., climate change) on the wood-pewee population that overlaps the RSA are predicted to be not significant. The contributions of the NSDF Project are therefore also considered not significant.

5.6.7.5 Golden-winged Warbler

5.6.7.5.1 Residual Effects Analysis

Habitat Availability

The NSDF Project is estimated to remove 27 ha of suitable breeding habitat for golden-winged warbler, which is 26.5% of suitable habitat in the LSA and 1.0% of suitable habitat in the RSA (Table 5.6.7-10). Sensory disturbance during the construction, operations and closure phases may reduce golden-winged warbler habitat availability in the LSA through avoidance. Noise levels greater than 50 dB can negatively affect birds (ECCC 2019). Golden-winged warbler may avoid otherwise suitable habitat in areas where NSDF Project activities create noise levels greater than 50 dB.

Table 5.6.7-10: Changes to Golden winged Warbler Breeding Habitat Availability in the Application Case

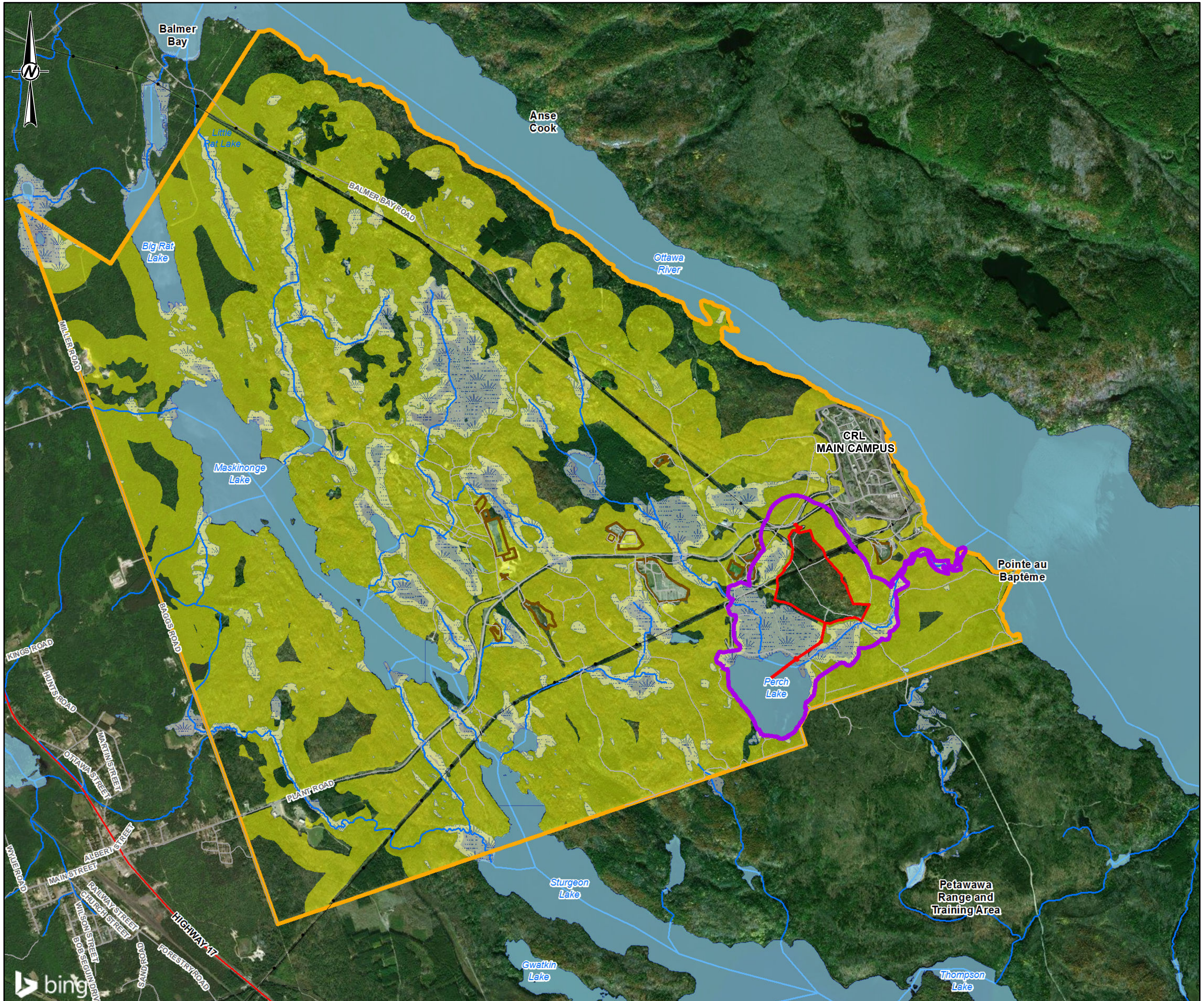
Habitat Suitability	Regional Study Area				Local Study Area			
	Base Case (ha)	Application Case (ha)	Change in Area (ha)	Percent Change (%)	Base Case (ha)	Application Case (ha)	Change in Area (ha)	Percent Change (%)
Suitable	2,621	2,594	-27	-1.0	102	75	-27	-26.5
Unsuitable	1,232	1,259	27	2.2	108	135	27	25.0

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Effects on golden-winged warbler from changes to habitat availability are expected because there will be a direct loss of suitable breeding habitat, and indirect habitat loss from avoidance due to sensory disturbance is also probable. Effects from sensory disturbance are conservatively assumed to cease after completion of closure activities; however, some individuals may adapt to sensory disturbance and may use suitable habitat within one to three years after construction is complete.

Habitat Distribution

The development of the NSDF Project is unlikely to have a measurable effect on golden-winged warbler habitat distribution and movement in the RSA given the small size of the SSA and its location in the southeastern portion of the RSA, where most existing human disturbance is concentrated (Figure 5.6.7-9). Golden-winged warblers are highly mobile and capable of moving around or over the NSDF Project infrastructure. Forest clearing in the SSA is approximately 33 ha. Golden-winged warblers may perceive this area of forest clearing as a barrier to movement (Desrochers and Hannon 1997); however, the land around the SSA will remain in natural cover, which is primarily forest, allowing individuals to move around the NSDF Project during transit (Figure 5.6.7-10). The SSA represents a large portion of the LSA (17.9%) and may affect golden-winged warbler movement, with individuals travelling along the perimeter of the LSA more frequently in the Application Case than in the Base Case as a result of the SSA being located in the centre of the LSA. However, the SSA is less likely to be perceived as a movement barrier by edge species, such as golden-winged warblers, than by interior-forest species.



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- HIGHWAY
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- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- GOLDEN-WINGED WARBLER HABITAT

1 0 1
1:35,000 KILOMETRES

NOTE(S)
1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)
1. BASEDATA MNRF 2016 AND CANVEC 2016
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CHALK RIVER, ONTARIO

TITLE
GOLDEN-WINGED WARBLER HABITAT AVAILABILITY AND DISTRIBUTION IN THE RSA – APPLICATION CASE

CONSULTANT
GOLDER

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- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- GOLDEN-WINGED WARBLER HABITAT

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NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

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Survival and Reproduction

Site clearing for the NSDF Project is not predicted to cause golden-winged warbler mortality. Adult golden-winged warblers are mobile and can avoid interactions with activities that could result in direct mortality, and mitigation will be implemented to avoid nest loss (Section 5.6.5.2.1). The loss of breeding habitat may affect reproductive success if individuals are displaced or return to breeding grounds to find habitat removed, and subsequently are unable to establish a new territory or establish a territory in lower quality habitat. The loss of suitable breeding habitat due to the NSDF Project is predicted to result in a small reduction in the carrying capacity of the LSA and RSA. However, this is unlikely to have a measurable effect on the golden-winged warbler population in the RSA given the small area of predicted habitat loss (1.0% of suitable habitat in the RSA) and overall abundance of suitable habitat in the RSA (68.0% of RSA).

Sensory disturbance, such as noise from construction of the NSDF Project may affect reproductive success and survival in the LSA by raising stress levels and interfering with communications (e.g., reducing ability to hear approaching predators or vocalizations by others of the same species; Ortega 2012). Thus, the carrying capacity of the LSA and RSA may be further reduced relative to that predicted based on habitat loss alone.

5.6.7.5.2 Prediction Confidence

The residual effects assessment for golden-winged warbler is based on a good understanding of golden-winged warbler ecology, threats to the persistence of the species and the species' tolerance to anthropogenic activities.

There is moderate uncertainty concerning the golden-winged warbler population in the RSA because few quantitative data are available. Some uncertainty exists in the accuracy of the mapping layer used to predict habitat availability, which was defined by relatively coarse vegetation community categories that did not always capture detailed habitat preferences. Moreover, the mapping could not be validated due to the limited amount of ground-truthing data available. This assessment dealt with uncertainty in map accuracy by making precautionary assumptions about habitat availability and occupancy in the study areas and most likely overestimating the amount of habitat loss and reduction in carrying capacity.

There is a moderate level of uncertainty associated with the future population status of golden-winged warbler in Canada. There are discrepancies among population trend estimates, with some suggesting steep declines across the species' range, and others suggesting stable population trends (ECCC 2016a). The federal recovery strategy has partially identified critical habitat for the species and outlines a schedule to further identify critical habitat by 2023, and one or more action plans will be developed for this species by 2022 (ECCC 2016a).

5.6.7.5.3 Residual Effects Classification

A summary of the classification of incremental adverse residual effects of the NSDF Project on golden-winged warbler in the Application Case is provided for each measurement indicator in Table 5.6.7-11. Residual effects after the implementation of effective mitigation are described, and are summarized according to direction, magnitude, geographic extent, duration/reversibility, frequency/timing and likelihood of the effect occurring following the methods described in Section 5.6.6.3 and the definitions provided in Table 5.6.6-1.

Table 5.6.7-11: Description of Residual Effects on Golden winged Warbler in the Application Case

Indicator	Characteristic	Rating/Effect Size
Habitat Availability	Direction	Negative
	Magnitude	Direct loss of 27 ha of suitable habitat (26.5% in LSA; 1.0% in RSA); reduced quality of nesting habitat and possible avoidance in the LSA from sensory disturbance during the construction and operations phases
	Geographic Extent	SSA (direct habitat loss); Local (sensory disturbance)
	Duration/Reversibility	Permanent /Irreversible (direct habitat loss); Long-term (sensory disturbance)
	Frequency/Timing	Continuous
	Likelihood	Certain (direct habitat loss); Probable (sensory disturbance)
Habitat Distribution	Direction	Negative
	Magnitude	Small change in movement in the LSA, with individuals travelling along the perimeter of the LSA more frequently as a result of the NSDF Project
	Geographic Extent	Local
	Duration/Reversibility	Permanent/Irreversible
	Frequency/Timing	Continuous
	Likelihood	Probable
Survival and Reproduction	Direction	Negative
	Magnitude	Small reduction in reproductivity from habitat loss and sensory disturbance
	Geographic Extent	Local
	Duration/Reversibility	Permanent/Irreversible (direct habitat loss); Long-term (sensory disturbance)
	Frequency/Timing	Continuous
	Likelihood	Probable

LSA = Local Study Area; RSA = Regional Study Area; SSA = Site Study Area.

5.6.7.5.4 Determination of Significance

The population of golden-winged warbler that overlaps with the RSA is not considered sensitive to changes in habitat availability or distribution because breeding habitat is not considered a limiting factor for this VC in the RSA, and suitable habitat is abundant (68.0% of RSA) and well distributed in the RSA. The RSA falls within one of the focal areas (GL10) identified to contain core populations that sustain the current breeding distribution and are important for expanding the population into adjacent areas; however, the RSA does not overlap grid squares identified to contain critical habitat within the focal area (ECCC 2016a). Golden-winged warblers are highly mobile and they demonstrate flexibility in habitat selection, including use of human disturbance such as roadsides and utility corridors, which create edge habitat preferred by this species. These characteristics suggest resilience and adaptability to changes in habitat availability and distribution. The population objective for golden-winged warbler, as identified in the federal recovery strategy, is to maintain self-sustaining populations in the focal areas, which indicates the population overlapping the RSA is considered to be relatively stable. Therefore, changes to golden-winged warbler survival and reproduction in the Base Case are considered to be within the resilience and adaptability limits of this species. Overall, there is no evidence to suggest the population that overlaps the RSA is not self-sustaining and ecologically effective in the Base Case.

In the Application Case, the SSA would permanently remove 27 ha of suitable breeding habitat during construction. Additional suitable breeding habitat in the LSA may be avoided due to sensory disturbance. The NSDF Project may result in a change in movement patterns at the local scale, but this change is not expected to alter the extent of occurrence of the population that overlaps with the RSA because the area of disturbance is small and localized, and golden-winged warblers are highly mobile and capable of using anthropogenic disturbances for breeding. With effective implementation of mitigation, the incremental changes due to the NSDF Project are not predicted to adversely affect the population of golden-winged warblers that overlaps with the RSA because habitat is unlikely to be a limiting factor in the RSA and direct mortality of individuals will be avoided by implementing appropriate mitigation. Therefore, effects from the NSDF Project are not predicted to exceed the resilience and adaptability limits of the golden-winged warbler population that overlaps with the RSA. Consequently, cumulative effects from the NSDF Project and previous and existing activities and developments in the RSA on the golden-winged warbler population that overlaps with the RSA are predicted to be not significant in the Application Case.

On-going fire suppression in the RSA may reduce golden-winged warbler habitat availability as forests progress towards old growth age and habitat edge attributes preferred by this species are lost. Climate change is also likely to affect the golden-winged warbler population for the foreseeable future, although the direction and magnitude of changes are uncertain because predictions are based on simulations that can be highly variable and many scenarios are possible. An anticipated longer growing season may have a positive effect on golden-winged warbler by allowing for this species to raise more than one brood per year. However, climate change is also predicted to increase the frequency and intensity of extreme weather events, including droughts, forest fires and heavy precipitation (ECCC 2016a; Huff and Thomas 2014). Extreme weather events during the breeding season can result in reduced fecundity and nest success. Forest fires may increase habitat availability by creating habitat edges preferred by this species. Individuals may also be susceptible to extreme weather events outside of the breeding season. The frequency and intensity of hurricanes are predicted to increase as a result of climate change, which may negatively affect individuals during fall migration and on wintering grounds.

Blue-winged warblers continue to expand northward, and this may be exacerbated by climate change and fire suppression (ECCC 2016a). Although both warbler species are considered early- to mid-successional habitat specialists, blue-winged warblers will start nesting at a later stage of succession and continue to nest further into succession than golden-winged warblers (Gill et al. 2001). An expansion of the blue-winged warbler range into the RSA would increase the likelihood of hybridization and competition with the golden-winged warbler population overlapping with the RSA (ECCC 2016a). However, further research is required to determine the taxonomic relationship between these species given that recent research suggests they are one species (Toews et al. 2016).

Overall, the weight of evidence from the analysis of the primary pathways predicts that changes to golden-winged warbler habitat availability, habitat distribution, and survival and reproduction in the RSA as a result of the NSDF Project are within the resilience and adaptability limits of the species. Continued fire suppression in the RSA, climate change and potential northward range expansion of the blue-winged warbler into the RSA are expected to also affect golden-winged warbler habitat availability, habitat distribution, and survival and reproduction in the RSA. However, only hybridization with blue-winged warbler has been identified as being of high concern to the persistence of the species among these threats (ECCC 2016a), and it is uncertain if this is a threat. Therefore, effects from continued fire suppression, climate change and potential northward range expansion of the blue-winged warbler into the RSA in conjunction with the effects of the NSDF Project and past and present activities and developments in the RSA are not predicted to exceed the resilience and adaptability limits of the golden-winged warbler population that overlaps with the RSA. Consequently, cumulative effects of previous and existing developments, the incremental effect of the NSDF Project, and consideration of future, beyond regional disturbance factors (e.g., climate change) on the golden-winged warbler population that overlaps the RSA are predicted to be not significant. The contributions of the NSDF Project are therefore also considered not significant.

5.6.7.6 Wood Thrush

5.6.7.6.1 Residual Effects Analysis

Habitat Availability

The NSDF Project is estimated to remove 28 ha of suitable breeding habitat for wood thrush, which is 32.6% of suitable habitat in the LSA and 2.6% of suitable habitat in the RSA (Table 5.6.7-12). Sensory disturbance during the construction, operations and closure phases may reduce wood thrush habitat availability in the LSA through avoidance. Noise levels greater than 50 dB can negatively affect birds (ECCC 2019). Wood thrush may avoid otherwise suitable habitat in areas where NSDF Project activities create noise levels greater than 50 dB.

Table 5.6.7-12: Changes to Wood Thrush Breeding Habitat Availability in the Application Case

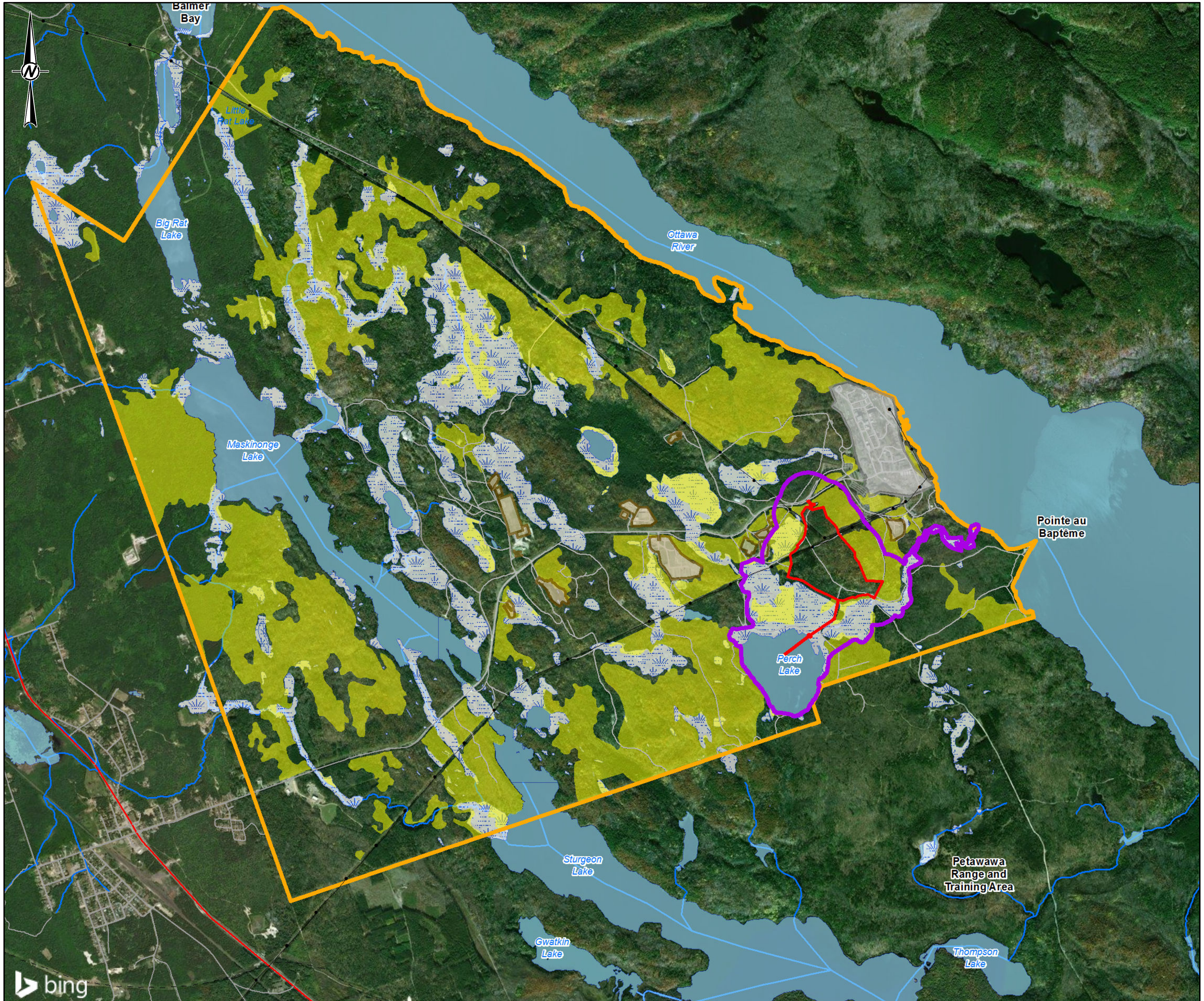
Habitat Suitability	Regional Study Area				Local Study Area			
	Base Case (ha)	Application Case (ha)	Change in Area (ha)	Percent Change (%)	Base Case (ha)	Application Case (ha)	Change in Area (ha)	Percent Change (%)
Suitable	1,076	1,047	-28	-2.6	86	58	-28	-32.6
Unsuitable	2,777	2,805	28	1.0	124	152	28	22.6

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Effects on wood thrush from changes to habitat availability are expected because there will be a direct loss of suitable breeding habitat, and indirect habitat loss from avoidance due to sensory disturbance is also probable. Changes to habitat availability from habitat loss are permanent because the ECM will remain deforested in perpetuity. Effects from sensory disturbance are conservatively assumed to cease after completion of closure activities; however, some individuals may adapt to sensory disturbance and may use suitable habitat within one to three years after construction is complete.

Habitat Distribution

The development of the NSDF Project is unlikely to have a measurable effect on wood thrush habitat distribution and movement in the RSA given the small size of the SSA and its location in the southeastern portion of the RSA where most existing human disturbance is concentrated (Figure 5.6.7-11). Wood thrushes are highly mobile and capable of moving around or over the NSDF Project infrastructure. Forest clearing in the SSA is approximately 33 ha. Wood thrushes may be reluctant to move through the open habitat created by the SSA (Desrochers and Hannon 1997; St. Clair et al. 1998); however, the land around the SSA will remain in natural cover, which is primarily forest, allowing individuals to move around the NSDF Project during transit. The SSA represents a large portion of the LSA (17.9%) and is expected to affect wood thrush movement, with individuals travelling along the perimeter of the LSA more frequently in the Application Case than in the Base Case, as a result of the SSA being located in the centre of the LSA (Figure 5.6.7-12).



LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- WOOD THRUSH HABITAT

1 0 1
1:35,000 KILOMETRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
WOOD THRUSH HABITAT AVAILABILITY AND DISTRIBUTION IN THE RSA – APPLICATION CASE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.7-11

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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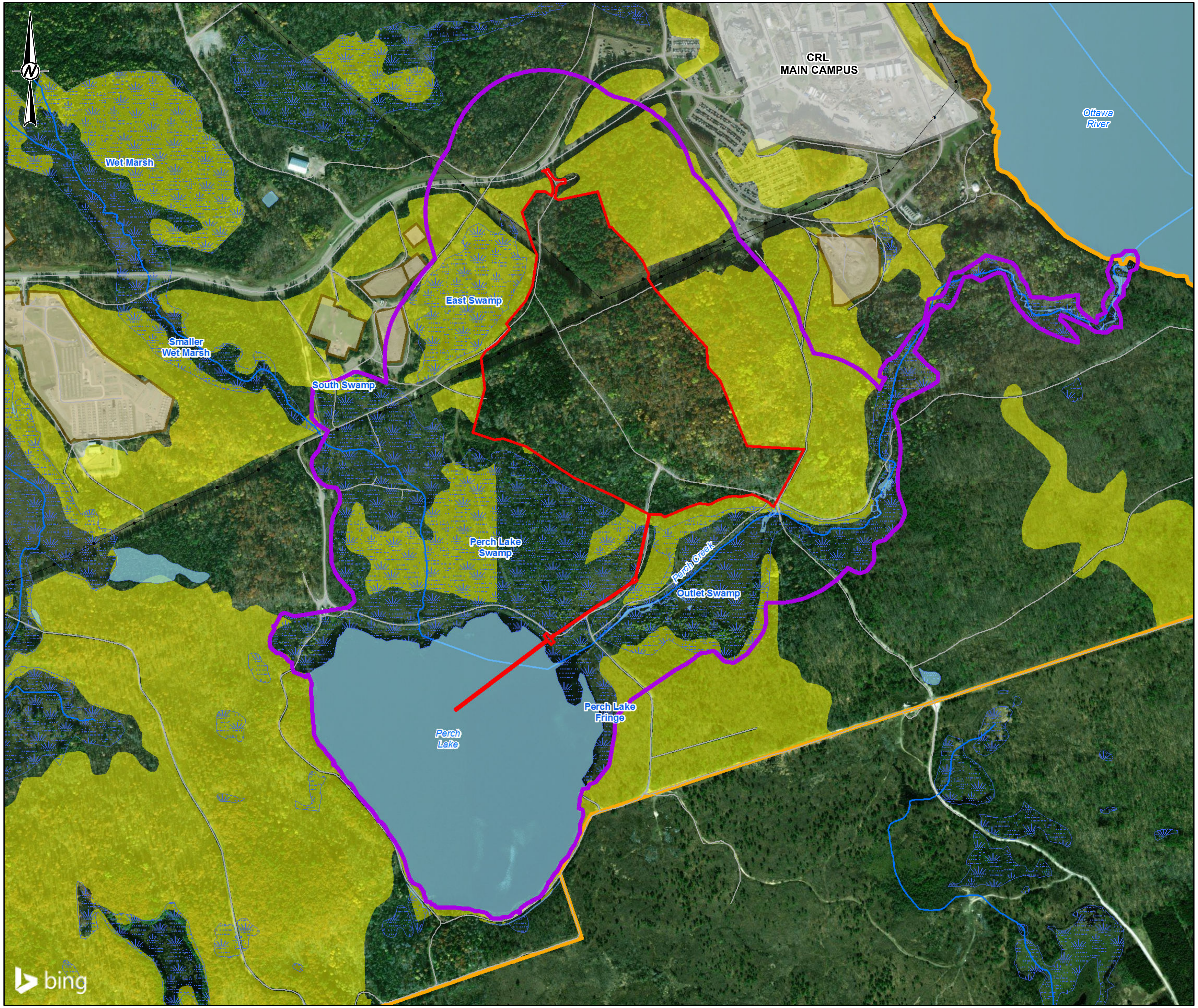

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- WOOD THRUSH HABITAT

250 0 250
1:10,000 METRES

NOTE(S)
1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)
1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
WOOD THRUSH HABITAT AVAILABILITY AND DISTRIBUTION IN THE LSA AND SSA – APPLICATION CASE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.7-12

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Survival and Reproduction

Site clearing for the NSDF Project is not predicted to cause wood thrush mortality. Adult wood thrushes are mobile and can avoid interactions with activities that could result in direct mortality, and mitigation will be implemented to avoid nest loss (Section 5.6.5.2.1). The loss of breeding habitat may affect reproductive success if individuals are displaced or return to breeding grounds to find habitat removed, and subsequently are unable to establish a new territory or establish a territory in lower quality habitat. The loss of suitable breeding habitat due to the NSDF Project is predicted to result in a small reduction in the carrying capacity of the LSA and RSA. However, this is unlikely to have a measurable effect on the wood thrush population in the RSA since suitable nesting habitat is broadly available in the RSA.

Sensory disturbance, such as noise from construction of the NSDF Project, may potentially reduce reproductive success and survival in the LSA by raising stress levels and interfering with communications (e.g., reducing ability to hear approaching predators or vocalizations by others of the same species; Ortega 2012). Thus, the carrying capacity of the RSA during the Application Case may be reduced relative to conditions in the Base Case.

5.6.7.6.2 Prediction Confidence

The residual effects assessment for wood thrush is based on a good understanding of this species' ecology and a moderate understanding of threats to the persistence of the species.

There is uncertainty concerning the status of the wood thrush population in the RSA because few quantitative data are available. Uncertainty also exists in the accuracy of the mapping layer used to predict habitat availability, which was defined by relatively coarse vegetation community categories that did not always capture detailed habitat preferences. Habitat selection is strongly based on microhabitat characteristics (Evans et al. 2011), which could not be determined from the vegetation community data. Finally, the mapping could not be validated due to the limited amount of ground-truthing data available. This assessment dealt with uncertainty in map accuracy by making precautionary assumptions about habitat availability and occupancy in the study areas, and most likely overestimated the amount of habitat loss and reduction in carrying capacity.

There is a moderate level of uncertainty associated with the future population status of wood thrush in Canada. Population trend estimates are generally consistent in showing short- and long-term population declines across the range of the species; however, declines are not universally severe and some populations, including in Ontario, appear to be relatively stable and self-sustaining (COSEWIC 2012b).

5.6.7.6.3 Residual Effects Classification

A summary of the classification of incremental adverse residual effects of the NSDF Project on wood thrush in the Application Case is provided for each measurement indicator in Table 5.6.7-13. Residual effects after the implementation of effective mitigation are described, and are summarized according to direction, magnitude, geographic extent, duration/reversibility, frequency/timing and likelihood of the effect occurring following the methods described in Section 5.6.6.3 and the definitions provided in Table 5.6.6-1.

Table 5.6.7-13: Classification of Residual Effects on Wood Thrush in the Application Case

Indicator	Characteristic	Rating/Effect Size
Habitat Availability	Direction	Negative
	Magnitude	Direct loss of 28 ha of suitable habitat; reduced quality of nesting habitat and possible avoidance in the LSA from sensory disturbance during the construction and operations phases
	Geographic Extent	SSA (direct habitat loss); Local (sensory disturbance)
	Duration/Reversibility	Permanent /Irreversible (direct habitat loss); Long-term (sensory disturbance)
	Frequency/Timing	Continuous
	Likelihood	Certain (direct habitat loss); Probable (sensory disturbance)
Habitat Distribution	Direction	Negative
	Magnitude	Small change in movement in the LSA, with individuals travelling along the perimeter of the LSA more frequently as a result of the NSDF Project
	Geographic Extent	Local
	Duration/Reversibility	Permanent/Irreversible
	Frequency/Timing	Continuous
	Likelihood	Probable
Survival and Reproduction Indicator	Direction	Negative
	Magnitude	Small reduction in carrying capacity from habitat loss and sensory disturbance
	Geographic Extent	Local
	Duration/Reversibility	Permanent/Irreversible (direct habitat loss); Long-term (sensory disturbance)
	Frequency/Timing	Continuous
	Characteristic	Rating/Effect Size

LSA = Local Study Area; SSA = Site Study Area.

5.6.7.6.4 Determination of Significance

The population of wood thrush that overlaps with the RSA is not considered sensitive to changes in habitat availability or distribution because breeding habitat is not considered a limiting factor for this VC in the RSA, and suitable habitat is well represented (27.9% of RSA) and well distributed in the RSA. Wood thrushes are highly mobile and they demonstrate flexibility in habitat selection, including use of anthropogenic habitats such as suburban residential areas and parks where suitable forest attributes are present (Evans et al. 2011). These characteristics suggest resilience and adaptability to changes in habitat availability and distribution. Wood thrushes have been observed using habitats in the RSA and surrounding areas in recent years (eBird 2017). Despite concerning population trend data indicating declines across the species' range, declines in Ontario are not significant (COSEWIC 2012b) and are more likely to be in more urbanized areas where habitat has been more heavily fragmented. Studies of Ontario populations suggest these populations are self-sustaining despite often extensive forest fragmentation (COSEWIC 2012b). Because Ontario populations are doing relatively well, changes to wood thrush survival and reproduction from previous developments in the province are considered to be within the resilience and adaptability limits of this species. Overall, there is no evidence to suggest the population that overlaps the RSA is not self-sustaining and ecologically effective in the Base Case.

In the Application Case, the SSA is predicted to remove 28 ha of suitable wood thrush habitat in the RSA. These habitat changes may also alter wood thrush movement in the LSA because wood thrushes may not be willing to cross the gap in the forest created by the SSA. Moreover, suitable habitat in the LSA may be avoided by wood thrushes due to sensory disturbance during the construction and operations phases. Effects from habitat loss are expected to be permanent because the development of the NSDF Project will result in the permanent reconfiguration of habitat on the landscape. Conversely, effects from sensory disturbance during the construction and operations phases of the NSDF Project are expected to be continuous, but reversible at the end of the operations phase (long term), although some individuals may adapt to sensory disturbance over the medium term. Although the NSDF Project is likely to cause adverse effects to wood thrush, the effects are relatively small in a population context. After implementation of mitigation, the incremental changes due to the NSDF Project are not predicted to adversely affect the population of wood thrush that overlaps with the RSA. Consequently, cumulative effects from the NSDF Project and previous and existing activities and developments in the RSA on the wood thrush population that overlaps with the RSA are predicted to be not significant in the Application Case.

On-going fire suppression may reduce wood thrush habitat availability as increasingly aging forests lose habitat attributes preferred by this species (e.g., dense understory; COSEWIC 2012b). Climate change is also likely to affect the wood thrush population for the foreseeable future, although the direction and magnitude of changes are uncertain because predictions are based on simulations that can be highly variable and many scenarios are possible. Warmer and drier conditions in Ontario due to climate change may alter the onset of spring and summer and the timing of insect hatches (Nituch and Bowman 2013). Insectivorous, long-distance migrants such as wood thrushes often exhibit a strong synchronization between breeding and peak food abundance, and climate change may affect this timing by creating a temporal mismatch between reproduction and optimal foraging conditions for prey (Both et al. 2009). On the contrary, an anticipated longer growing season may have a positive effect on wood thrush by allowing for this species to increasingly raise two broods per year. Climate change is also predicted to increase the frequency and intensity of extreme weather events, including droughts, forest fires and heavy precipitation (Huff and Thomas 2014). Forest fires may increase habitat availability in the medium term as the forest understory regenerates. Other extreme weather events that result in forest disturbances (e.g., winter ice storms) may similarly increase habitat availability (COSEWIC 2012b). However, extreme weather events during the breeding season can result in reduced fecundity and nest success. Individuals may also be susceptible to extreme weather events outside of the breeding season. The frequency and intensity of hurricanes are predicted to increase as a result of climate change, which may negatively affect individuals during fall migration and on wintering grounds.

Overall, the weight of evidence from the analysis of the primary pathways predicts that changes to wood thrush habitat availability, habitat distribution, and survival and reproduction in the RSA because of the NSDF Project are within the resilience and adaptability limits of the species. Continued fire suppression in the RSA and climate change are expected to also affect wood thrush habitat availability, habitat distribution, and survival and reproduction in the RSA. However, neither has been identified as a major threat to the persistence of the species (COSEWIC 2012b). Therefore, effects from continued fire suppression and climate change in conjunction with the effects of the NSDF Project and past and present activities and developments in the RSA are not predicted to exceed the resilience and adaptability limits of the wood thrush population that overlaps with the RSA. Consequently, cumulative effects of previous and existing developments, the incremental effect of the NSDF Project and consideration of future, beyond regional disturbance factors (e.g., climate change) on the wood thrush population that overlaps the RSA are predicted to be not significant. The contributions of the NSDF Project are therefore also considered not significant.

5.6.7.7 Bats

5.6.7.7.1 Residual Effects Analysis

Habitat Availability

The RSA contains extensive spatial coverage of potential maternity roost habitat (Table 5.6.7-14). The reduction in habitat availability caused by the NSDF Project at the RSA scale is relatively minor (i.e., 1%). At the LSA scale, there will be a larger relative decrease in the availability of potential maternity roost habitat (reduction of 32.6%).

Table 5.6.7-14: Changes to Availability of Potential Bat Maternity Roost Tree Habitat in the Application Case

Habitat Suitability	Regional Study Area				Local Study Area			
	Base Case (ha)	Application C ase (ha)	Change in Area (ha)	Percent Change (%)	Base Case (ha)	Application C ase (ha)	Change in Area (ha)	Percent Change (%)
Suitable	2,943	2,915	-28	-1	86	58	-28	-32.6
Unsuitable	910	938	28	3.1	124	152	28	22.6

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Site clearing and sensory disturbance during the construction and operations phases of the NSDF Project could also result in adverse changes to the availability of potential bat maternity roosting habitat in the LSA adjacent to the SSA if the level of disturbance causes avoidance and abandonment of occupied maternity roosts. Detailed information on how bats respond to anthropogenic noise is limited and varies among species; however, it is known that female bats may abandon their maternity roosts and young if noise is at a sufficient level. Bats have been found to abandon roosts when they are directly disturbed by human activity, especially those causing loud and sudden noises (California Department of Transportation 2016). Information on how noise (decibel) levels effect roosting bats is not currently available. Noise frequencies that overlap with echolocation frequency ranges (i.e., approximately 10 to 70 kHz) are expected to have the greatest effect on bats (Heffner et al. 2003, 2013; Koay et al. 2002, 2003). Harrison (1965) found that little brown myotis did not respond to frequencies above 40 kHz when in torpor (i.e., while roosting). A study by Luo et al. (2014) found bats were more sensitive to noise when it occurred closer to sunset as opposed to earlier in the daily roosting period and responded least to traffic noise and most to vegetation noise (e.g., rustling of leaves), possibly because traffic noise was at a lower frequency than their hearing range. Noise produced by vehicles, construction equipment and industrial and commercial facilities is usually below 10 kHz (Berglund et al. 1996; Nemeth and Brumm 2009). Bats may rapidly become habituated to repeated and prolonged noise exposure (e.g., bats roosting under bridges) (Luo et al. 2014). Potential maternity roosting habitat is predicted to be affected in the immediate perimeter of the tree stands surrounding the SSA.

Maternity roosts are only seasonally occupied. Because vegetation clearing for the NSDF Project will be conducted outside of the bat maternity roosting period (May 1 to August 31) when potential roost trees are not occupied, the NSDF Project will not result in a loss of actively used habitat. The RSA is dominated by forested ecosystems and the estimated number of suitable roost trees for the entire property, including suitable roost trees in sapling stands, exceeds 116,000 (Table 5.6.7-15). The number of suitable roost trees varies across the RSA, but is substantially higher in stand 216, which encompasses most of the area to be affected in the SSA, compared to elsewhere in the RSA (Table 5.6.7-15). This difference may be an artifact of sampling intensity, which was much higher in stand 216 than in other forested stands in the RSA.

Table 5.6.7-15: Estimated Number of Suitable Roost Trees in the Site and Regional Study Areas

Study Area	Number of Suitable Roost Trees[a]	Area (ha)	Average Roost Tree Density (#/ha)
RSA outside of SSA	110,405	3,514	31
SSA	6,485	37	175
Total (CRL site)	116,890	3,551[b]	33

a) Includes sapling stands.

b) The total area considers the total area within the CRL site covered by the FRI dataset and excludes aquatic habitat and minor gaps and slivers in GIS. For that reason, there is a discrepancy between this value and the total RSA area (if total of suitable + unsuitable habitat is added, the total is 3,853 ha).

RSA = Regional Study Area; SSA = Site Study Area; FRI = Forest Resource Inventory; GIS = geographic information system.

Acoustic monitoring for bats was carried out by CNL across the RSA during June to August 2017 to confirm activity of the three SARA-listed bat species within the stands undergoing assessment of roost tree habitat potential and within the area to be cleared for the NSDF Project (i.e., the SSA). This acoustic monitoring was undertaken using detectors set in a grid pattern within the SSA and randomly in the rest of the RSA (Appendix 5.6-4: Figures 1 and 2). Acoustic monitoring was also conducted at eight bat boxes installed as compensatory habitat to offset losses of maternity roost habitat associated with the NSDF Project. Acoustic monitoring in the SSA during the roost emergence window indicates that SARA-listed bats are roosting in suitable roost trees in the SSA, although estimated occupancy per suitable roost tree is lower than in most other stands in the RSA (Table 5.6.7-16; Appendix 5.6-4). A telemetry study was started in 2019 and will continue through 2020. This study has so far identified 15 different tree roosts on the CRL site. As such, although suitable roost trees are very abundant in stand 216, the available data indicate that many of them remain unoccupied. The intensity of roost use by SARA-listed bats estimated from acoustic detectors deployed in the SSA is consistent with individual roosting bats or small groups. The acoustic data yielded no evidence of large maternal roosting colonies of little brown myotis or northern myotis in the SSA. Little brown myotis were also confirmed to use the five of the eight bat boxes that were installed at the CRL site. A total of eight little brown myotis were observed in the bat boxes during weekly checks of the bat boxes from May 10 to July 18, 2018. In 2019, preliminary results demonstrate that half of the bat boxes are being used since the beginning of May and occupied by a few individuals. On July 16, 2019, one of the bat boxes was confirmed to be functioning as a maternity roost for little brown myotis, and four pregnant females, two juvenile males and two juvenile females were captured.

Overall, the data strongly support a conclusion that some roosts used by SARA-listed bats will be damaged or destroyed by the NSDF Project, but that potential roost tree occupancy is low (Appendix 5.6-4). Data collected during the roost emergence window in the SSA did not identify intensity of roost occupancy values consistent with maternal roosts used by large numbers of little brown myotis (Appendix 5.6-4). Spatial coverage for data collection within the SSA was high, but lack of detection of large maternal roosting colonies of little brown myotis

does not guarantee that none are present. A precautionary conclusion given the amount of available habitat would be that some larger maternal roosting colonies of little brown myotis could be present in the SSA. The data collected by CNL during the summer of 2017 and 2019 indicate that suitable maternity roost trees that are currently unoccupied are present in the RSA outside of the SSA in sufficient abundance to accommodate the three SARA-listed bat species that will be displaced as a result of the NSDF Project (Appendix 5.6-4).
The availability of additional maternity roosting habitat for displaced bats is high because maternity roosts are not likely a limiting factor within the RSA. Instead, bat populations overlapping with the RSA are limited by WNS and occur at densities that are likely to be well below the carrying capacity of the available habitat.

The 2019 telemetry study identified that large-tooth aspen are the preferred roost tree for the three bat species at risk located at the CRL site. Mitigation to protect and enhance preferred areas at the CRL site as part of a comprehensive Sustainable Forest Management Plan has the potential to offset impacts from the NSDF Project. Additionally, little brown myotis were found to occupy the bat boxes that were installed at the NSDF Project, including using these boxes as maternity roosts.

Table 5.6.7-16: Bat Species at Risk Stand Occupancy and Suitable Maternity Roost Data from the Site Study Area

Stand ID	Age Class	# SARA-Listed Species Calls/Detector Night (primary emergence window)	# All Species Calls/Detector Night (primary emergence window)	Density of Suitable Roost Trees (trees/ha)	Area of Stand within SSA (ha)	Calculated # Suitable Roost Trees (within SSA)
215	Mature	Predicted – 0.7	Predicted – 6.6	Predicted – 48.5	<0.1	1
216	Mature	0.6	3.1	262.6	22.7	5,952
218	Mature	0	0	50	0.9	44
219	Mature	0	19.3	Predicted – 48.5	3.6	175
221	Mature	Predicted – 0.66	Predicted – 6.6	Predicted – 48.5	<0.1	<1
222	Immature	0.3	0.9	Predicted – 30.8	2.4	75
223	Immature	0.3	2.0	Predicted – 30.8	1.6	49
232	Unclassified	Not assessed (not treed)			<0.1	—
354	Mature	0.4	13.5	86.7	2.2	188
501	Unclassified	Not assessed (not treed)			3.8	—
				Totals	37.2	6,485

SARA = *Species at Risk Act*; SSA = Site Study Area.

Some roosting habitat adjacent to the SSA could be adversely affected (i.e., through sensory disturbance) while it is occupied. All three species of bat exhibit high site fidelity to their maternity roosting sites, and therefore, the loss of maternity roosting habitat, even while unoccupied, has the potential to displace some roosting bats that return to the area the summer after disturbance has occurred and their former roost tree(s) have been removed.

Sensory disturbance during the construction and operations phases is assumed to degrade the quality of potential roosting habitat for bats in the LSA; however, the degree to which habitat would be avoided by bats is unknown and the effect is considered to be probable to occur. The effect would be highest during construction, with some low-level disturbance occurring through the operations phase.

The federal recovery strategy for the three bat species considered here describes the threat of roost destruction in WNS-affected areas as having a high level of concern and causal certainty (meaning there is strong evidence to link the threat to stresses on population viability; Environment Canada 2015). Active and inactive maternity roosts are considered residences for bats under SARA.

Habitat Distribution

On the regional landscape, the SSA will result in the creation of a minor gap in otherwise relatively contiguous area of potential roosting habitat (Figure 5.6.7-13). The SSA contained linear gaps in the otherwise contiguous area of potential roosting habitat caused by East Mattawa Road and the two hydroelectric corridors in the Base Case. At the local scale, the NSDF Project will result in a relatively larger gap in the local distribution of potential maternity roost habitat in the Application Case, compared to the regional distribution (Figure 5.6.7-14).

The distribution of potential maternity roost habitat is also related to gaps and corridors between forested areas that are used for commuting and foraging. Little brown myotis, northern myotis and tri-colored bat commute between their forest roost habitat and forage areas and use watercourses (i.e., streams), forest edges, or travel above the forest canopy. They may use newly created edges of the SSA, which would improve their ability to disperse or search for food and water in the Application Case. There is uncertainty with this prediction because not all species use edge habitats in the same way and they have differences in their tolerance for gap size in forest canopy coverage.

Although a positive change in movement patterns at a local scale is possible during the operations phase, the overall net effect of the NSDF Project on habitat distribution is negative because there will be a loss of potential maternity roosting habitat for little brown myotis, northern myotis and tri-colored bat and a gap in potential maternity roosting habitat distribution, with the highest relative effects at the local scale. At a broader, national level, the NSDF Project is not expected to reduce the extent of occurrence of these three species.

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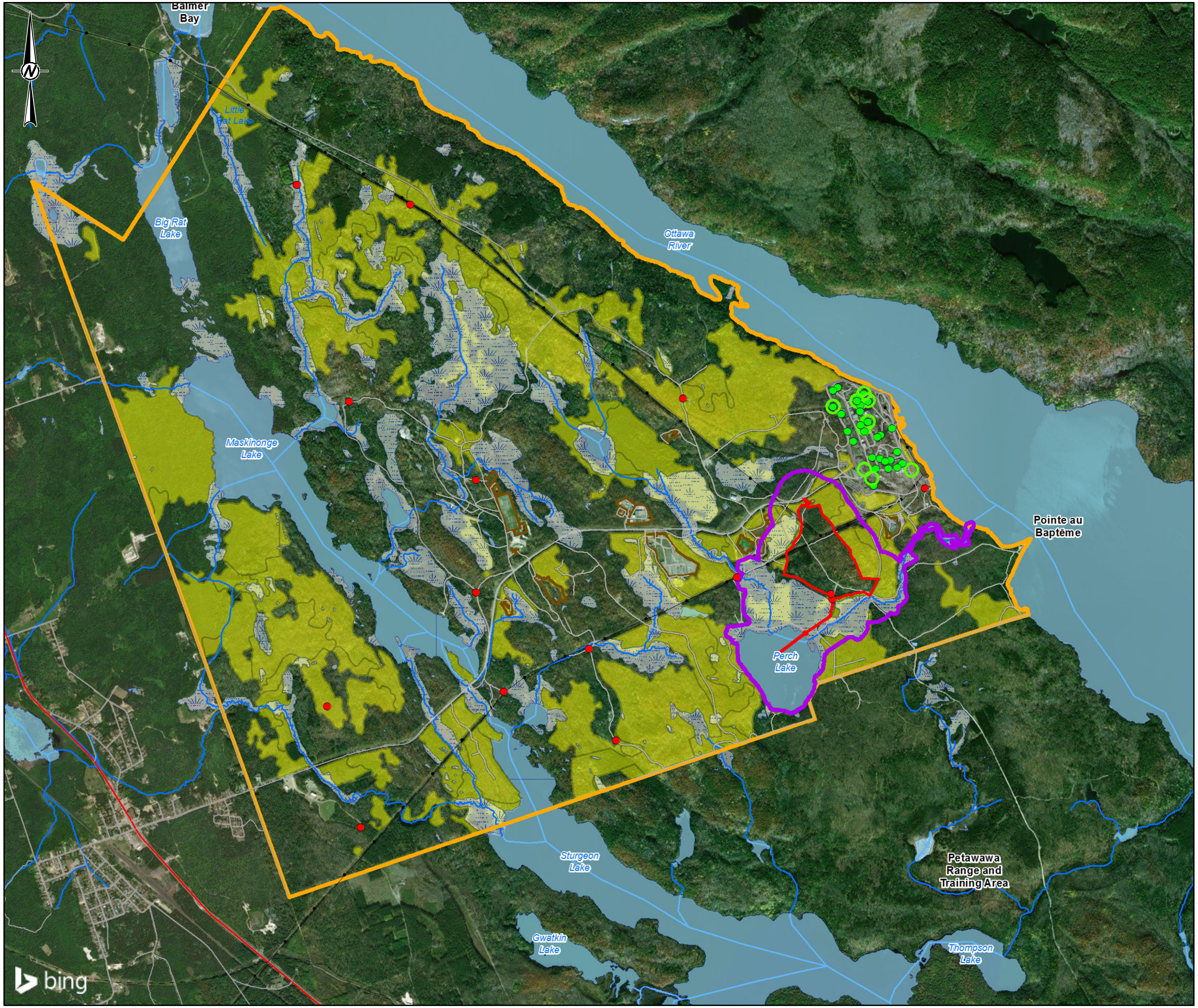

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- POTENTIAL BAT MATERNITY ROOSTING HABITAT[2]

CNL STAFF BAT MONITORING LOCATIONS

- 2016 NO SARA-LISTED SPECIES RECORDED
- 2016 - AT LEAST 1 OF 3 SARA-LISTED SPECIES RECORD
- 2015 NO SARA-LISTED SPECIES RECORDED [2]
- 2015 - AT LEAST 1 OF 3 SARA-LISTED SPECIES RECORD

1 0 1
KILOMETRES
1:35,000

NOTE(S)
1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.
2. POTENTIAL BAT MATERNITY ROOSTING HABITAT IS BASED ON HABITAT CONDITIONS, MATERNITY ROOST PRESENCE AND BAT OCCUPANCY HAS NOT YET BEEN VERIFIED.

REFERENCE(S)
1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
BAT HABITAT AVAILABILITY AND DISTRIBUTION IN THE RSA – APPLICATION CASE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.7-13

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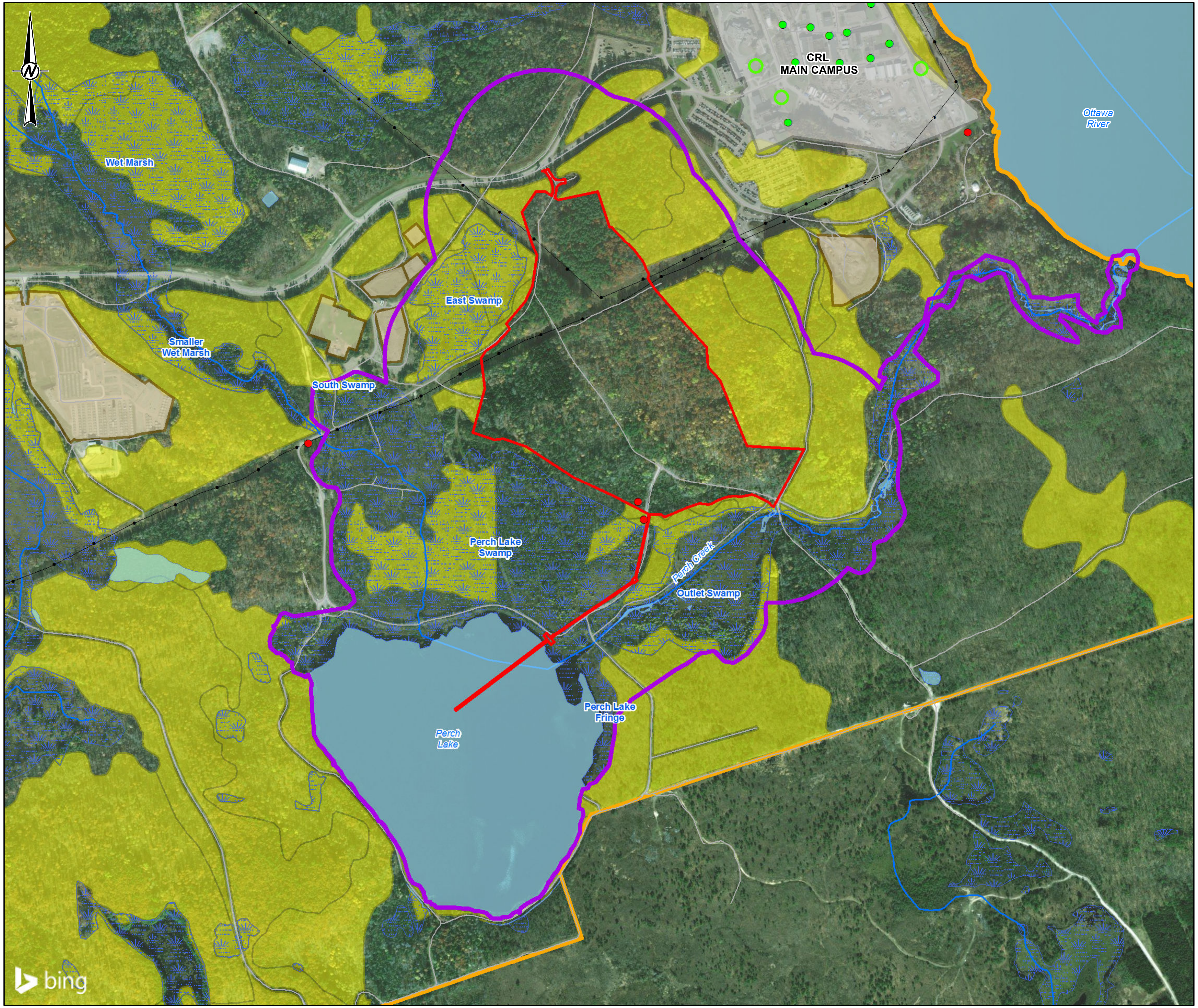

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- FENCE
- INFRASTRUCTURE
- STOCKPILE AREA
- CRL MAIN CAMPUS
- WASTE MANAGEMENT SITES (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
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250 0 250

1:10,000 METRES

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CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

BAT HABITAT AVAILABILITY AND DISTRIBUTION IN THE LSA AND SSA – APPLICATION CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.7-14

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Survival and Reproduction

Little brown myotis, northern myotis and tri-colored bat are already impaired at a population level in the Base Case due to the devastating effects of WNS at hibernacula. There will be no direct mortality of bats as a result of the NSDF Project, as the largest potential cause of mortality, removal of trees containing maternity roosts with juveniles that are not yet mobile, has been avoided through clearing outside of the period when roosts are occupied. Blasting activities are also not expected to result in direct bat mortality to bats that may be roosting under rocks as blasting will occur outside of the roosting period.

Sensory effects of noise and vibration from industrial activities (i.e., the construction and operations phases of the NSDF Project) has the potential to affect bat survival by altering their ability to effectively carry out echolocation (Mackay and Barclay 1989; Schaub et al. 2008; Siemers and Schaub 2011). Available research has not resulted in definition of measurable thresholds that may negatively affect bat activity (e.g., decibel levels). Noise has been found to negatively affect foraging by passive-listening bat species, especially when noise frequencies occur at the same frequency as prey noises (Jones 2008, Schaub et al. 2008, Siemers and Schaub 2011). Consequently, passive-listening bats have been found to avoid areas with high noise levels (e.g., adjacent to highways) (Schaub et al. 2008). However, echolocating species, such as little brown myotis, have been found to adapt the amplitude and duration of their calls to the ambient noise level of an environment (Luo and Wiegrebe 2016). Because bats are highly mobile, they are able to avoid areas with elevated noise. The creation of noise therefore likely represents more of an effect on habitat availability, if the noise causes bats to avoid previously occupied maternity roost habitat that is in or around areas with high noise levels (see Habitat Availability discussion above). Habitat availability is likely not limiting for bat species that already occur below carrying capacity because of WNS.

5.6.7.7.2 Prediction Confidence

CNL has initiated a research project in collaboration with Trent University to capture and track bats back to roost trees. This work is on-going and will provide valuable information on roost tree preference characteristics for the bat species at risk present at CRL and likely being displaced by the NSDF Project. Prior to this study, the surveys conducted by CNL during the summer of 2017 provided field assessment and quantification of the abundance and distribution of suitable maternity roost trees within the area to be cleared (i.e., within the SSA). The acoustic and roost tree data collected by CNL during the summer of 2017 indicate there are suitable and not fully occupied maternity roost trees in the RSA outside of the SSA. It is likely these suitable and not fully occupied maternity roost trees are in sufficient abundance to accommodate the three SARA-listed bat species that will be displaced as a result of the NSDF Project (Appendix 5.6-4). There is a high level of certainty that some roosts used by SARA-listed bats will be damaged or destroyed by the NSDF Project, but that potential roost tree occupancy is low. Based on acoustic monitoring in 2017 conducted in the SSA and elsewhere in the RSA, there is a moderate level of certainty that large maternity roosting colonies of little brown myotis and northern myotis are not present within the SSA. Northern myotis are not known to have large maternity roost colonies (i.e., in the 100s of individuals), and based on activity patterns from the acoustic data, it is unlikely, albeit possible, that there are large maternity roost colonies for little brown myotis within the SSA. High certainty that maternity roosting colonies are not present can only be achieved through visual emergence counts at individual roost trees.

There is a moderate level of certainty that noise from vehicles, construction equipment and the NSDF Project will not negatively affect roosting or foraging bats through sensory disturbance, as noise frequencies generated by vehicles, construction equipment and industrial facilities are generally below the hearing range of bats.

The predictions of the availability and distribution of maternity roosting habitat within the RSA has been updated with some field survey effort in 2017; however, it is still largely based on desktop vegetation community data, which itself is primarily based on a relatively old spatial dataset. There are attendant levels of error in using spatial data that have not undergone a high degree of ground-truthing. The ground-truthing of the number of suitable roost trees at a high degree of survey intensity within the SSA has improved the prediction of the availability and distribution of maternity roosting habitat within the SSA. However, the survey intensity in other areas of the RSA was not as high, and predictions on the availability and distribution of maternity roosting habitat has a higher degree of uncertainty as a result of having to use greater levels of predictions to fill in gaps in spatial coverage.

5.6.7.7.3 Residual Effects Classification

A summary of the classification of incremental adverse residual effects of the NSDF Project on bats in the Application Case is provided for each indicator in Table 5.6.7-17. Residual effects after the implementation of effective mitigation are described, and are summarized according to direction, magnitude, geographic extent, duration/reversibility, frequency/timing and likelihood of the effect occurring following the methods described in Section 5.6.6.3 and the definitions provided in Table 5.6.6-1.

Table 5.6.7-17: Classification of Residual Effects on Bats in the Application Case

Indicator	Characteristic	Rating/Effect Size
Habitat Availability	Direction	Negative
	Magnitude	Direct loss of 28 ha of potential maternity roosting habitat (1% of RSA Base Case or 32.6% of LSA Base Case); potential avoidance of adjacent maternity roosting habitat due to sensory disturbance in the LSA
	Geographic Extent	SSA (direct habitat loss); Local (sensory disturbance)
	Duration/Reversibility	Permanent/Irreversible (direct habitat loss); Medium-term (sensory disturbance)
	Frequency/Timing	Continuous
	Likelihood	Probable (direct habitat loss) Possible (avoidance of maternity roosting habitat)
Habitat Distribution	Direction	Negative
	Magnitude	Creation of a gap in potential maternity roost habitat but overall a negligible change in movement corridors between maternity roosting habitat patches due to high mobility of species and relatively small gap created in area with high forest cover
	Geographic Extent	Local
	Duration/Reversibility	Permanent/Irreversible
	Frequency/Timing	Continuous
	Likelihood	Possible
Survival/ Reproduction	Direction	Neutral
	Magnitude	n/a
	Geographic Extent	n/a
	Duration/Reversibility	n/a
	Frequency/Timing	n/a
	Likelihood	Possible

Note: If a net effect was identified as positive or neutral, no additional effects characteristics, other than probability of occurrence were summarized.

LSA = Local Study Area; RSA = Regional Study Area; SSA = Site Study Area; n/a = not applicable.

5.6.7.7.4 Determination of Significance

Populations of little brown myotis, northern myotis and tri-colored bats that overlap the RSA are highly sensitive to changes in survival and reproduction because WNS has resulted in dramatic declines of these species across the eastern portions of their Canadian range, which includes the RSA. Because of their rapidly declining populations, these species are more vulnerable to additional threats, including changes in habitat availability, distribution, or other factors affecting the survival and reproduction of the remaining individuals (ECCC 2018c). Therefore, the existing level of pressure on these bat species in the Base Case has likely already exceeded their resilience and adaptability limits.

The grouping behaviour shown by bats in maternity roosts also makes them more sensitive to the loss of certain habitat features because the removal of relatively small numbers of habitat features, such as snags, can have a disproportionately large effect on local populations, if large numbers of bats previously congregated in snags that will be permanently removed. However, because WNS is such a strong limiting factor that overrides other potential causes of decline, maternity roosting habitat availability is not likely a limiting factor, at least not in places where such habitat is abundant, such as within the RSA. In the RSA, relatively undisturbed, mature forest stands are available and interspersed with numerous small lakes and wetland areas, which represent high quality and widely available foraging habitat.

All three species are inherently resilient to changes in their habitat based on their high degree of mobility, and one of the three species, little brown myotis, is well adapted to human disturbance, commonly using human structures for maternity roosting habitat and confirmed using the bat boxes at the CRL site, including as maternity roosts. Northern myotis have been recorded to roost in bat boxes (Whitaker et al. 2006) and tri-colored bats will possibly roost in anthropogenic structures, but not as commonly as little brown myotis.

Rapid declines in abundance due to WNS may have already exceeded the resilience and adaptability limits of bats in the Base Case. Therefore, in the Base Case, little brown myotis, northern myotis and tri-colored bat populations that overlap with the RSA are considered unlikely to be self-sustaining or ecologically effective. Consequently, the cumulative effects of existing disturbance and especially the introduced WNS are considered significant in the Base Case.

In the Application Case, the NSDF Project will remove a small amount of roosting habitat. Importantly, because vegetation clearing and blasting will be undertaken outside of the maternity roosting season, no mortality of roosting bats is expected as a result of the NSDF Project and effects of the NSDF Project to survival and reproduction are considered neutral. The SSA will permanently remove 28 ha of potential maternity roosting habitat. This represents approximately 30% of available maternity roosting habitat in the LSA and 1% in the RSA. Additional areas of roosting habitat in the LSA that are immediately adjacent to the SSA may also be avoided due to sensory disturbance during the construction and operations phases of the NSDF Project. The NSDF Project may also result in changes in local movement patterns by widening existing gaps in the forest canopy created by East Mattawa Road and the two hydroelectric corridors, and installation of a six-foot high perimeter fence. These local-scale changes are not expected to alter the extent of populations that overlap with the RSA because bats are highly mobile and capable of long commute distances, well beyond the boundaries of the RSA. The remaining availability of potential maternity roosting habitat in the Application Case is not likely a limiting factor in the RSA, and CNL has committed to mitigation such as bat boxes and a comprehensive Sustainable Forest Management Plan. Therefore, the contribution of the NSDF Project to the existing significant adverse cumulative effect to bats is predicted to be negligible (i.e., no detectable changes to bat populations), and the Project does not contribute to the spread of WNS, which is the primary driver of the existing significant adverse cumulative effect.

On-going fire suppression in the RSA may increase bat habitat availability as forests progress towards old growth age and habitat attributes preferred by these species (e.g., snags, large-diameter cavity trees) become increasingly available. Climate change is also likely to affect bat populations for the foreseeable future, although the direction and magnitude of changes are uncertain because predictions are based on simulations that can be highly variable and many scenarios are possible. Severity of climate change as a threat to the sustainability of species at risk bat populations in Canada is identified as unknown (ECCC 2018c). Warmer and drier conditions in Ontario due to climate change may alter the onset of spring and summer and the timing of insect hatches (Nituch and Bowman 2013). Therefore, climate change may affect synchronization between bat breeding and peak food abundance by creating a temporal mismatch between reproduction and optimal foraging conditions for prey (ECCC 2018c). Overall, the weight of evidence from the analysis of primary pathways predicts that changes to bat habitat availability, habitat distribution, and survival and reproduction in the RSA as a result of the NSDF Project are expected to result in no detectible adverse effect to bat population in the RSA. In addition, CNL had implemented and committed to mitigation that may offset the potential adverse effects of the NSDF Project. Therefore, the contribution of the NSDF Project is not significant, nor is it expected to contribute to potential future adverse effects associated with climate change.

5.6.7.8 Blanding's Turtle

5.6.7.8.1 Residual Effects Analysis

Habitat Availability

The NSDF Project is estimated to remove 26 ha of critical habitat for Blanding's turtle, which represents a loss of 14.5% of the critical habitat in the LSA and 0.9% of the critical habitat in the RSA (Table 5.6.7-18). The direct removal of 26 ha is mainly composed of upland habitat. The transfer line to Perch Lake was included in the Project footprint and, as such, some wetland habitat was conservatively assumed to be removed by the transfer line. However, the transfer line will be installed underground using high-pressure directional drilling and so will not require surface disturbance (i.e., avoids the destruction of critical habitat). A small trench (2 m depth) will be excavated in the shoreline of Perch Lake to install the discharge transfer line, and a steel pile foundation will be used to suspend the line over the soft sediments in the open water section of the lake.

The destruction of critical habitat for the Blanding's turtle will require a permit under Section 73 of SARA. ECCC issues permits for activities affecting species listed on Schedule 1 of SARA on a case-by-case basis. CNL is in on-going engagement with ECCC regarding this species at risk and the management of the CRL site and consequent protection and conservation of the population and its habitats. Critical habitat will be assessed annually to ensure no significant loss at CRL and to determine compensation measures initiated at CRL or elsewhere. As such, the residual effect from the NSDF Project on Blanding's turtle habitat availability is predicted to be neutral.

Four Priority 2 culverts will be replaced within two years after the approval of the NSDF Project. Artificial nest mounds will be constructed on both sides of these culverts following guidelines developed by the Northeast Blanding's Turtle Working Group (NBTWG, no date). These artificial nesting mounds will be monitored for use by turtles during the nesting period using methods adapted from provincial protocols (MNR 2013b). Specifically, nesting surveys will be conducted at least once per week during the nesting period (May 15 to June 30); additional surveys will be completed after periods of rain to capture potential increases in nesting behaviour associated with even light rainfall (MNR 2013b; Golder 2019a). Nest mound maintenance (e.g., vegetation removal) will also be completed during nest mound inspections, if females are not present. More details on the locations of nesting mounds are presented under Survival and Reproduction.

Table 5.6.7-18: Changes to Blanding’s Turtle Critical Habitat and Potential Habitat Availability in the Application Case

Habitat Suitability	Regional Study Area				Local Study Area			
	Base Case (ha)	Application Case (ha)		Base Case (ha)	Application Case (ha)		Base Case (ha)	Application Case (ha)
Critical Habitat	2,788	2,762	-26	-0.9	179	153	-26	-14.5
Potential Critical Habitat	571	571	0	0	0	0	0	0
Unsuitable Habitat	493	519	26	5.3	31	57	26	83.9

Sensory disturbance (e.g., noise, light) during the construction, operations and closure phases could indirectly reduce Blanding’s turtle habitat availability in the LSA if Blanding’s turtles avoid areas adjacent to the SSA. The population of turtles using the RSA has likely adapted somewhat to the current level of activity in the RSA. Additionally, records of this species nesting in active sand and gravel pits, as well as along roadsides are not uncommon (ECCC 2018b), which suggests Blanding’s turtles can tolerate some level of anthropogenic sensory disturbances. The incremental increase in noise and light caused by the NSDF Project is not predicted to have a measurable effect on the behaviour of Blanding’s turtles in adjacent habitats (such as Perch Lake). Blasting activities in the SSA are expected to meet the DFO guidelines for protection of fish and fish habitat from vibrations, chemicals and sedimentation, and it is anticipated that this protection will also extend to turtles and turtle habitat. Additionally, Blanding’s turtles will be excluded from access to the SSA, so it is not anticipated that vibrations from activities within the SSA will have an effect on Blanding’s turtles.

The measures included in the Blanding’s Turtles Road Mortality Mitigation Plan serve to compensate for the removal of 26 ha of critical turtle habitat due to NSDF project construction by: increasing connectivity of habitat on either side of Plant Road using culverts, promoting turtle abundance through protection of nesting mounds and installation of exclusionary fencing. These compensatory measures are designed to meet the species population and distribution objectives outlined in the Recovery Strategy for the Blanding’s Turtles (ECCC 2018b).

A neutral net change to critical habitat availability for Blanding’s turtles as a result of the NSDF Project is probable because CNL has committed to assessing the amount of critical habitat on the CRL site on an annual basis to ensure no significant loss at CRL. Effects from changes to habitat availability will occur at the regional to beyond regional scale depending on where compensation measures are initiated. Effects from direct habitat loss will be infrequent (i.e., occur once during Project construction) and reversible in the long term with the implementation of compensation measures and the creation of nesting habitat at four Priority 2 culverts. Effects from sensory disturbance are not expected to be measurable, but any minor effects that might occur would be reversible over the long term.

Habitat Distribution

The development of the NSDF Project will have a minor effects on critical habitat distribution and connectivity for Blanding's turtle in the RSA. Critical habitat and potential critical habitat remains abundant and well connected in the RSA in the Application Case (Figure 5.6.7-15). Mitigation will be implemented to avoid and minimize the loss and fragmentation of critical habitat:

- The NSDF Project will use many existing roads instead of creating new ones, and road upgrades will occur at the local scale.
- The transfer line to Perch Lake will be installed underground using high-pressure directional drilling.
- Four Priority 2 culverts will replaced within two years after approval of the NSDF Project. Replaced culverts will be enhanced by having nesting mounds created on both sides of the culvert, as well as by planting native vegetation around the culvert entrances, while maintaining a clear line of site through the culvert (Golder 2019a). These changes are anticipated to increase habitat connectivity for turtles at Application Case. Additionally, Priority 2 culverts are currently inspected weekly during the turtle active season (May to October) and after periods of heavy rainfall (≥7 mm/hr) (Golder 2019a). These inspections will continue throughout the life of the CRL site. During the inspections, barriers that can impede the passage of turtles through the culverts are removed or modified (Golder 2019a). More details on Priority 2 culverts are presented in the Blanding's turtle Survival and Reproduction section, below.

The main Blanding's turtle migration corridors will remain intact within the LSA and RSA. In particular, the wetland complexes which are likely the principal movement routes will remain in their existing condition and the NSDF Project will not alter their connectivity. The replacement of four Priority 2 culverts may improve habitat connectivity relative to baseline conditions. The creation of artificial nesting mounds near the four Priority 2 culverts will increase the availability of nesting habitat and mitigate potential barrier effects from erecting exclusion fencing (i.e., it is uncertain if Blanding's turtles use existing culverts to cross roads).

The NSDF Project is surrounded by wetlands that are known to provide habitat for Blanding's turtles (Figure 5.6.7-16) and there are some areas within the SSA and LSA that have the potential to be nesting habitat for Blanding's turtle. The development of the NSDF Project will alter Blanding's turtle movement patterns and access to potential nesting habitat in the SSA because the SSA will be surrounded by a fence that will exclude wildlife, including Blanding's turtles, from accessing the site.

This species shows site fidelity to wetlands that are used as overwintering habitat and to areas that are used for nesting year after year. Therefore, the movements of this species from overwintering areas to nesting areas could be disrupted by the development of the NSDF Project. However, despite a two-year telemetry study and considerable search effort in and around the SSA (Section 5.6.4.9.2), no evidence of Blanding's turtle occurrence or movement through the SSA has been recorded. The local change in connectivity may therefore affect only a small portion of the regional population, namely individuals that overwinter around Perch Lake and that travel northwards through the SSA during the active period (May 1 to September 30). These individuals would have to travel around the outside of the fence if they need to move around the SSA to reach locations they require to carry out their life history requirements such as foraging, thermoregulation and nesting. If Blanding's turtles use the SSA as a movement corridor between habitats, the NSDF Project will increase travel distances.

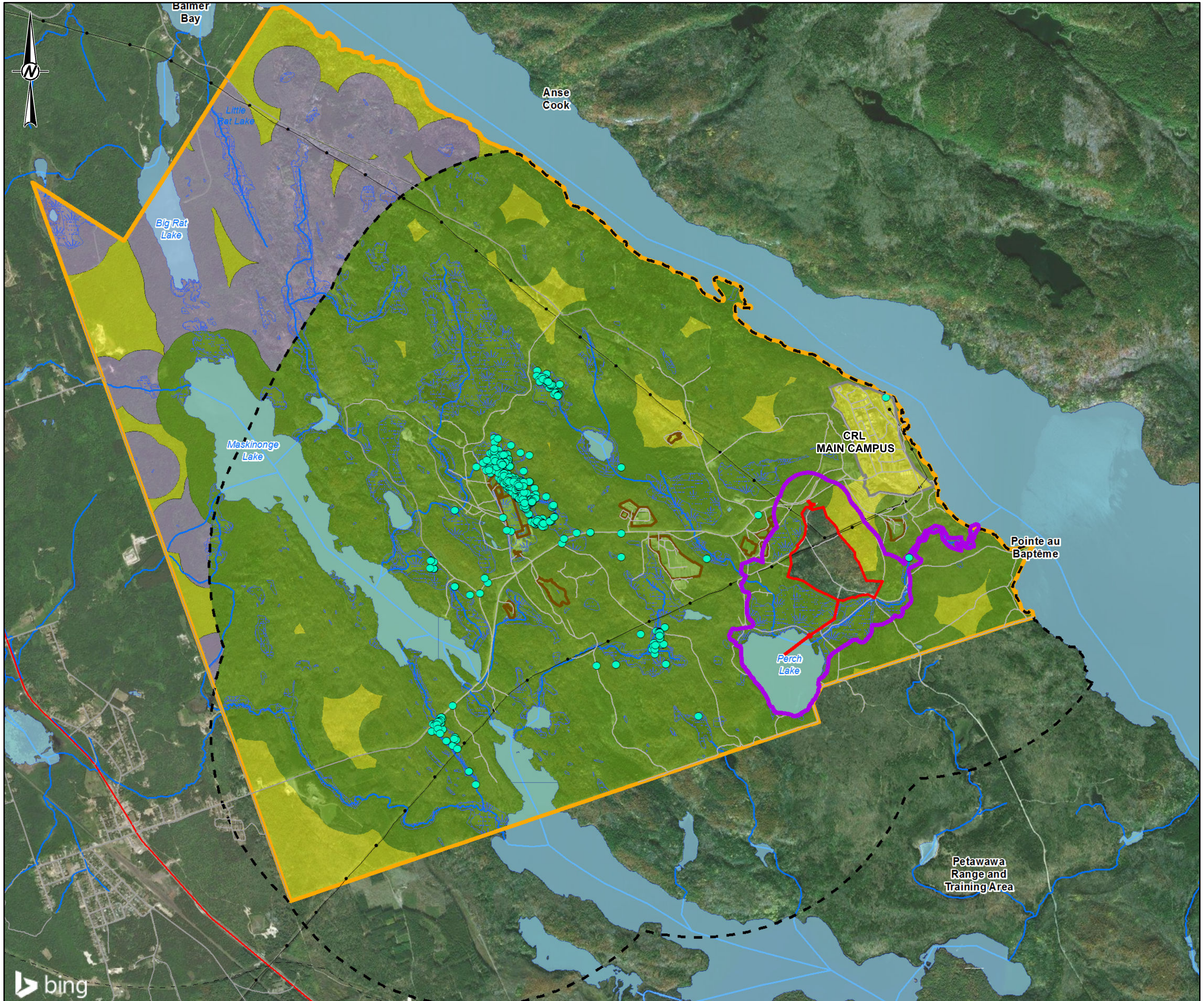
Effects on Blanding's turtles from changes to habitat distribution are probable because the SSA could alter the movement of turtles in the LSA; however, it is uncertain if the SSA is used for movement and nesting functions at baseline. Effects will be continuous and permanent because the development of the NSDF Project will result in the permanent reconfiguration of habitat on the landscape.

Survival and Reproduction

Site clearing is not expected to cause Blanding's turtle mortality because it will be performed in the winter when individuals are hibernating and wetlands (i.e., potential hibernation habitat) will be affected only by the addition of the transfer line to Perch Lake. Additionally, to avoid negative interactions with nesting turtles, road grading and levelling activities will not be completed during the turtle terrestrial season (May 15 to September 30). In addition, in-water work will not occur between October 1 and April 15 to avoid adverse effects to hibernating turtles.

Temporary exclusion fencing will be installed around the NSDF EMR footprint during construction of the NSDF Project. This temporary exclusion fencing will be replaced by permanent fencing by the end of construction of the NSDF Project. This permanent reptile exclusion fencing will be installed around the perimeter of the site and will remain in place for the life of the NSDF Project to avoid having Blanding's turtles access the active site and become at risk of injury or mortality. Exclusion fencing will be installed according to provincial guidelines for the target species, including Blanding's turtle (MNR 2013c). Inspection of temporary and permanent fencing will be undertaken annually. Therefore, effects on Blanding's turtle survival from NSDF Project activities within the fenced perimeter are neutral.

As the SSA supports Blanding's turtle critical habitat, specifically upland habitat adjacent to wetlands that has the potential to be nesting habitat, the permanent loss of critical habitat due to the NSDF Project has the potential to result in a change in reproductive success until the females using this habitat find new nesting areas. Effects on Blanding's turtle reproduction from the loss of critical habitat are possible at the local scale. Effects from habitat loss are anticipated to be continuous and permanent. To help limit movement requirements for females to reach nesting areas and to compensate for potential losses caused by the NSDF Project, nesting mounds will be created on both sides of the Priority 2 culverts (culverts J2, K1, C9, and V22) after the culverts have been replaced (Figure 5.6.7-17). These nest mounds will be created after the approval of the NSDF Project. To improve the chance of successful nesting wire-screen cages will be deployed over areas were eggs have been laid. Up to a total of 30 cages will be deployed in the RSA. These nest cages will be designed according to guidelines adapted from Gillingwater (2008) and Ratnaswamy et al. (1997) (Golder 2019a). Nest cages will be deployed during the nesting season (May 15 to June 30) and weekly inspections of the cages will be completed from the end of the nesting period through to the end of the hatchling emergence period (July 1 to October 15). Cages will be retrieved prior to May 15 of the following year. Implementation of this mitigation has the potential to result in a net benefit to Blanding's turtle nesting habitat and reproductive success because of the NSDF Project.



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- SITE STUDY AREA
- BLANDING'S TURTLE OBSERVATION
- BLANDING'S TURTLE CRITICAL HABITAT
- BLANDING'S TURTLE POTENTIAL CRITICAL HABITAT
- BLANDING'S TURTLE UNSUITABLE HABITAT
- BLANDING'S TURTLE OBSERVATION 2 km RADIUS

1 0 1

1:35,000 KILOMETRES

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CHALK RIVER, ONTARIO

TITLE
BLANDING'S TURTLE HABITAT AVAILABILITY AND DISTRIBUTION IN THE RSA – APPLICATION CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.7-15

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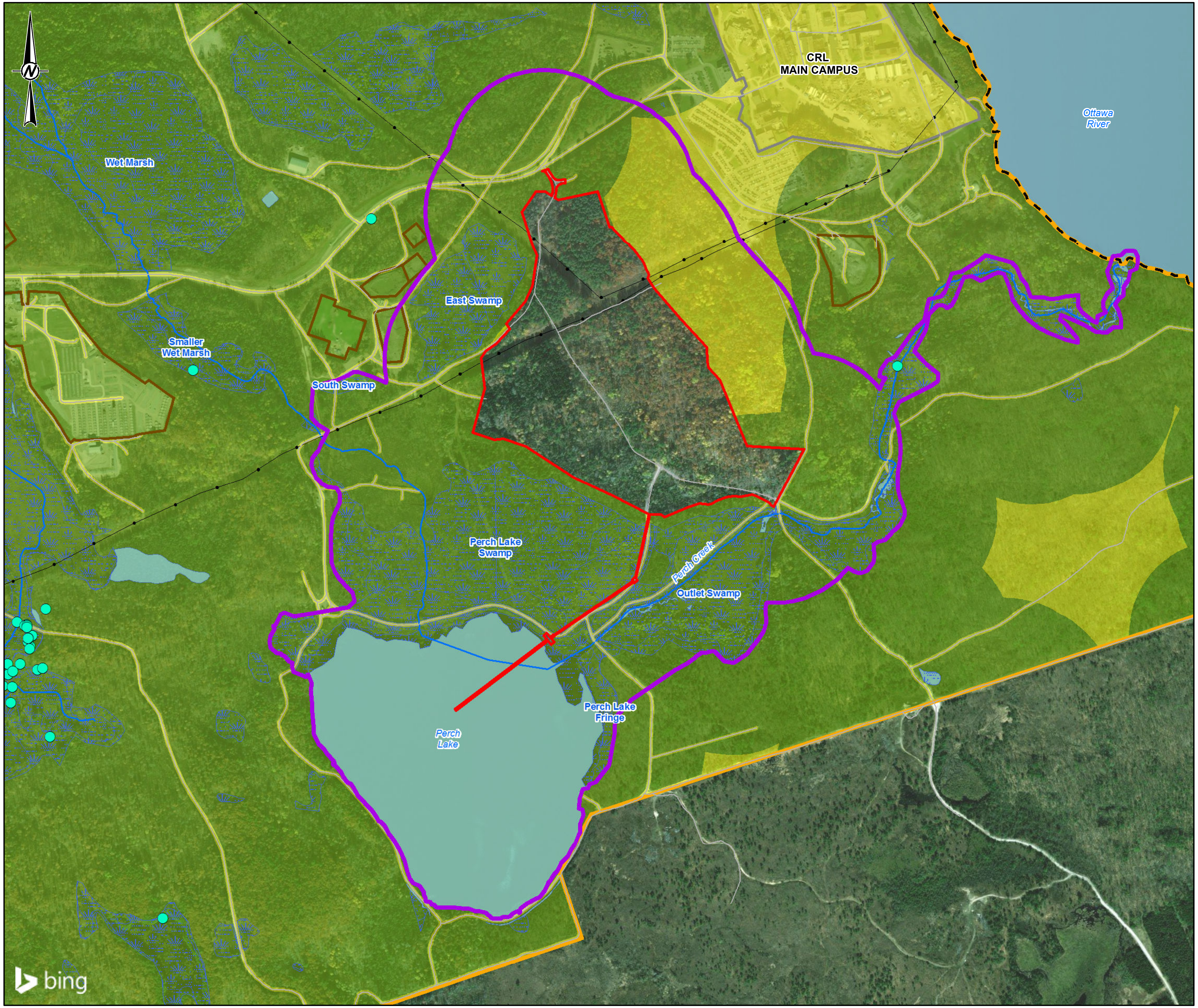

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- BLANDING'S TURTLE OBSERVATION
- BLANDING'S TURTLE CRITICAL HABITAT
- BLANDING'S TURTLE UNSUITABLE HABITAT
- BLANDING'S TURTLE OBSERVATION 2 km RADIUS

250 0 250

1:10,000 METRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

BLANDING'S TURTLE HABITAT AVAILABILITY AND DISTRIBUTION IN THE LSA AND SSA – APPLICATION CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.7-16

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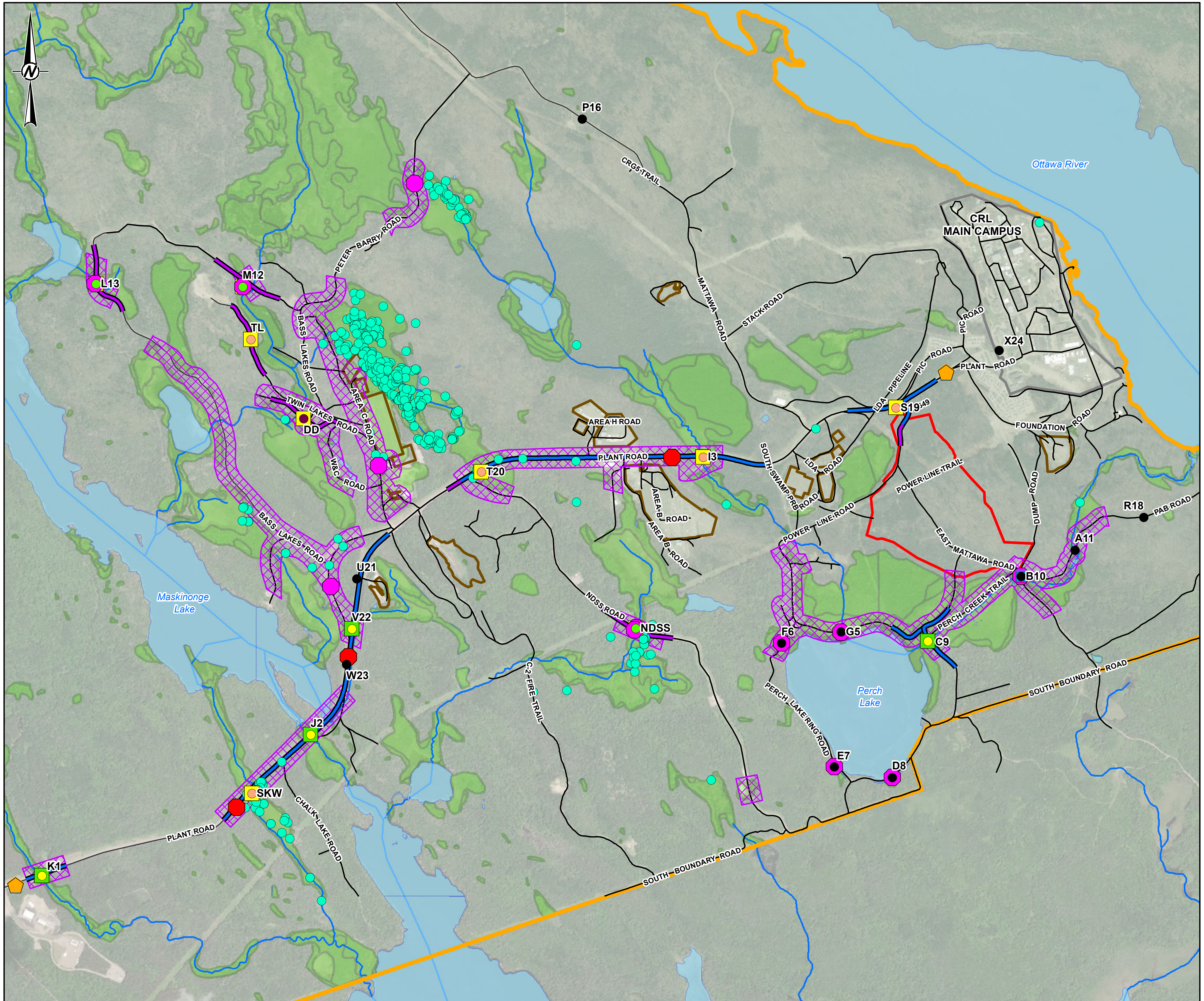

LEGEND

- ROAD
- RIVER/STREAM
- WATERBODY
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- CRL PROPERTY
- NEAR SURFACE DISPOSAL FACILITY (NSDF) PROJECT SITE
- WETLANDS

DESCRIPTION

- CULVERT
- PRIORITY 1 CULVERT
- PRIORITY 2 CULVERT
- PRIORITY 3 CULVERT
- CULVERT TO BE INSTALLED IN 2019
- BLANDING'S TURTLE OBSERVATION
- BOX TUNNEL CROSSING
- REPTILE HOTSPOT

MITIGATION MEASURES IMPLEMENTED AT BASE CASE

- ARTIFICIAL NEST MOUNDS
- ELECTRONIC SLOW SPEED SIGN (MAY 15-JUNE 30)
- PERMANENT TURTLE CROSSING SIGN; SLOW SPEED LIMIT POSTING (MAY 15 - JUNE 30)
- EXCLUSION FENCING

MITIGATION MEASURES IMPLEMENTED AT APPLICATION CASE

- ARTIFICIAL NEST MOUNDS
- PERMANENT TURTLE CROSSING SIGN; SLOW SPEED LIMIT POSTING (MAY 15 - JUNE 30)
- EXCLUSION FENCING

0.5 0 0.5

1:20,000 KILOMETRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT CHALK RIVER, ONTARIO

TITLE

BLANDING'S TURTLE MITIGATION TO BE IMPLEMENTED AT APPLICATION CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	PR
PREPARED	PR
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.7-17

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Road mortality is one of the main threats to Blanding's turtles and is thought to lead to population declines for this species. CNL has committed to reducing road mortality through implementation of the *Blanding's Turtle Road Mortality Mitigation Plan*. Application of the plan is predicted to greatly reduce potential for road mortality in the Base Case. However, increased traffic as a result of the NSDF Project has the potential to increase the road mortality risk for Blanding's turtles in some places around the SSA. East Mattawa Road will be upgraded to accommodate the traffic going to and from the ECM. Traffic to the SSA during construction will predominantly be from Plant Road to East Mattawa Road and during the operations phase will predominantly be from ER-3 (Emergency Road) to East Mattawa Road.

Four Priority 2 culverts (culverts J2, K1, C9, and V22) will be replaced within two years after the NSDF Project has been approved (Figure 5.6.7-17) and will mitigate effects from the NSDF Project. After replacement, these culverts will have appropriate permanent fencing installed for 200 m on either side of the culvert to guide turtles through the tunnel. Following approval of the NSDF Project, additional permanent exclusion fencing will be installed in reptile hotspots along Plant Road (Figure 5.6.7-17). Inspection of permanent fencing and culverts will be undertaken weekly during the active turtle season (April to October) and after heavy rainfall events (≥7 mm/hr) (Golder 2019a).

Once Priority 2 culverts are replaced, they will be enhanced by planting native vegetation around the culvert entrances, while maintaining a clear line of site through the culvert (Golder 2019a). To monitor the use of culverts by turtles, game cameras will be installed at all new and replaced Priority 1 and Priority 2 culverts; camera installation will occur during construction of the NSDF Project. These cameras will be programmed to take at least three photos at one-minute intervals throughout the nesting period.

To reduce potential road mortality of turtles during the construction of the NSDF Project, a "sentinel" will drive in front of big trucks that travel along Plant Road, ER-3 (Emergency Road), and East Mattawa Road. Additional monitoring for turtles will also be completed along Plant Road during peak traffic hours.

To increase employee, contractor, and visitor awareness about the presence of turtles on the CRL site, the following mitigations will be implemented prior to the construction of the NSDF Project:

- An additional 12 permanent turtle crossing signs will installed along Plant Road and secondary roads (Figure 5.6.7-17); and
- The presence of turtles on the NSDF site will communicated to contractors and visitors at the outer gate or B700 lobby.

Road mortality surveys will continue to be completed weekly along Plant Road and along hotspots on secondary roads during the active turtle season (April to October) (Figure 5.6.7-17; Golder 2019a). As part of the adaptive management component of the *Blanding's Turtle Road Mortality Mitigation Plan*, results from the road mortality surveys will be used to consider the implementation of additional mitigation. For example, if there are road mortality hotspots, permanent exclusion fencing, crossing structures, and/or reduced speed limits during the nesting period may be implemented at these locations.

Adaptive management is an important part of the *Blanding's Turtle Road Mortality Mitigation Plan*. Depending on results of monitoring, CNL is committed to taking additional actions, as required, to achieve a neutral or positive contribution to Blanding's turtles. Potential additional actions would be developed as needed, but could including activities such as incubating Blanding's turtle eggs in facilities that would located on the CRL Site, which would result in improved recruitment into the population. Eggs that are incubated would be those rescued from the CRL site and more broadly from Renfrew County and hatchlings would be released in the RSA or other areas where eggs were collected to support the local Blanding's turtle population.

If the mitigations listed above are effective, then the risk of road mortality on Blanding's turtle from the increased traffic associated with the NSDF Project is not anticipated to affect the local population. Effects on Blanding's turtle survival and reproduction from road mortality are possible at the local scale. Effects from road mortality due to the NSDF Project are anticipated to be infrequent but irreversible (permanent). Mitigation implemented for the NSDF Project has the potential to reduce mortality of Blanding's turtles. This reduction in mortality would be in addition to the reductions in turtle mortality predicted for Base Case after all mitigation is implemented (Section 5.6.4.9.3). Implementation of adaptive management by CNL, including potential for additional measures to improve survival and reproduction of Blanding's turtles, such as egg incubation, provides confidence that the NSDF Project will not cause a net reduction is Blanding's turtle survival and reproduction.

5.6.7.8.2 Prediction Confidence

The residual effects assessment for Blanding's turtle is based on an adequate knowledge of the species' life history characteristics and some understanding of the sensitivities of populations of long-lived organisms to anthropogenic disturbance.

CNL conducted surveys for Blanding's turtles from 2009 to 2018, which resulted in observations of individual Blanding's turtles and confirmation of some hibernation habitat in the RSA and LSA. There is high confidence that a Blanding's turtle population is present in the RSA and a high likelihood that they use the LSA. However, their use of the SSA has not been confirmed and the location of suitable nesting habitat in the RSA, LSA, and SSA has not been confirmed. The use of the habitat within the SSA by Blanding's turtles is not known. This assessment used a precautionary approach to manage uncertainty and assumed that nesting habitat was present in the SSA. This approach may have resulted in an overestimation of the potential effects of the NSDF Project on Blanding's turtles. As part of the SARA permitting process for the removal of critical habitat, ECCC will require the identification and mapping of Blanding's turtle habitats within the SSA to characterize the habitat loss and determine site-specific actions to be taken to compensate for the habitat loss due to the NSDF Project.

The effectiveness of the *Blanding's Turtle Road Mortality Mitigation Plan* remains uncertain as it has only recently been implemented and monitoring has just been initiated. However, other road mitigation plans for this species have been effective in keeping turtles off roads and reducing roadkill. Therefore, this mitigation has a moderate level of certainty. Adaptive management committed to by CNL provides additional confidence that mitigation implemented for the NSDF Project will result in no net loss to Blanding's turtles as a result of the Project relative to the Base Case.

There is a high level of uncertainty associated with the long-term conservation prospects for the Great Lakes / St. Lawrence population of Blanding's turtle. Evidence suggests that populations are declining across the species' range in Canada. If the declining population trend is not reversed or accelerates over the next decade, then Blanding's turtle may be up-listed from Threatened to Endangered, as recommended by COSEWIC (2016).

5.6.7.8.3 Residual Effects Classification

A summary of the classification of incremental adverse residual effects of the NSDF Project on Blanding's turtle in the Application Case is provided for each indicator in Table 5.6.7-19. Residual effects after the implementation of effective mitigation are described, and are summarized according to direction, magnitude, geographic extent, duration/reversibility, frequency/timing and likelihood of the effect occurring following the methods described in Section 5.6.6.3 and the definitions provided in Table 5.6.6-1.

Table 5.6.7-19: Description of Residual Effects on Blanding's Turtle in the Application Case

Indicator	Characteristic	Rating/Effect Size
Habitat Availability	Direction	Neutral
	Magnitude	No loss of critical habitat
	Geographic Extent	Regional to beyond regional[(a)]
	Duration/Reversibility	Long-term
	Frequency/Timing	Infrequent / Once during construction
	Likelihood	Probable
Habitat Distribution	Direction	Negative
	Magnitude	Potential change in movement corridors between habitat patches due to development of the NSDF Project
	Geographic Extent	Local
	Duration/Reversibility	Permanent/Irreversible
	Frequency/Timing	Continuous
	Likelihood	Probable
Survival and Reproduction	Direction	Neutral
	Magnitude	No reduction in reproductive success
	Geographic Extent	Regional to beyond regional[(a)]
	Duration/Reversibility	Long-term
	Frequency/Timing	Continuous
	Likelihood	Probable

RSA = Regional Study Area; LSA = Local Study Area; SSA = Site Study Area.

[(a)] Effects will be beyond regional if compensation measures are implemented outside of the RSA

5.6.7.8.4 Determination of Significance

The population of Blanding's turtles that overlaps with the RSA is considered highly sensitive to changes in habitat availability, distribution, and survival and reproduction. Two of the primary threats (noted as the highest levels of concern) to this species are road and networks and exotic and invasive species (European common reed [*Phragmites australis* ssp. *australis*]) (ECCC 2018b). Isolation of local populations resulting from land conversion and habitat loss is also of special concern for this species (ECCC 2018b).

Blanding's turtles display fidelity to hibernation and nesting habitat, and therefore its elimination can result in long distance travel in search of new habitat and the use of lower quality habitat. A total of 179 ha and 2,788 ha of critical habitat for Blanding's turtle is estimated to be present in the LSA and RSA, respectively, in the Base Case. An additional 571 ha of potential critical habitat is estimated to be present in the RSA. Hibernation habitat has been confirmed in several wetlands/waterbodies in the RSA and the LSA. Likely nesting habitat occurs throughout the LSA and RSA in numerous sandy outcrops that CNL has noted. In particular, there is some potential within the hydroelectric corridors that run through the SSA, the sandy outcrop adjacent to Perch Lake and the sand dunes at Pointe au Baptême. However, nesting locations have not yet been confirmed. Movement corridors likely exist through wetlands such as the Perch Creek riparian corridor and the north–south trending wetlands across Plant Road, though movement across Plant Road remains unconfirmed. Roadkill is a particular concern to the survival and reproduction of this species because it has low rates of recruitment and population growth. Two individuals from this population have been killed on the roads within the RSA in the last six years.

The Ottawa Valley Forest, which encompasses the RSA, is one of the last remaining “strong holds” for Blanding’s turtle in Ontario and Canada (Van Dyke 2011). Available data suggest that Blanding’s turtles survive and reproduce successfully in the RSA and that the RSA likely is important for the conservation of this species. Because the RSA may act as a refuge for Blanding’s turtles, road mortality on the CRL site is a primary concern for the sustainability of the regional Blanding’s turtle population. That is, there is concern that the RSA could function as a population sink because turtles are attracted to the abundant habitat on the CRL site but may suffer high rates of road mortality. For this reason, CNL started implementing a detailed *Blanding’s Turtle Road Mortality Mitigation Plan* (Golder 2019a) in 2019, and will continue to implement the plan moving forward. The *Blanding’s Turtle Road Mortality Mitigation Plan* is designed to reduce or eliminate turtle road mortality at CRL and increase connectivity among habitats.

With the implementation of the comprehensive mitigation outlined in the *Blanding’s Turtle Road Mortality Mitigation Plan*, along with monitoring and adaptive management, CNL’s activities in the RSA are predicted to have a net neutral or positive effect on the local Blanding’s turtle population during the Base Case. That is, the mitigation that is or will be implemented on the CRL site is considered sufficient to limit and offset mortality from previous an existing anthropogenic activities in the RSA. There is uncertainty regarding the effectiveness of mitigation, but CNL is committed to monitoring and adaptive management, including implementing additional conservation actions should these be necessary, such that CRLs operations result in a net neutral or positive effect on the Blanding’s turtle population in the RSA.

In the Application Case, the SSA would result in a long-term loss of 26 ha of critical habitat during construction. This is a loss of upland habitat and riparian habitat within the SSA that has the potential to be used for nesting, thermoregulation and summer inactivity. Females who use the SSA for nesting have the potential to experience a reduction in reproductive success until they find new areas within which to nest. Additionally, females may need to travel greater distances if the availability of new nesting sites is limited and/or use lower quality habitats. The use of lower quality habitats could affect hatchling success rates. In searching for new habitats, individual Blanding’s turtles may become exposed to other risks (e.g., roads). Potential effects associated with critical habitat loss have been identified according to a precautionary approach. The importance of effects may be overestimated because the occupancy of critical habitat identified in the SSA remains unconfirmed despite considerable survey effort. To mitigate these potential effects, CNL will create new nesting mounds on both sides of Priority 2 culverts after they are replaced. Nest mounds will be monitored weekly during the nesting season and after periods of rain and maintenance of these mounds (e.g., vegetation removal) will also be completed at this time, if females are not present. Additionally, critical habitat will be assessed annually to ensure no significant loss at CRL and to determine compensation measures initiated at CRL or elsewhere.

Climate change is expected to affect Blanding’s turtle habitat availability, habitat distribution, and survival and reproduction in the RSA. Although the severity of climate change as a threat to the sustainability of Blanding’s turtle populations in Canada is currently unknown, available evidence suggests this species is highly sensitive to climate change (ECCC 2018b). Mitigation implemented on the CRL site during the Base Case and Application Case are anticipated to result in net neutral or positive effects on the local Blanding's turtle population. However, effects from climate change in the RSA may result in a negative effect (independent of CNL operations) on the Blanding's turtle population that overlaps with the RSA.

The weight of evidence suggests that, with mitigation committed to by CNL, effects from the NSDF Project will not jeopardize the survival of the regional Blanding's turtle population. With sufficient mitigation implemented at the CRL site, reductions in Blanding's turtle road mortality are possible, even with increased traffic volumes associated with the NSDF Project. Moreover, critical habitat will be assessed annually to ensure no significant loss at CRL and to determine compensation measures initiated at CRL or elsewhere (see Section 5.6.8).

5.6.7.9 Eastern Milksnake

5.6.7.9.1 Residual Effects Analysis

Habitat Availability

The LSA and SSA contain a variety of habitats (i.e., wetlands, forests, open areas) that may contain the microhabitat features to support egg laying, thermoregulation and/or hibernation (Section 5.6.4.10.1), and therefore suitable habitat for eastern milksnake is predicted to be lost due to the NSDF Project. The amount of suitable habitat for eastern milksnake affected by the NSDF Project could not be quantified for this assessment because targeted surveys for milksnakes have not been completed in the SSA, and their habitat preferences could not be determined from vegetation community mapping due to their generalist behaviour and reliance on microhabitats (e.g., rotting logs, stumps, mammal burrows, sand, rock crevices and natural or human debris) to carry out their life history requirements.

This species uses microhabitats such as rotting logs to lay eggs, and this type of microhabitat is likely abundant in the RSA and LSA due to the prevalence of mature forest habitat (Section 5.6.4.1.1). The likelihood of a natural hibernaculum being found in the SSA is low given its proximity to built structures on the CRL main campus northeast of the SSA, which are favoured for hibernacula and correspond with the majority of milksnake observations in the RSA (Figure 5.6.4-20). Because the SSA is dominated by closed canopy forest, opportunities for thermoregulation are likely limited and this likely reduces the overall quality of other potential microhabitats in the SSA compared to the RSA. In the absence of more detailed information on milksnake habitat availability in the SSA, a precautionary approach is followed and the NSDF Project is predicted to have an adverse, measurable effect on milksnake habitat availability at the LSA scale in the Application Case. This effect is predicted to be negligible at the RSA scale because the available information suggests that higher quality habitats are relatively more abundant in the RSA than the LSA.

Sensory disturbance associated with noise, light and vibration during construction, operations and closure phases may indirectly reduce eastern milksnake habitat availability in the LSA if snakes avoid otherwise suitable habitat. Given their preference for utilizing built structures, eastern milksnake may be somewhat tolerant of human disturbance. Moreover, snakes have lost the anatomy for hearing airborne sounds and instead detect sounds via vibration, suggesting that they are less sensitive to noise but may be particularly sensitive to vibrations (Christensen et al. 2012). The potential for vibrations to interfere with their hunting behaviour may be low given their preference to hunt at night and given that construction activities will primarily be restricted to daylight hours. As a precaution, vibration from the NSDF Project is predicted to reduce habitat availability for milksnake in the LSA due to avoidance in the Application Case.

Habitat Distribution

The development of the NSDF Project may alter the movement patterns of milksnakes and could restrict access to potential hibernacula and egg-laying habitat in the SSA. The SSA will be surrounded by a fence that will exclude wildlife, including milksnakes, from accessing the site. Individuals would need to travel around the outside of the fence if they need to move around the SSA to reach locations they require to carry out their life history requirements such as foraging, thermoregulation and egg-laying. If milksnakes use the SSA as a movement corridor between habitats, the NSDF Project will increase travel distances. The SSA is surrounded by wetlands that may provide habitat for milksnake and will not be disturbed by the NSDF Project. Therefore, migration corridors through these wetland complexes will remain intact within the LSA and RSA.

Changes in habitat distribution due to the NSDF Project are predicted to be local and will have a minor effect on the potential habitat distribution and connectivity for milksnake in the RSA. Habitat for this species is predicted to remain abundant and well connected in the RSA in the Application Case.

Survival and Reproduction

The NSDF Project has the potential to result in the incidental take of hibernating snakes during vegetation clearing and grubbing, which is proposed to take place during hibernation (i.e., October/November to April). Clearing during the milksnake hibernation period is necessary to avoid incidental take of migratory birds and bats during the migratory bird nesting period and bat maternity roosting period (Section 5.6.5.2.1). The likelihood of a natural hibernaculum being found in the SSA is low given its proximity to built structures on the CRL main campus northeast of the SSA, which are favoured for hibernacula and correspond with the majority of milksnake observations in the RSA (Figure 5.6.4-20).

Reptile exclusion fencing will be installed prior to the hibernation period (prior to August) and remain in place for the life of the NSDF Project so that snakes cannot re-enter the site prior to site clearing or access the site during operation. Exclusion fencing will be installed according to provincial guidelines for the target species, including milksnake (MNR 2013c). The area within the fence will be searched prior to site clearing and construction to capture and relocate any herpetofauna including milksnakes to outside of the fenced area.

The permanent loss of suitable habitat due to the NSDF Project may displace individuals and reduce their survival and reproductive success. Milksnakes are known to display fidelity to their hibernation sites. Therefore, if a hibernaculum is discovered within the SSA, the removal of this feature would displace the snake(s) that hibernate there and jeopardize their survival. Compensation habitat would be required to accommodate the displaced snakes. Likewise, females using potential egg-laying sites in the SSA would need to find other suitable locations for this activity. The reproductive success of these females may be reduced until a new egg-laying site can be found.

The population of milksnakes overlapping the RSA is predicted to be resilient to potential mortality from the destruction of a hibernaculum during vegetation clearing because populations in Ontario are not considered at risk by the Committee on the Status of Species at Risk in Ontario, which delisted the species in 2016, and predation by natural predators appears to be the only source of adult mortality in the RSA.

Road-related mortality is predicted to increase in the RSA and LSA due to the NSDF Project because new roads will be created and traffic will increase during the construction and operations phases. This effect will be minimized through the road mitigation strategy (largely developed for Blanding's turtle), which includes safe crossing structures under roads and fencing along roads, which will act to prevent all herpetofauna from accessing roadways. Additional mitigations to avoid road mortality for this species include enforcement of existing

CRL site speed limits on access roads, driver education, speed bumps and signage. Therefore, the risk of road mortality due to increased traffic as a result of the NSDF Project will be small.

5.6.7.9.2 Prediction Confidence

There is high confidence that a milksnake population is present in the RSA based on the location of known occurrence records in the RSA at the CRL main campus. There is a reasonable possibility that milksnakes use the LSA given its proximity to known occurrence records and an understanding of their home range sizes. However, their use of habitat in the SSA and LSA to carry out egg laying, hibernation and/or thermoregulation has not been confirmed. Much of the SSA is heavily forested, which would limit basking opportunities for thermoregulation, but it may contain microhabitats suitable for egg-laying and hibernating. Milksnake has been shown to avoid forested habitat because of its low thermal quality (Row and Blouin-Demers 2006b). Nevertheless, in the absence of specific data on milksnake habitat use in the SSA and LSA, this assessment used a precautionary approach to manage uncertainty and assumed that milksnakes are present in the SSA. This approach may overestimate the potential effects of the NSDF Project on milksnakes.

There is a high degree of confidence in CNL's ability to manage road mortality for this species because a comprehensive *Blanding's Turtle Road Mortality Mitigation Plan* is being developed for Blanding's turtle that will also benefit milksnakes, and because CNL has a demonstrated record of zero milksnake fatalities due to vehicle collision in the RSA, despite the majority of milksnake observations occurring in an area of high vehicle use (i.e., the CRL main campus).

5.6.7.9.3 Residual Effects Classification

A summary of the classification of incremental adverse residual effects of the NSDF Project on eastern milksnake in the Application Case is provided for each measurement indicator in Table 5.6.7-20. Residual effects after the implementation of effective mitigation are described, and are summarized according to direction, magnitude, geographic extent, duration/reversibility, frequency/timing and likelihood of the effect occurring following the methods described in Section 5.6.6.3 and the definitions provided in Table 5.6.6-1.

Table 5.6.7-20: Description of Residual Effects on Eastern Milksnake in the Application Case

Indicator	Characteristic	Rating/Effect Size
Habitat Availability	Direction	Negative
	Magnitude	Direct loss of some suitable milksnake habitat; potential avoidance of otherwise suitable habitat due to sensory disturbance in the LSA
	Geographic Extent	SSA (direct habitat loss); Local (sensory disturbance)
	Duration/Reversibility	Permanent/Irreversible (direct habitat loss); Medium-term (sensory disturbance)
	Frequency/Timing	Continuous
	Likelihood	Probable
Habitat Distribution	Direction	Negative
	Magnitude	Change in movement corridors around the perimeter of the NSDF Project
	Geographic Extent	Local
	Duration/Reversibility	Permanent/Irreversible
	Frequency/Timing	Continuous
	Likelihood	Probable
Survival and Reproduction	Direction	Negative
	Magnitude	Change in survival and/or reproduction due to incidental take or loss of habitat used for hibernation and/or egg-laying; increased risk of injury/mortality on roads
	Geographic Extent	Local
	Duration/Reversibility	Medium-term (loss of egg-laying habitat and/or hibernacula); Permanent/Irreversible (roadkill)
	Frequency/Timing	Infrequent (loss of egg-laying habitat, loss of hibernacula, roadkill)
	Likelihood	Possible (loss of egg-laying habitat, roadkill), Unlikely (incidental take/loss of hibernacula

LSA = Local Study Area; RSA = Regional Study Area; SSA = Site Study Area.

5.6.7.9.4 Determination of Significance

The population of eastern milksnake that overlaps with the RSA is considered sensitive to changes in habitat availability, distribution, and survival and reproduction. However, milksnakes are habitat generalists, meaning they use a variety of habitats and microhabitats that have the likelihood to be available throughout the RSA. They use man-made structures such as old building foundations for hibernation and roadways to thermoregulate and so are somewhat tolerant to human disturbances. These characteristics suggest some resilience and adaptability to changes in habitat availability and distribution. Although eastern Ontario represents some of the best remaining habitat for milksnakes in the province, populations are thought to occur at low densities across the species' range (COSEWIC 2014).

The known occurrence records for this species in the RSA occur within the CRL main campus. Therefore, it is likely that at least a portion of the milksnake population in the RSA is hibernating on or near the campus and likely in the foundations of old buildings. The likelihood of a natural hibernaculum being found in the SSA is somewhat unlikely given the proximity of the SSA to built structures, which are favoured for hibernacula. As such, the change in habitat availability for hibernation due to the SSA is unlikely to have an ecologically measurable effect on the survival of the population. This species uses microhabitats such as rotting logs to lay eggs. Given the likely abundance of this type of microhabitat in the RSA, the removal of such habitat within the SSA is unlikely to have an ecologically measurable effect on the survival of the population. Although it is assumed that milksnakes are using habitats within the SSA for some of their life history requirements, the reduction of habitat availability due to the NSDF Project is considered to be within the resilience and adaptability limits of this species.

The NSDF Project may result in a change in movement patterns at the local scale, but this change is not expected to alter the extent of occurrence of the population that overlaps with the RSA because the area of disturbance is small and localized, and eastern milksnakes are habitat generalists capable of using a variety of habitats to carry out their life history requirements.

Roadkill has been identified as a primary concern for the survival and reproduction of this species (COSEWIC 2014). Although it is not currently a concern in the RSA, road mortality risk is predicted to increase with the NSDF Project. In the Application Case, the SSA would be fenced with reptile exclusion fencing to prevent direct injury or mortality to this species from construction activities. Fencing of the SSA would require individual milksnakes to travel greater distances around the perimeter of the site to seek new habitats. In searching for new habitats, the risk of road mortality due to vehicle strikes may increase for milksnake. Populations of this species may be particularly vulnerable to increases in adult mortality because they are long-lived, have delayed sexual maturity and may only produce a clutch of eggs every second year (Environment Canada 2015). The increase in traffic related to the NSDF Project and consequently the risk of road injury or mortality will be mitigated through the comprehensive *Blanding's Turtle Road Mortality Mitigation Plan*, which will also serve other reptiles such as milksnake.

There is no evidence to suggest that the milksnake population that overlaps the RSA is not self-sustaining and ecologically effective in the Base Case; environmental stresses of primary concern in other portions of the species' range (i.e., habitat loss and road mortality) do not appear to be important factors affecting the milksnake population that overlaps with the RSA. The NSDF Project has the potential to affect habitat availability, distribution, and survival and reproduction. However, with effective implementation of mitigation, the incremental changes due to the NSDF Project are not predicted to adversely affect the population of milksnake that overlaps with the RSA because habitat is unlikely to be a limiting factor in the RSA and direct mortality of individuals will be minimized or avoided by implementing appropriate mitigation. Therefore, effects from the NSDF Project are not predicted to exceed the resilience and adaptability limits of the milksnake population that overlaps with the RSA. Consequently, cumulative effects from the NSDF Project and previous and existing activities and developments in the RSA on the milksnake population that overlaps with the RSA are predicted to be not significant in the Application Case.

Given that milksnakes are habitat generalists, on-going fire suppression in the RSA is unlikely to have a substantial effect on the population that overlaps the RSA, though forested habitat has low thermal quality and therefore may be used less frequently than more open habitats (Row and Blouin-Demers 2006b). Climate change has not been identified as a threat to this species (Environment Canada 2015). Consequently, cumulative effects of previous and existing developments, the incremental effect of the NSDF Project, and consideration of future, beyond regional disturbance factors (e.g., climate change) on the eastern milksnake population that overlaps the RSA are predicted to be not significant. The contributions of the NSDF Project are therefore also considered not significant.

5.6.7.10 Monarch Butterfly

5.6.7.10.1 Residual Effects Analysis

Habitat Availability

The NSDF Project is estimated to remove about 5 ha of suitable summer breeding habitat for monarch butterfly, which is 6.3% of suitable habitat in the LSA and 0.6% of suitable habitat in the RSA (Table 5.6.7-21). All of the removed habitat will be in the form of roadside and utility corridor habitat. However, there may be some opportunity for milkweed to establish in the SSA along roadsides and in other vegetated areas around project infrastructure during the operations phase, temporarily offsetting habitat loss before the footprint is planted to grass at closure and maintained into perpetuity. Additionally, some habitat may be formed along the edges of the SSA post-closure, permanently offsetting some of the habitat loss during construction.

Table 5.6.7-21: Changes to Monarch Butterfly Summer Habitat Availability in the Application Case

Habitat Suitability	Regional Study Area				Local Study Area			
	Base Case (ha)	Application C ase (ha)	Change in Area (ha)	Percent Change (%)	Base Case (ha)	Application C ase (ha)	Change in Area (ha)	Percent Change (%)
Suitable	805	800	-5	-0.6	80	75	-5	-6.3
Unsuitable	3,047	3,052	5	0.2	130	135	5	3.8

Sensory disturbance associated with noise and vibration during the construction, operations and closure phases may indirectly reduce monarch butterfly habitat availability in the LSA if monarch butterflies avoid these sources of disturbance. Noise effects on invertebrates are generally poorly understood and largely unstudied; however, many invertebrates including lepidopterans (butterflies and moths) are capable of hearing and may respond to anthropogenic noise (Morley et al. 2014). It has been demonstrated that moths and nocturnal butterflies respond to high- and ultrasonic-frequency airborne vibrations, which helps them avoid echolocating bats (Treat 1955; Yack and Fullard 1999). Some diurnal butterflies have been shown to be sensitive to low-frequency sounds, and it has been postulated that this may be a defense mechanism against vocalizing avian predators (Ribarič and Gogala 1996). Caterpillars of a number of lepidopterans including monarch butterfly have also been found to respond to sound; individuals freeze, contract, flick their bodies and even drop off vegetation presumably as a predator or parasitoid defense mechanism (Taylor 2008 and references within).

Studies also demonstrate some lepidopterans can produce sounds. Some moths have been found to emit ultrasonic clicking sounds to confuse echolocating bats (Miller 1991) and some diurnal butterflies produce clicking sounds during specific flight behaviours that presumably serve as a communication method (e.g., Kane 1982), but this phenomenon does not appear prevalent among butterfly families (Ribarič and Gogala 1996; Murillo-Hiller 2006). Caterpillars of 49 butterfly species that form symbiotic relationships with ants have been found to emit low- to mid-frequency substrate-borne calls (pulses), presumably to maintain ant association, whereas no sound production by caterpillars has been identified in 81 butterfly species (DeVries 1991).

Although there is a paucity of literature on invertebrate response to sound and vibration, available evidence suggests it is unlikely that most butterflies and other diurnal invertebrates that do not emit sounds (which could be affected by interference) respond measurably to anthropogenic noise. Diurnal butterflies generally use visual mechanisms for communication and predator avoidance (Silberglied 1984 in Yack and Fullard 1999). Monarch butterflies are not known to emit sound and their primary predator defense mechanism is based on visual avoidance of the bold patterning of both caterpillars and adults once the predator discovers that the butterfly tastes bad and subsequently avoids other individuals with similar patterning. Additionally, monarch butterflies are frequently observed foraging along roadsides and in public spaces and flying over highways, suggesting high tolerance to anthropogenic noise. Based on these conclusions, habitat availability for monarch butterflies in the LSA is not predicted to change due to avoidance resulting from sensory disturbance from the NSDF Project.

Habitat Distribution

The development of the NSDF Project is unlikely to have a measurable effect on monarch butterfly habitat distribution and movement in the RSA, given the small size of the SSA and the limited amount of suitable habitat available in the SSA in the Base Case (Figure 5.6.7-18 and Figure 5.6.7-19). Most of the suitable habitat in the LSA is in the form of wetlands, which will not be disturbed by the NSDF Project and will continue to serve as a movement corridor through the LSA. Adult monarch butterflies are highly mobile and capable of moving around or over the NSDF Project infrastructure. Additionally, most of land cleared during construction of the NSDF Project is forested in the Base Case and forest clearing may increase movement opportunity in the LSA due to the increase in open land cover.

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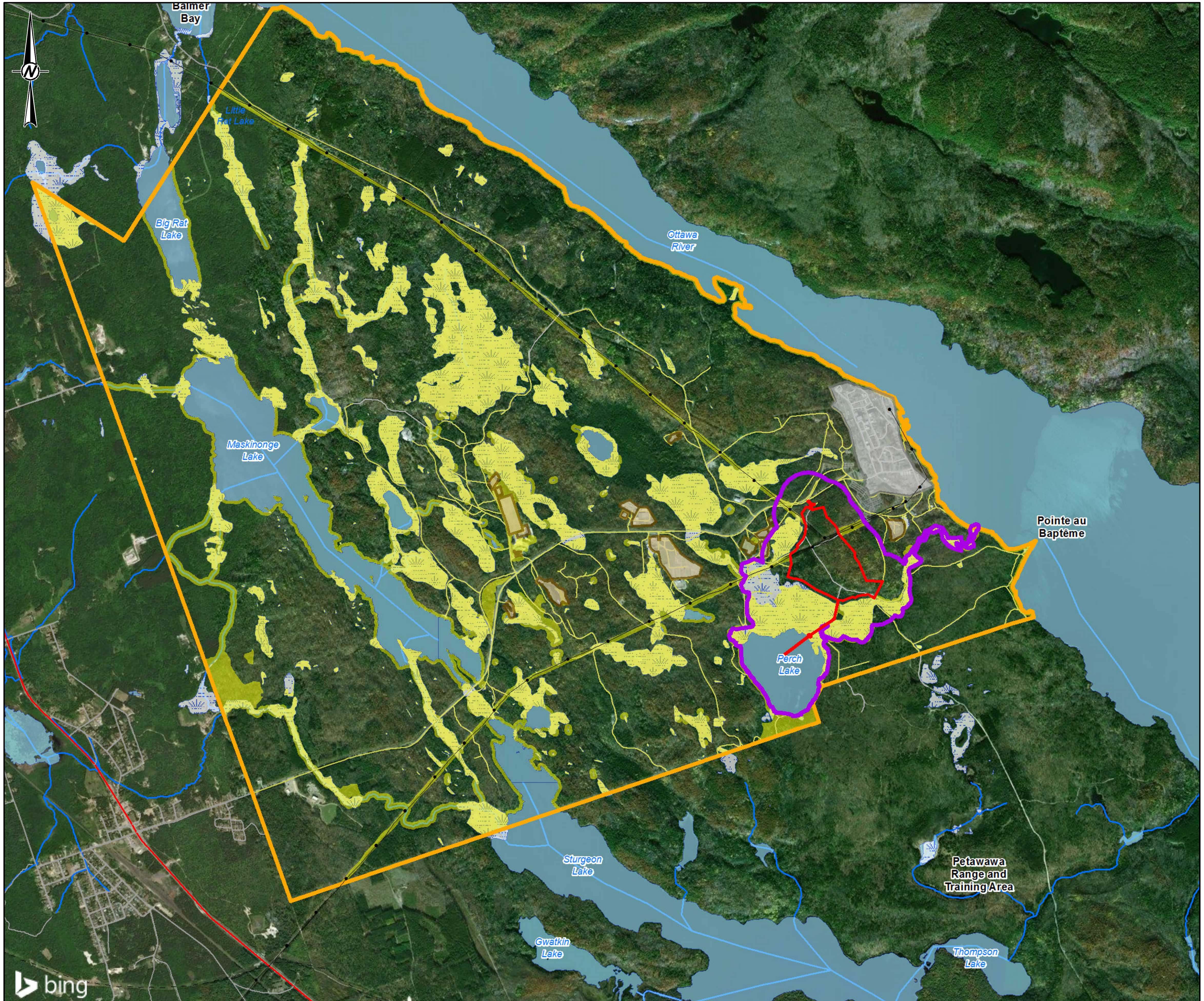

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- MONARCH BUTTERFLY HABITAT

1 0 1

1:35,000 KILOMETRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

MONARCH BUTTERFLY HABITAT AVAILABILITY AND DISTRIBUTION IN THE RSA – APPLICATION CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.7-18

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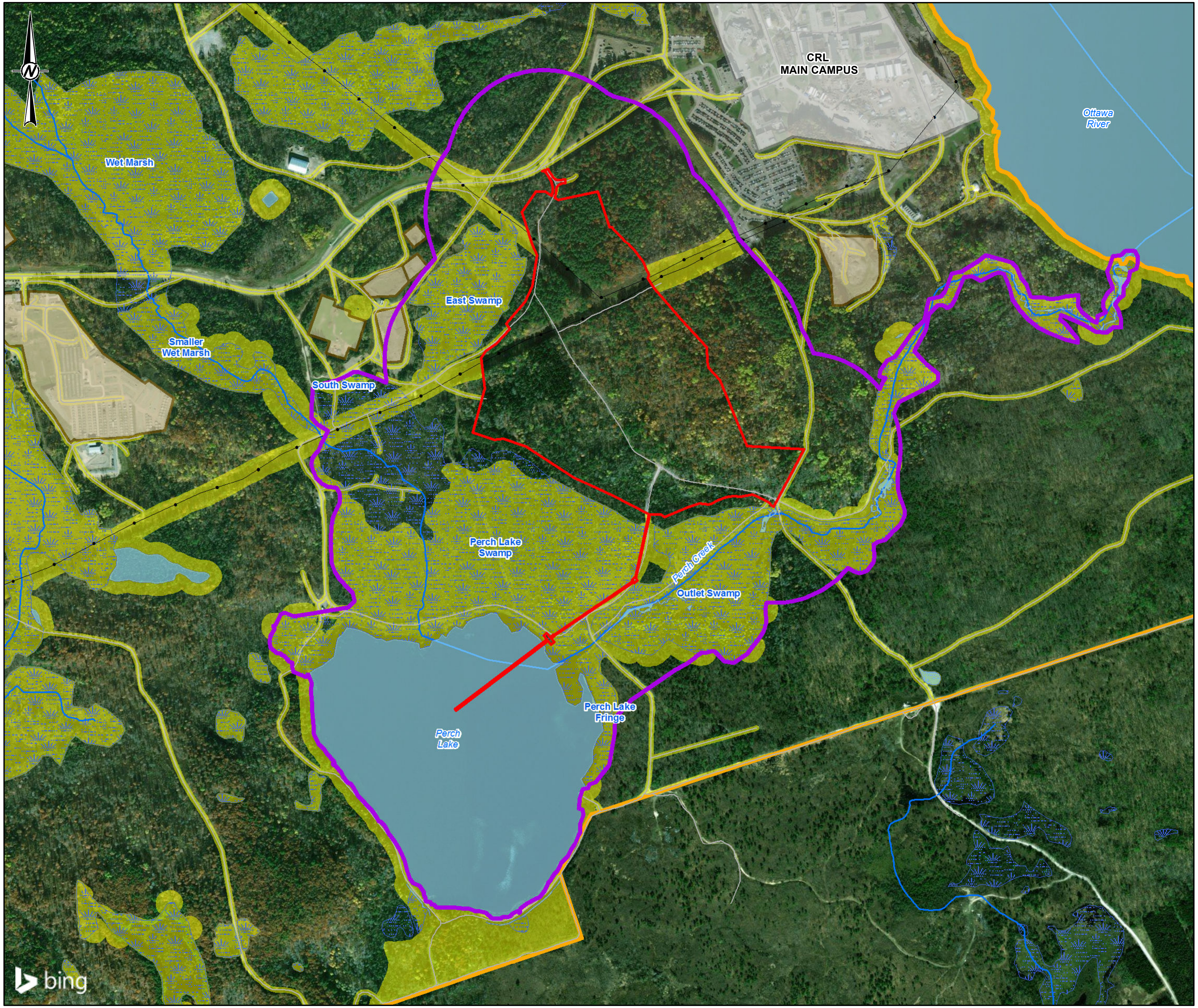

LEGEND

- HIGHWAY
- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- REGIONAL STUDY AREA (CRL SITE)
- LOCAL STUDY AREA
- SITE STUDY AREA
- MONARCH BUTTERFLY HABITAT

250 0 250

1:10,000 METRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA MNRF 2016 AND CANVEC 2016
2. IMAGERY: © 2020 MICROSOFT CORPORATION © 2020 MAXAR ©CNES (2020) DISTRIBUTION AIRBUS DS
3. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

MONARCH BUTTERFLY HABITAT AVAILABILITY AND DISTRIBUTION IN THE LSA AND SSA – APPLICATION CASE

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.6.7-19

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Survival and Reproduction

Site clearing for the NSDF Project is not predicted to cause monarch butterfly mortality. Adult monarch butterflies are highly mobile and can avoid interactions with activities that could result in direct mortality, and mitigation will be implemented to avoid mortality of other life stages (Section 5.6.5.2.1).

The loss of summer breeding habitat may affect reproductive success if individuals are displaced or return the following summer to find habitat removed. The loss of suitable breeding habitat due to the NSDF Project is predicted to result in a small reduction in the carrying capacity of the LSA and RSA. However, this is unlikely to have a measurable effect on the monarch butterfly population in the RSA given the small area of predicted habitat loss (0.6% of suitable habitat in the RSA) and overall good representation of suitable habitat remaining in the RSA (20.8% of RSA) in the Application Case.

5.6.7.10.2 Prediction Confidence

Suitability of habitat for breeding ultimately depends on the availability of milkweed host plants for monarch caterpillars and this information cannot be determined from the vegetation mapping. Therefore, there is a moderate level of uncertainty about the amount of suitable habitat present in the study areas. The assumption that all open habitats provide summer breeding habitat represents a conservative overestimate of habitat availability in the Base Case and the amount of habitat to be removed by the NSDF Project in the Application Case.

There is a moderate level of uncertainty associated with the future population status of monarch butterfly in Canada. Although threats to overwintering populations in Mexico are perceived to be the most direct causes of overall decline in monarch butterfly numbers in North America, some studies have reported declining trends in summer breeding populations, though these findings have not been consistent among studies and locations (COSEWIC 2010).

5.6.7.10.3 Residual Effects Classification

A summary of the classification of incremental adverse residual effects of the NSDF Project on monarch butterfly in the Application Case is provided for each measurement indicator in Table 5.6.7-22. Residual effects after the implementation of effective mitigation are described, and are summarized according to direction, magnitude, geographic extent, duration/reversibility, frequency/timing and likelihood of the effect occurring following the methods described in Section 5.6.6.3 and the definitions provided in Table 5.6.6-1.

Table 5.6.7-22: Description of Residual Effects on Monarch Butterfly in the Application Case

Indicator	Characteristic	Rating/Effect Size
Habitat Availability	Direction	Negative
	Magnitude	Loss of 5 ha of suitable habitat (6.3% in LSA; 0.6% in RSA)
	Geographic Extent	SSA
	Duration/Reversibility	Permanent/Irreversible (though some habitat may form temporarily during the operations phase and permanently in the post-closure phase)
	Frequency/Timing	Continuous
	Likelihood	Certain
Habitat Distribution	Direction	Neutral
	Magnitude	Small change in habitat distribution due to habitat loss, but increased movement opportunity due to increase in open land cover in LSA
	Geographic Extent	Local
	Duration/Reversibility	Permanent/Irreversible
	Frequency/Timing	Continuous
	Likelihood	Probable
Survival and Reproduction	Direction	Negative
	Magnitude	Small reduction in reproductivity from habitat loss
	Geographic Extent	Local
	Duration/Reversibility	Permanent/Irreversible
	Frequency/Timing	Continuous
	Likelihood	Probable

LSA = Local Study Area; RSA = Regional Study Area; SSA = Site Study Area.

5.6.7.10.4 Determination of Significance

The population of monarch butterflies that overlaps with the RSA is not considered sensitive to changes in habitat availability or distribution because breeding habitat is not considered a limiting factor for this criterion in the RSA, and suitable habitat is well represented (20.8% of RSA) and well distributed in the RSA. Fire suppression has likely reduced habitat availability for this species in the RSA, but monarch butterflies are highly mobile and they demonstrate flexibility in habitat selection, including use of human disturbances such as road verges and utility corridors, which are maintained in early seral stages preferred by this species. These characteristics suggest resilience and adaptability to changes in habitat availability and distribution. Although southern Ontario supports some of the highest concentrations of breeding monarch butterflies in Canada (COSEWIC 2010; ECCC 2016b), the RSA is unlikely to be an important breeding area given that it is mostly forested and approaching the northern limit of milkweed distribution in Ontario. Mortality of individuals (all life stages) due to deleterious vegetation management practices along linear corridors and reductions in carrying capacity of the RSA due to reductions in habitat availability are unlikely to have had ecologically measurable effects on the population. Therefore, changes to monarch butterfly survival and reproduction in the Base Case are considered to be within the resilience and adaptability limits of this species. Overall, there is no evidence to suggest the population that overlaps the RSA is not self-sustaining and ecologically effective in the Base Case.

In the Application Case, the SSA would permanently remove about 5 ha of suitable breeding habitat during construction. The NSDF Project may result in a change in movement patterns at the local scale, but this change is not expected to alter the extent of occurrence of the population that overlaps with the RSA because the area of disturbance is small and localized, monarch butterflies are highly mobile and capable of using disturbed habitats for breeding and clearing of forest in the SSA may increase movement in the LSA. With effective implementation of mitigation, the incremental changes due to the NSDF Project are not predicted to adversely affect the population of monarch butterflies that overlaps with the RSA because habitat is unlikely to be a limiting factor in the RSA and direct mortality of individuals will be avoided by implementing appropriate mitigation. Therefore, effects from the NSDF Project are not predicted to exceed the resilience and adaptability limits of the monarch butterfly population that overlaps with the RSA. Consequently, cumulative effects from the NSDF Project and previous and existing activities and developments in the RSA on the monarch butterfly population that overlaps with the RSA are predicted to be not significant in the Application Case.

On-going fire suppression in the RSA may reduce monarch butterfly habitat availability as early successional land cover types progress towards mature and old growth forest. However, most of the suitable habitat for monarch butterfly in the RSA is in the form of wetland and linear disturbance, which are not expected to succeed to forest.

Climate change modelling predicts significant negative effects on overwintering and migrating populations of monarch butterfly (COSEWIC 2010). Climate change may also affect breeding populations. Climate change is predicted to increase the frequency and intensity of extreme weather events, including droughts, forest fires and heavy precipitation (ECCC 2016b; Huff and Thomas 2014). Extreme weather events during the breeding season can result in reduced survival, reproduction and growth rates (ECCC 2016b). Forest fires may increase habitat availability by creating open habitat preferred by this species. Individuals may also be susceptible to extreme weather events outside of the breeding season. The frequency and intensity of hurricanes are predicted to increase as a result of climate change, which may negatively affect migrating and overwintering individuals. However, the direction and magnitude of effects from climate change are uncertain because predictions are based on simulations that can be highly variable and many scenarios are possible.

Overall, the weight of evidence from the analysis of the primary pathways predicts that changes to monarch butterfly habitat availability, habitat distribution, and survival and reproduction in the RSA as a result of the NSDF Project are within the resilience and adaptability limits of the species. Continued fire suppression in the RSA and climate change are expected to also affect monarch butterfly habitat availability, habitat distribution, and survival and reproduction in the RSA. However, neither of these threats has been identified as being of high concern to breeding populations (ECCC 2016b). Therefore, effects from continued fire suppression and climate change in conjunction with the effects of the NSDF Project and past and present activities and developments in the RSA are not predicted to exceed the resilience and adaptability limits of the monarch butterfly population that overlaps with the RSA. Consequently, cumulative effects of previous and existing developments, the incremental effect of the NSDF Project, and consideration of future, beyond regional disturbance factors (e.g., climate change) on the monarch butterfly population that overlaps the RSA are predicted to be not significant. The contributions of the NSDF Project are therefore also considered not significant.

5.6.7.11 Reasonably Foreseeable Developments Case

For the terrestrial environment, the RSA was used as the scale at which cumulative effects to terrestrial biodiversity VCs were assessed. Regional disturbance factors (e.g., forestry and climate change) were considered if they were likely to affect vegetation communities or populations of wildlife VCs that overlap with the RSA. The assessment considered the Base Case, which represents existing conditions and characterizes effects from previous and existing developments and activities, as well as the Application Case, which represents the effects of the Base Case combined with the predicted incremental effects from the NSDF Project through all project phases for each VC. The Base Case reflects the effects of existing disturbances in the area, such as forestry, transportation, agricultural, mining, and residential and recreational development.

As defined in the preceding sections, residual effects on terrestrial VCs are primarily associated with vegetation clearing and grubbing and the associated loss or alteration of existing vegetation and topographical features, sensory disturbance from NSDF Project activities during construction and operations, and increased risk of injury or mortality on roads due to equipment and vehicle traffic. The cumulative effects from the NSDF Project and previous and existing activities and developments in the RSA on the population of terrestrial biodiversity VCs that overlap with the RSA are predicted to be not significant for all VCs, with the exception of bats and Blanding's turtle, discussed in the following sub-sections.

RFDs expected within the CRL site (i.e., the RSA) that may interact with the terrestrial environment include new or upgrades to research and development facilities, construction and operation of the SMR, new support infrastructure, and on-going decommissioning and environmental remediation activities. New support infrastructure and research and development facilities will generally be located within existing disturbed areas on the CRL site (i.e., no disturbance to largely undeveloped areas) where erosion and sediment control practices and surface water management systems already in place will be implemented. Disturbance of approximately 3.5 ha including potentially undisturbed areas of the CRL site, may be required for development of the SMR based on the candidate site selected (Global First Power 2019). The three candidate sites for locating SMR on the CRL site are located away from the SSA (Figure 8.2.1-1). It is expected that removal of and other potential effects on terrestrial habitat including to species at risk through development of SMR will be reduced through consideration of siting and through mitigation similar to that implemented for the NSDF Project. Potential effects from these revitalization activities, as well as construction and operation of the SMR, are not expected to spatially overlap with potential effects on terrestrial biodiversity from the NSDF Project, which are limited to the SSA and LSA.

The revitalization of the CRL site is planned to occur over the 10 year period 2016 to 2026. The workforce numbers and types of work required for site revitalization activities over that period are expected to maintain a similar condition to the site revitalization activities occurring at present on-site, therefore reflected in Base Case characterization such as traffic monitoring. This workforce is anticipated to be approximately equal to that required for the construction of the NSDF Project and the existing roads within the CRL site will continue to be used to access the site. Traffic generated for construction and operations of the SMR will be small compared to that required for NSDF and negligible compared to on-going CRL site operations. Mitigation has been or will be implemented on the CRL Site to limit and offset traffic-related wildlife mortality from previous and existing anthropogenic activities in the RSA.

The end-state plan for the CRL site will be to return lands disturbed by site activities to a condition that is physically stable and safe in keeping with the land use and landscape of the day. Therefore, decommissioning and environmental remediation activities are anticipated to positively affect terrestrial biodiversity. Once existing infrastructure is removed and the CRL site is reclaimed and ceases to be frequented by large numbers of employees, the level of anthropogenic disturbance within the site will be greatly reduced, benefiting the terrestrial environment in the RSA.

RFDs, as currently understood, will either have no spatial overlap or are likely to positively affect terrestrial biodiversity, so no residual adverse cumulative effects are identified. Future, beyond regional disturbance factors (e.g., climate change) were considered qualitatively as part of the Application Case.

5.6.7.11.1 Bats

As noted in Section 5.6.7.7, populations of little brown myotis (*Myotis lucifugus*), northern myotis (*Myotis septentrionalis*) and tri-colored bats (*Perimyotis subflavus*) that overlap the terrestrial environment RSA are highly sensitive to changes in survival and reproduction because white nose syndrome has resulted in dramatic declines of these species across the eastern portions of their Canadian range, which includes the RSA. Therefore, the existing level of pressure on these bat species in the Base Case has likely already exceeded their resilience and adaptability limits and they are unlikely to be self-sustaining or ecologically effective. Consequently, the cumulative effects of existing disturbance and especially the introduced white nose syndrome are considered significant in the Base Case (i.e., even before the NSDF Project).

The NSDF Project will contribute a small increment to this existing significant adverse cumulative effect. Importantly, because vegetation clearing will be undertaken outside of the maternity roosting season, no mortality of roosting bats is expected as a result of the NSDF Project and effects of the NSDF Project to survival and reproduction are considered neutral. In addition, the remaining availability of potential maternity roosting habitat is not likely a limiting factor in the terrestrial environment RSA. The contribution of the NSDF Project to the existing significant adverse cumulative effect to bats is predicted to be negligible (i.e., no detectable changes to bat populations), and the Project does not contribute to the spread of white nose syndrome, which is the primary driver of the existing significant adverse cumulative effect.

Maternity roost habitat is currently not considered critical habitat under the *Species At Risk Act* (ECCC 2018) and as such, offsetting the removal of potential bat maternity roost trees is not required. However, the use of appropriately designed bat boxes can increase the availability of maternity roosting locations and may aid in the recovery of bats (ECCC 2018). Bat boxes have been installed in suitable locations in the terrestrial environment RSA is recommended to mitigate the incremental contribution of the NSDF Project. Monitoring is being conducted to determine if boxes are being used. As well, a comprehensive Sustainable Forest Management Plan is being developed for the CRL site, with an objective to ensure the long-term retention of trees serving as maternity roosts for bat species.

5.6.7.11.2 Blanding's Turtle

The SSA would results in the long-term removal of 26 ha of critical habitat for Blanding's turtle critical habitat during construction, which represents 14.5% of the currently available critical habitat in the LSA. The upland habitat and riparian habitat affected by the NSDF Project has the potential to be used by Blanding's turtle for nesting, thermoregulation and summer inactivity. Females who use the area for nesting may experience a reduction in reproductive success until they find new areas within which to nest. Additionally, females may need to travel greater distances if the availability of new nesting sites is limited and/or use lower quality habitats. The use of lower quality habitats could affect hatchling success rates. In searching for new habitats, individual Blanding's turtles may become exposed to other risks (e.g., roads).

With the implementation of the comprehensive mitigation outlined in the *Blanding's Turtle Road Mortality Mitigation Plan*, along with monitoring and adaptive management, CNL's activities in the RSA are predicted to have a net neutral or positive effect on the local Blanding's turtle population during the Base Case. That is, the mitigation that is or will be implemented on the CRL site is considered sufficient to limit and offset mortality from previous an existing anthropogenic activities in the RSA. There is uncertainty regarding the effectiveness of mitigation, but CNL is committed to monitoring and adaptive management, including implementing additional conservation actions should these be necessary, such that CRLs operations result in a net neutral or positive effect on the Blanding's turtle population in the RSA.

Potential effects associated with critical habitat loss have been identified according to a precautionary approach. The importance of effects may be overestimated because the occupancy of critical habitat identified in the SSA remains unconfirmed despite considerable survey effort. To mitigate these potential effects, CNL will create new nesting mounds on both sides of Priority 2 culverts after they are replaced. Nest mounds will be monitored weekly during the nesting season and after periods of rain and maintenance of these mounds (e.g., vegetation removal) will also be completed at this time, if females are not present. Additionally, critical habitat will be assessed annually to ensure no significant loss at CRL and to determine compensation measures initiated at CRL or elsewhere.

The weight of evidence suggests that, with mitigation committed to by CNL, effects from the NSDF Project will not jeopardize the survival of the regional Blanding's turtle population. With sufficient mitigation implemented at CRL, reductions in Blanding's turtle road mortality are possible, even with increased traffic volumes associated with the NSDF Project. Moreover, critical habitat will be assessed annually to ensure no significant loss at CRL and to determine compensation measures initiated at CRL or elsewhere.

5.6.8 Monitoring and Follow-up

This section of the EIS provides the conceptual outline for any monitoring and follow-up programs recommended to confirm the predictions made in the terrestrial biodiversity assessment (Table 5.6.8-1). Monitoring programs recommended for Canada warbler, eastern whip-poor-will, eastern wood-pewee, golden-winged warbler, wood thrush, bats, Blanding's turtle and eastern milksnake will be integrated into CNL's existing Species at Risk Program.

Table 5.6.8-1: Monitoring and Follow-up Programs for Terrestrial Biodiversity

Valued Component	Project Phase and Potential Effects	Monitoring Program Objective	Conceptual Monitoring/ Follow-up Program	Suggested Duration	Implementing Program
Canada warbler	▪ Habitat Availability: Permanent, direct loss of 28 ha of suitable habitat. Long-term reduction in quality of nesting habitat and possible avoidance in the LSA from sensory disturbance. ▪ Habitat Distribution: Small, permanent change in local movement. ▪ Survival and Reproduction: Small reduction in reproductivity from habitat loss and sensory disturbance.	Verify environmental assessment predictions through collection of data on relative abundance and other key demographic parameters for breeding bird populations that overlap with the RSA.	Data on relative abundance and other key demographic parameters for breeding birds in the RSA will be collected during pre- and post-construction surveys using automated recording units. Collected data will be used to evaluate trends in populations of breeding birds that overlap with the RSA, including Canada warbler, eastern whip-poor-will, eastern wood-pewee, golden-winged warbler and wood thrush. If declining trends are observed for these species in the RSA, then the need for additional mitigation will be evaluated.	Every 5 years.	Monitoring will be integrated into CNL's existing Species at Risk Program.
Eastern whip-poor-will	▪ Habitat Availability: Permanent, direct loss of 2 ha of suitable habitat. ▪ Habitat Distribution: Small, permanent change in local movement. ▪ Survival and Reproduction: Small reduction in reproductivity from habitat loss and sensory disturbance.				
Eastern wood-pewee	▪ Habitat Availability: Permanent, direct loss of 18 ha of suitable habitat. ▪ Habitat Distribution: Small, permanent change in local movement. ▪ Survival and Reproduction: Small reduction in reproductivity from habitat loss and sensory disturbance.				
Golden-winged warbler	▪ Habitat Availability: Permanent, direct loss of 27 ha of suitable habitat. ▪ Habitat Distribution: Small, permanent change in local movement. ▪ Survival and Reproduction: Small reduction in reproductivity from habitat loss and sensory disturbance.				
Wood thrush	▪ Habitat Availability: Permanent, direct loss of 28 ha of suitable habitat. ▪ Habitat Distribution: Small, permanent change in local movement. ▪ Survival and Reproduction: Small reduction in reproductivity from habitat loss and sensory disturbance.				
Bats	▪ Habitat Availability: Permanent, direct loss of 28 ha of potential maternity roosting habitat. ▪ Habitat Distribution: Gap in potential maternity roosting habitat, but negligible change in local movement patterns. ▪ Survival and Reproduction: No residual effects due to the NSDF Project.	▪ Verify effectiveness of bat boxes as maternity roosting habitat offsetting measure, by determining number of individuals and species of bats using boxes for roosting habitat	▪ Installation of bat boxes in suitable locations in the RSA is recommended to offset the incremental contribution of the NSDF Project to cumulative effects on SARA-listed bats. Monitoring is being conducted at least weekly to determine if bat boxes are being used. Boxes not being used may be moved to an alternate location. ▪ A project in collaboration with Trent University is currently underway, where bats are being trapped and tracked back to the roost site (natural tree or bat box). ▪ Guano collection is being performed as well. This work has a duration of two years and will provide CNL with a better understanding of habitat occupancy by the bat species at risk, including bat boxes, and habitat preference. This work will support the objective of addressing knowledge gaps on the three bat species at risk.	Bat boxes will remain in place throughout the construction and operations phases. Visual monitoring of bat boxes will be conducted weekly every year during the pre-construction phase and will continue through construction and for three years after start of operations.	Monitoring will be integrated into CNL's existing Species at Risk Program.

Table 5.6.8-1: Monitoring and Follow-up Programs for Terrestrial Biodiversity

Valued Component	Project Phase and Potential Effects	Monitoring Program Objective	Conceptual Monitoring/ Follow-up Program	Suggested Duration	Implementing Program
Blanding's turtle	▪ Habitat Availability: Direct, long-term loss of 26 ha of critical habitat. ▪ Habitat Distribution: Permanent change in local movement. ▪ Survival and Reproduction: Reduced reproductive success and mortality of individuals over the lifespan of the NSDF Project.	Confirm effectiveness of mitigation through tracking wildlife mortality and use information for adaptive management.	Wildlife-vehicle collision monitoring will be conducted in the SSA. —Vehicle-caused Blanding's turtle mortality will be reported and data will be compiled in a database that can be used to inform adaptive management for the site.	On-going during the construction and operations phases and closure.	Monitoring will be integrated into CNL's existing Species at Risk Program.
		Identify and map critical habitat in the .	As part of the SARA permitting process for the removal of critical habitat, critical habitat will be assessed annually to ensure no significant loss at CRL and to determine compensation measures initiated at CRL or elsewhere. Monitoring will be integrated into CNL's existing Species at Risk Program.	Critical habitat will be assessed annually to ensure no significant loss at CRL and to determine compensation measures initiated at CRL or elsewhere.	Habitat compensation will be implemented as part of the SARA permitting process and consist of the creation of nest mounds for the species.
		Confirm integrity temporary and permanent of exclusion fencing.	Exclusion fencing will be inspected for integrity	Annually during the construction and operations phases and closure.	Monitoring will be integrated into CNL's existing Species at Risk Program.
		Confirm integrity of culverts	Culverts will be inspected for barriers to turtle movements	Weekly during the active season for Blanding's turtle (April 15 to October 15)	Monitoring will be integrated into CNL's existing Species at Risk Program.
		Confirm integrity of artificial nest mounds	Nesting mounds will be inspected for suitability and mounds will be maintained by removing vegetation as needed.	Weekly during the nesting season for Blanding's turtle (May 15 to June 30).	Monitoring will be integrated into CNL's existing Species at Risk Program.
		Confirm integrity of nest cages	Nest cages will be inspected for integrity.	Weekly during the nesting and hatchling emergence season for Blanding's turtle (May 15 to October 15)	Monitoring will be integrated into CNL's existing Species at Risk Program.
		Confirm use of culverts by Blanding's turtles	Cameras will be installed at culverts and will record photographs on a time-lapse basis. Photographs will be reviewed and data compiled.	Continuously during the active season for Blanding's turtle (April 15 to October 15) every year for the next 5 years.	Monitoring will be integrated into CNL's existing Species at Risk Program.
Eastern milksnake	▪ Habitat Availability: Direct, permanent loss of habitat. ▪ Habitat Distribution: Permanent change in local movement. ▪ Survival and Reproduction: increased risk of injury/mortality on roads	Confirm effectiveness of road mitigation to minimize or eliminate the potential for road mortality in the LSA.	Exclusion fencing will be inspected for integrity	Annually during the construction and operations phases and closure.	Monitoring will be integrated into CNL's existing Species at Risk Program.
		Confirm effectiveness of road mitigation to minimize or eliminate the potential for road mortality in the LSA.	Road mortality surveys to be conducted weekly during pre-construction and operations within the NSDF Project site. During construction, mortality survey to be conducted daily during the species active period (April 15 to September 30).	On-going during construction and operation phases.	Monitoring will be integrated into CNL's existing Species at Risk Program.
Monarch butterfly	▪ Habitat Availability: Permanent, direct loss of 5 ha of suitable habitat. ▪ Habitat Distribution: Small, permanent change in local movement. ▪ Survival and Reproduction: Small reduction in reproductivity from habitat loss.	N/A[(a)]	N/A[(a)]	N/A[(a)]	N/A[(a)]

SSA = Site Study Area; LSA = Local Study Area; RSA = Regional Study Area; ECCC = Environment and Climate Change Canada; SARA = *Species at Risk Act*; N/A = not applicable.

[(a)]Monitoring programs are not proposed for monarch butterfly.

5.6.9 Conclusions

VCs refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous peoples, the scientific community or the public (The Agency 2018). Selection of VCs for the terrestrial biodiversity assessment was accomplished using a coarse and fine filter approach. Coarse filter VCs were identified to permit an assessment of the effects of the NSDF Project to terrestrial biodiversity broadly, whereas fine filter VCs focused the assessment on individual biodiversity features, such as species. Combined, the coarse and fine filter VCs were selected to provide a holistic assessment of the potential effects of the NSDF Project on terrestrial biodiversity.

All SARA-listed species with confirmed observation records within the CRL site were considered as potential VCs at the species level. Species with a very low likelihood of occurrence in the LSA, for which habitat was not present in the LSA, or for which effects of the NSDF Project were unlikely, were excluded as VCs. Rationale for inclusion and exclusion of each species at risk identified during surveys undertaken in the CRL site is presented in Appendix 5.6-1.

The VCs selected for the terrestrial biodiversity assessment were: vegetation communities migratory birds, Canada warbler, eastern whip-poor-will, eastern wood-pewee, golden-winged warbler, wood thrush, bats, Blanding's turtle, eastern milksnake and monarch butterfly. The assessment endpoint for terrestrial biodiversity is the maintenance of self-sustaining and ecologically effective vegetation communities or wildlife populations. Ecosystem availability, ecosystem distribution and ecosystem composition were selected as the measurement indicators for the vegetation communities VC. Habitat availability, habitat distribution, and survival and reproduction were selected as the measurement indicators for the terrestrial biodiversity species VCs.

Residual effects to terrestrial VCs are primarily associated with vegetation clearing and grubbing and the associated loss or alteration of existing vegetation and topographical features; sensory disturbance from NSDF Project activities during the construction and operations phases; and increased risk of injury/mortality on roads to Blanding's turtle and eastern milksnake due to equipment and vehicle traffic.

The cumulative effects from previous and existing activities and developments in the RSA on the population of terrestrial biodiversity VCs that overlaps with the RSA are predicted to be not significant for most VCs in the Base Case. Populations of little brown myotis, northern myotis and tri-colored bats that overlap the RSA are highly sensitive to changes in survival and reproduction because WNS has resulted in dramatic declines of these species across the eastern portions of their Canadian range, which includes the RSA. Therefore, the existing level of pressure on these bat species in the Base Case has likely already exceeded their resilience and adaptability limits and they are unlikely to be self-sustaining or ecologically effective. Consequently, the cumulative effects of existing disturbance and especially the introduced WNS are considered significant in the Base Case.

With the implementation of comprehensive mitigation, CNL's activities in the RSA are predicted to have a net neutral or positive effect on the local Blanding's turtle population during the Base Case. That is, the mitigation that is or will be implemented on the CRL Site is considered sufficient to limit and offset mortality from previous and existing anthropogenic activities in the RSA. There is uncertainty regarding the effectiveness of mitigation, but monitoring and adaptive management will be implemented so that CNL achieves a net neutral or positive effect (i.e., not significant) on the Blanding's turtle population at CRL.

In the Application Case, the NSDF Project will contribute small incremental adverse effects to most VCs, but in no case does the NSDF Project jeopardize the survival of the regional population of a VC. In the case of bats and Blanding’s turtles, potential adverse effects are reduced or eliminated with substantial mitigation. For example, because vegetation clearing will be undertaken outside of the maternity roosting season, no mortality of roosting bats is expected as a result of the NSDF Project and effects or the NSDF Project to survival and reproduction are considered neutral. In addition, the remaining availability of potential maternity roosting habitat in the Application Case is not likely a limiting factor in the RSA, and CNL has committed to a comprehensive Sustainable Forest Management Plan to protect and improve roosting habitat in the RSA through time. Installation of bat boxes in suitable locations in the RSA has been undertaken to mitigate the incremental contribution of the NSDF Project to roost habitat loss. Monitoring conducted by CNL on existing bat boxes (installed in 2017) suggests that these are used, including as maternity roosts. This mitigation will further reduce the residual effect of the NSDF Project on bats. Therefore, the contribution of the NSDF Project to the existing significant adverse cumulative effect to bats is predicted to be negligible.

The NSDF Project would result in the long-term removal of 26 ha of proposed Blanding’s turtle critical habitat during construction. This is a loss of upland habitat within the SSA that has the potential to be used for nesting, thermoregulation and summer inactivity. Critical habitat will be assessed annually to ensure no significant loss at CRL and to determine compensation measures initiated at CRL or elsewhere. Females who use the SSA for nesting may experience a reduction in reproductive success until they find new areas within which to nest. In addition, the interruption or barrier to Blanding’s turtles moving through the SSA will result in the need to travel longer distances around the SSA in search of resources and will increase their risk of injury or mortality on roads. Increased traffic volume associated with the NSDF Project has the potential to increase road mortality, which is the primary potential contribution of the NSDF Project to existing significant adverse effects identified for Blanding’s turtles.

The increase in traffic related to NSDF Project and consequently the risk of road injury or mortality, will not be significant, as CNL is currently upgrading infrastructures located in priority areas for the Blanding's turtle. The *Blanding’s Turtle Road Mortality Mitigation Plan* is also currently being implemented at CNL. Mitigation specific to the NSDF Project will also improve conditions for Blanding’s turtle on the CRL Site. In addition, the existing CNL Employee Education Program will be adapted to the NSDF Project prior to construction. All employees and contractors will be trained on the identification and safe handling of Blanding’s turtle to help the turtles across the road. The removal of critical habitat for Blanding’s turtle will require a SARA permit under Section 73(3).

With mitigation, the contribution of the NSDF Project to significant effects in the RSA is considered minor (Table 5.6.9-1). The weight of evidence suggests that, with mitigation committed to by CNL, effects from the NSDF Project will not jeopardize the survival of the regional Blanding’s turtle population. With enough mitigation implemented at CRL, reductions in Blanding’s turtle road mortality are possible, even with increased traffic volumes associated with the NSDF Project.

Table 5.6.9-1: Summary of Predicted Residual Adverse Effects for Terrestrial Biodiversity Valued Components

Valued Components	Assessment Endpoint	Residual Adverse Effects	Project Effect Occurs in	Contributing Project Activity	Proposed Mitigation	Significance of the NSDF Project
Vegetation communities	Maintenance of self-sustaining and ecologically effective vegetation communities.	▪ Permanent loss of 33 ha of forested communities. ▪ Permanent changes to the distribution of forested habitats; no changes to the distribution of wetlands. ▪ Permanent edge effects may alter adjacent vegetation community richness.	All phases	▪ Vegetation clearing and grubbing	▪ The SSA has been designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. ▪ A 30 m buffer will be established along identified wetlands near the SSA; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion. ▪ A 5 m treeline buffer is established from all property lines on the SSA to limit disturbance to vegetation and large tree roots at the treeline.	Not Significant
Canada warbler	Maintenance of self-sustaining and ecologically effective populations.	▪ Permanent loss of 28 ha of suitable habitat. ▪ Possible long-term avoidance in the LSA from sensory disturbance. ▪ Permanent small change in movement in the LSA. ▪ Permanent small reduction in carrying capacity.	All phases	▪ Vegetation clearing and grubbing ▪ Mobilization of equipment ▪ Hauling of materials ▪ Blasting	▪ The SSA has been designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. ▪ A 30 m buffer will be established along identified wetlands near the SSA; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion. ▪ A 5 m treeline buffer is established from all property lines on the SSA to limit disturbance to vegetation and large tree roots at the treeline. ▪ Avoid conducting the activities with highest levels of noise and habitat disturbance during most sensitive life history phase (i.e., breeding and nesting for birds) by conducting vegetation clearing and grubbing before April 8 or after August 31 to avoid effects on nesting birds.	Not Significant
Eastern whip-poor-will		▪ Permanent loss of 2 ha of suitable habitat. ▪ Possible long-term avoidance in the LSA from sensory disturbance. ▪ Permanent small change in movement in the LSA. ▪ Permanent small reduction in carrying capacity.				Not Significant
Eastern wood-pewee		▪ Permanent loss of 18 ha of suitable habitat. ▪ Possible long-term avoidance in the LSA from sensory disturbance. ▪ Permanent small change in movement in the LSA. ▪ Permanent small reduction in carrying capacity.				Not Significant
Golden-winged warbler		▪ Permanent loss of 27 ha of suitable habitat. ▪ Possible long-term avoidance in the LSA from sensory disturbance. ▪ Permanent small change in movement in the LSA. ▪ Permanent small reduction in carrying capacity.				Not Significant
Wood thrush		▪ Permanent loss of 28 ha of suitable habitat. ▪ Possible long-term avoidance in the LSA from sensory disturbance. ▪ Permanent small change in movement in the LSA. ▪ Permanent small reduction in carrying capacity.				Not Significant

Table 5.6.9-1: Summary of Predicted Residual Adverse Effects for Terrestrial Biodiversity Valued Components

Valued Components	Assessment Endpoint	Residual Adverse Effects	Project Effect Occurs in	Contributing Project Activity	Proposed Mitigation	Significance of the NSDF Project
Bats	Maintenance of self-sustaining and ecologically effective populations.	▪ Permanent loss of 28 ha of potential maternity roost habitat. ▪ Potential long-term avoidance of adjacent maternity roosting habitat in the LSA from sensory disturbance. ▪ Permanent negligible change in movement corridors between maternity roosting habitat patches.	All phases	▪ Vegetation clearing and grubbing ▪ Mobilization of equipment ▪ Hauling of materials ▪ Blasting	▪ The SSA has been designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. ▪ A 30 m buffer will be established along identified wetlands near the SSA; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion. ▪ A 5 m treeline buffer is established from all property lines on the SSA to limit disturbance to vegetation and large tree roots at the treeline. ▪ Avoid conducting the activities with highest levels of noise and habitat disturbance during most sensitive life history phase (i.e., maternity roosting for bats) by conducting vegetation clearing and grubbing before April 8 or after August 31 to avoid effects on bat maternity roosts. ▪ Bat boxes are relatively inexpensive and can be highly effective at providing habitat for roosting little brown myotis and possibly northern myotis. Tri colored bats are less likely to use bat boxes, but may use other forms of artificial roosting habitat; these options may be considered. Installation of bat boxes in suitable locations in the RSA is recommended to offset the incremental contribution of the NSDF Project to cumulative effects on SARA listed bats. ▪ In consultation with CNL biologists and in consideration of future losses of anthropogenic structures that may provide roosting habitat, offsetting in the form of 16 bat boxes was recommended. Bat boxes were installed in May 2017. Each two chambered box (Bat Conservation International approved design) was installed back to back on wooden poles in eight different locations around the proposed NSDF location. Occupancy was confirmed in July 2018 and has been increasing since then. This box design is suggested to have capacity for 350–400 individual bats per box, providing roosting habitat for a potential maximum of 6,400 individual bats (with 16 boxes). ▪ Criteria for appropriate siting included accessibility of box locations for installation and future monitoring of utilization/effectiveness, avoidance of areas with radiological contamination in surface water features and appropriate distance to anthropogenic disturbances to avoid sensory effects (i.e., noise). Immature forested areas adjacent to larger uncontaminated waterbodies and wetlands are high priority locations because these forest types do not currently provide high quality roosting habitat and would be most benefited by installation of bat roost boxes to expand the spatial coverage of potential roosting habitat within the RSA. Final site selection will be at the discretion of CNL biologists. ▪ Monitoring is being conducted at least weekly to determine if boxes are being used. Boxes not being used may be moved to an alternate location. ▪ A project in collaboration with Trent University is currently underway, where bats are being trapped and tracked back to the roost site (natural tree or bat box). Guano collection is being performed as well. This work has a duration of two years and will provide CNL with a better understanding of habitat occupancy by the bat species at risk, including bat boxes, and habitat preference. This work will support the objective of addressing knowledge gaps on the three bat species at risk ▪ A comprehensive Sustainable Forest Management Plan will be implemented to ensure the long-term retention of trees serving as maternity roosts for the bat species	Not Significant

Table 5.6.9-1: Summary of Predicted Residual Adverse Effects for Terrestrial Biodiversity Valued Components

Valued Components	Assessment Endpoint	Residual Adverse Effects	Project Effect Occurs in	Contributing Project Activity	Proposed Mitigation	Significance of the NSDF Project
Blanding's turtle	Maintenance of self-sustaining and ecologically effective populations.	▪ Long-term loss of 26 ha of critical habitat with implementation of mitigation to ensure no significant loss of critical habitat; ▪ Permanent change in potential movement corridors between habitat patches ▪ Long-term increased risk of injury or mortality on roads from increased traffic (but mitigation may be sufficient to prevent this effect) ▪ Permanent increased risk of mortality from changes to movement patterns	All phases	▪ Vegetation clearing and grubbing ▪ Mobilization of equipment ▪ Hauling of materials ▪ Installation and maintenance of perimeter fencing	▪ The SSA has been designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. ▪ A 30 m buffer will be established along identified wetlands near the SSA; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion. ▪ A 5 m tree-line buffer is established from all property lines on the NSDF site to limit disturbance to vegetation and large tree roots at the treeline ▪ Critical Blanding's turtle habitat will be assessed annually to ensure no significant loss at CRL and to determine compensation measures initiated at CRL or elsewhere. ▪ Artificial nest mounds will be constructed on both sides of new and replaced culverts ▪ New and replaced culverts will be enhanced by planting native vegetation around the culvert entrances, while maintaining a clear line of site through the culvert ▪ Reptile exclusion fencing will be installed around the perimeter of the SSA prior to initiating activities during the construction phase and prior to the active Blanding's turtle season (i.e., prior to April). This mitigation will also benefit milksnakes. ▪ Damaged or ineffective fencing and signage will be repaired. ▪ Road grading and levelling activities will not be completed during the turtle terrestrial season (May 15 to September 30). ▪ Temporary exclusion fencing will be installed around the NSDF EMR footprint during construction of the NSDF Project. This temporary exclusion fencing will be replaced by permanent fencing by the end of construction of the NSDF Project. Exclusion fencing will benefit both Blanding's turtles and milksnakes. ▪ A road mortality survey will be completed for turtles and milksnake in the species' active seasons of April 15 to September 30 ▪ After replacement, culverts will have appropriate permanent fencing installed for 200 m on either side of the culvert to guide turtles through the tunnel. ▪ Following approval of the NSDF Project, additional permanent exclusion fencing will be installed in reptile hotspots along Plant Road ▪ Drivers have standard safety training and are provided with environmental awareness training. ▪ Enforce existing CRL site speed limits on access roads. ▪ Post signs warning drivers of high use wildlife areas and reduce speed limits in these areas. ▪ Employees in vehicles encountering wildlife of concern (e.g., Blanding's turtle) on roads are required to communicate the presence of wildlife on the roads to other employees working in the area and to CNL's Environmental Staff. ▪ The existing CNL Employee Education Program will be adapted to the NSDF Project prior to construction. All employees and contractors will be trained on the identification and safe handling of Blanding's turtle to help the turtle across the road. ▪ As per CNL's *Management of Land, Habitat and Wildlife* procedure (CNL 2018b), dead or wounded animals on roads must be reported to the environmental department. ▪ Blanding's turtle collisions with vehicles will be monitored, which provides feedback for adaptive management.	Not Significant

Table 5.6.9-1: Summary of Predicted Residual Adverse Effects for Terrestrial Biodiversity Valued Components

Valued Components	Assessment Endpoint	Residual Adverse Effects	Project Effect Occurs in	Contributing Project Activity	Proposed Mitigation	Significance of the NSDF Project
Eastern milksnake	Maintenance of self-sustaining and ecologically effective populations.	▪ Direct loss of some suitable milksnake habitat ▪ Potential avoidance of otherwise suitable habitat due to sensory disturbance in the LSA Permanent small change in movement in the LSA ▪ Permanent small reduction in carrying capacity	All phases	▪ Vegetation clearing and grubbing ▪ Mobilization of equipment ▪ Hauling of materials ▪ Blasting	▪ A 5 m tree-line buffer is established from all property lines on the NSDF site to limit disturbance to vegetation and large tree roots at the treeline ▪ Temporary exclusion fencing will be installed around the NSDF EMR footprint during construction of the NSDF Project. This temporary exclusion fencing will be replaced by permanent fencing by the end of construction of the NSDF Project ▪ Damaged or ineffective fencing and signage will be repaired. ▪ Drivers have standard safety training and are provided with environmental awareness training. ▪ Enforce existing CRL site speed limits on access roads. ▪ Post signs warning drivers of high use wildlife areas and reduce speed limits in these areas. ▪ Employees in vehicles encountering wildlife of concern (e.g., milksnake) on roads are required to communicate the presence of wildlife on the roads to other employees working in the area and to CNL's Environmental Staff. ▪ The existing CNL Employee Education Program will be adapted to the NSDF Project prior to construction. All employees and contractors will be trained on the identification and safe handling of milksnake to help the snake across the road. ▪ As per CNL's *Management of Land, Habitat and Wildlife* procedure (CNL 2018b), dead or wounded animals on roads must be reported to the environmental department. ▪ Milksnake collisions with vehicles will be monitored, which will provide feedback for adaptive management	Not Significant
Monarch butterfly	Maintenance of self-sustaining and ecologically effective populations	▪ Permanent loss of 5 ha of suitable habitat. ▪ Permanent small change in movement in the LSA. ▪ Permanent small reduction in carrying capacity.	All phases	▪ Vegetation clearing and grubbing	▪ The SSA has been designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. ▪ A 30 m buffer will be established along identified wetlands near the SSA; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion. ▪ If vegetation clearing is scheduled in open habitat between late May and October, the habitat will be searched in advance of construction for the presence of milkweed. Removal of milkweed between May and October will be managed in accordance with CNL Environmental Protection Program.	Not Significant

SSA = Site Study Area; LSA = Local Study Area; RSA = Regional Study Area; ECM = engineered containment mound; ECCC = Environment and Climate Change Canada

5.7 Ambient Radioactivity and Ecological Health

This section of the Environmental Impact Statement (EIS) for the Canadian Nuclear Laboratories (CNL) Near Surface Disposal Facility (NSDF) Project seeks to understand and characterize existing ambient radioactivity at the Chalk River Laboratories (CRL) site. The focus of this section is to summarize the results of the ecological health assessments, specifically as they relate to effects to ecological (i.e., non-human) receptors from changes in ambient radioactivity as well as non-radiological effects to ecological receptors.

5.7.1 Scope of the Assessment

The ambient radioactivity and ecological health assessment follows the overall environmental assessment approach and methods described in Section 5.1 Environmental Assessment Approach. The assessment was completed following the key steps listed below:

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries and assessment cases** for the ambient radioactivity and ecological health assessment (refer to Sections 5.7.2 Valued Components and Section 5.7.3 Assessment Boundaries). The VCs and measurement indicators used to assess NSDF Project-related changes to ecological health are described, along with the spatial and temporal boundaries at which the assessment occurred and the assessment cases considered.
- **Step 2 – Describe the existing conditions** (refer to Section 5.7.4 Description of the Environment). Existing ambient radioactivity conditions in the local and regional areas are described, including the combined effects of previous and existing developments (Base Case). The existing environment represents the historical and current environmental pressures that have shaped the observed patterns in the environment (i.e., natural variation), and provide a reference to which the effects of the NSDF Project can be compared.
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 5.7.5 Project Interactions and Mitigation). Project components and/or activities with the potential to change ecological health are identified and mitigation developed to limit or avoid effects are presented. A pathways analysis is then used to focus further assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects to ecological health. Where effects are adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects to ecological health after incorporating mitigation are carried forward to Step 4 for further analysis and residual effects characterization.
- **Step 4 – Present the methods and results of the residual effects analysis** (refer to Section 5.7.6 Residual Effects Analysis). This section summarizes the methods used to predict and characterize residual effects to ecological health from primary effects pathways. The results of the ecological risk assessment are presented including the characterization of residual incremental effects of the NSDF Project and the cumulative effects of the NSDF Project in combination with other reasonably foreseeable developments (if applicable).

- **Step 5 – Describe the level of certainty and management of uncertainty** (refer to Section 5.7.7 Prediction Confidence and Uncertainty). Evaluate the available literature, data and models used for the ecological health assessment and describe the level of certainty that can be placed on predicted residual effects. This section will also identify how the uncertainty has been managed so that the effects are not underestimated.
- **Step 6 – Classify and determine the significance of the predicted residual effects** (refer to Section 5.7.8 Residual Effects Classification and Determination of Significance). Residual effects predicted from primary pathways are classified and a determination of the significance of the predicted residual effects of the NSDF Project on ecological health is made. Relative to other sections, the ecological health assessment uses a slightly different approach to the classification of residual effects and evaluation of significance, because several of the criteria (e.g., geographical extent, duration, frequency and reversibility) are already incorporated into the risk estimates and, therefore, are not independent variables.
- **Step 7 – Identify monitoring and follow-up** required to confirm effects predictions and address uncertainty (refer to Section 5.7.9 Monitoring and Follow-up).
- **Step 8 – Present a consolidated summary of conclusions** and outcomes of the assessment of residual effects on ecological health (refer to Section 5.7.10 Conclusions).

Information and concerns raised by the public, communities of interest, and Indigenous peoples during engagement that influenced the scope of the ecological health assessment are summarized in Table 5.7.1-1. Other general areas of interest and questions raised during the engagement that pertain to the ecological health assessment (if any) are documented in CNL's Indigenous Engagement Report (CNL 2020a) and Stakeholder Activity Reports (CNL 2017a,b, 2019a).

Table 5.7.1-1: Summary of Issues Raised During Engagement Activities that Influenced the Scope of the Ecological Health Assessment

Issue	How the Issue Was Included in the Assessment
Effects on fish from potential for contamination in the Ottawa River from the NSDF Project	The spatial boundaries of the assessment were selected to include consideration of potential effects to the Ottawa River. The ecological health assessment considered potential changes in surface water in Perch Creek and meeting guidelines within the Perch Creek basin is protective of fish in the Ottawa River. The RSA was expanded to include a reach of the Ottawa River extending 8 km downstream of CRL in response to comments received from the public.
Potential for radioactivity from gases from the capped facility	Potential changes in air quality from the NSDF Project were evaluated in the ecological health assessment during the operations phase.
Potential for changes in groundwater quality to affect uses downstream of the ECM	Potential changes in groundwater quality from the NSDF Project were evaluated in the ecological health assessment and included potential changes from treated effluent discharge from the WWTP, and seepage from the ECM during the operations phase and post-closure phase.
Treatment of leachate	Leachate from the ECM will be collected and pumped to the WWTP for treatment prior to discharge.
Potential leakage of leachate from the ECM	Potential leakage of leachate from the ECM during operations will be mitigated through the design and implementation of a composite base liner system, a leachate detection system and a leak collection system. Potential leakage from the ECM during the operations phase and post-closure phase is considered in the ecological health assessment.

WWTP = Wastewater Treatment Plant; ECM = engineered containment mound; RSA = Regional Study Area

5.7.2 Valued Components

VCs refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community or the public (The Agency 2018). A functioning ecosystem involves interactions of multiple species ranging in size and complexity from bacteria to apex wildlife predators. Each species is likely to respond differently to levels of substances present in environmental media (air, water, soil, vegetation, foodstuffs). Because it is not possible to directly assess the risk for each individual species, it is necessary to simplify the complex ecosystem into organism groups and trophic linkages. To this end, the general ecology of the NSDF Project site was reviewed using existing information and the species present were divided into major ecosystem components representing different potential health exposure pathways. Representative receptor taxa were selected as indicator species for each valued component and are listed in Table 5.7.2-1.

Representative receptor taxa were selected from those that are documented to occur or potentially occur in the local and regional study areas (see Section 5.7.3.1 Spatial Boundaries), have a relatively high potential for exposure to potentially affected media, play a key role in the food web and represent a variety of habits and trophic levels (CNL 2016a). A smaller group of indicator species was chosen to represent VCs selected for assessment. Indicator species were chosen based on at least one of the following criteria:

- reflective of the main exposure pathways, feeding habits and habitats, on the site, and particularly those associated with the highest exposures;
- known to reside on the site, and therefore, are potentially exposed to environmental effects from the NSDF Project;
- represent a major plant or animal group;
- represent their trophic level, resulting in representation for all trophic levels and therefore, all exposure pathways;
- sensitive to stressors;
- occupy a unique niche in the habitat or have a unique diet;
- ecologically significant (e.g., classified as species at risk); and
- have a special socio-economic importance or value (e.g., due to their economic value or cultural importance).

These indicator species (VCs) were used in the effects assessment to estimate potential exposures to radiological and non-radiological constituents. The indicator species listed in Table 5.7.2-1 include those species identified and assessed for biodiversity effects in Section 5.5 and Section 5.6.

Table 5.7.2-1: Valued Components and Indicator Species for Ecological Health Assessment

Environmental Component	Taxa	Category	Valued Components		Effects (Habitat, Exposure)	Indicator Species	Justification for Inclusion in Exposure Assessment
			Population Group or Habitat Type	Species (including Species at Risk or Regionally Rare Species)			
Aquatic environment	Benthic Macroinvertebrate	Crustaceans	n/a	n/a	Exposure	Benthic Invertebrates	Indicator species for changes in sediment quality
	Zooplankton	Crustaceans	Pelagic invertebrate	n/a	Exposure	Zooplankton	Indicator species for changes in water quality
	Fish	Small Pelagic forage (omnivores)	Fish and Fish Habitat	▪ Bluntnose Minnow ▪ Common Shiner ▪ Creek Chub ▪ Pumpkinseed ▪ Blacknose Shiner ▪ Fathead Minnow ▪ Pearl Dace	Habitat, Exposure	Bluntnose Minnow	Present in Perch Creek, represents small pelagic fish
		Small - Benthivorous	Fish and Fish Habitat	▪ Johnny Darter Brown Bullhead ▪ Black Bullhead Longnose Dace	Habitat, Exposure	Black Bullhead	Present in Perch Creek, represents small benthivorous fish
		Large - Benthivorous	Fish and Fish Habitat	▪ Lake Sturgeon ▪ White Sucker	Habitat, Exposure	n/a[a]	Not present in the LSA, where surface water concentrations are higher than in the Ottawa River
		Small - Carnivorous	Fish	▪ Logperch ▪ Fallfish ▪ Yellow Perch ▪ Mottled Sculpin	Habitat, Exposure	n/a[a]	Not present in the LSA, where surface water concentrations are higher than in the Ottawa River
		Large - Carnivorous	Fish	▪ Northern Pike	Habitat, Exposure	Northern Pike	Present in Perch Lake, represents Large Carnivorous fish

Table 5.7.2-1: Valued Components and Indicator Species for Ecological Health Assessment

Environmental Component	Taxa	Category	Valued Components		Effects (Habitat, Exposure)	Indicator Species	Justification for Inclusion in Exposure Assessment
			Population Group or Habitat Type	Species (including Species at Risk or Regionally Rare Species)			
Terrestrial Environment	Plant	Aquatic	Vegetation Communities	n/a	Exposure	Reed (food for predators)	Present in the wetlands in the LSA, represents aquatic vegetation communities, food chain
		Terrestrial	Vegetation Communities	n/a	Exposure	Red maple	Present in the LSA, represents terrestrial vegetation communities
	Insect	Pollinator	n/a	▪ Monarch butterfly	Exposure	Monarch butterfly	Present in the LSA, represents Pollinators
	Detritivore	Terrestrial Invertebrate	n/a	n/a	Exposure	Earthworm	Indicator species for changes in soil quality
	Mammal	Small - Insectivores	Bats	▪ Little brown myotis ▪ Eastern small-footed myotis ▪ Northern myotis ▪ Tri-coloured bat	Habitat, Exposure	Little brown myotis	Present in the LSA, represents small insectivores
		Small – Herbivore	n/a	n/a	Exposure	Meadow vole	Present in the LSA, represents small herbivorous mammals
		Large – Herbivore	n/a	n/a	Exposure	White-tailed deer[(b)]	Present in the LSA, represents large herbivorous mammals, public interest
		Large - Herbivore	n/a	n/a	Exposure	Moose	Present in the LSA, make use of aquatic habitat, represents large herbivorous mammals, Indigenous interest

Table 5.7.2-1: Valued Components and Indicator Species for Ecological Health Assessment

Environmental Component	Taxa	Category	Valued Components		Effects (Habitat, Exposure)	Indicator Species	Justification for Inclusion in Exposure Assessment
			Population Group or Habitat Type	Species (including Species at Risk or Regionally Rare Species)			
Terrestrial Environment (continued)	Mammals (continued)	Small - Omnivorous	n/a	n/a	Exposure	Short-tailed shrew	Present in the LSA, represents small omnivorous mammals
		Large - Omnivorous	n/a	n/a	Exposure	Black bear[(b)]	Present in the LSA, represents large omnivorous mammals, public interest
		Large - Carnivorous	n/a	▪ Eastern wolf	Exposure	Eastern wolf[(b)]	Present in the LSA, represents large carnivorous mammals, public interest
	Reptile	Semi-terrestrial	Turtle	▪ Blanding's turtle ▪ Snapping turtle	Habitat, Exposure	Snapping turtle[(c)]	Present in the LSA, represents semi-terrestrial reptiles (turtle)
		Semi-terrestrial	Snake	n/a	Exposure	Common watersnake	Present in the LSA, represents semi-terrestrial reptiles (snake)
		Terrestrial	Snake	n/a	Exposure	Eastern milksnake	Present in the LSA, represents terrestrial reptiles (snake)
	Amphibian	Semi-aquatic	Frog	n/a	Exposure	Green frog	Present in the wetlands in the LSA, represents semi-aquatic amphibians

Table 5.7.2-1: Valued Components and Indicator Species for Ecological Health Assessment

Environmental Component	Taxa	Category	Valued Components		Effects (Habitat, Exposure)	Indicator Species	Justification for Inclusion in Exposure Assessment
			Population Group or Habitat Type	Species (including Species at Risk or Regionally Rare Species)			
Terrestrial Environment (continued)	Bird	Small – Insectivores	Migratory birds	▪ Wood thrush ▪ Veery ▪ Eastern wood-pewee ▪ Black-throated blue warbler ▪ Least flycatcher ▪ Chestnut-sided warbler ▪ Common yellowthroat ▪ Mourning warbler ▪ Brown thrasher ▪ Golden-winged warbler ▪ Canada warbler	Habitat, Exposure	Canada warbler	Present in the LSA, represents small insectivores birds
		Large Insectivores	Migratory birds	▪ Eastern whip-poor-will ▪ Yellow-bellied sapsucker	Habitat, Exposure	Eastern whip-poor-will	Present in the LSA, represents large insectivore birds
		Small Omnivores	Migratory birds	▪ Purple finch ▪ Rose-breasted grosbeak ▪ White-throated sparrow	Exposure	Purple finch	Present in the LSA, represents small omnivore birds

Table 5.7.2-1: Valued Components and Indicator Species for Ecological Health Assessment

Environmental Component	Taxa	Category	Valued Components		Effects (Habitat, Exposure)	Indicator Species	Justification for Inclusion in Exposure Assessment
			Population Group or Habitat Type	Species (including Species at Risk or Regionally Rare Species)			
Terrestrial Environment (continued)	Bird (continued)	Large Omnivores	n/a	▪ Northern flicker ▪ Ruffed grouse	Exposure	Ruffed grouse	Present in the LSA, represents large omnivore birds
		Small Carnivores	n/a	▪ Belted kingfisher	Exposure	Belted kingfisher	Present in the LSA, represents small carnivore birds
		Large Carnivores	Raptors	▪ Bald eagle	Exposure	Bald eagle	Present in the LSA, represents large carnivore birds, public interest
		Small semi-aquatic	Waterfowl	▪ American black duck ▪ Mallard	Exposure	Mallard	Present in the LSA, represents small semi-aquatic birds, public interest
		Large semi-aquatic	n/a	▪ Great blue heron	Exposure	Great blue heron	Present in the LSA, represents large semi-aquatic birds, public interest

(a) These species are not selected as they do not represent the bounding case from dose assessment perspective.

(b) These species were not selected on basis of their large home range

(c) Snapping turtle is selected as the surrogate for Blanding's turtle for exposure.

LSA = Local Study Area; n/a = not applicable.

Assessment endpoints are qualitative expressions used to assess the significance of residual effects on VCs and represent the key properties of the VC that should be protected for future human generations (i.e., incorporates sustainability). The assessment endpoint is the protection of ecological health. Measurement indicators represent properties of the environment, that when changed, could result in or contribute to an effect on an assessment endpoint. The measurement indicators for the ecological health assessment are outlined in Table 5.7.2-2.

Table 5.7.2-2: Assessment Endpoint and Measurement Indicators for the Ecological Health Assessment

Valued Component	Assessment Endpoint	Measurement Indicators
Indicator species listed in Table 5.7.2-1	Protection of ecological health	■ Changes to air quality ■ Changes to groundwater quality ■ Changes to sediment quality ■ Changes to surface water quality ■ Changes to soil quality ■ Changes to vegetation quality

5.7.3 Assessment Boundaries

5.7.3.1 Spatial Boundaries

The spatial boundaries for ecological health were thus selected to incorporate relevant portions of the study areas for air quality, groundwater quality and surface water quality to evaluate the environmental changes that could contribute to effects on ecological health. The spatial boundaries for the characterization of ambient radioactivity and subsequent effects assessment are as follows (Figure 5.7.3-1):

- **Site Study Area (SSA):** The SSA is the NSDF Project footprint (i.e., where Project activities would be undertaken, including the NSDF Project's proposed facilities, buildings and infrastructure).
- **Local Study Area (LSA):** The LSA is selected in consideration of the NSDF Project footprint and the spatial extent of potential direct effects of the Project on the VCs. The LSA adapted from the groundwater and surface water LSA and is designated as the spatial extent of the Perch Creek and Perch Lake Watershed, and includes Perch Lake and its tributaries and Perch Creek. The Ottawa River in the vicinity of the mouth of Perch Creek is also included in the LSA.
- **Regional Study Area (RSA):** The RSA is defined as the area within which the potential effects of the NSDF Project may interact with the effects of other existing or reasonably foreseeable developments. Ecological receptors in the vicinity of the engineered containment mound (ECM) could be exposed to airborne and waterborne emissions, as well as direct gamma radiation from the waste. Doses to ecological receptors exposed to the aquatic habitat of East Swamp Stream were calculated to provide a bounding estimate of potential exposure. Therefore, the RSA for ecological health is a combination of the air quality and aquatic environment RSAs as this is the largest extent of potential cumulative effects on ecological health. The air quality RSA is defined as an approximately 7.4 km circular radius surrounding the LSA, and the aquatic RSA extends roughly 8 km downstream in the Ottawa River to Harrington Bay.

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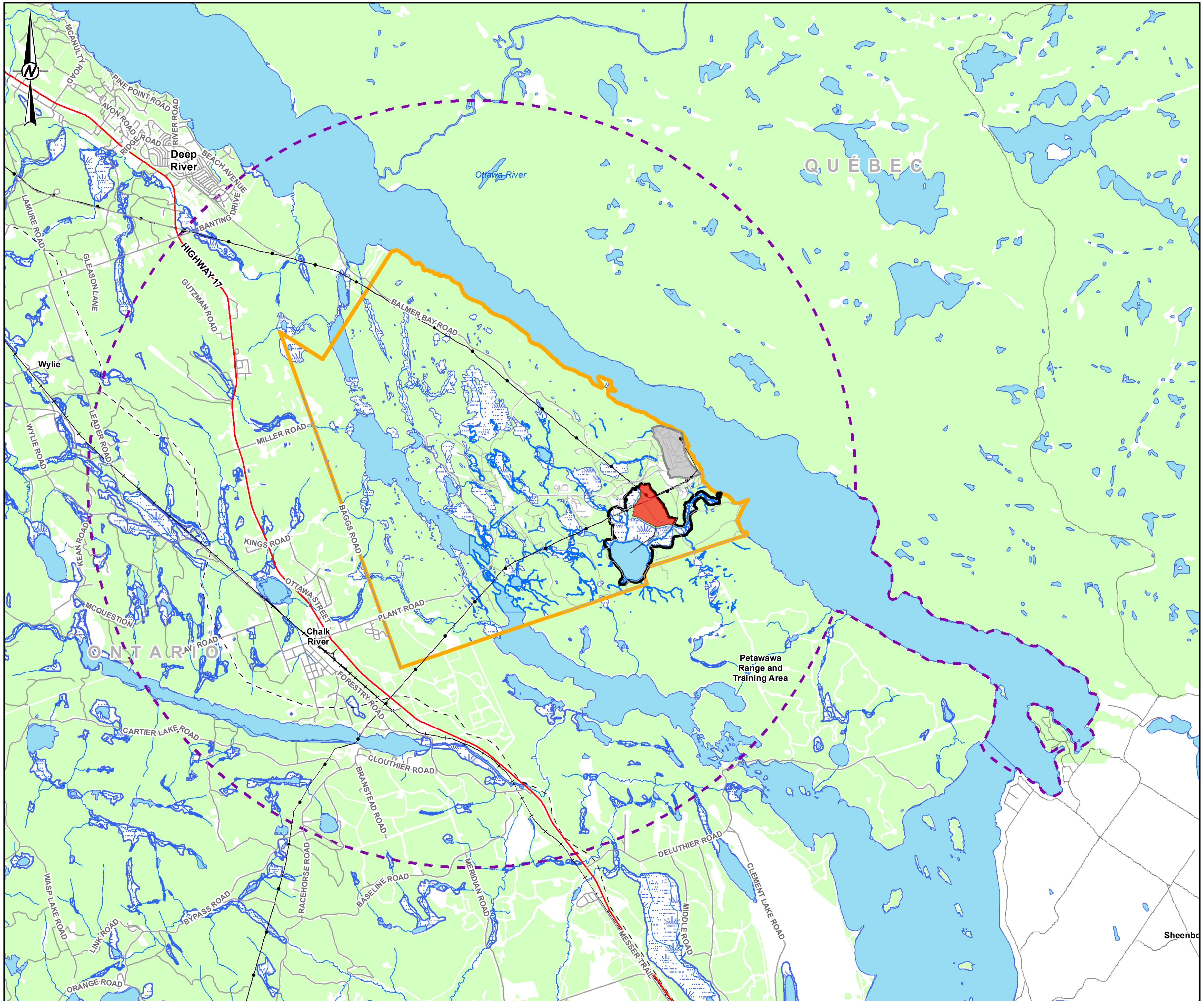

LEGEND

- HIGHWAY
- ROAD
- RAILWAY
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- NSDF PROJECT
- CRL MAIN CAMPUS
- CRL SITE
- LOCAL STUDY AREA
- REGIONAL STUDY AREA

2.5 0 2.5

1:75,000 KILOMETRES

REFERENCE(S)

1. BASEMAP:SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. HIGHWAYS AND FIRST NATION RESERVES MNRF 2016
4 PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
SPATIAL BOUNDARIES SELECTED FOR THE ECOLOGICAL HEALTH ASSESSMENT

CONSULTANT GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0018	FINAL 2	5.7.3-1

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5.7.3.2 Temporal Boundaries

Temporal boundaries (i.e., project phases) establish the timeframe during which NSDF Project effects are assessed. The temporal boundary represents the timeframe during which project activities are actively occurring and considers the duration of predicted residual effects. The duration of an effect is defined as the amount of time between the start and end of a Project activity or stressor (which is related to the project phases) plus the time required for the residual effect to be reversed. In some cases, a residual effect may be irreversible within the temporal boundaries of the Project or if the effects were predicted to last so far into the future that they could not be predicted with any level of certainty (e.g., residual effect lasts for thousands of years). The following phases were identified for the NSDF Project:

- **Construction phase**: This phase includes site preparation and all activities associated with the construction of the NSDF Project. This phase includes activities such as installing the necessary supporting and/or ancillary facilities and infrastructure to facilitate NSDF Project operations, inactive commissioning and systems testing, and transportation of construction materials. Construction activities are expected take place from 2021 to 2023.
- **Operations phase**: This phase includes all activities associated with waste placement, water management, Wastewater Treatment Plant (WWTP) operations, vehicle movements into and from the SSA, and maintenance activities. Operations activities are expected to last approximately 50 years (i.e., 2024 to 2070).
- **Closure phase:** includes activities necessary to complete the installation of the final cover and implementation of long-term monitoring. Closure activities are expected to start in 2070 and continue through to 2100, after which the NSDF Project will transfer into the post-closure phase.
- **Post-closure phase:** has two discrete periods: institutional control and post-institutional control. The institutional control period includes implementation of controls throughout 2100 to 2400 (i.e., 300 years). During institutional control, environmental monitoring will continue to demonstrate compliance with the environmental assessment conditions. Post-institutional control occurs after year 2400 and continues indefinitely.

5.7.3.3 Assessment Cases

The assessment cases considered in the ambient radioactivity assessment include the Base Case and Application Case (the Reasonably Foreseeable Developments Case has not been considered for the reasons outlined below):

- **Base Case:** This scenario represents existing conditions and characterizes combined effects from previous and existing developments and activities. The Base Case reflects the effects of existing disturbances, such as forestry, transportation, agricultural, mining, and residential and recreational development. Current effects from the existing CRL facilities and operations, for example, are considered part of the Base Case.
- **Application Case:** This scenario represents predictions of the effects of the Base Case combined with the effects that may result from the NSDF Project. The Application Case considers potential effects from the NSDF Project during the operations phase and the post-closure phase.

- **Reasonably Foreseeable Developments (RFD) Case:** This scenario represents predictions of the cumulative effects of the Application Case, which includes the Base Case, plus projects that are currently under application review or that have officially entered a regulatory application process, and are therefore, considered reasonably foreseeable. Because RFDs will either have no spatial overlap or are likely to positively affect ecological health, an RFD Case is not presented as part of this assessment. RFDs within the CRL site (i.e., the RSA) include only the new or upgrades to research and development facilities, construction and operations of the Small Modular Reactor, new support infrastructure, and on-going decommissioning and environmental remediation activities. Revitalization projects at the site (i.e., new or upgrades to research and development facilities, new support infrastructure) and decommissioning include several small projects staged over a 10-year period where best practices, mitigation and monitoring for management of emissions will to be followed. No process intakes of water from or discharges to surface or groundwater, or releases to air beyond the potential for a limited amount of steam from dry cooling towers are identified in the description of the planned Small Modular Reactor (Global First Power 2019). During normal operations, the Small Modular Reactor will introduce a very small radiological exposure to the environment near the plant, within the CRL site (Global First Power 2019). The incremental radiological (in proximity to the Small Modular Reactor) and non-radiological emissions from RFD Projects at any one time are expected to be small, distributed across the CRL site and removed from the more intensive activities within the SSA (i.e., the NSDF Project footprint).
- The NSDF Project will enable the remediation of contaminated lands and legacy waste management areas (WMAs) and decommissioning of outdated infrastructure at the site and CNL's other business locations to support future CNL work. The end-state plan for the CRL site will be to return lands disturbed by site activities to a condition that is physically stable and safe in keeping with the land use and landscape of the day. Therefore, decommissioning and environmental remediation activities are anticipated to positively affect ecological health.

5.7.4 Description of the Environment

This section uses effluent and environmental monitoring data from CRL and the surrounding area to establish a Base Case characterization of ambient radioactivity in environmental media. It describes the current CRL radiological effluents and the environmental concentrations of radiological contaminants for each environmental medium that could potentially be affected by the NSDF Project. Where possible, five-year datasets (e.g., from 2014 to 2018) are provided.

5.7.4.1 Background Sources of Radiation and Radioactivity

Background radiation and radioactivity is present in the environment due to natural and anthropogenic (human-made) sources independent of CRL operations. The magnitude of radiation dose from natural sources varies greatly, both spatially and temporally. The main natural sources of radiation are cosmic rays; naturally occurring radionuclides in air, water and food; and naturally occurring radionuclides in the soil, rocks and building materials used in homes (CNSC 2013).

Cosmic radiation originates from celestial events and the sun. This cosmic radiation and the secondary particles produced penetrate the Earth's atmosphere and give an external radiation dose at the Earth's surface. Naturally occurring radionuclides such as uranium, potassium and thorium are present in soils, rocks and building materials. These naturally occurring radionuclides also contribute to the external gamma radiation dose. Naturally occurring radionuclides are also incorporated into plants, animals and water from surrounding soils and rocks. Humans ingest these foodstuffs and receive an internal radiation dose. Radon gas, a product of the decay of uranium in soil, is inhaled and also contributes to the internal radiation dose.

The average annual doses in Canada are shown on Figure 5.7.4-1; the total annual dose of natural background radiation is approximately 1.8 millisieverts (mSv) (CNSC 2013).

Some radionuclides released from CRL are already present in environmental media due to natural and anthropogenic sources, such as atmospheric fallout from global weapons testing. Where applicable, environmental concentrations are compared to expected background levels or measurements of samples from reference areas outside the RSA, in order to distinguish the effect of CRL operations from radiological contamination that is present due to other sources.

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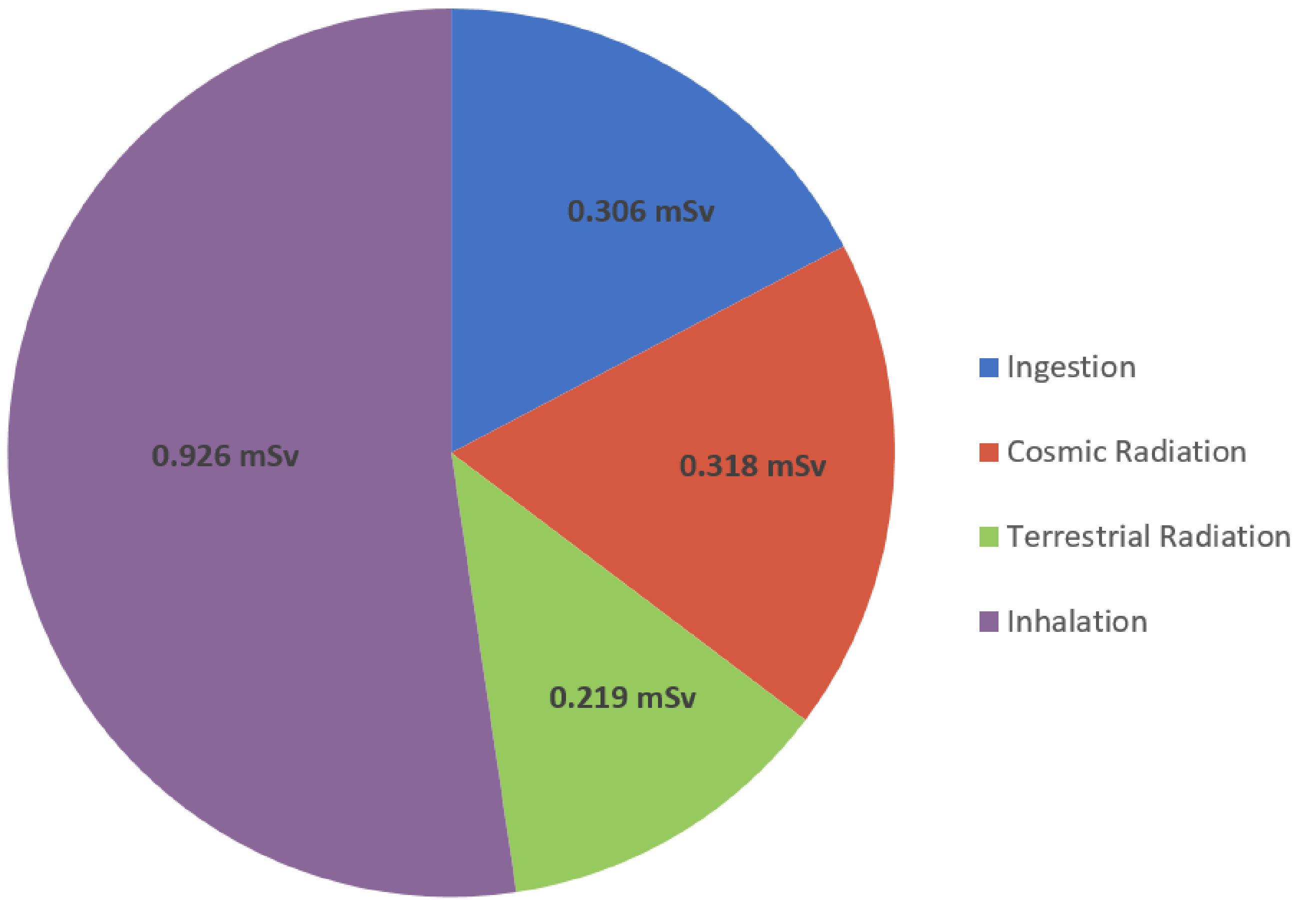

REFERENCE(S)

CLIENT
CANADIAN NUCLEAR LABORATORIES

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	PR
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
AVERAGE BACKGROUND RADIATION DOSES IN CANADA (MSV/Y) (CNSC 2013)

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	**5.7.4-1**

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5.7.4.2 Radioactive Releases from Chalk River Laboratories

This section summarizes the radioactive releases from CRL operations to the environment, including airborne and liquid effluents. The airborne radiological Effluent Verification Monitoring Program includes continuous monitoring of argon-41, mixed fission product noble gases, carbon-14, tritium oxide, elemental tritium, iodine-125, iodine-131, gross alpha particulates and gross beta particulates, from applicable operational facilities on the CRL site.

In 2018, the major sources of airborne radiological effluent from CRL operations (CNL 2019b) were:

- the B109 stack that exhausts ventilation and cooling air from the National Research Universal (NRU) reactor; and
- secondary roof vents and fugitive emissions exhausting various rooms within NRU.

The liquid radiological Effluent Verification Monitoring Program includes 13 monitoring points, in addition to upstream monitoring points used for reference. These locations are routinely monitored for gross alpha particulates, gross beta particulates and tritium oxide. Depending on the monitoring location, liquid effluent monitoring is performed at these locations using automatic samplers, weekly or monthly grab samples, or composite sampling. Tritium, gross alpha and gross beta are analyzed at least monthly for all monitoring locations, and weekly for the CRL site Process Sewer and Sanitary Outfall. Gamma spectroscopy is performed on liquid effluent samples at a frequency ranging from weekly to annually or as needed, depending on the effluent stream. CRL's radiological liquid effluent monitoring locations are shown on Figure 5.7.4-2. The environmental monitoring locations are discussed later in this section.

In 2018, the major sources of liquid radiological effluent at CRL site and the associated monitoring locations (CNL 2019b) are as follows:

- NRU reactor, Waste Treatment Centre (monitored at the Process Outfall);
- active laundry facility (monitored at the Sanitary Outfall);
- surface water and groundwater runoff from the WMAs (monitored at on-site surface waters); and
- groundwater discharges to the Ottawa River from sources inside the Controlled Area (monitored with on-site groundwater wells).
- It is noted that the NRU reactor and Moly Production Facility were placed in a safe shutdown state on March 31, 2018, and the active laundry facility ceased operations during 2018.

Leachate from WMA A and the Liquid Dispersal Area (LDA) may be particularly relevant due to their proximity to the SSA. These are sources of strontium-90 and tritium, which are monitored as part of the CRL Environmental Monitoring Program (CNL 2018a), and are monitored downstream at the Perch Creek weir effluent monitoring location. Monitoring includes monitoring downgradient of the WMAs and surface waterbodies in various locations.

The annual sum of airborne and liquid effluent releases from 2014 to 2018 is presented in Table 5.7.4-1. Derived Release Limits (DRLs) have been developed for the CRL site based on Canadian Standard Association (CSA) Standard N288.1-14 (CSA Group 2014). They are calculated limits for airborne and liquid releases of radionuclides such that the highest radiation dose to a member of the public does not exceed 1 mSv. While DRLs are relevant to the dose received by off-site human receptors, they are provided in this section only for context regarding the magnitude of releases. The major radiological contaminants in terms of percentage of DRL are argon-41 (0.74% of DRL in 2018), iodine-131 (0.0003% of DRL in 2018), mixed fission product noble gases (0.003% of DRL in 2018) and airborne tritium oxide (0.002% of DRL in 2018).

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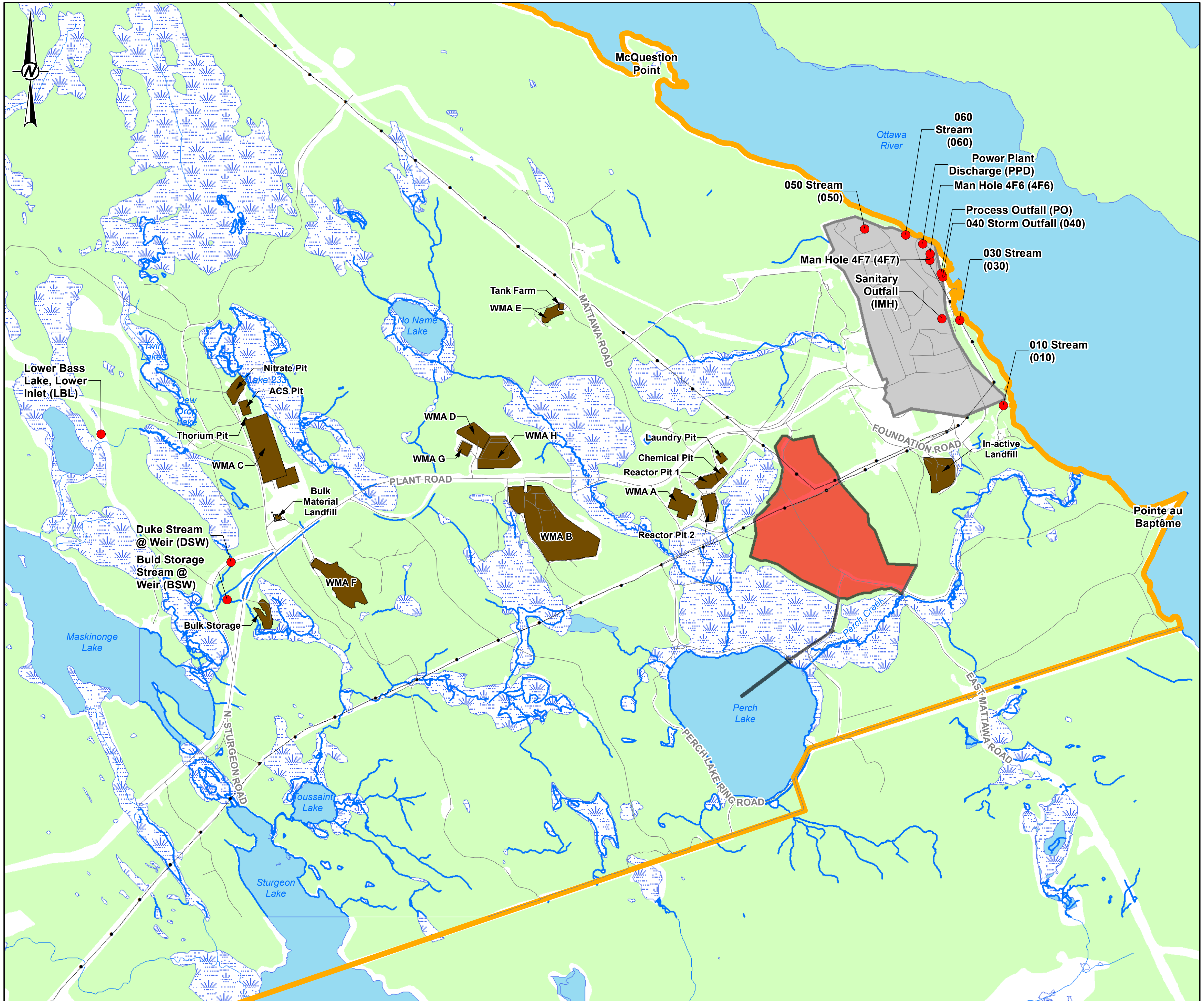

LEGEND

- ROADS
- RAILWAY
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- SITE STUDY AREA (NSDF PROJECT SITE)
- CRL MAIN CAMPUS
- CRL SITE
- WASTE MANAGEMENT AREA (WMA) [1]
- LIQUID EFFLUENT MONITORING LOCATION

500 0 500

1:20,000 METRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
RADIOLOGICAL LIQUID EFFLUENT MONITORING LOCATIONS AT CHALK RIVER LABORATORIES

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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Table 5.7.4-1: Chalk River Laboratories Annual Effluent Releases from 2014 to 2018

	(Annual) Derived Release Limit[1]	2014	2015	2016	2017	2018	2014–2018 Average
Airborne Releases							
Argon-41 (Bq/yr)	2.20E+17	9.37E+15	1.29E+16	1.07E+16	1.16E+16	2.59E+15	9.43E+15
Carbon-14 (Bq/yr)	7.28E+15	8.69E+11	3.77E+11	4.84E+11	4.90E+11	2.54E+11	4.95E+11
Tritium oxide (Bq/yr)	9.20E+16	2.60E+14	2.77E+14	2.30E+14	2.50E+14	2.29E+14	2.49E+14
Iodine-131 (Bq/yr)	2.25E+13	2.06E+11	1.03E+11	5.17E+10	3.82E+08	1.02E+08	7.22E+10
Mixed fission product noble gases (BqMeV/yr)	1.65E+17	2.11E+15	1.20E+15	8.50E+14	6.50E+12	6.50E+12	8.35E+14
Xenon-133 (Bq/yr)	2.78E+18	8.68E+15	4.89E+15	3.12E+15	0.00	0.00	3.34E+15
Liquid Releases							
Tritium oxide (Bq/yr)	3.42E+17	3.07E+13	3.94E+13	3.50E+13	3.81E+13	1.93E+13	3.25E+13
Gross alpha (Bq/yr)	4.40E+12	9.07E+08	6.94E+08	6.60E+08	7.66E+08	6.88+08	7.57E+08
Gross beta (Bq/yr)	8.02E+13	2.62E+11	3.96E+10	3.22E+10	4.17E+10	2.84E+10	8.08E+10

Source: CNL 2019b, c.

Note: The release limits listed above are about one third of the Derived Release Limits to account for the CRL site dose constraint of 0.3 mSv/yr to the most exposed critical group

Bq/yr = Becquerels per year; BqMeV/yr = Becquerels-mega-electron volts per year; mSv/yr = millisieverts per year.

1) Derived Release Limits for airborne releases are effluents released from CRL Stacks. Derived Release Limits for airborne releases are calculated in Bq/week and are listed here as Bq/year. Derived Release Limits for liquid releases are for liquid effluents from the CRL Process Outfall to the Ottawa River. Derived Release limits for liquid releases are calculated in Bq/month and are listed here in Bq/year.

5.7.4.3 Environmental Monitoring Program

This section describes the Environmental Monitoring Program within and outside of the CRL site boundary. The environmental monitoring program is the source of the Base Case radioactivity characterization data described in subsequent sections. The characterization of Base Case radioactivity utilizes an eight-year dataset from 2011 to 2018; this is considered to be the most accurate dataset in terms of representing the background radioactivity at CRL prior to NSDF operations. It is noted that additional future site activities may affect the Base Case radioactivity prior to NSDF operations. For example, on March 31, 2018, the NRU was placed into a guaranteed safe shutdown state followed by storage with surveillance thus an overall reduction in related emissions is anticipated in future years. The reactor will remain in that state until decommissioning, which is currently scheduled to begin in 2028 (CNL 2019b).

The CRL Environmental Monitoring Program includes sampling and analysis of surface water, groundwater, sediment, soil, vegetation, ambient air, milk, garden produce, game animals, farm animals and fish (CNL 2018a). Environmental monitoring of radiation in air includes continuous monitoring stations for ambient gamma, noble gases, carbon-14 and tritium. Results are reported in the annual CRL Environmental Monitoring Report. Monitoring of soil and vegetation on the CRL site has been performed through supplementary studies, including plume update studies and wetland contamination surveys conducted through the CRL Groundwater Monitoring Program.

Monitoring locations are displayed for the on-site portion of the CRL Environmental Monitoring Program on Figure 5.7.4-3. Off-site monitoring locations for radioactive air monitoring and radioactive liquid/biological monitoring are shown on Figure 5.7.4-4 and Figure 5.7.4-5, respectively. A summary of the radiological Environmental Monitoring Program monitoring parameters is shown in Table 5.7.4-2 and are described in more detail in the following sections

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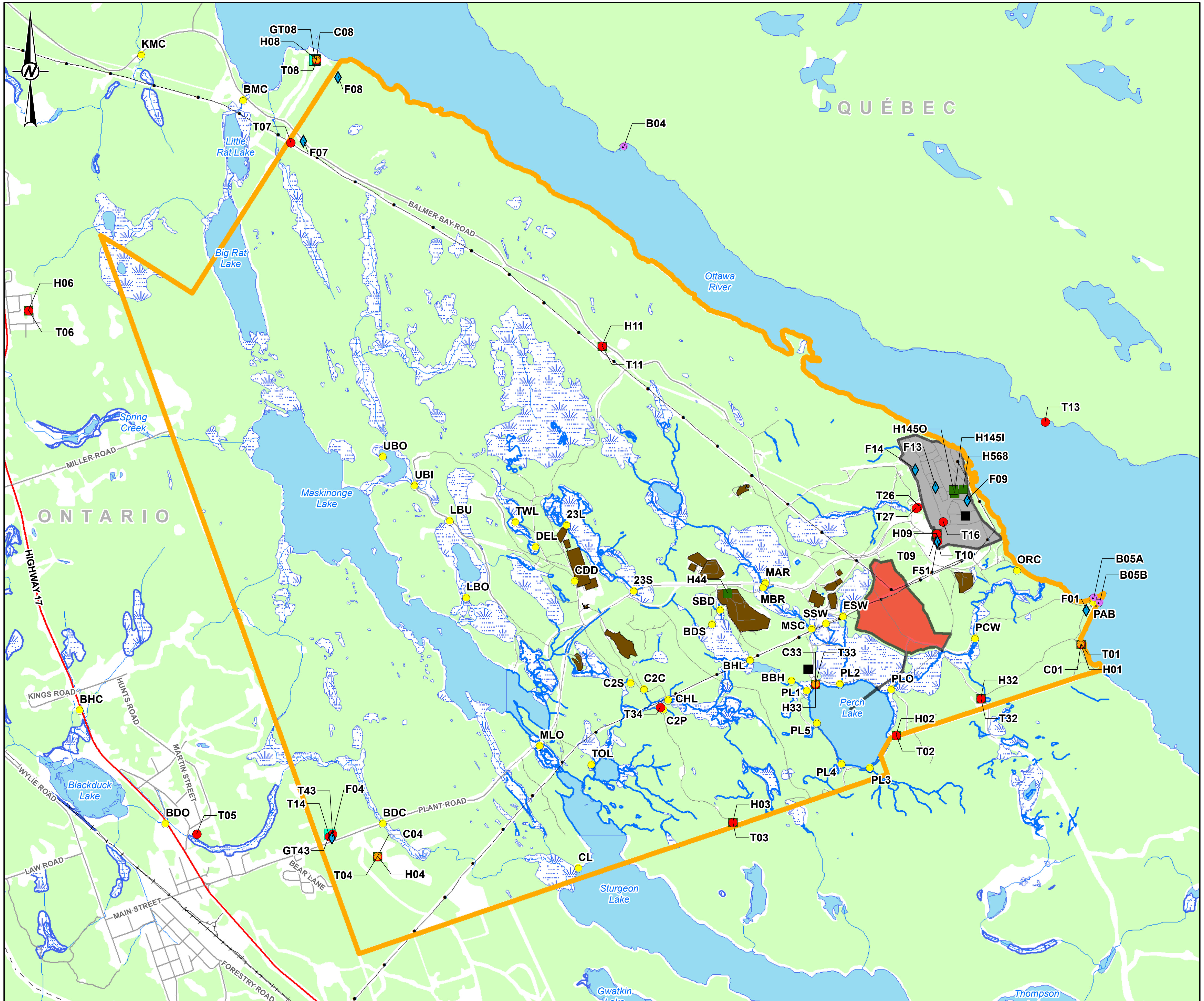

LEGEND

- HIGHWAY
- ROAD
- RAILWAY
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- SITE STUDY AREA (NSDF PROJECT SITE)
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- CRL SITE
- BEACH SEDIMENT SAMPLE
- C-14 AIR
- THERMOLUMINESCENT DOSIMETER
- SURFACE WATER SAMPLE
- WET AND DRY DEPOSITION
- TRITIUM - AIR
- GAMMA TRACER
- METEOROLOGIC TOWER

1 0 1

1:35,000 KILOMETERS

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
RADIOLOGICAL ENVIRONMENTAL MONITORING LOCATIONS WITHIN THE CHALK RIVER LABORATORIES SITE

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.7.4-3

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

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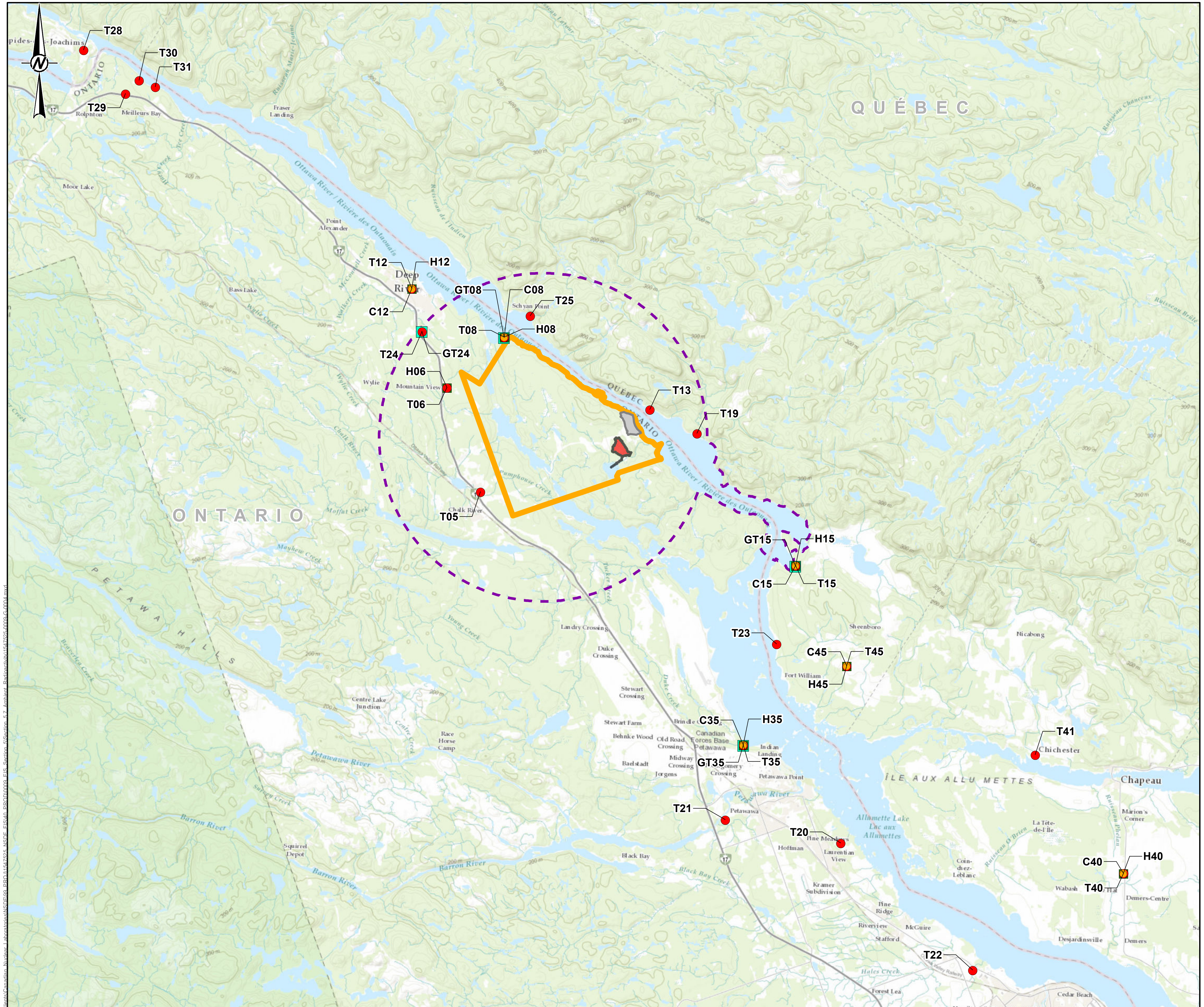

LEGEND

- SITE STUDY AREA (NSDF PROJECT SITE)
- CRL MAIN CAMPUS
- CRL SITE
- REGIONAL STUDY AREA
- C-14 AIR
- THERMOLUMINESCENT DOSIMETER
- TRITIUM - AIR
- GAMMA TRACER

5 0 5

1:175,000 KILOMETERS

REFERENCE(S)

1. BASEMAP: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
OFF SITE RADIOACTIVE AIR QUALITY MONITORING LOCATIONS

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.7.4-4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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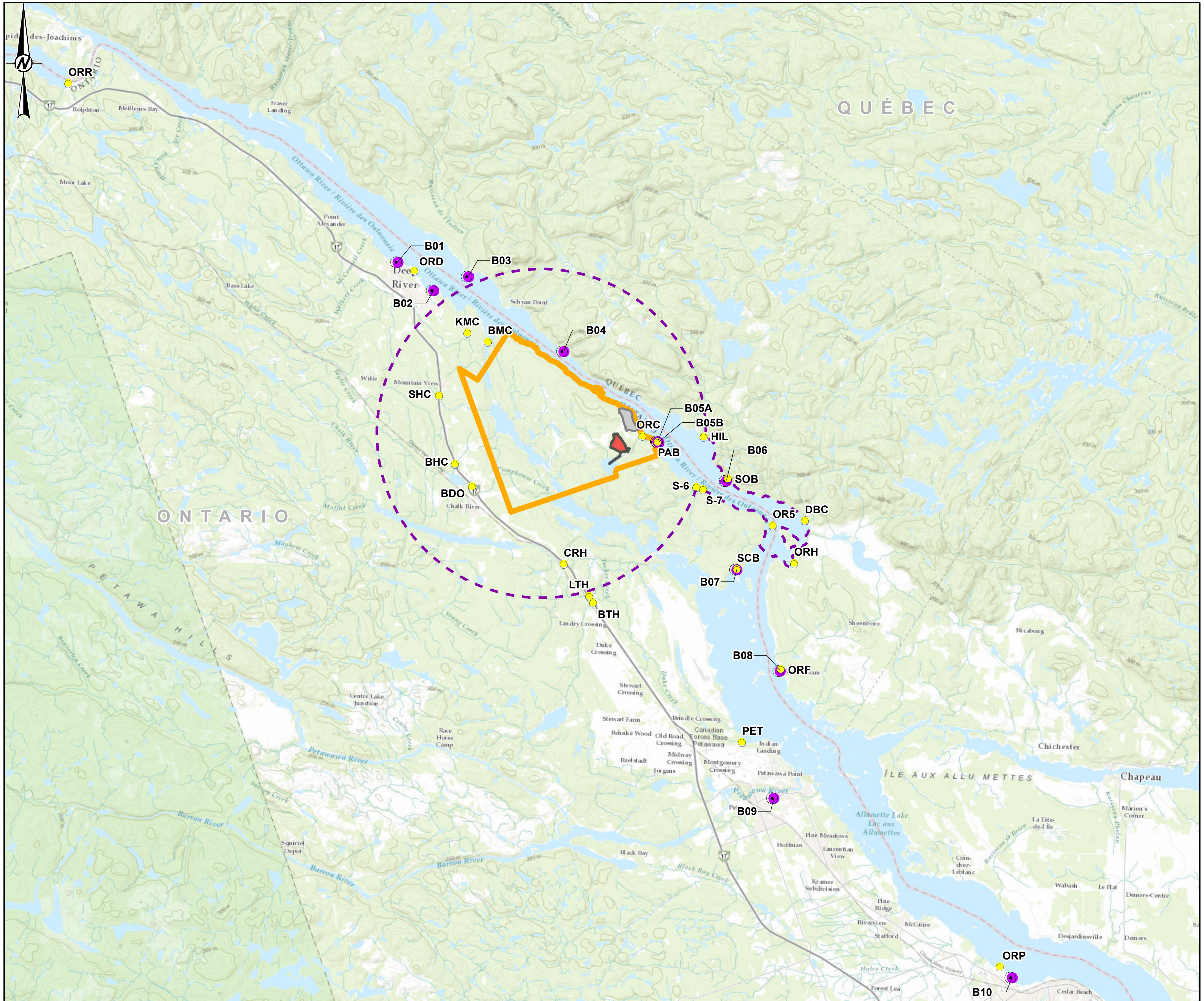

LEGEND

- SITE STUDY AREA (NSDF PROJECT SITE)
- CRL MAIN CAMPUS
- CRL SITE
- REGIONAL STUDY AREA
- BEACH SEDIMENT SAMPLE
- SURFACE WATER SAMPLE

5 0 5

1:175,000 KILOMETERS

REFERENCE(S)

1. BASEMAP: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

OFF SITE RADIOACTIVE LIQUID AND BIOLOGICAL MONITORING LOCATIONS

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.7.4-5

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

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Table 5.7.4-2: Summary of Chalk River Laboratories' Environmental Monitoring Program

Environmental Medium	Analysis	Sample Locations	Frequency
External gamma	Ambient gamma dose (TLD)	20 monitoring stations on and off site	Continuous sampling, analyzed quarterly and annually
Air	Noble gas dose (GammaTRACER radiation detector)	5 locations on and off site	Continuous
Air	Ambient tritium	14 locations on and off site	Continuous sampling, quarterly analysis
Air	Ambient carbon-14	8 locations on and off site	Continuous
Surface water	▪ Gross alpha ▪ Gross beta ▪ Tritium ▪ Gamma spectroscopy ▪ Total strontium	45 locations on and off site	Daily to annually
Groundwater	▪ Gross alpha ▪ Gross beta ▪ Tritium ▪ Carbon-14 ▪ Gamma spec	180 on-site monitoring wells	Annual or semi-annual (spring and fall)
Soil and vegetation	▪ Gross alpha ▪ Gross beta ▪ Gamma spectroscopy	Supplementary study locations on CRL site (plume updates, investigations)	Supplementary studies on 5- or 10-year frequency or as required
Beach sand	Gamma spectroscopy	9 public beaches along Ottawa river	Annual
Fish	▪ Gross alpha ▪ Gross beta ▪ Gamma spectroscopy	Three locations in Ottawa River, One lake on CRL site	Annual
Terrestrial animals	▪ Gross alpha ▪ Gross beta ▪ Gamma spectroscopy ▪ Tritium ▪ Organically bound tritium	▪ Game animals within 25 km of CRL site ▪ Beef samples from one off-site farm	Annual
Terrestrial plants	▪ Gross alpha ▪ Gross beta ▪ Gamma spectroscopy ▪ Free water tritium	Five private gardens and one farmers market off site	Annual, during growing season
Milk	▪ Tritium ▪ Carbon-14 ▪ Iodine-131 ▪ Gamma spectroscopy	One local dairy in Pembroke	▪ Monthly analysis (iodine-131) ▪ Quarterly analysis of weekly samples (tritium, carbon-14, gamma spectroscopy)

Source: CNL 2019b.

TLD = Thermoluminescent Dosimeters.

5.7.4.4 Radioactivity in the Atmospheric Environment

Airborne radiological contaminants are monitored as part of the CRL Environmental Monitoring Program. This includes measurements of ambient gamma dose, noble gas dose, tritium in air and carbon-14 in air. Monitoring is undertaken on the CRL main campus, at the CRL site boundary and at relevant off-site locations.

5.7.4.4.1 Ambient Gamma Dose

Ambient gamma dose measurements performed using Thermoluminescent Dosimeters (TLDs) yield total annual dose, including dose imparted by natural background sources and dose associated with releases from CRL operations. All TLD measurements have been corrected for exposure during storage, handling and transport by subtracting the exposure received by control TLDs. These control TLDs are housed during the measurement period within lead shielding in a specifically constructed building at CRL, where background radiation from subsoil, radon and building materials is very low. Consequently, the reported TLD results do not include exposure from high-energy cosmic radiation that penetrates the low background building and lead shielding in which the control TLDs are stored. The locations of all TLDs are shown in Section 5.7.4.3.

The TLD results are compared to the expected terrestrial gamma radiation dose in Ottawa, which occurs as a result of naturally occurring radionuclides in the earth, air and building materials. The outdoor external radiation dose rate in locations throughout Canada has been characterized based on TLD measurements at Canadian Environmental Stations from 1976 to 1984 (NCRP 1987). The closest monitoring location utilized in this study is Ottawa, approximately 185 km southeast of the CRL site. After subtracting the contribution of cosmic radiation, the average external gamma radiation dose from terrestrial radiation in Ottawa is approximately 282 plus/minus 114 microgray[1] (µGy) per year. The annual doses measured from 2014 to 2018 in the SSA, LSA and RSA are shown in Table 5.7.4-3.

While no TLDs are placed within the NSDF project site, one is located near Perch Lake within the LSA. Remaining TLDs in the vicinity of the CRL site are considered to be representative of the RSA, and additional TLDs are located at population centres beyond the RSA. The Perch Lake TLD has measured annual doses ranging from 298 to 327 µGy from 2014 to 2018 (CNL 2019b). The TLDs placed within the RSA have measured annual doses ranging from 265 to 644 µGy from 2014 to 2018 (CNL 2019b). Doses were comparable to the average terrestrial gamma radiation in Ottawa for all LSA monitoring locations except the Main Gate location, which is within the CRL main campus. This monitoring location recorded the highest doses of all TLDs in the monitoring program, with 2014 to 2018 annual doses ranging from 482 to 644 µGy (CNL 2019b). Annual doses at locations beyond the RSA have ranged from 263 to 461 µGy from 2014 to 2018 (CNL 2019b). Doses at some of these locations exceed the average terrestrial gamma radiation measured in Ottawa (282 ±114 µGy/yr). Additional discussion regarding the contribution of CRL emissions to ambient gamma dose is included in Section 5.7.4.4.2 Radioactive Noble Gas.

In addition to these TLD doses recorded annually, ambient radiation surveys have been conducted at specific areas throughout CRL, as a means of assessing possible contamination associated with groundwater plumes. Of particular interest with respect to the NSDF are ambient radiation surveys conducted at the East Swamp, which is immediately west of the NSDF and may be affected by NSDF operations. The East Swamp has existing contamination due to groundwater plumes from the Chemical Pit and Reactor Pit 2 as a result of legacy operations. Surveys conducted in 2002 and 2012 at the East Swamp have included measurements of ambient

[1] Note: 1 Gy = 1 Sv for external gamma radiation.

radiation over a 15 m by 15 m grid, covering a 150 m by 250 m area, and collected ambient dose rates at approximately 1 m height. In 2002, the ambient radiation levels in the East Swamp coincided with the Chemical Pit groundwater plume and reached a maximum of 13,500 nanosieverts per hour (nSv/hr). In the 2012 survey, radiation field locations were similar, but the maximum dose rate was 4,000 nSv/hr. Dose rates primarily resulted from gamma-emitting radionuclides in surface soil and vegetation. Monitoring of these media is discussed in Section 5.7.4.7 Radioactivity in Soil. Ambient radiation fields measured in East Swamp in 2012 are shown on Figure 5.7.4-6.

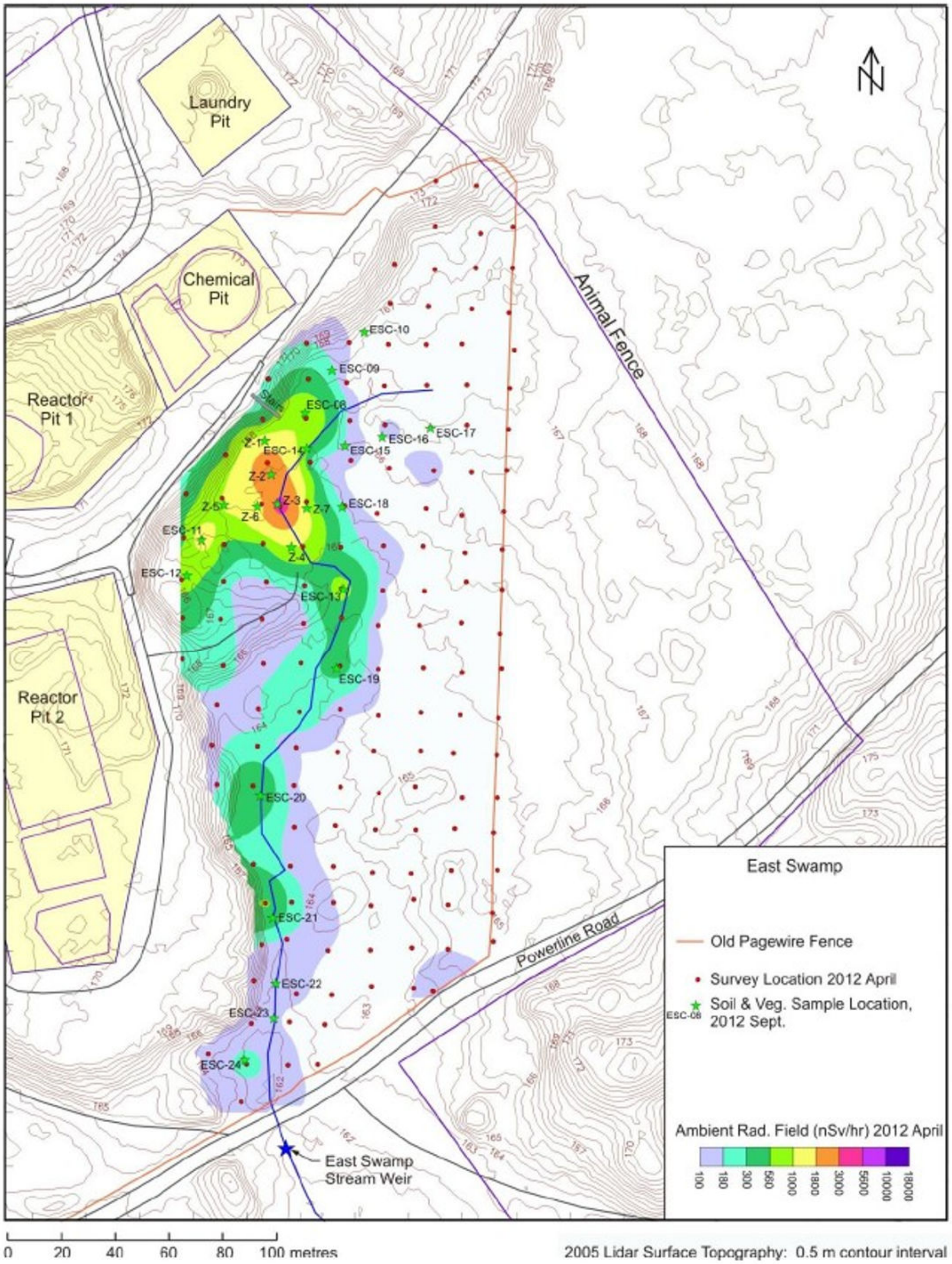
Table 5.7.4-3: Annual Ambient Gamma Dose Measured by Thermoluminescent Dosimeters

	2014	2015	2016	2017	2018	2014–2018 Average
Local Study Area						
Perch Lake Main (A33)	317	327	301	299	298	308.4
Regional Study Area						
East Mattawa Rd. (A32)	334	363	326	330	297	330.0
C-2 Fire trail (A03)	347	351	334	323	317	334.4
C-2 Fire trail at hydro line (A34)	301	265	301	301	287	291.0
Pointe au Baptême (A01)	321	342	315	344	274	319.2
Main Gate (A09)	594	626	598	644	482	588.8
Balmer Bay (A08)	376	407	374	383	323	372.6
Bldg. 560 Outdoors (A43)	336	365	369	384	352	361.2
Ottawa St. Chalk River (A05)	421	428	407	406	386	409.6
Mountain View Subdivision (A06)	319	350	309	318	277	314.6
Beyond Regional Study Area						
MacDonald, Deep River (A12)	387	429	393	412	368	397.8
Harrington Bay (A15)	434	398	427	441	395	419.0
Pembroke, Lloyd St. (A22)	323	352	352	333	332	338.4
NPD Des-Joachims (A28)	461	416	431	441	411	432.0
NPD Hwy 17 Gate (A29)	409	421	421	437	387	415.0
NPD Reactor Site (A30)	404	442	415	432	403	419.2
Petawawa Filtration Plant (A35)	368	375	379	374	353	369.8
Demers Centre (A40)	393	393	398	396	371	390.2
Rankin (A42)	348	382	351	402	378	372.2
Sheenboro (A45)	292	329	288	313	263	297.0

Source: CNL 2019b.

Note: All units presented in microgray (μGy).

NPD = Nuclear Power Demonstration.



CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
2012 EAST SWAMP AMBIENT GAMMA SURVEYING RESULTS

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0012	FINAL 2	5.7.4-6

REFERENCE(S)
1. BASEMAP PROVIDED BY CNL

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5.7.4.4.2 Radioactive Noble Gas

Continuous monitoring of dose rate from airborne noble gases is performed at five locations of interest. This is accomplished with dual Geiger tube GammaTRACER systems, allowing the external gamma dose rate resulting from CRL operations to be distinguished from background. This contribution is primarily from the noble gas argon-41. Measurements of total noble gas ambient dose equivalent are shown in Table 5.7.4-4.

No monitoring of noble gas is performed within the SSA. One GammaTRACER is placed at the southwestern edge of the CRL site, and one is at the northwestern edge near Balmer Bay. These locations are within the RSA.

From 2014 to 2018, the annual gamma dose within the RSA attributable to noble gases released from CRL operations have ranged from 6.1 microsieverts (μSv) to 83.2 μSv. Doses are generally highest near Balmer Bay since it is in the path of prevailing wind from the atmospheric releases on site (CNL 2019d). It is noted that due to variability in releases and environmental conditions, this observation is not necessarily true each year (e.g., noble gas dose is higher at Harrington Bay in 2015). Three GammaTRACERs are placed at population centres beyond the RSA. From 2014 to 2018, the annual gamma dose at these locations attributable to noble gases released from CRL operations have ranged from 7.4 to 90.6 μSv.

Table 5.7.4-4: Noble Gas Annual Dose Measured by GammaTRACERs (μSv)

	2014	2015	2016	2017	2018	2014–2018 Average
Regional Study Area						
Building 560 (GT43)	11.7	18.7	32.3	39.7	6.1	21.7
Balmer Bay (GT08)	55.9	66.4	81.0	83.2	31.8	63.7
Beyond Regional Study Area						
Harrington Bay (GT15)	N/A	90.6	60.6	29.9	11.0	48.0
Deep River (GT24)	26.5	32.1	57.4	48.1	7.4	34.3
Petawawa (GT35)	24.1	40.8	49.8	31.7	10.4	31.4

Source: CNL 2019b.
Note: GammaTRACER units are calibrated to ambient dose equivalent, H*(d), with d = 10 mm (ICRP 1991).
μSv = microsieverts; N/A = not available.

Measurements of noble gas dose at the locations above provide an indication of the contribution of CRL emissions to the annual ambient gamma doses described in Section 5.7.4.4.1 Ambient Gamma Dose. By subtracting noble gas doses from TLD measurements[2], the terrestrial background dose in the absence of CRL noble gas emissions may be distinguished. This is shown in Table 5.7.4-5 for the four locations where TLDs and GammaTRACERs are co-located. It is observed that after subtracting the contribution of CRL noble gas emissions, the terrestrial gamma dose at all four locations is comparable to the average terrestrial gamma dose for Ottawa (282 ±114 μGy/yr).

[2] Prior to subtracting noble gas dose from TLD values, the noble gas doses in μSv were converted to absorbed dose in air (air kerma [i.e., kinetic energy released in matter]) using a conversion factor of 1.2 μSv/μGy (Klemic et al. 1999).

Table 5.7.4-5: Average Annual Chalk River Laboratories Noble Gas Dose Compared to Ambient Gamma Dose

	2014–2018 Average Ambient Gamma Dose Measured by Thermoluminescent Dosimeters (μGy)	2014–2018 Average Noble Gas Dose Measured by GammaTRACER (μGy)	2014–2018 Ambient Gamma Dose Without CRL Noble Gas Contribution (μGy)
Balmer Bay (A08/GT08)	373	64	316
Building 560 (A43/GT43)	361	22	318
Harrington Bay (A15/GT15)	415[(a)]	48	392
Petawawa (A35/GT35)	370	31	347

(a) This average omits the value recorded in 2014, in order to achieve consistency with respect to the GammaTRACER dataset, which does not include a measurement from 2014.

μGy = microgray.

5.7.4.4.3 Tritium in Air

Ambient tritium in air is monitored at locations throughout the CRL main campus, at the CRL site boundary and at population centres off site. Tritium is monitored using passive diffusion samplers. These are liquid scintillation vials containing a solution of 50% glycol and 50% water, designed to sample air at a rate of 1 L/day. These samples are collected and analyzed quarterly using liquid scintillation counting[3]. The reported annual average tritium concentrations are calculated based on these quarterly measurements; uncertainties are reported in the CRL *Environmental Monitoring Report* based on counting statistics (CNL 2019b).

No ambient tritium monitors are within the boundary of the SSA. The Perch Lake Main monitoring station is located within the LSA. From 2014 to 2018, the average tritium concentrations in air at this location are less than 2.3 Becquerels per cubic metre (Bq/m^3). From 2014 to 2018, average tritium concentrations in the RSA range from less than 0.4 Bq/m^3 at the C-2 Fire Trail location to 21.6 Bq/m^3 at the on-site Sewage Treatment Plant. Tritium monitoring is performed at off-site population centres beyond the RSA. Tritium concentrations at these locations are below the detection level, and have averaged less than 0.26 Bq/m^3 from 2014 to 2018 (Table 5.7.4-6).

Elevated tritium concentrations have been measured at the Sewage Treatment Plant and Main Gate locations. These locations are close to the NRU stack, which is the primary source of tritium emissions at the CRL site. Additionally, elevated tritium concentrations have been observed at the WMA B Gate monitoring station. This location is near WMA B, which has been a source of airborne tritium releases.

[3] Liquid scintillation counting (LSC) is the standard laboratory method to quantify the radioactivity of low energy radioisotopes, mostly beta-emitting and alpha-emitting isotopes (PerkinElmer Inc. 2019).

Table 5.7.4-6: Annual Average Tritium Concentration in Air (Bq/m^3)

	2014	2015	2016	2017	2018	2014–2018 Average
Local Study Area						
Perch Lake Main (A33)	V 2.4	2.5	2.6	2.0	2.2	V 2.3
Regional Study Area						
East Mattawa Rd. (A32)	1.4	1.5	1.7	1.5	1.8	1.6
C-2 Fire trail (A03)	V 0.3	V 0.4	<0.35	0.4	<0.42	V 0.4
Main Gate (A09)	4.3	3.2	4.5	4.6	4.0	4.1
Pointe au Baptême (A01)	1.2	1.3	1.2	1.3	V1.1	V 1.2
Sewage Treatment Plant (A568)	9.8	16.4	23.5	32.9	25.3	21.6
Balmer Bay, W Mattawa Rd. (A08)	V 0.8	V 0.7	0.6	0.6	V 0.4	V 0.6
WMA B Gate (A44)	4.8	3.1	5.7	3.8	4.8	4.44
Mountain View Subdivision (A06)	N/D	N/D	N/D	<0.19	<0.24	0.22
Beyond Regional Study Area						
MacDonald, Deep River (A12)	<0.2	V 0.5	<0.18	<0.33	<0.09	V 0.26
Harrington Bay (A15)	<0.2	V 0.4	<0.26	<0.21	<0.19	V 0.25
Petawawa Filtration Plant (A35)	N/D	N/D	N/D	N/D	N/D	N/D
Demers Centre (A40)[(a)]	N/A	N/A	N/A	N/A	N/A	N/A
Sheenboro (A45)	<0.2	V 0.3	<0.14	<0.31	<0.23	V 0.24

Source: CNL 2019b, Table 7-9 and 7-10.

Note: Table 7-10 includes transcription errors for A03, A08, A32, A33, A43, A44, and A568. These are corrected based in Table 7-9 and 2018 Environmental Monitoring Report (CNL 2019b).

a) Monitoring at Demers Centre was discontinued at the end of 2013.

Bq/m^3 = Becquerels per cubic metre; <= results below the detection level; "V" indicates an average calculated using one or more results below detection level; N/D = results below the critical level (i.e., not detected); N/A = Not available.

5.7.4.4.4 Carbon-14 in Air

Carbon-14 is monitored in air at locations on the CRL main campus, at the CRL site boundary and off site at local population centres. Carbon-14 is monitored with the use of passive samplers employing mixed calcium-sodium hydroxide pellets. Carbon-14 evolved from the pellets was analyzed by liquid scintillation counting. No carbon-14 monitoring is within the boundaries of the SSA. The Perch Lake Main monitoring location is close to the SSA, and is considered to be representative of the LSA. Carbon-14 is monitored at three locations within the CRL main campus, which are considered to be within the RSA. Four carbon-14 monitoring locations exist in population centres beyond the RSA. These are in Deep River, Harrington Bay, Petawawa and Sheenboro. At all locations, concentrations of carbon-14 in air are close to or below the detection level (Table 5.7.4-7).

Table 5.7.4-7: Annual Average Carbon-14 Concentration in Air (Bq/m³)

	2014	2015	2016	2017	2018	2014–2018 Average
Local Study Area						
Perch Lake Main (A33)	V 0.07	0.13	0.14	0.34	V 0.01	V 0.14
Regional Study Area						
Pointe au Baptême (A01)	V 0.06	V 0.03	V 0.08	0.012	V -0.002	V 0.04
Balmer Bay, W Mattawa Rd. (A08)	V 0.08	V 0.07	0.05	V 0.09	V 0.1	V 0.08
CRL, near Bldg. 580 (A43)	V 0.07	V 0.08	V 0.06	V 0.07	V 0.0017	V 0.06
Beyond Regional Study Area						
MacDonald, Deep River (A12)	V 0.08	V 0.06	V 0.07	V 0.06	V 0.07	V 0.07
Harrington Bay (A15)	V 0.06	V 0.04	V 0.07	V 0.08	V 0.005	V 0.05
Petawawa Filtration Plant (A35)	V 0.07	V 0.05	V 0.08	V 0.06	V -0.01	V 0.05
Sheenboro (A45)	V 0.08	V 0.02	V 0.06	V 0.07	V -0.03	V 0.04

Source: CNL 2019b

<= results below the detection level; "V" indicates an average calculated using one or more results below detection level; Bq/m³ = Becquerels per cubic metre.

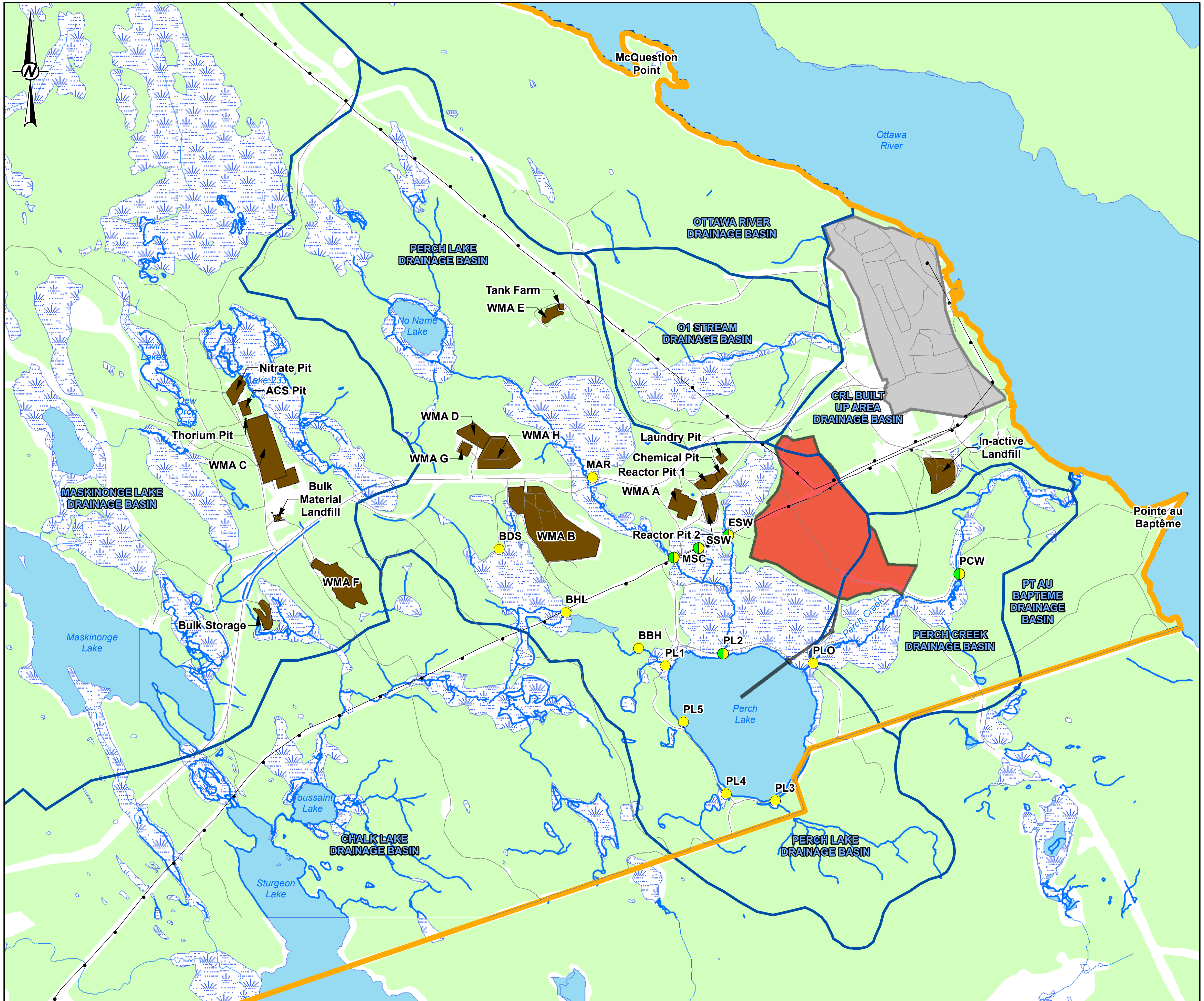
5.7.4.5 Radioactivity in Surface Water

Surface water is monitored at on-site lakes and streams, off-site streams and locations in the Ottawa River both upstream and downstream of the CRL site. The results of radiological monitoring of off-site streams are not discussed in this Base Case characterization, as there are no direct liquid emissions to these streams from the NSDF Project.

No surface waterbodies are present within the boundaries of the SSA. The SSA is located within the Perch Lake basin. Surface waterbodies in the Perch Lake basin are currently affected by the presence of several WMAs, including the CRL LDA. The surface water monitoring locations that are closest to the SSA are the East Swamp weir, Perch Lake Inlet 2, Perch Lake Outlet and Perch Creek weir. The location of these monitoring stations is displayed on Figure 5.7.4-7. Note that while this figure displays non-radiological sampling locations, these are not considered in the assessment of Base Case radioactivity.

Table 5.7.4-8 displays the radioactivity in surface waterbodies that are closest to the SSA. These locations have the highest potential to be affected by NSDF Project operations, and are considered to be within the LSA. Additional surface water monitoring stations exist within the CRL site, within the Maskinonge Lake Basin and upstream locations within the Perch Lake Basin (e.g., B Hydro Line) and Main Stream Culvert). These monitoring locations are not included within this Base Case characterization, as they are not expected to be affected by the NSDF Project.

The East Swamp weir is located immediately west of the SSA. This monitoring location is downstream of the Laundry Pit, Reactor Pit 2 and Chemical Pit. The Perch Lake Inlet 2 monitoring station is located farther downstream, and receives discharge from the East Swamp Stream, South Swamp Stream and Main Stream. The Perch Lake Outlet and Perch Creek weir monitoring stations represent downstream locations at the exit point of Perch Lake and along Perch Creek, which flows from Perch Lake to the Ottawa River



LEGEND

- ROADS
- RAILWAY
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- DRAINAGE BASIN
- SITE STUDY AREA (NDSF PROJECT SITE)
- CRL MAIN CAMPUS
- CRL SITE
- WASTE MANAGEMENT AREA (WMA) [1]
- SAMPLING LOCATION
- WEIR
- SAMPLING LOCATION AND WEIR

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
LOCATIONS OF SURFACE WATER MONITORING STATIONS AND WEIRS

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.7.4-7

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Table 5.7.4-8: Radioactivity (Bq/L) in Surface Waters near the Site Study Area

	2014	2015	2016	2017	2018	2014–2018 Average
East Swamp at Weir (ESW), west of the Site Study Area						
Tritium	286	348	V 323	305	317	V 316
Gross alpha	0.204	0.059	V 0.064	0.072	0.127	V 0.105
Gross beta	193	224	256	154	217	209
Total strontium	80.8	95	125	47	55	81
Cobalt-60	0.180	0.401	0.26	0.17	0.31	0.26
Caesium-137	0.123	0.14	0.17	0.1	0.17	0.14
Perch Creek at Weir (PCW), east of the Site Study Area						
Tritium	2,720	3,172	4,233	2,056	2,645	2,965
Gross alpha	0.03	<0.022	V 0.02	0.03	V 0.04	V 0.03
Gross beta	9.44	11	7	9	V 9	V 9.1
Total strontium	3.80	3.4	3.26	3.03	4.25	3.5
Cobalt-60	V 0.01	<0.01	<0.009	<0.01	<0.009	V 0.01
Caesium-137	V 0.01	<0.008	<0.008	<0.009	<0.009	V 0.009
Perch Lake Outlet (PLO), south of the Site Study Area						
Tritium	2,188	2,780	2,328	1,367	2,025	2,138
Gross beta	12.7	12	11	10	13	12
Perch lake Inlet 2 (PL2), south of the Site Study Area						
Tritium	3,249	2,275	1,605	1,354	1,793	2,055
Gross alpha	0.038	0.05	0.05	0.05	0.05	0.05
Gross beta	14.43	14	14	12	11.9	13
Cobalt-60	0.025	0.014	0.03	0.02	<0.005	V 0.019
Caesium-137	0.012	0.013	0.009	0.009	<0.004	V 0.009

Source: CNL 2019b.

<= results below the detection level; ”V” indicates an average calculated using one or more results below detection level;
Bq/L = Becquerels per litre.

The primary radiological contaminants of concern in Perch Lake Basin waters are tritium and gross beta (consisting mainly of strontium-90 and its daughter yttrium-90). Tritium levels at Perch Lake Basin monitoring stations near the SSA have ranged from 286 to 4,233 Becquerels per litre (Bq/L) from 2014 to 2018. Additionally, elevated gross beta readings have been recorded, particularly at the East Swamp weir location, where levels have reached 256 Bq/L. Trace amounts of cobalt-60 and caesium-137 have been measured in the Perch Lake Basin waters and have been at or below detection levels at the Perch Lake and Perch Creek weir monitoring stations.

Off-site monitoring of surface water includes inland streams, as well as locations in the Ottawa River both upstream and downstream of CRL site. There are no liquid emissions to off-site streams from the proposed NSDF Project, and therefore these are not described in the background characterization.

Radioactivity at upstream and downstream locations in the Ottawa River is presented in Table 5.7.4-9. Annual average background tritium concentrations are less than 4 Bq/L at locations upstream of CRL. Of particular relevance to the NSDF Project is the Pointe au Baptême monitoring location. This is downstream of the CRL site near the boundary, and is immediately downstream of the Perch Creek Outlet, which could potentially be affected by the NSDF. The tritium concentrations at this location are slightly above background, with annual average values up to 67.9 Bq/L from 2014 to 2018.

Monitoring stations located farther downstream on the Ottawa River are considered to be representative of the area beyond the RSA. Concentrations of radiological contaminants at these locations are low, with annual average tritium concentrations less than 9 Bq/L.

Table 5.7.4-9: Average Radioactivity (Bq/L) in the Ottawa River, Upstream and Downstream of Chalk River Laboratories

	2014	2015	2016	2017	2018	2014–2018 Average
Rolphton (ORR), 28 km upstream						
Tritium	<1.2	V 1.7	2.1	3.5	2.62	V 2.2
Gross beta	0.042	0.04	0.046	0.046	0.047	0.044
Gross alpha	0.0115	0.0091	0.0072	0.0074	0.0068	0.0084
Total strontium	0.0048	0.0019	n/a	n/a	n/a	0.0034
Caesium-137	V 0.0016	V 0.0012	V 0.0006	V 0.0003	V 0.0003	V 0.0008
Deep River (ORD), 9 km upstream						
Tritium	<1	V 1.4	2.2	3.6	2.7	V 2.2
Gross beta	0.046	0.039	0.052	0.054	0.053	0.049
Gross alpha	0.0095	0.0079	0.0065	0.007	0.0059	0.0074
Total strontium	<0.0052	V 0.0027	n/a	n/a	n/a	V 0.0040
Caesium-137	V 0.0007	V 0.002	V 0.0006	<0.0004	<0.0004	V 0.0008
Pointe au Baptême (PAB), CRL downstream boundary						
Tritium	41	48	67.9	20.2	17.6	39
Gross beta	V 0.23	V 0.12	0.233	0.138	0.168	V 0.18
Gross alpha	0.0073	0.014	0.017	0.016	0.025	0.016
Highview (OR5), 8 km downstream						
Tritium	N/D	<6.34	N/D	<0.775	2.91	3.34
Gross beta	0.04	0.001	0.117	0.046	0.058	0.052
Harrington Bay (ORH), 9 km downstream						
Tritium	<2	1.4	3.4	3.2	2.9	2.58
Gross beta	0.05	0.028	0.049	0.053	0.058	0.048
Gross alpha	0.021	0.0078	0.0082	0.0084	0.0049	0.010
Total strontium	V 0.003	V 0.0008	n/a	n/a	n/a	0.0019
Caesium-137	V 0.0020	V 0.0018	<0.0014	<0.0011	<0.001613	V 0.00158

Source: CNL 2019b, d.

<= results below the detection level; "V" indicates an average calculated using one or more results below detection level; n/a = not applicable (analysis only conducted when gross beta levels are significantly higher than normal); Bq/L = Becquerels per litre; N/D = results below the critical level (i.e., not detected).

5.7.4.6 Radioactivity in Groundwater

Groundwater is monitored at locations throughout the CRL site as part of the CRL Groundwater Monitoring Program. This program evaluates and reports groundwater concentrations of a large suite of radiological and non-radiological parameters for samples collected from approximately 180 monitoring wells located at 32 different monitoring sites. Monitoring sites include CRL WMAs, lands previously affected by past operational activities, and the developed part of the CRL site. These monitoring activities are performed annually or twice-yearly around the perimeters of operating areas as a means of monitoring the conditions and behaviour of the facilities and operations. Results of the Groundwater Monitoring Program are presented each year in the CRL Groundwater Monitoring Program annual report. These data provide operational feedback on the conditions and behaviour of facilities, including the performance of existing remedial measures (e.g., infiltration barriers). The Groundwater Monitoring Program includes wells that are upgradient of the monitored areas, in order to provide reference values.

Where groundwater contamination is present, this routine monitoring is augmented by periodic detailed evaluations of subsurface contaminant distributions and movement. These provide characterization of existing contaminant plumes. The monitoring of contaminant plumes provides the basis for observing environmental effects and evaluating future effects, including confirming the applicability of remedial measures.

Groundwater monitoring is performed in the LSA at locations within the CRL site where contamination is of concern. Reference wells located upstream of WMAs are considered representative of ambient radiological contaminant concentrations in these areas. The highest concentrations and widest variety of radioactive contaminants in groundwater on the CRL site are located downgradient of the Chemical Pit (CNL 2019d). Total beta activity associated with strontium-90 in groundwater between the Chemical Pit and the East Swamp is on the order of 10,000 to 70,000 Bq/L. Gross alpha, caesium-137 and cobalt-60 in groundwater are also elevated (AECL 2014a). For the groundwater monitoring locations downstream of the Chemical Pit, the highest concentrations of these contaminants in 2014 were 12 Bq/L for caesium-137 (LDA-22), 6.39 Bq/L for cobalt-60 (LDA-21) and 4.57 Bq/L for gross alpha (LDA-22). Characterization of the groundwater plume from the Chemical Pit has also included the sampling of pore water from the East Swamp (indicative of groundwater discharging to the surface water). Gross alpha, total beta and strontium-90 activities were found to range from <3 to <8 Bq/L, 230 to 4,900 Bq/L and 120 to 2,960 Bq/L, respectively (CNL 2015a). Downgradient of WMA A, total beta activity in groundwater was generally between 3,000 and 10,000 Bq/L with a peak of 30,000 Bq/L. Downgradient of Reactor Pit 2, total beta activity in groundwater was generally between 2,000 and 15,000 Bq/L with a peak of 22,100 Bq/L (CNL 2015b).

The reference wells closest to the SSA are labelled LDA-3 and GD-42. LDA-3 is located upgradient of Reactor Pit 1, west of the SSA. The GD-42 well is located upgradient of the non-radiological landfill, northeast of the SSA, although this is not directly applicable to the Base Case characterization as it is located in a different drainage basin. The location of WMAs adjacent to the NSDF Project and routine groundwater monitoring locations are shown on Figure 5.7.4-8. Figure 5.7.4-8 also shows the location of individual monitoring wells relative to the Reactor Pit. The location of individual monitoring wells relative to the non-radiological landfill is shown on Figure 5.7.4-9. The concentration of radiological contaminants, as measured by spring and fall measurements, in these reference (i.e., background) wells is shown in Table 5.7.4-10. It is noted that gamma spectral analysis of samples in the groundwater monitoring program is only performed where the concentration of total beta activity exceeded 2 Bq/L, or where gross alpha activity was detected (CNL 2019d). Therefore, gamma spectral analysis was not performed at the reference wells LDA-3 and GD-42. Full gamma spectrum results for all applicable monitoring wells in the groundwater monitoring program are available in the CRL *Groundwater Monitoring Program Annual Report for 2017* (CNL 2019d). The results for specific radionuclides where concentrations have exceeded detection limits (e.g., caesium-137 and cobalt-60) in Chemical Pit samples are discussed above.

Table 5.7.4-10: Radioactivity in Reference Wells near the Site Study Area (Bq/L)

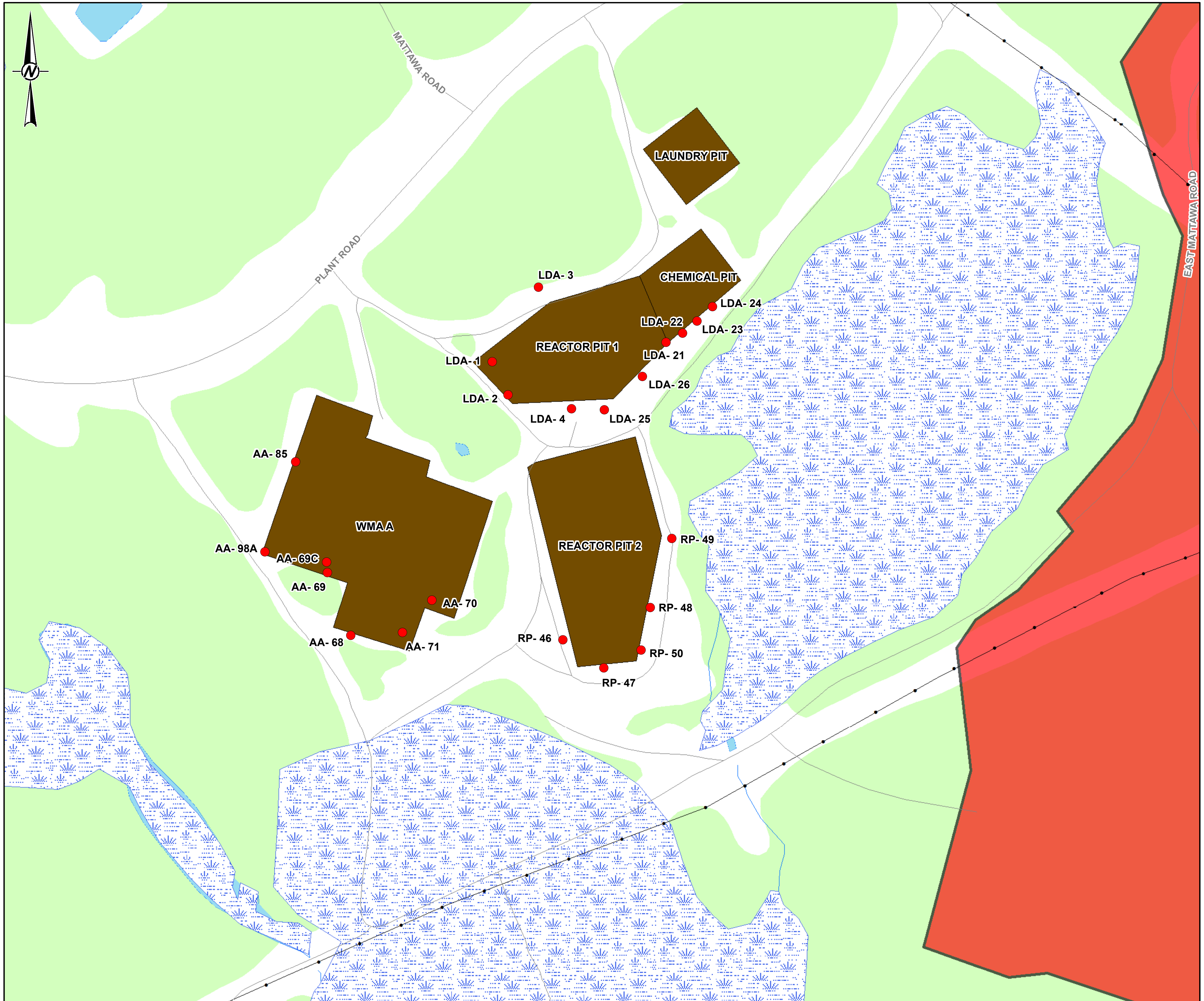
	2013	2014	2015	2016	2017	2013–2017 Average
Reference wells near Site Study Area (SSA)						
LDA-3[a], upgradient of Reactor Pit 1, West of SSA (Same drainage basin as NSDF)						
Tritium	97.3	67.7	<49.4	126.03	79.7	84.0
Total alpha	<0.25	<0.14	<0.17	<0.17	<0.17	<0.15
Total beta	<0.51	<0.38	1.98	<0.56	<1.08	<0.7
GD-42[b], upgradient of the non-radiological landfill, northeast of SSA (Different drainage basin as NSDF)						
Tritium	399	398	274.76	164.25	108.46	269
Total alpha	<0.24	<0.26	<0.23	<0.21	<0.18	<0.22
Total beta	<0.26	<0.32	<0.31	<0.22	<0.22	<0.27

Source: CNL 2015b, 2016b, 2019d; AECL 2012, 2013, 2014b.

a) = radiological data presented for LDA-3 is the average between the two sampling events for that year.

b) = monitoring of the GD-42 wells began in 2011.

<= results below the detection level, or an average calculated using one or more results below detection level; Bq/L = Becquerels per litre; N/A = not available.



LEGEND

- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- SITE STUDY AREA (NSDF PROJECT SITE)
- WASTE MANAGEMENT AREA (WMA)[1]
- CRL SITE
- GWMP MONITORING WELL

NOTE(S)
1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)
1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
LOCATION OF WASTE MANAGEMENT AREAS AND GROUNDWATER MONITORING AREAS

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.7.4-8

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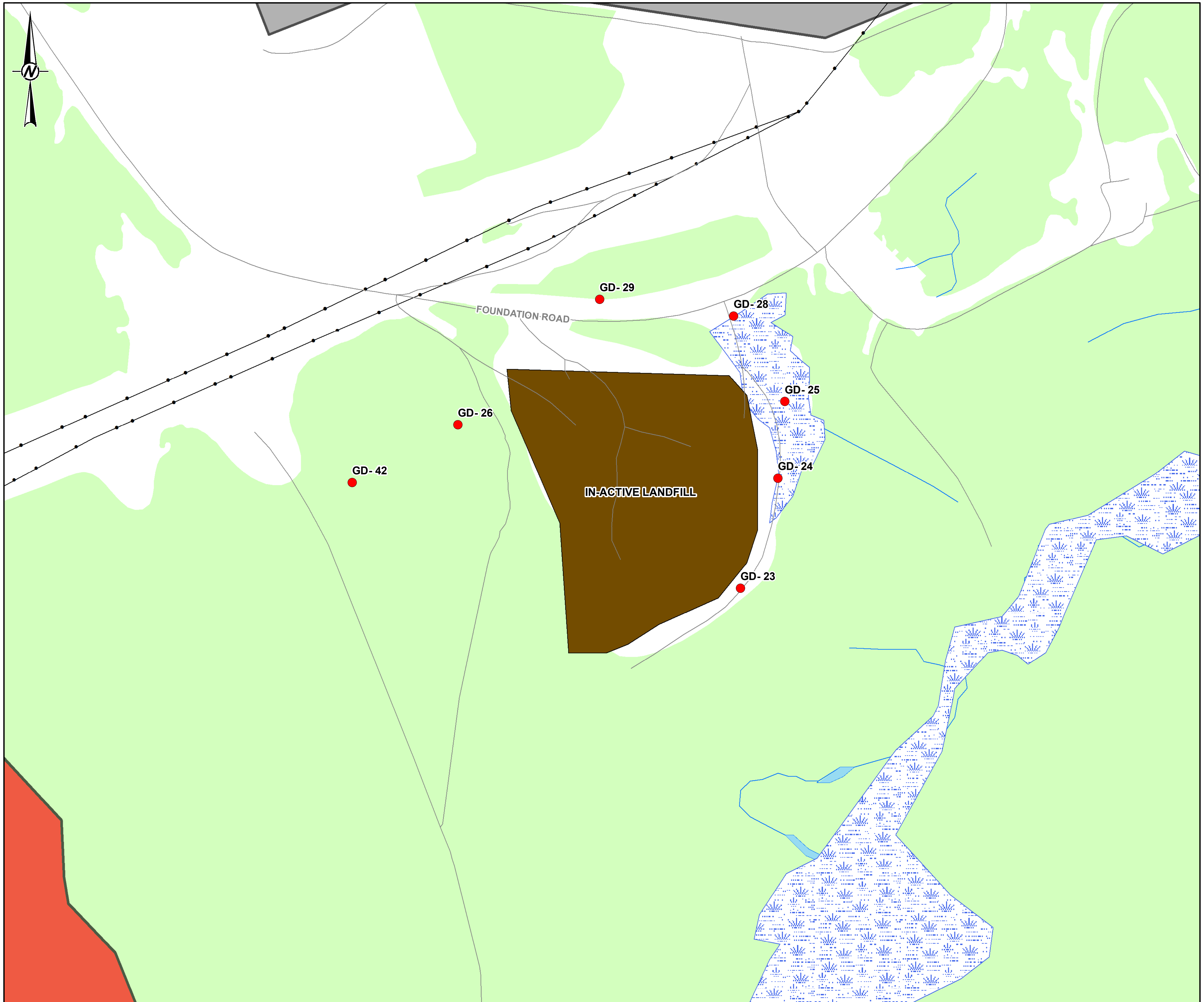

LEGEND

- ROAD
- TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- SITE STUDY AREA (NSDF PROJECT SITE)
- CRL MAIN CAMPUS
- WASTE MANAGEMENT AREA (WMA)[1]
- CRL SITE
- GWMP MONITORING WELL

50 0 50

1:2,500 METRES

NOTE(S)

1. LIQUID DISPOSAL AREA ENCOMPASSES REACTOR PIT 1 AND 2, CHEMICAL PIT AND LAUNDRY PIT.

REFERENCE(S)

1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
LOCATION OF INDIVIDUAL GROUNDWATER MONITORING WELLS RELATIVE TO INACTIVE LANDFILL

CONSULTANT GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.7.4-9

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Investigations of contamination in East Swamp have included measurements of radioactivity in pore water (CNL 2015b). The East Swamp has existing contamination due to groundwater plumes from the Chemical Pit and Reactor Pit 2. Since it is immediately west of the SSA, this contamination is relevant to the Base Case radioactivity characterization for the SSA. Surveying conducted in 2012 included collection and analysis of pore water at seven locations, labelled Z-1 to Z-7 on Figure 5.7.4-10. The radiological contamination in these samples is shown in Table 5.7.4-11. All gross alpha concentrations in these pore water samples were less than detection limits (<8 Bq/L). Total beta ranged from 180 Bq/L to a maximum of 4,900 Bq/L. Strontium-90 concentrations ranged from 120 Bq/L to a maximum of 2,960 Bq/L. The East Swamp contamination study utilized these concentrations to estimate distribution coefficients of radionuclides in soil, which is the ratio of radionuclide concentrations in the solid phase to the concentrations in solution.

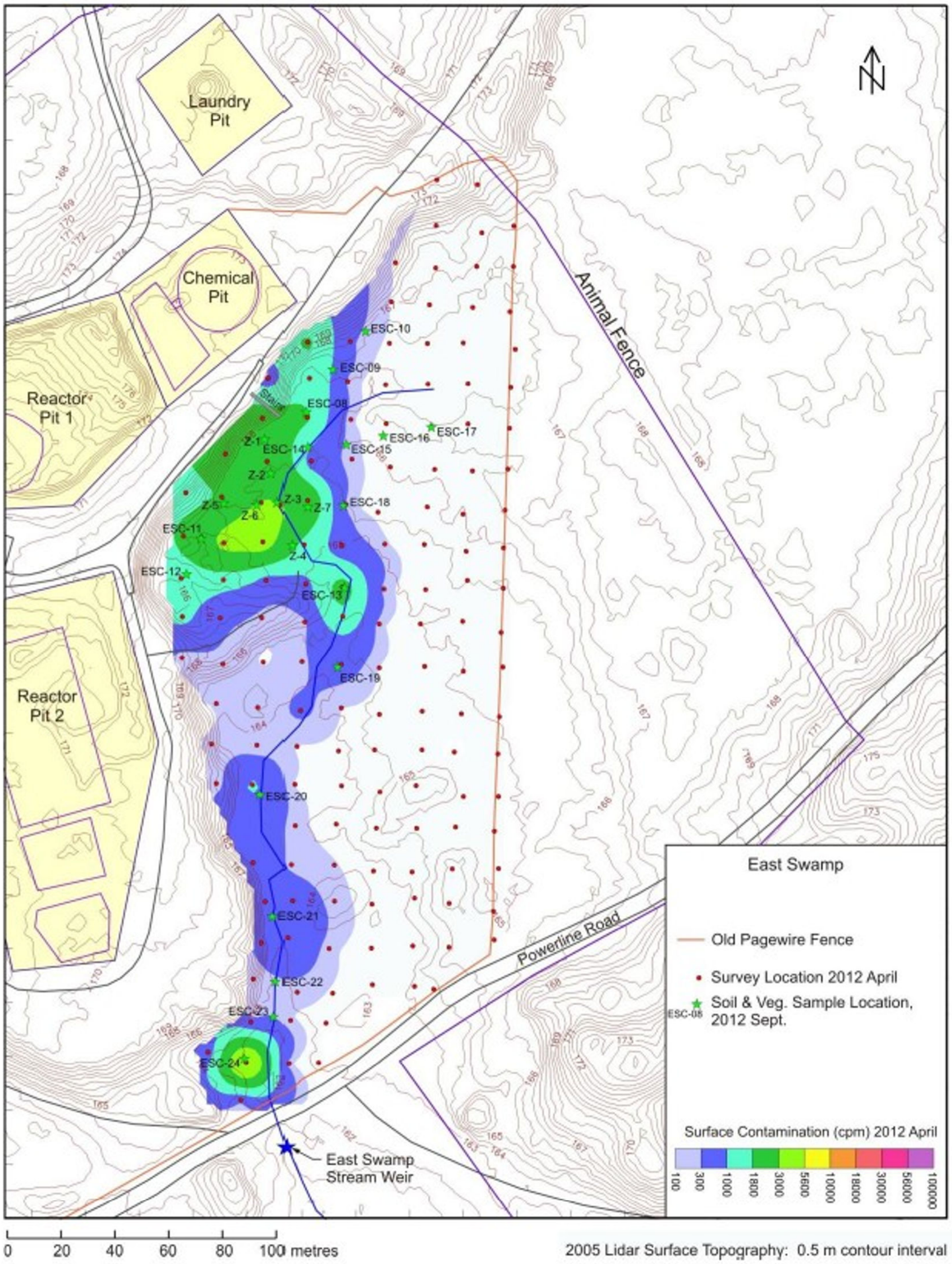
Table 5.7.4-11: Radioactivity in Pore Water Samples from 2012 East Swamp Survey (Bq/L)

Location	Gross Alpha	Total Beta	Strontium-90
Z-1	<3	1,300	770
Z-2	<7	4,900	2,960
Z-3	<6	520	308
Z-4	<3	980	500
Z-5	<3	1,600	950
Z-6	<6	180	120
Z-6 Replicate	<8	230	130
Z-7	<3	780	482

<= results below the detection level; Bq/L = Becquerels per litre.

Tritium concentrations in pore water in the East Swamp stream have averaged 430 Bq/L in the period 2008 to 2012 compared to background tritium concentrations of approximately 300 Bq/L (CNL 2015b).

Further groundwater sampling at the SSA was completed by AMEC Foster Wheeler in October and December 2016 (AMEC 2016, 2017). Tritium, gross alpha and total beta activities were found to range from <64 to 155 Bq/L, <0.009 to 0.552 Bq/L and <0.01 to 1.06 Bq/L, respectively. These results are slightly elevated in comparison to ambient radiological conditions in groundwater observed near the SSA for some parameters (i.e., gross alpha). It is noted that these ranges are based on two monitoring events for the SSA.



CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT

TITLE
2012 EAST SWAMP SURVEY GRID DISPLAYING PORE WATER SAMPLING LOCATIONS Z-1 TO Z-7

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0012	FINAL 2	5.7.4-10

REFERENCE(S)
1. BASEMAP PROVIDED BY CNL

5.7.4.7 Radioactivity in Soil and Vegetation

Geotechnical investigations in 2016 (Golder 2016) included a radiological screening of soil samples prior to off-site non-radiological analysis. No radiological contamination was found at the SSA, although it is noted that no quantitative analysis was performed for radiological contaminants beyond screening with a contamination meter.

Measurements of radionuclide concentrations in soil have been performed at specific areas of concern within the CRL site, and included studies of ambient radiation, as well as soil, groundwater and vegetation contamination in areas affected by groundwater plumes from WMAs at CRL.

Radiological contamination in the East Swamp Wetland is relevant to the NSDF Project, as this area is immediately west of the SSA. Because this wetland is potentially downgradient of parts of the SSA, characterization of the contamination present is important in defining Base Case conditions. The East Swamp Wetland has existing contamination associated with a shallow subsurface plume from the Chemical Pit (see Figure 5.3.2-4 in Section 5.3) and a second plume from Reactor Pit 2 (see Figure 5.3.2-5 in Section 5.3). The surface contamination distribution in the East Swamp has been characterized on a five-year frequency with radiation field surveys, surface surveys and vegetation contamination surveys performed in 2002, 2007 and 2012. In 2002 and 2012, these surveys included wetland soil and vegetation sampling to determine the radionuclide concentrations in these media. Surveying was conducted over a 150 m by 350 m area, using a 15 m by 15 m grid spacing. Additional relevant surveying has been performed to characterize the Chemical Pit plume; this has included measurements of radionuclides in soil (AECL 2014a). Surveying in East Swamp is done on a five-year cycle.

Sub-surface Soil in the Chemical Pit Plume

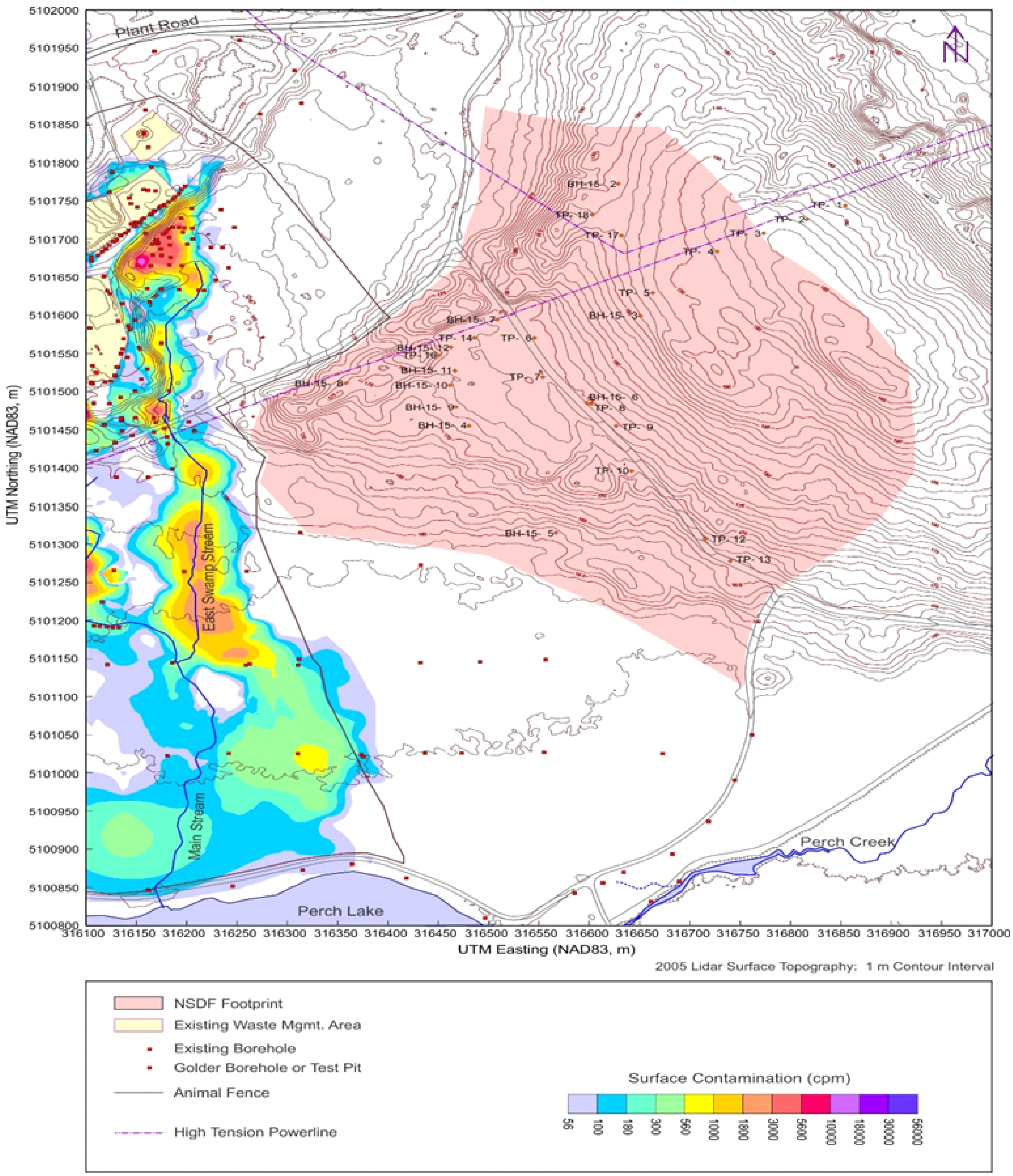
Surveying of the Chemical Pit plume conducted in 2002 included measurements of subsurface soil immediately downgradient of the Chemical Pit in the East Swamp (AECL 2014a). Figure 5.7.4-8 provides an indication of the spatial extent of the Chemical Pit plume in the East Swamp. Total beta concentrations in borehole samples ranged from 580 to 345,000 Becquerels per kilogram (Bq/kg). Gross alpha activity ranged from less than 110 to 760 Bq/kg. Gamma spectroscopy was performed on samples with more than 2,000 Bq/kg of total beta activity, and the anthropogenic gamma emitters cobalt-60, caesium-137 and americium-241 were detected. Concentrations of cobalt-60 in soil ranged from background (<10 Bq/kg) to 2,680 Bq/kg. Concentrations of caesium-137 in soil ranged from background (<20 Bq/kg) to 970 Bq/kg. Concentrations of americium-241 ranged from background (<70 Bq/kg) to 1,110 Bq/kg.

Surficial Soil in the East Swamp

The 2002 East Swamp soil survey found total beta concentrations ranging from 850 Bq/kg at background locations east of the contaminated region to 1,845,000 Bq/kg at locations where the plume discharges to surface (CNL 2015b). Alpha activity concentrations ranged from background levels (100 Bq/kg) in reference locations to a maximum of 8,570 Bq/kg in the Chemical Pit groundwater discharge zone. Cobalt-60 soil concentrations in East Swamp range from background (100 Bq/kg) to 151,000 Bq/kg. Caesium-137 soil concentrations range from 3,000 Bq/kg to 5,700 Bq/kg. For cobalt-60 and caesium-137, the highest concentrations were observed within the Chemical Pit groundwater plume discharge zone.

The 2012 soil survey found total beta concentrations ranging from 1,040 Bq/kg to 1,562,000 Bq/kg, with the maximum levels occurring where the Chemical Pit groundwater plume discharges to surface (CNL 2015b). Alpha activity concentrations ranged from 170 to 74,300 Bq/kg, with the maximum occurring in the Chemical Pit groundwater discharge zone. Cobalt-60 concentrations were measured ranging from 20 Bq/kg to 102,000 Bq/kg, while caesium-137 concentrations ranged from 40 to 105,000 Bq/kg. Both maximum concentrations occurred within the Chemical Pit groundwater plume.

Figure 5.7.4-11 displays a map of surface contamination in the Perch Lake Wetland based on a compilation of data collected in 2009, 2011 and 2012 and with some data from 1997. This map is useful for visualizing the spatial extent of contamination in the Perch Lake Wetland, and locations of contamination with respect to the SSA.



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REFERENCE(S)
1. BASEMAP PROVIDED BY CNL

CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT

TITLE
EXISTING SURFACE CONTAMINATION IN THE PERCH LAKE WETLAND WEST AND SOUTH OF THE NSDF PROJECT SITE

CONSULTANT: GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0012	FINAL 2	5.7.4-11

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No monitoring of soil is performed in the RSA as part of the CRL Environmental Monitoring Program. The CNSC *Independent Environmental Monitoring Program* (CNSC 2016) has included measurements of radioactivity in soil near the towns of Chalk River (approximately 8 km southwest of CRL) and Chapeau (approximately 25 km southeast of CRL). In 2014, caesium-137 measured in soil near Chalk River was present at a concentration of 5.81 Bq/kg dry weight, while at Chapeau, 6.54 Bq/kg dry weight was measured (CNSC 2016).

Site-specific background values for radiological contaminants in soil have been established by the *Environmental Risk Assessment of Chalk River Laboratories* (CNL 2019e), *Analysis of Surface Soil Samples from the Proposed NSDF Site Technical Report* (CNL 2017c) and *Additional Radionuclide Information for the NSDF Surface Soils* (CNL 2018b). Soil data from 43 locations on the Chalk River site, generally unaffected by CNL operations, were used to calculate the upper limit of background concentrations. Background concentrations of additional radiological parameters were taken from northeastern Ontario regional measurements or Ministry of the Environment, Conservation and Parks background site condition standard values (MOE 2011). Upper-limit background values for caesium-137 in soil have been calculated as 23.8 Bq/kg (CNL 2019e). It is noted that higher background values may exist. For example, Milton et al. (2001) measured caesium-137 concentrations in soil of approximately 200 Bq/kg at the CRL site, and approximately 35 Bq/kg at Petawawa.

Site-specific background concentrations of metals in soil were also established in the *Background Concentrations of Metals in Soils at the CRL Site* memorandum (CNL 2018c). Local background levels were estimated considering 37 sampling locations across the CRL site. The 97.5th percentile was calculated for each metal, which is the same method used by the Ministry of the Environment, Conservation and Parks in the development of the Ontario Typical Range (OTR_{98}). Concentrations were generally less than the established OTR_{98}, with the exception of mercury (0.15 micrograms per gram [µg/g]) which was marginally greater than its OTR_{98} of 0.13 µg/g.

In 2017, 142 trees in the SSA were sampled for tritium, gross alpha, and gross beta radiation (AECL 2017). All tritium, gross alpha, and total beta concentrations measured in the composite samples of tree wood collected from the SSA met CNL criteria for unrestricted off-site release of the wood as well as the CNSC's unconditional clearance criteria.

5.7.4.8 Radioactivity in Aquatic Sediment

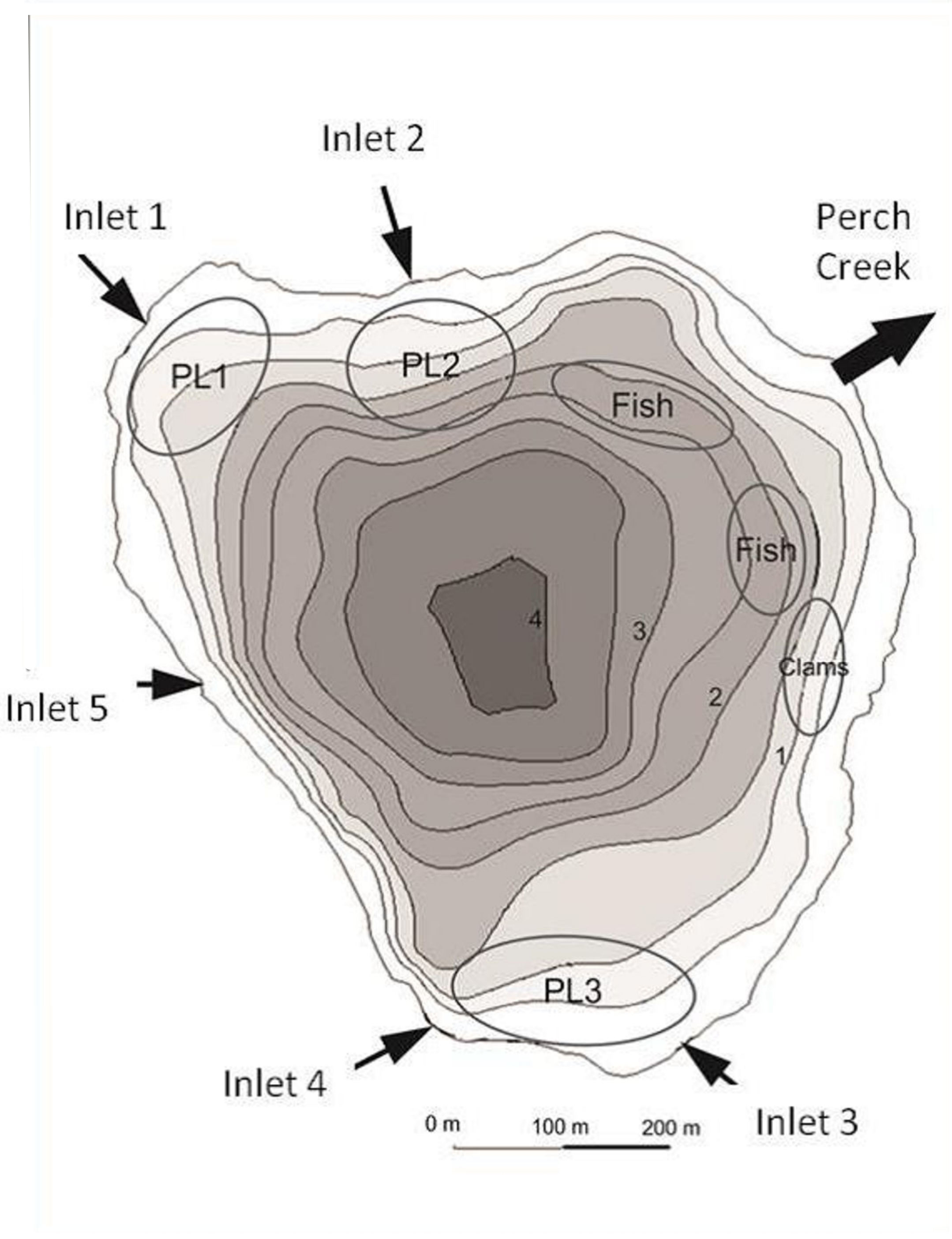
No sediment is present within the SSA. Sediment has been monitored periodically in Perch Lake, which may be affected by the NSDF and is considered to be representative of the LSA. Sampling locations for studies completed in 2003 and 2013 are shown on Figure 5.7.4-12. The measurements of tritium oxide and organically bound tritium from these studies are shown in Table 5.7.4-12.

Table 5.7.4-12: Perch Lake Sediment Sampling Results

Site	Year 2003		Year 2013	
	Tritium Oxide (Bq/L)	Organically Bound Tritium (Bq/L)	Tritium Oxide (Bq/L)	Organically Bound Tritium (Bq/L)
PL1	3,960 ±75	1,995 ±88	1,706 ±13	691 ±18
PL2	12,550 ±250	2,970 ±149	1,729 ±17	741 ±15
PL3	1,320 ±26	490 ±25	1,579 ±16	952 ±38

Source: CNL 2016b

Bq/L = Becquerels per litre.



REFERENCE(S)
1. BASEMAP PROVIDED BY CNL

CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT

TITLE
PERCH LAKE SEDIMENT SAMPLING LOCATIONS

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0012	FINAL 2	5.7.4-12

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Additionally, concentrations of strontium-90, caesium-137 and cobalt-60 in Perch Lake sediments have been reported in the CRL *Environmental Risk Assessment* (CNL 2019e). Concentrations of strontium-90 in Perch Lake sediment ranged from 845 Bq/kg to a maximum of 4,290 Bq/kg dry weight. Concentrations of caesium-137 in Perch Lake sediment ranged from 63.4 Bq/kg to a maximum of 355 Bq/kg dry weight. Concentrations of cobalt-60 in Perch Lake sediment ranged from 124 Bq/kg to a maximum of 296 Bq/kg dry weight.

Beach sand is routinely monitored at locations on the Ottawa River, including four upstream reference locations, two locations at the CRL site downstream boundary (both near Pointe au Baptême), and five locations farther downstream of the CRL site. The upstream locations are used to establish background concentrations of radionuclides. The CRL site boundary locations are considered to represent the RSA. Concentrations of caesium-137 are slightly elevated at the CRL site boundary, with annual averages ranging from 2.7 to 29.8 Bq/kg from 2014 to 2018. Sediment monitoring locations farther downstream of the CRL site are considered to be representative of the area beyond the RSA. Sediment monitoring results averaged for upstream, property boundary and downstream locations from 2014 to 2018 are shown in Table 5.7.4-13.

Table 5.7.4-13: Average Radionuclide Concentrations in Ottawa River Sediment (Bq/kg dry weight)

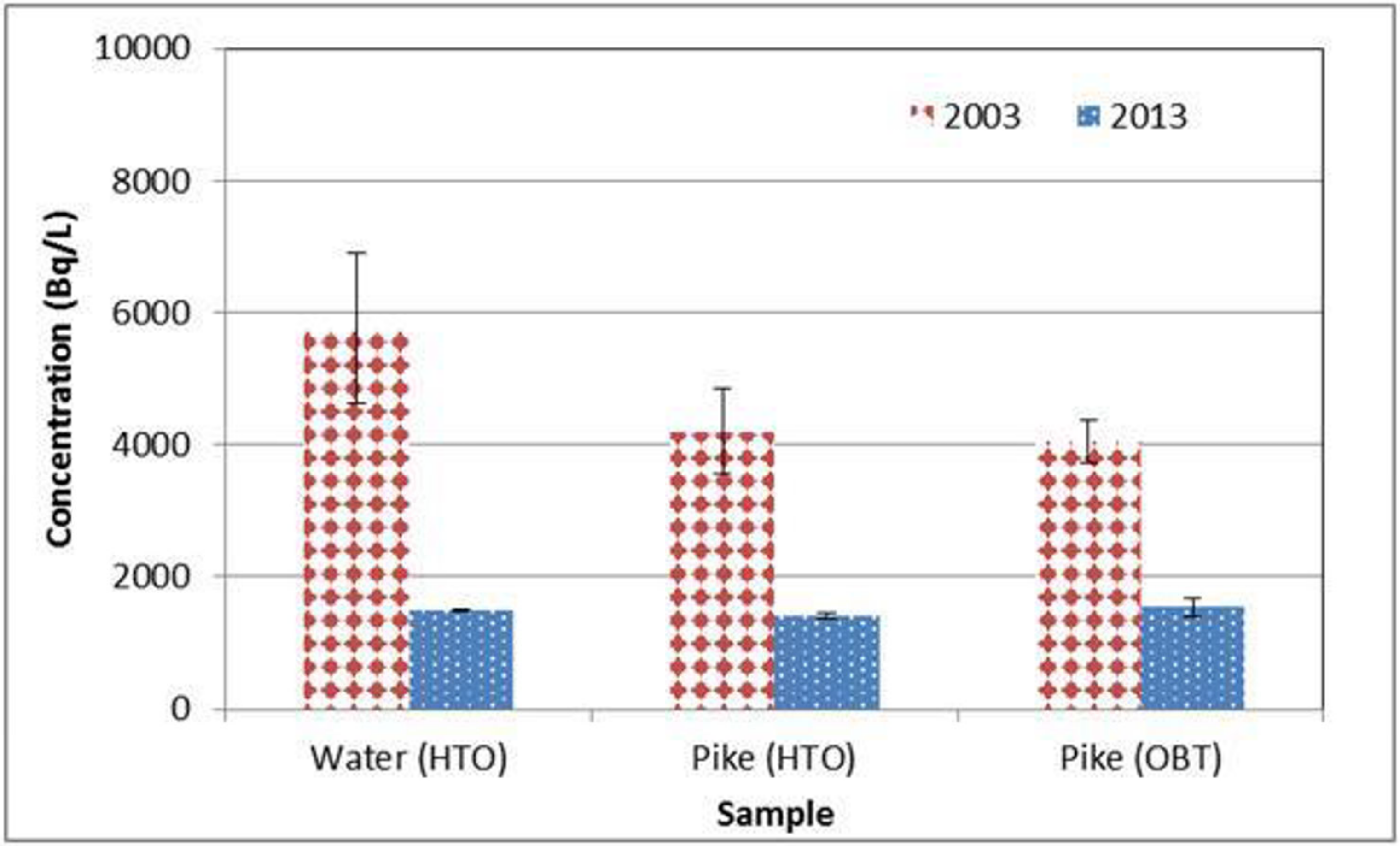
	2014	2015	2016	2017	2018	Average
Reference locations (Upstream)						
Caesium-134	<0.23	<0.25	<0.25	<0.31	<0.23	V 0.25
Caesium-137	4.7	3.7	3.51	4.31	4.36	4.1
Cobalt-60	<0.3	<0.3	<0.25	0.32	<0.24	V 0.28
Potassium-40	790	616	685	876	620	717
Regional Study Area (CRL Site Boundary)						
Caesium-134	<0.27	<0.24	<0.26	<0.23	<0.38	V 0.28
Caesium-137	29.8	18.1	29.15	29.5	2.7	21.9
Cobalt-60	<0.3	<0.3	<0.27	<0.22	<0.36	V 0.29
Potassium-40	594	701	745	674	955	734
Beyond Regional Study Area (Downstream Locations)						
Caesium-134	<0.26	<0.26	<0.24	<0.27	<0.3	V 0.27
Caesium-137	6.7	6.6	6.81	7.21	5.46	6.6
Cobalt-60	<0.3	<0.3	<0.25	<0.28	<0.31	V 0.29
Potassium-40	759	894	744	865	919	836

Source: CNL 2019b

<= results below the detection level; "V" indicates an average calculated using one or more results below detection level; Bq/kg = Becquerels per kilogram.

5.7.4.9 Radioactivity in Fish

Fish are collected annually from upstream and downstream locations on the Ottawa River and from Chalk Lake. There are no fish habitats located in the SSA. Fish have periodically been sampled from Perch Lake. Studies conducted in 2003 and 2013 included measurements of tritium oxide in water as well as tritium oxide and organically bound tritium in fish and clams (CNL 2016b). The results of these studies are shown on Figure 5.7.4-13 and Figure 5.7.4-14. Tritium oxide concentrations in water are less than the maximum acceptable concentration of 7,000 Bq/L specified for drinking water (Health Canada 2019). Based on a water content of 75% by mass (CSA Group 2014) and an internal dose conversion coefficient of 0.000138 micrograys per day per Becquerel per kilogram (μGy/day) / (Bq/kg) as presented in the Environmental Risk Assessment (AECL 2014c), the concentrations of tritium in fish and clams are significantly less than concentrations that would result in doses exceeding the benchmark of 400 μGy/hr for aquatic biota.



LEGEND

REFERENCE(S)

CLIENT
CANADIAN NUCLEAR LABORATORIES

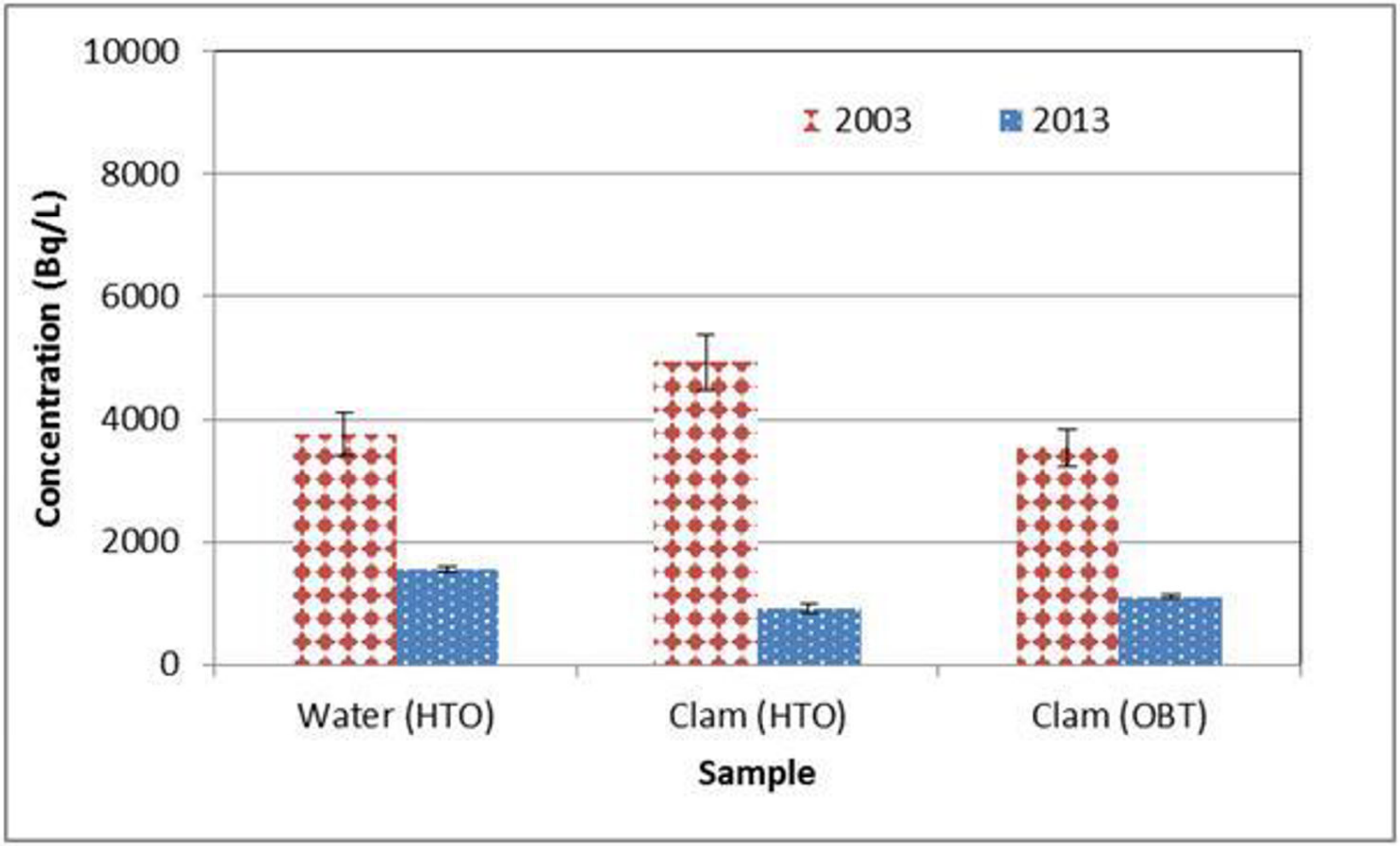
PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	PR
PREPARED	PR
REVIEWED	CS
APPROVED	AB

TITLE
TRITIUM OXIDE ACTIVITY CONCENTRATIONS OF WATER, AND TRITIUM OXIDE AND ORGANICALLY BOUND TRITIUM ACTIVITY CONCENTRATIONS OF PIKE SAMPLED IN JUNE OF 2003 AND 2013

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	**5.7.4-13**



LEGEND

REFERENCE(S)

CLIENT
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PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

CONSULTANT
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DATE	NOVEMBER 2020
DESIGNED	PR
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APPROVED	AB

TITLE
TRITIUM OXIDE ACTIVITY CONCENTRATIONS OF WATER, AND TRITIUM OXIDE AND ORGANICALLY BOUND TRITIUM ACTIVITY CONCENTRATIONS OF CLAMS SAMPLED IN JUNE OF 2003 AND 2013

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	**5.7.4-14**

Fish are sampled from Chalk Lake, which is partly within the CRL site boundary and is therefore considered to be representative of the RSA. While this location is within the CRL site, it is not expected to be affected by the NSDF Project, since the NSDF will not drain to the Maskinonge Lake Basin, which contains Chalk Lake. Radioactivity in fish at these locations is presented in Table 5.7.4-14. Elevated tritium concentrations have been measured in fish from Chalk Lake. Average concentrations in 2018 of tritium oxide and organically bound tritium in Chalk Lake fish were 15.6 Bq/kg and 12.32 Bq/kg, respectively. For comparison, in 2018 Ottawa River fish upstream of CRL at Mackey had concentrations of less than 0.88 Bq/kg and less than 1.11 Bq/kg for tritium oxide and organically bound tritium.

Table 5.7.4-14: Radioactivity (Bq/kg fresh weight) in Fish Sampled from Chalk Lake

	2014	2015	2016	2017	2018	2014–2018 Average
Chalk (Sturgeon) Lake						
Carbon-14	303	278	299	293	284.2	291
Caesium-134	V 0.14	<0.19	<0.13	<0.12	<0.11	V 0.14
Caesium-137	8.3	14	11.9	9.7	8.12	10.4
Tritium	33	38	25	18	15.6	25.9
Organically bound tritium	26	24.5	23	<19	12.32	V 21.0
Gross alpha	0.22	V 0.3	N/D	V 0.33	V 0.63	V 0.37
Gross beta	144	162	139	203	196.3	169
Potassium-40	147	151	138	146	137.3	144

Source: CNL 2019b.

Note: Table 7-18 includes transcription errors for caesium-137, gross alpha and gross beta, 2015. Values corrected based in Table 7-18 in Environmental Monitoring Report (CNL 2019b).

<= results below the detection level; ”V” indicates an average calculated using one or more results below detection level; Bq/kg = Becquerels per kilogram; N/D = results below the critical level (i.e., not detected).

Fish are sampled from one upstream location and two downstream locations in the Ottawa River. Radioactivity in fish from downstream locations could potentially be affected by the SSA via discharge from the Perch Lake basin to the Ottawa River. The RSA fish monitoring results are displayed in Table 5.7.4-15.

Table 5.7.4-15: Radioactivity (Bq/kg fresh weight) in Fish Sampled from the Ottawa River

	2014	2015	2016	2017	2018	2014–2018 Average
Highview, 9 km downstream of CRL						
Carbon-14	372	269	V 263	248	249	V 280
Caesium-134	<0.14	<0.12	<0.12	<0.11	<0.11	V 0.12
Caesium-137	18.5	49.9	26.4	11.7	8.61	23.0
Tritium	8.4	V 4	V 3.1	9.9	V 0.88	V 5.3
Organically bound tritium	2.9	8.6	5.3	5.22	<1.11	V 4.6
Gross alpha	N/D	V 0.85	<0.09	V 0.37	V 0.14	V 0.36
Gross beta	131	168	162	151	166	156
Potassium-40	149	150	139	101	145.5	137
Waltham, 42 km downstream						
Carbon-14	254	236	V 272	235	250.5	V 250
Caesium-134	V 0.15	<0.14	<0.12	<0.09	<0.09	V 0.12
Caesium-137	8.3	24.1	10.9	5.6	6.17	11.0
Tritium	12	6	8.7	V 2.2	<1.61	V 6.1
Organically bound tritium	2.7	8.3	296	V 2.07	2.14	V 62.2
Gross alpha	N/D	V 0.18	N/D	V 0.41	V 0.44	V 0.34
Gross beta	143	163	163	136	138.7	149
Potassium-40	150	175	113	94	120.3	130
Ottawa River at Mackey, 28 km Upstream						
Carbon-14	267	260	240	241	236	V 249
Caesium-134	<0.14	<0.31	<0.14	<0.12	<0.11	V 0.16
Caesium-137	8.5	6.3	6.2	4.8	8.61	6.9
Tritium	5.3	V 2	<0.28	V 13	<0.88	V 4.3
Organically bound tritium	1.1	V 3.9	N/D	V 3.59	<1.11	V 2.4
Gross alpha	V 0.02	V 1.7	V 0.49	V 0.69	<0.14	V 0.61
Gross beta	154	142	167	151	166	156
Potassium-40	163	144	159	110	146	144

Source: CNL 2019b

Note: Table 7-18 includes transcription errors for carbon-14, caesium-137, gross alpha and gross beta, 2015, Highview; caesium-137, gross alpha, gross beta 2015 and tritium 2016, Waltham; and gross alpha 2015, Ottawa River. Values corrected based in Table 7-18 in Environmental Monitoring Report (CNL 2019b).

<= results below the detection level; V" indicates an average calculated using one or more results below detection level; Bq/kg = Becquerels per kilogram; N/D = results below the critical level (i.e., not detected); N/A = not available.

The CRL *Environmental Risk Assessment* included estimates of radiation dose to fish at various locations on the CRL site, including East Swamp, West Swamp, Perch Lake and Perch Creek. The average and maximum radiation dose calculated for fish present in these locations is shown in Table 5.7.4-16 (AECL 2014c).

Table 5.7.4-16: Dose to fish in East Swamp, Perch Creek and Perch Lake

Receptor	Mean Combined Dose (µGy/hr)	Maximum Combined Dose (µGy/hr)
East Swamp		
Red-belly Dace	17.0	55.13
West Swamp		
Red-belly Dace	16.0	45.25
Perch Lake		
Pumpkinseed	2.92	3.51
Brown Bullhead	2.93	3.53
Perch Lake Inlet 1		
Red-belly Dace	9.21	18.3
Perch Lake Inlet 2		
Red-belly Dace	1.92	3.51
Perch Creek		
Creek Chub	1.26	1.58

In 2018, tissue concentrations of tritium, organically bound tritium, and gross alpha and beta (Table 5.7.4-17) and gamma spectral analysis (Table 5.7.4-18) were measured in fish from Perch Lake (CNL 2018d). The results are presented below.

Table 5.7.4-17: Radioactivity in Fish in Perch Lake

Receptor	Mean Tissue Concentration (Bq/kg)	Maximum Tissue Concentration (Bq/kg)
Tritium		
Bullhead[1]	758	758
Pumpkinseed[2]	789	789
Perch[3]	—	676
Pike[3]	—	772
Organically Bound Tritium		
Bullhead	646	794
Pumpkinseed	532	580
Perch	—	582
Pike	—	864
Gross Alpha		
Bullhead	V 2.35	5.49
Pumpkinseed	V 2.74	4.89
Perch	—	<-0.45
Pike	—	<-0.14
Gross Beta		
Bullhead	9076	12382
Pumpkinseed	8188	10917
Perch	—	11591
Pike	—	2802

Source: CNL 2018d

"V" indicates an average calculated using one or more results below detection level; Bq/kg = Becquerels per kilogram; <= below laboratory detection limit; "—" = not calculated as there was only one sample, see max

1) Bullhead dataset includes 6 discrete tissue samples.

2) Pumpkinseed dataset includes 5 discrete tissue samples.

3) Perch and pike datasets include 1 discrete sample each.

Table 5.7.4-18: Gamma Spectral Analysis of Fish in Perch Lake

Parameter	Mean Tissue Concentration (Bq/kg)				Maximum Tissue Concentration (Bq/kg)			
	Bullhead[1]	Pumpkinseed[2]	Perch[3]	Pike[3]	Bullhead[1]	Pumpkinseed[2]	Perch[3]	Pike[3]
Potassium-40	90.8	79.4	—	—	150.7	133.4	121.1	47.0
Caesium-137	3.91	3.22	—	—	6.03	5.10	4.43	2.26
Thallium-208	V 1.09	V 0.458	—	—	1.83	0.994	<0.397	<0.252
Lead-212	V 5.25	V 6.51	—	—	27.5	29.9	5.02	<0.297
Lead-214	V 2.04	V 3.21	—	—	6.35	12.2	<0.858	<0.405
Uranium-235	V 0.915	V 0.637	—	—	2.40	1.75	<0.539	<0.202
Uranium-238	V 13.7	V 18.2	—	—	29.8	35.4	<20.5	<3.91

Source: CNL 2018d

“V” indicates an average calculated using one or more results below detection level; Bq/kg = Becquerels per kilogram; <= below laboratory detection limit; “—” = not calculated as there was only one sample, see max

Only the radiological parameters that were detected in at least one sample from any fish species have been listed in the table.

1) Bullhead dataset includes 6 discrete tissue samples.

2) Pumpkinseed dataset includes 5 discrete tissue samples.

3) Perch and pike datasets include 1 discrete sample each.

5.7.4.10 Radioactivity in Terrestrial Foodstuffs

5.7.4.10.1 Terrestrial Animals

No monitoring of terrestrial animals is performed specifically within the SSA or LSA. Radioactivity in large game animals (e.g., deer) is measured when animals are hunted or killed accidentally in the vicinity of the CRL site. Samples obtained from within 25 km are considered to be representative of the RSA. The concentration of radioactivity in the flesh and bones of terrestrial animals are shown in Table 5.7.4-19 and Table 5.7.4-20, respectively.

Historically, elevated levels of radioactivity have been measured in large game animals from within 25 km of the CRL site (e.g., approximately 1,100 Bq/L tritium in large game animal flesh sample in 2001). This is related to historical contamination of the CRL WMAs (CNL 2016c). Fences installed in 2004 to prevent game animal access to areas with surface contamination have led to a reduction in radioactivity in local game animals. The average tritium concentrations in the flesh of large game animals collected within 25 km of the CRL site from 2014 to 2018 have ranged from 11 to 510 Bq/kg. Average gross beta activity ranged from 111 to 313 Bq/kg, where naturally occurring potassium-40 was the primary contributor (Table 5.7.4-19 and Table 5.7.4-20). Tritium concentrations in the flesh of large game animals collected beyond 50 km of the CRL site from 2014 to 2018 have ranged from less than 0.87 to 11 Bq/kg.

Table 5.7.4-19: Radioactivity in Flesh of Large Game Animals (Bq/kg fresh weight)

	2014	2015	2016	2017	2018	2014–2018 Average
Regional Study Area (game animals within 25 km)						
Tritium	11	88	510	439	22	214
Organically bound tritium	V 3.3	V 56	V 73	154	9.3	V 59.1
Gross beta	111	313	138	119	154	167
Gross alpha	<0.5	<0.4	<0.05	0.72	0.5	V <0.43
Total strontium	<0.6	N/D	V 0.43	1	0.4	V 0.61
Potassium-40	87	228	101	98	119	126.6
Cobalt-60	<0.2	<0.4	<0.15	<0.12	<0.11	V <0.20
Caesium-134	<0.2	<0.3	<0.12	<0.12	<0.09	V <0.17
Caesium-137	8.4	62	11	3.16	22.3	21.4

Source: CNL 2019c.

Note: Values reported for each year represent the average radionuclide concentrations measured from multiple animals. The “average” column indicates the average of these annual values (not weighted by number of samples).

<= results below the detection level; ”V” indicates an average calculated using one or more results below detection level Bq/kg = Becquerels per kilogram; N/D = results below the critical level (i.e., not detected)

Table 5.7.4-20: Radioactivity in Bones of Large Game Animals (Bq/kg fresh weight)

	2014	2015	2016	2017	2018	2014–2018 Average
Regional Study Area (game animals within 25 km)						
Gross beta	251	798	986	5150	134	1464
Gross alpha	112	36	42	<10.6	11	V 42.3
Total strontium	V 38	V 36	V 22	471	64	V 126
Potassium-40	162	57	83	<34.5	27	V 72.7
Cobalt-60	<1.8	<1.8	<1.9	<1.28	<0.93	V <1.5
Caesium-134	<1.8	<1.7	<1.8	<1.3	<0.97	V <1.5
Caesium-137	V 2.0	V 4	V 2	<0.89	5	V 2.8

Source: CNL 2019b.

Note: Values reported for each year represent the average radionuclide concentrations measured from multiple animals. The “average” column indicates the average of these annual values (not weighted by number of samples).

<= results below the detection level; ”V” indicates an average calculated using one or more results below detection level; Bq/kg = Becquerels per kilogram

The dose to large mammals was estimated in the CRL *Environmental Risk Assessment* (AECL 2014a), based on measured radionuclide concentrations in flesh and bone from animals accidentally killed on CRL site and on modelled concentrations of radionuclides in air. The dose to deer from radionuclides in tissue and argon-41 in air was estimated to range from 0.038 to 0.064 µGy/hr. The estimated total dose to eastern wolf (*Canis lupus lycaon*) is similar and considerably less than the benchmark of 100 µGy/hr.

5.7.4.10.2 Terrestrial Plants

Garden produce is sampled annually from gardens and farmers markets at off-site population centres. Additionally, garden produce is sampled from Killaloe, 55 km south of the SSA, to evaluate background radioactivity. Samples are collected annually and analyzed for tritium (free tritium is shown in Table 5.7.4-21 and organically bound tritium in Table 5.7.4-22), gross beta (Table 5.7.4-23), gross alpha (Table 5.7.4-24) and caesium-137 (Table 5.7.4-25). Results are grouped into fruit, root or vegetable categories. The Chalk River and Balmer Bay sampling locations are within the RSA, while remaining locations are beyond the RSA.

No produce is grown for human consumption at the SSA or within the CRL site boundary. It is noted that the SSA will be subject to vegetation management procedures, such that no vegetation that could penetrate waste will be allowed to grow.

At the reference location (Killaloe), free water tritium concentrations in produce have averaged less than 3 Bq/kg. This is comparable to reference measurements from across Ontario, which range from 1 to 6 Bq/kg (OPG 2013). Elevated tritium concentrations were measured at the locations closest to the CRL site. At Balmer Bay, tritium concentrations in all produce from 2014 to 2018 averaged 18 Bq/kg, with an average of 21.3 Bq/kg in vegetable produce (Table 5.7.4-21). At Deep River, tritium concentrations in all produce from 2014 to 2018 have averaged 11.5 Bq/kg. Additionally, elevated tritium concentrations have been measured at Pembroke, but this is likely associated with a local non-CNL industry in the area.

Table 5.7.4-21: Free Tritium in Plant Produce (Bq/kg fresh weight)

	2014	2015	2016	2017	2018	2014–2018 Average
Fruit						
Killaloe	<2	N/D	N/D	N/D	N/D	V <2
Pembroke	18	10	<2.8	8.3	4.1	V 8.6
Balmer Bay	25	N/A	17	15	19	19
Deep River	26	12	5.6	11	5	11.9
Chalk River	10	6	4.3	7.4	<2.8	V 6.1
Petawawa	<3	<3	<2.4	<2.4	4.1	V <3.0
Sheenboro	5	3	4.58	<2.7	N/D	V 3.8
Root						
Killaloe	N/D	4	N/D	N/D	N/D	V 4.0
Pembroke	10	7	N/D	6.1	7.4	V 7.6
Balmer Bay	11	N/A	8.7	14	N/A	11.2
Deep River	12	17	9.2	12	10	12.0
Chalk River	<2	<3	4.9	3.7	N/D	V 3.4
Petawawa	<3	N/A	N/D	N/D	N/D	V 3.0
Sheenboro	3	<2	<2.7	<2.4	N/D	V 2.5
Vegetable						
Killaloe	N/D	<3.4	N/D	<2.4	<2.7	V <2.8
Pembroke	16	14	4.4	4	18	11.3
Balmer Bay	24	16	15	12	21	17.6
Deep River	23	16	25	6	5	15.0
Chalk River	4	5	84	3	10	21.2
Petawawa	8	N/D	N/D	3	5	V 5.3
Sheenboro	<3	4	5.6	12	N/D	V 6.2

Source: CNL 2019b.

<= results below the detection level; "V" indicates an average calculated using one or more results below detection level; Bq/kg = Becquerels per kilogram; N/A = not available; N/D = results below the critical level (i.e., not detected).

Table 5.7.4-22: Organically Bound Tritium in Plant Produce (Bq/kg fresh weight)

	2014	2015	2016	2017	2018	2014–2018 Average
Fruit						
Killaloe	N/D	<2.1	3.78	N/D	N/D	V 2.94
Pembroke	0.8	8.9	3.93	4.2	6.8	4.93
Balmer Bay	1.2	N/A	7.06	9.8	10.5	7.14
Deep River	0.6	9.3	4.48	7.1	6.1	5.52
Chalk River	1.87	<2	3.36	3.8	<2.4	V 2.69
Petawawa	<0.1	<2.8	3.78	V 1.4	<2.6	V 2.14
Sheenboro	0.4	2.6	<2	3.0	N/D	V 2
Root						
Killaloe	<0.4	11	<1.9	N/D	N/D	V 4.43
Pembroke	1.1	8.9	N/D	3.6	4.4	V 4.5
Balmer Bay	1.5	N/A	6.22	11	N/A	6.24
Deep River	1.4	6.6	6.15	7.1	6.4	5.53
Chalk River	1	3.3	3.45	<2.3	N/D	V 2.51
Petawawa	0.1	N/A	2.97	2.3	3.9	2.32
Sheenboro	2.1	3	3.28	2.5	N/D	V 2.72
Vegetable						
Killaloe	<0.3	12	1.5	<2.1	N/D	V 3.98
Pembroke	8.7	41	4	<4.3	16.1	17.5
Balmer Bay	7.7	6.2	7.2	12	9	8.42
Deep River	0.6	3.3	8.5	4.5	4.3	4.24
Chalk River	0.6	4	2.9	5.7	3.4	3.32
Petawawa	0.8	<1.7	<2.0	5.0	3.8	V 2.66
Sheenboro	0.9	2.6	6.05	4.4	N/D	V 3.49

Source: CNL 2019b.

<= results below the detection level; "V" indicates an average calculated using one or more results below detection level; Bq/kg = Becquerels per kilogram; N/D = results below the critical level (i.e., not detected); N/A = not available.

Table 5.7.4-23: Gross Beta Activity in Plant Produce (Bq/kg fresh weight)

	2014	2015	2016	2017	2018	2014–2018 Average
Fruit						
Killaloe	109	68	66	52	52	69.4
Pembroke	50	79	81	197	46	90.6
Balmer Bay	110	N/A	72	49	41	68
Deep River	114	121	70	54	44	80.6
Chalk River	104	91	90	80	96	92.2
Petawawa	91	261	77	63	65	111
Sheenboro	61	52	82	57	42	58.8
Root						
Killaloe	114	170	158	65	90	119
Pembroke	163	148	130	105	165	142
Balmer Bay	119	N/A	135	103	N/A	119
Deep River	117	159	133	134	111	131
Chalk River	140	128	70	131	38	101
Petawawa	134	N/A	140	171	133	145
Sheenboro	102	94	84	111	82	94.6
Vegetable						
Killaloe	183	58	199	168	204	162
Pembroke	109	216	147	53	292	163
Balmer Bay	79	174	101	113	133	120
Deep River	104	97	119	87	129	107
Chalk River	98	148	134	120	129	126
Petawawa	124	124	132	145	154	136
Sheenboro	184	286	54	56	88	134

Source: CNL 2019b.

”V” indicates an average calculated using one or more results below detection level; Bq/kg = Becquerels per kilogram; N/A = not available.

Table 5.7.4-24: Gross alpha Activity in Plant Produce (Bq/kg fresh weight)

	2014	2015	2016	2017	2018	2014–2018 Average
Fruit						
Killaloe	<0.74	N/D	0.08	0.04	0.43	V 0.32
Pembroke	0.74	0.2	0.2	0.4	0.3	0.37
Balmer Bay	N/D	N/A	N/D	<0.05	0.3	V 0.18
Deep River	4.52	0.19	N/D	<0.2	0.2	V 1.28
Chalk River	N/D	0.18	N/D	N/D	0.3	V 0.24
Petawawa	N/D	0.1	N/D	N/D	0.5	V 0.3
Sheenboro	N/D	0.81	0.26	N/D	0.2	V 0.42
Root						
Killaloe	12.8	0.41	0.61	0.08	0.5	2.88
Pembroke	34.9	<0.49	0.11	0.35	1.53	V 7.48
Balmer Bay	N/D	N/A	N/D	2.4	N/A	V 2.4
Deep River	N/D	0.53	0.29	0.2	0.5	0.38
Chalk River	1.13	0.21	N/D	1.6	0.4	V 0.84
Petawawa	N/D	N/A	N/D	0.76	0.42	V 0.59
Sheenboro	30.8	0.24	0.19	0.06	1.04	6.47
Vegetable						
Killaloe	0.73	0.15	N/D	1.8	1.5	V 1.05
Pembroke	N/D	1.33	0.64	V 0.54	0.89	0.85
Balmer Bay	0.57	<1.17	N/D	2.1	0.75	V 1.15
Deep River	0.3	1.03	N/D	0.91	0.8	0.76
Chalk River	0.34	0.5	0.6	<0.24	0.39	V 0.41
Petawawa	<0.26	N/D	0.46	<0.38	0.35	V 0.36
Sheenboro	1.13	1.07	0.65	0.29	0.90	0.81

Source: CNL 2019b.

<= results below the detection level; "V" indicates an average calculated using one or more results below detection level; Bq/kg = Becquerels per kilogram; N/D = results below the critical level (i.e., not detected); N/A = not available.

Table 5.7.4-25: Caesium-137 in Plant Produce (Bq/kg fresh weight)

	2014	2015	2016	2017	2018	2014–2018 Average
Fruit						
Killaloe	<0.09	<0.11	0.10	<0.1	<0.04	V 0.09
Pembroke	<0.09	<0.13	<0.09	<0.1	<0.1	V <0.10
Balmer Bay	<0.09	N/A	<0.13	<0.1	0.1	V 0.11
Deep River	<0.14	<0.12	<0.11	<0.1	<0.1	V <0.11
Chalk River	<0.13	<0.11	<0.08	<0.1	<0.1	V <0.10
Petawawa	0.31	0.16	0.57	<0.1	0.1	V 0.25
Sheenboro	<0.11	<0.11	<0.14	<0.1	<0.1	V <0.11
Root						
Killaloe	<0.19	<0.1	<0.08	<0.08	<0.04	V <0.10
Pembroke	<0.21	<0.1	<0.15	<0.05	<0.16	V <0.13
Balmer Bay	0.53	N/A	0.19	<0.13	N/A	V 0.28
Deep River	<0.19	<0.11	<0.15	<0.10	0.21	V <0.15
Chalk River	<0.3	<0.11	<0.13	<0.09	<0.09	V <0.14
Petawawa	0.51	N/A	0.54	<0.12	0.12	V 0.32
Sheenboro	0.64	<0.1	<0.08	<0.12	<0.24	V 0.24
Vegetable						
Killaloe	<0.22	0.31	<0.12	<0.16	<0.17	V 0.20
Pembroke	<0.13	<0.12	<0.24	<0.14	<0.17	V <0.16
Balmer Bay	<0.1	<0.19	<0.10	1.99	<0.10	V 0.50
Deep River	<0.16	<0.14	<0.11	<0.08	<0.08	V <0.11
Chalk River	<0.26	<0.16	0.18	<0.17	<0.12	V 0.18
Petawawa	<0.13	<0.19	<0.23	<0.19	0.30	V <0.21
Sheenboro	<0.27	0.46	0.34	<0.25	<0.16	V 0.30

Source: CNL 2019b.

<= results below the detection level; "V" indicates an average calculated using one or more results below detection level; Bq/kg = Becquerels per kilogram; N/A = not available.

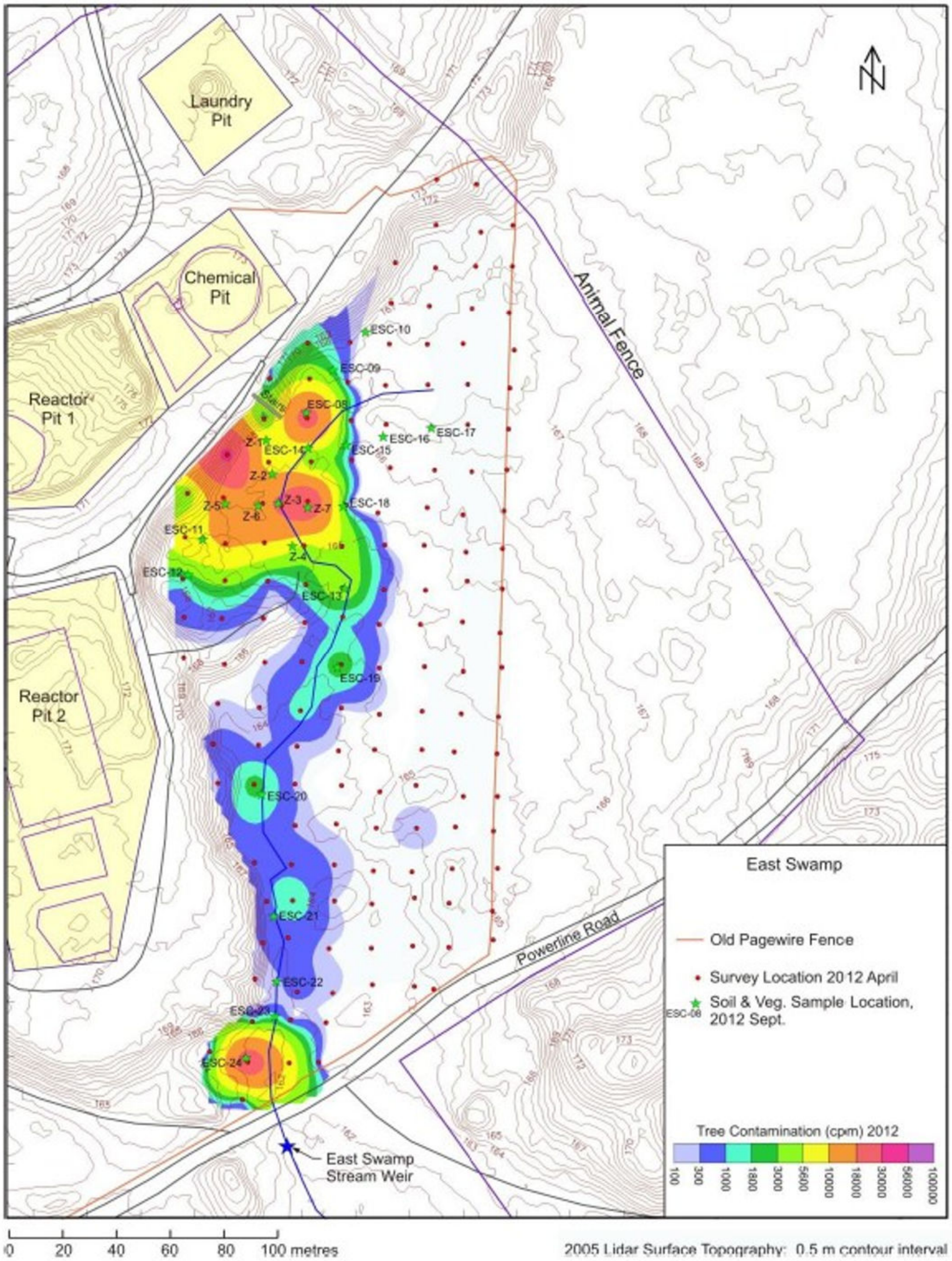
Gamma spectroscopy has demonstrated that the majority of gross beta activity is due to naturally occurring potassium-40. Gross beta results are highly variable due to the variability in naturally occurring radionuclides at the monitoring locations. Low-level gross alpha activity was detected in produce samples from all areas, including the reference area. Naturally occurring alpha emitters likely account for the observed alpha activity. The caesium-137 measurements in garden produce are frequently below the detection level. Some low-level (approximately 2.0 Bq/kg) caesium-137 concentrations have been detected in local produce. Caesium-137 is not solely attributable to CRL operations as it is present in the environment from atmospheric fallout from global weapons tests and the Chernobyl nuclear accident.

In addition to monitoring garden produce as part of the Environmental Monitoring Program, surveys of contamination resulting from groundwater plumes at CRL have included sampling and analysis of vegetation. Radiological surveying conducted at the East Swamp is particularly relevant to the NSDF Project, as it is immediately west of the SSA and may be affected by NSDF Project activities. Contamination exists in the East Swamp as a result of groundwater plumes from the Chemical Pit and Reactor Pit 2. Vegetation sampling was conducted in the East Swamp during 2002, 2007 and 2012 surveys. These surveys included measuring contamination of tree surfaces, leaves/ferns (in 2002), tree cores/branches (in 2012) and surface vegetation (in 2012).

Tree surface contamination was measured with a Ludlum 44-9 pancake Geiger-Mueller detector, which responds to alpha, beta and gamma radiation, and was used with the detector in contact with the trunk, approximately 1 m off the ground. Tree surface contamination results from 2012 are shown on Figure 5.7.4-15.

Total beta activities in tree leaves surveyed in 2002 were on average 1.25 times higher than beta activity in soil (see East Swamp soil monitoring results in Section 5.7.4.7 Radioactivity in Soil). Alpha activity in tree leaves and ferns at the East Swamp background location were 7 Bq/kg and 13 Bq/kg dry weight, respectively. Throughout East Swamp, alpha activity in tree leaves average 10 Bq/kg, with a maximum of 24 Bq/kg. Activity in ferns was slightly higher, with average values of 15 Bq/kg and a maximum of 47 Bq/kg. These results are considered to be very close to background, indicating negligible alpha emitter uptake into vegetation. Caesium-137 concentrations were generally greater in vegetation than in soil at East Swamp, with an average factor of 4.9 times higher for ferns and 1.2 times higher for trees. Cobalt-60 concentrations in vegetation were a small fraction of that in soil.

In 2012, total beta activity in vegetation was on average 1.2 times higher than that in soil, with ratios ranging from 0.17 to 6.2 more beta activity in vegetation than corresponding soil samples. Gross alpha activity in vegetation was at or near background levels of 13 Bq/kg, with the exception of vegetation from the Chemical Pit groundwater discharge zone where levels were elevated (260 Bq/kg). Caesium-137 concentrations ranged from background to a maximum of 11,400 Bq/kg. Cobalt-60 concentrations in vegetation were a small fraction of that observed in soil.



CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
VEGETATION CONTAMINATION IN THE EAST SWAMP IN 2012

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0012	FINAL 2	**5.7.4-15**

REFERENCE(S)
1. BASEMAP PROVIDED BY CNL

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5.7.4.10.3 Milk

No milk production occurs within the SSA, LSA or RSA. Milk is sampled monthly from a dairy farm in Pembroke, considered to be beyond the RSA. Samples are analyzed to quantify the concentration of tritium and other radionuclides. The average annual concentration of radionuclides in milk from the dairy in Pembroke is shown in Table 5.7.4-26.

The contaminants tritium, carbon-14 and caesium-137 are associated with CRL operations and were measured in milk samples at detectable levels. Tritium concentrations were comparable to the natural background range of 5 to 11 Bq/L (CNL 2017d; NCRP 1987). Local non-CNL industries in Pembroke may influence the measured tritium concentrations in milk samples. Concentrations of carbon-14 in milk samples have ranged from 15 to 18 Bq/L. This is comparable to the natural background level of 15 Bq/L (CNL 2017d; UNSCEAR 1993).

Concentrations of caesium-137 have remained at approximately 0.02 Bq/L from 2012 to 2016. This is comparable to the estimated background concentrations of caesium-137 in milk in Canada, which are estimated to range from 0.0017 Bq/L to 0.024 Bq/L due to atmospheric nuclear weapons testing and the Chernobyl nuclear accident (CNL 2017d; Health Canada 2001). Naturally occurring radionuclides such as potassium-40 were also detected in milk samples.

Table 5.7.4-26: Average Concentration of Radioactivity in Milk (Bq/L) from the Dairy in Pembroke

	2012	2013	2014	2015	2016	2012–2016 Average
Tritium	<3	2.8	2.4	<2.4	<0.31	V 2.2
Carbon-14	17	16.7	17	17	18	17
Caesium-137	0.02	0.021	0.02	0.012	0.016	0.018
Iodine-131	<0.1	<0.1	<0.1	<0.1	<0.1	V <0.1
Actinium-228	<0.05	<0.07	<0.08	<0.05	<0.05	V <0.06
Potassium-40	47	55.1	59.1	66	60	57
Radium-226	<0.02	<0.02	<0.03	<0.02	<0.02	V <0.02
Thorium-228	<0.03	<0.04	<0.05	<0.04	<0.03	V <0.04

Source: CNL 2017d.

<= results below the detection level; "V" indicates an average calculated using one or more results below detection level; Bq/L = Becquerels per litre.

5.7.5 Project Interactions and Mitigation

5.7.5.1 Methods

This section describes the process by which interactions between NSDF Project components and activities and ecological health were identified and evaluated. Potential effects pathways are identified and mitigation developed to eliminate and/or reduce effects is presented. A pathways analysis is then used to focus the assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects will be adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects after incorporation of mitigation are further characterized in subsequent subsections of the assessment. As such, this section helps to focus the remainder of the assessment on those interactions (effects pathways) with the potential to result in residual adverse effects.

The first part of the analysis was to identify the potential effects pathways for all stages of the NSDF Project. The next step in the analysis was the development of environmental design features and mitigation that could be incorporated into the NSDF Project to eliminate and/or reduce adverse effects to ecological receptors. Environmental design features included project design elements, environmental best practices and management policies and procedures. Environmental design features and mitigation were developed through an iterative process between the NSDF Project's engineering and environmental teams, combined with input from project-specific or regional engagement with other interested parties. The design features and/or mitigation were selected considering their effectiveness for implementation and maintenance, and their appropriateness within the context of the identified effects pathways.

After incorporation of mitigation, potential pathways were evaluated into the following categories using scientific knowledge, logic, experience with similar developments and the effectiveness of environmental design features and mitigation:

- **No linkage:** The pathway is removed by environmental design features or mitigation such that the NSDF Project would not be expected to result in a measurable environmental change relative to Base Case values and therefore would have no residual effects to ecological receptors.
- **Secondary pathway:** The pathway could result in a measurable minor environmental change, but would have a negligible residual effect to ecological receptors relative to guideline values and is not expected to contribute cumulatively to other NSDF Project effects or to the effects of other previous, existing or reasonably foreseeable developments to cause a significant effect.
- **Primary pathway:** The pathway is likely to result in an environmental change relative to the guideline values that could contribute to residual effects to ecological receptors.

Environmental design features and mitigation that have been or could be incorporated into the NSDF Project to eliminate and/or reduce adverse effects were considered. Potential pathways that were completely removed due to implementation of environmental design or mitigation were not assessed further. Pathways that were assessed to be secondary and demonstrated to have a negligible residual effect to ecological receptors through simple qualitative or semi-quantitative evaluation of the pathway were also not advanced for further assessment.

Primary pathways were carried forward for more detailed quantitative and qualitative effects analysis to characterize the residual effects of the NSDF Project and the NSDF Project in combination with other previous, existing and reasonably foreseeable developments.

5.7.5.2 Results

Pathways through which all stages of the NSDF Project may interact with and result in changes to measurement indicators for ecological health is provided in Table 5.7.5-1.

Table 5.7.5-1: Pathways Analysis for Ambient Radioactivity and Ecological Health Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
▪ Project activities during the operations and closure phase: ▪ Phased development of disposal cells in the ECM ▪ On-site transportation of waste and placement in the ECM ▪ Progressive closure of disposal cells and installation of final cover ▪ Surface water management ▪ Operation of the WWTP ▪ Discharge of treated effluent from the WWTP	▪ Dust may be created during the handling of bulk materials, and emissions of gases may be released during storage and disposal of radioactive materials, which can affect ecological health. ▪ Emissions may be released from the WWTP to air during operations, which can affect ecological health.	▪ CNL's procedure for Management and Monitoring of Emissions (CNL 2018e), which includes operational control monitoring and verification monitoring will be implemented. ▪ The buildup of gaseous emission from waste in closed cells is mitigated by gas venting in the final cover. ▪ The Dust Management Plan (AECOM 2018a) for the NSDF Project will include: ▪ restricting or suspending activities if unacceptable amounts of dust are generated due to winds or other site conditions; ▪ use of water spraying or misting techniques (e.g., water trucks) as the primary dust control method; ▪ use of fixatives (e.g., chemical suppressant) for dust control, and for use as daily/interim cover; ▪ suspension of excavating, loading, hauling and disposal operations when wind speeds exceed the specified criterion; and ▪ vehicles that have come into contact with contamination will be required to pass through the vehicle decontamination facility ▪ Processed wastewater will not be heated within the WWTP (raising the temperature increases potential release rates). ▪ There is active ventilation within the WWTP building and active ventilation exhaust will be filtered through HEPA prior to release. ▪ A perimeter fence around the NSDF will be implemented to prevent terrestrial land-based wildlife from gaining access to the ECM. Given the transient nature of exposure to birds and the low expected ambient concentrations, low exposures are expected for birds and as such no specific mitigations have been proposed.	Primary
	▪ Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) may cause changes to groundwater quality in the wetland and downstream surface water quality, which can affect ecological health.	▪ The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses the best available technology that is economically achievable and capable of meeting regulatory requirements. ▪ Effluent discharge targets for wastewater discharges are protective of the environment and human health. ▪ Discharge targets for non-radiological contaminants are sourced from federal and provincial guidelines for protection of aquatic biota. ▪ Discharge targets for radionuclides are the Canadian Drinking Water Guidelines with the exception of tritium for which a site-specific target is developed (Section 3.4.2.5.1). ▪ Treated effluent will be sampled to confirm that it meets effluent discharge targets before release to the environment. ▪ When applied, the proposed exfiltration gallery will promote the exfiltration of treated water into the local groundwater regime where further retention of radioactivity by the geosphere is anticipated. ▪ The Perch Lake diffuser design provides additional dilution of treated effluent at the point of release ▪ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water quality. ▪ Appropriate procedures will be in place to effectively identify spill occurrences in the event treated effluent is released to areas other than directly to the exfiltration gallery and initiate appropriate emergency responses	Primary
▪ Project activities during the operations and closure phase: ▪ Surface water management ▪ Operation of the WWTP ▪ Discharge of treated effluent from the WWTP	▪ Leakage of leachate from the ECM during operations and closure may cause changes to groundwater quality in the wetland and downstream surface water quality, which can affect ecological health.	▪ Design of the ECM includes base grading configured in a herringbone pattern with ridges and valleys to promote leachate transport to the leachate collection system for removal. ▪ The base liner design includes primary and secondary liner systems designed to have redundancy in case of premature degradation and are a combination of natural and synthetic barrier systems. These include a compacted clay liner (CCL), two geosynthetic clay liners (GCL) and an HDPE geomembrane. ▪ Clay materials were selected for the CCL and GCL components of the liner system as these materials are anticipated to maintain their function as hydraulic barriers throughout and beyond the design life of the disposal facility (i.e., 550 years; 50 years of operations and 500 years post-closure). ▪ The HDPE geomembrane design for the liner will be compatible with the leachate generated by the waste and provide a long service life. ▪ The base liner system will include an underlying compacted clay liner to supplement the primary and secondary liner system. ▪ The leachate collection system design will provide access points for inspections, maintenance, repairs, and replacements. ▪ Appropriate responses to leachate leakage and contamination will be implemented as described in the Operations and Maintenance Plan (AECOM 2019).	No Linkage
▪ Project activities during the post-closure phase:	▪ Volatiles (e.g., radon, tritium) may be released to air, which can affect ecological health.	▪ A passive landfill gas venting system will be constructed at the same time as installation of the ECM final cover system.	▪ Primary

Table 5.7.5-1: Pathways Analysis for Ambient Radioactivity and Ecological Health Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
▪ On-going long-term performance monitoring, transfer of NSDF Project into the post-institutional control period		▪ The landfill gas monitoring probes will also be installed around the perimeter of the ECM to detect evidence of potential landfill gas migration away from the ECM. ▪ Radon-emitting wastes will be preferentially placed in the lower levels of the ECM.	
	▪ Leachate may be released to soil via overtopping the berm, which can affect ecological health.	▪ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound and minimize leachate generation. ▪ The cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity. ▪ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. ▪ The ECM final grading and drainage plan includes collection ditches along the top of the ECM berm road to collect side slope drainage. ▪ Environmental monitoring will be completed as required during the institutional control period for the NSDF Project to confirm that the final cover is functioning as intended.	Primary
	▪ Leachate may be released through the base liner to groundwater, which can affect ecological health.	▪ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound and minimize leachate generation. ▪ The cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity. ▪ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. ▪ The ECM final grading and drainage plan includes collection ditches along the top of the ECM berm road to collect side slope drainage. ▪ The design life for the ECM is 550 years to meet the required time period to allow for radioactive decay of the waste placed in the facility (i.e., until it has decayed to levels that do not present a risk to the public and environment). ▪ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to groundwater quality.	Primary

ECM = engineered containment mound; WWTP = Wastewater Treatment Plant; HDPE = high density polyethylene.

5.7.5.2.1 No Linkage Pathways

The following pathway was assessed as having no measurable environmental change and hence, no linkage to residual effects on ecological health VCs.

- **Leakage of leachate from the ECM during operations and closure may cause changes to groundwater quality in the wetland and downstream surface water quality, which can affect ecological health.**

Design of the ECM includes base contours that have been developed using a herringbone pattern with ridges and valleys to promote leachate transport to the leachate collection system for removal. The base liner design includes both primary and secondary liner systems that are designed to have redundancy in case of premature degradation and are a combination of natural and synthetic barrier systems. The primary liner will include a leachate collection system with the secondary liner housing a leak detection system. The composite base liner will contain perforated high density polyethylene (HDPE) collection and monitoring pipes. The HDPE geomembrane was selected as it is compatible with the leachate generated by the waste and is expected to perform as an effective hydraulic and diffusion barrier over the 550-year design life (i.e., 50 years of operations and 500 years post-closure, see Section 3.4.1.4). The base liner system will include an underlying compacted clay liner to supplement the primary and secondary liner system. The leachate collection and monitoring system design will provide access points for monitoring, inspections, maintenance, repairs and replacements.

The primary liner system will contain the leachate collection system and will convey leachate to a single collection point for removal from the ECM, for transfer to the WWTP for treatment. The primary liner system serves as the primary source of protection for the natural environment below the ECM from leachate migration. The secondary liner system will contain the leak detection system, which will be used to detect leaks in the unlikely event that the primary liner system fails. Leachate collected by the leachate collection system will be pumped to the on-site WWTP for treatment.

Perimeter berms consist of three main geotechnical elements, or layers, each contributing to the soundness and integrity of the berm itself and the whole ECM. A *Slope Stability Analysis* (AECOM 2018b) was completed to provide the information needed to support the design of the base slopes, sidewalls and side slopes of the ECM. The *Slope Stability Analysis* addresses the range of anticipated loading conditions, under both short-term and long-term scenarios, to confirm that the slope designs will satisfy minimum factor-of-safety requirements for stability. Size and shape of the berms and each of the elements and layers were determined using a seismic design basis, including the *National Building Code of Canada 2015* (NRCC 2015).

The implementation of the design of the ECM, the liner systems, and the perimeter berms will reduce the potential for changes to groundwater and surface water quality from the NSDF Project site. As such, this pathway was determined to have no linkage to effects on ecological health.

5.7.5.2.2 Secondary Pathways

No secondary pathways were identified as having residual effect on ecological health.

5.7.5.2.3 Primary Pathways

Primary pathways identified for ecological health and that are evaluated in the residual effects analysis (Section 5.7.6 Residual Effects Analysis) include:

- During the operations and closure phases:
  - **Dust may be created during the handling of bulk materials and emissions of gases may be released during storage and disposal of radioactive materials, which can affect ecological health.**
  - **Emissions may be released from the WWTP to air during operations, which can affect ecological health.**
  - **Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) can cause changes to groundwater quality in the wetland and downstream surface water quality, which can affect ecological health.**
- During the post-closure phase:
  - **Volatiles (e.g., radon, tritium) may be released to air, which can affect ecological health.**
  - **Leachate may be released to soil via overtopping the berm, which can affect ecological health.**
  - **Leachate may be released through the base liner to groundwater, which can affect ecological health.**

5.7.6 Residual Effects Analysis

This section describes the specific methods used to assess the residual effects on ecological health for the NSDF Project activities and pathways identified as primary in Table 5.7.5-1. The approach used to predict residual effects is described below, along with the scenarios, models, policies, guidelines and standards considered in the analysis. The radiological dose assessment is discussed Section 5.7.6.1 and the non-radiological exposure assessment is discussed in Section 5.7.6.2.

5.7.6.1 Radiological Dose Assessment

5.7.6.1.1 Application Case Methods

The majority of the information in the Residual Effects Analysis for the radiological dose assessment is taken from the following sources:

- NSDF *Safety Analysis Report* (SAR) (CNL 2020b) presents the analysis and results of radiological atmospheric emissions during the operations phase;
- groundwater quality modelling (Section 5.3.2) presents the analysis and results of radioactivity in groundwater during the operations phase;
- surface water quality modelling (Section 5.4.2) presents the analysis and results of radiological waterborne effluent during the operations phase;
- PostSA (Arcadis and Quintessa 2020b) presents the analysis and results for radiological contaminants in environmental media during the post-closure phase; and
- EcoRA (Arcadis 2020a) presents the analysis and results of the radiological dose assessment to ecological receptors during the post-closure phase.

The radiological dose assessment considers the ways in which ecological receptors (introduced in Section 5.7.2) could be exposed to radioactivity present in the various environmental media.

5.7.6.1.1.1 Operations and Closure Phases

For the assessment of environmental media and ecological health in the pre-closure (operations) phase of the project, the main supporting information is from modelling completed for groundwater quality (Section 5.3.2.6) and surface water quality (Section 5.4.2.6). The main supporting document for the atmospheric emissions of radiological contaminants is the NSDF *Safety Analysis Report* (SAR) (CNL 2020b). A general background of the methods of the SAR follows.

Safety Analysis Report – Atmospheric Emissions

The SAR describes the design of the facility, and subsequently analyzes the hazards and potential consequences present in the operations of the facility. The purpose of the SAR is:

- to demonstrate the adequacy of the NSDF Project design in support of the licensing process;
- to demonstrate that the proposed design of the facility conforms to CNSC regulatory requirements and guidance provided by the International Atomic Energy Agency, and will provide for safe operation over the operational life;

- to identify the hazards, describe how hazards are controlled and/or mitigated, and describe the management system in place to ensure the controls are effectively and consistently applied;
- to undertake a quantitative and qualitative assessment of the radiological and non-radiological safety of the NSDF Project during the operations and closure phases;
- to undertake a quantitative and qualitative assessment of the radiological and non-radiological safety of the NSDF Project during the operations and closure phases; and
- to provide necessary information to support an EIS which will address the requirements of the *Canadian Environmental Assessment Act, 2012* (CEAA 2012) and *REGDOC-2.11.1, Waste Management, Volume III: Assessing the Long-Term Safety of Radioactive Waste Management* (CNSC 2018).

The scope of the SAR is to present the operational safety analysis of the NSDF Project based on the detailed design package, proposed operations and identified hazards. The SAR uses the most up-to-date information about the NSDF Project design to form the basis of the assessment. In the SAR, nuclear safety is assessed for normal operations as well as accident conditions for on- and off-site human receptors and the environment. The timeframe assessed includes the construction period, approximate 50-year operations period, and 30-year closure period.

Normal Operations refers to the most likely, expected process and work tasks that take place on a day-to-day basis. The assessment of Normal Operations assumes that all processes and procedures are followed, that workers are properly trained, and that all CNL compliance programs are being adhered to.

For Normal Operations, the dose constraint for workers is 20 mSv/yr and for the public a dose constraint of 0.3 mSv/yr is applied in accordance with the CRL *Licence Conditions Handbook* (CNSC 2019). The dose constraint for the public is achieved by ensuring that off-site radionuclide releases are well below *Derived Release Limits (DRL) for AECL's Chalk River Laboratories* (CNL 2018f). The NSDF Project is designed so the potential release of radionuclides during normal operations is less than a target of 1% of the corresponding release limits and DRL.

Accident conditions are separated into three categories based on frequency of occurrence, and are evaluated further in Section 7.0:

- Anticipated Operational Occurrence: An event that deviates from normal operations and is expected to occur once to several times during the operating lifetime of the facility. An Anticipated Operational Occurrence does not result in significant damage.
- Design Basis Accident: A rare event that is expected to occur once in 10,000 years, but much less frequently than an Anticipated Operational Occurrence. The NSDF Project is designed to perform under the conditions of a Design Basis Accident.
- Beyond Design Basis Accident: A very rare event that has more severe consequences, but occurs less frequently than a Design Basis Accident. A Beyond Design Basis Accident is expected to occur less than once in 10,000 years.

The objectives of the safety analysis are to demonstrate the following requirements under normal operations, Anticipated Operational Occurrences, Design Basis Accidents and Beyond Design Basis Accidents in the NSDF Project:

- the safety of the off-site public and on-site workers is protected;
- the dose acceptance criteria are met;
- there are no significant adverse effects on the environment;
- the adequacy of the NSDF Project design; and
- the proposed design of the NSDF Project conforms to regulatory requirements and guidance provided by the CNSC and the International Atomic Energy Agency (IAEA).

The SAR considers the following primary pathways in the evaluation of environmental effects:

- Dust may be created during handling of bulk materials and emissions of gases may be released during storage and disposal of radioactive materials, which can affect ecological health.
- Emissions may be released from the WWTP to air during operations, which can affect ecological health.

Gases and dust released from the ECM or WWTP can diffuse into the environment where they will be dispersed by wind. Some contaminants will be absorbed by vegetation which could then be consumed by animals and people.

Contaminants released through the treated effluent will reach Perch Lake. Once in the aquatic environment, there will be further dilution in Perch Creek and then in the Ottawa River. Contaminants may be taken up by aquatic flora and fauna. However, given that the effluent discharge meets applicable discharge requirements, exposure to humans and biota through this pathway are considered negligible during the operations and closure phase.

The radiological inventory of the ECM includes low-level waste associated with bulk unpackaged wastes and packaged wastes. The radionuclides assessed in the SAR are presented in Table 5.7.6-1.

Table 5.7.6-1: Radionuclides Assessed in the Safety Analysis Report

Radionuclides	
Ag-108m (metastable isotope silver-108)	Pu-239 (isotope plutonium-239)
Am-241 (isotope Americium-241)	Pu-241 (isotope plutonium-241)
Am-243 (isotope Americium-243)	Pu-242 (isotope plutonium-242)
C-14 (isotope carbon-14)	Ra-226 (isotope radium-226)
Cl-36 (isotope chlorine-36)	Se-79 (isotope selenium-79)
Co-60 (isotope cobalt-60)	Sn-126(isotope tin-126)
Cs-135 (isotope caesium-135)	Sr-90 (isotope strontium-90)
Cs-137 (isotope caesium-137)	Tc-99 (isotope technetium-99)
H-3 (isotope hydrogen-3 [Tritium])	Th-230 (isotope thorium-230)
I-129 (isotope Iodine-129)	Th-232 (isotope thorium-232)
Mo-93 (isotope molybdenum-93)	U-233 (isotope uranium-233)
Nb-94 (isotope Niobium-94)	U-234 (isotope uranium-234)
Ni-59 (isotope nickel-59)	U-235 (isotope uranium-235)
Ni-63 (isotope nickel-63)	U-238 (isotope uranium-238)
Np-237 (isotope neptunium-237)	Zr-93 (isotope zirconium-93)

Source: CNL 2020b

The SAR examines the potential hazards that could result from normal operations and the consequences of abnormal events and accidents. The SAR uses a systematic and comprehensive method to identify all hazards and accident scenarios which includes:

- hazard identification;
- identification of major hazards and postulated initiating events associated with the NSDF Project design and operations;
- hazard analysis of the consolidated list of major hazards and postulated initiating events for the NSDF Project facilities;
- failure mode, effects and criticality analysis (FMECA) of the WWTP; and
- safety analysis of normal operation, Anticipated Operational Occurrences, Design Basis Accidents and Beyond Design Basis Accidents using credible/relevant scenarios.

The hazard identification was conducted early in the design process (AECOM 2016). The objective of the hazard identification was to list characteristics associated with systems, structures and components with the potential for radiological or chemical harm to people or the environment.

The hazards posed by the NSDF Project, with the exception of the WWTP, were identified based on the safety analysts' engineering judgement, and were recorded on the Safety Hazards Checklist and documented in Hazard Identification (AECOM 2016). The Safety Hazards Checklist was used to record relevant details and safeguards for the identified hazards.

The WWTP hazard identification involved completing a preliminary failure modes and effects analysis (FMEA) for the WWTP components and subcomponents based on the 30% design piping and instrumentation diagrams (AECOM 2016). The preliminary FMEA for the WWTP components was developed to identify failure modes and effects based on the safety analysts' engineering judgement. The WWTP preliminary FMEA is documented in Hazard Identification (AECOM 2016).

Groundwater Quality

As described in Section 5.3.2.6.2.1, effects to groundwater quality is from discharge of treated wastewater to ground via the exfiltration gallery. The treated effluent discharge will meet ecological-based guidelines for all non-radiological. The treated effluent discharge will meet Canadian drinking water guidelines for all radionuclides at the point of discharge with the exception of tritium which will meet Canadian drinking water guidelines at Perch Creek discharge to the Ottawa River. The assessment of radiological discharges to surface water (Section 5.4.2) has confirmed no impacts on aquatic biota from the treated effluent discharges. Additionally, although expected to be negligible, monitoring of effluent (surface water) quality against the effluent discharge targets will be carried out.

Waterborne Effluent

As considered in Section 5.4.2, the total average annual volume of leachate, contact stormwater and decontamination water under this operating scenario is 13,320 m^3/yr. This operating scenario represents the anticipated wastewater generated over approximately 50 years of the ECM for one active cell and nine filled (closed) cells based on:

- two weeks of 22.5 m^3/hr discharge (8 hr/day) corresponding to a storm event (i.e. 2,520 m^3); and
- 120 days of 11.25 m^3/hr discharge (8 hr/day) corresponding to normal operations (i.e. 10,800 m^3).

This single annual effluent flow of 13,302 m^3/yr is discharged under two receiving environment scenarios:

- **Scenario 1:** 50% of WWTP effluent discharges to an exfiltration gallery ultimately leading to the East Swamp Wetland and the remaining 50% directly discharges to Perch Lake via an end-of-pipe diffuser.
- **Scenario 2:** 100% of WWTP effluent discharges directly to Perch Lake via an end-of-pipe diffuser.

For the operations phase modelling, it is conservatively assumed that no dilution occurs along the groundwater flowpath from the WWTP effluent discharge to the East Swamp Stream. The annual average flow rate of the East Swamp stream, which drains the wetland, is 72,000 m^3/yr. Average annual outflow from this wetland is via East Swamp Stream to Perch Lake, which discharges to the Ottawa River via Perch Creek at approximately 2,200,000 m^3/yr.

Both aquatic and terrestrial species will be exposed to contaminated surface water and sediment in the East Swamp Stream, Perch Lake, Perch Creek and Ottawa River. As further dilution will occur in the Perch Lake, Perch Creek and Ottawa River, exposure within the aquatic environment of the East Swamp Stream is bounding. Therefore, doses to ecological receptors were calculated based on water and sediment concentrations in East Swamp Stream.

Treated effluent discharged to the exfiltration gallery will contain small quantities of residual contaminants. Treated effluent will enter the East Swamp Stream, and proceed to Perch Lake, Perch Creek and the Ottawa River as described above. The concentrations of radionuclides in the treated effluent are assumed to be equal to

CNL's effluent discharge targets, as presented in Table 5.7.6-2. This is a conservative assumption, as the majority of releases will be below these target values as a result of treatment. Concentrations of radionuclides in the East Swamp Stream can be derived by applying a dilution factor of 0.19, which was calculated based on the flow rate of 72,000 m^3/yr in the East Swamp Stream and the treated effluent flow rate of 13,320 m^3/yr.

Releases of tritium represent a special case as tritium in the form of tritium oxide will not be removed from the leachate during processing at the WWTP via filtration and ion exchange treatment. For this reason, concentration of tritium in effluent was estimated based on its inventory in bulk waste, leachate generation rate and the total quantity of wastewater.

Table 5.7.6-2: Maximum Concentrations of Radionuclides in the Treated Effluent

Radionuclide	Maximum Concentrations in Treated Effluent (Bq/L)[(a)]
Ag-108m (metastable isotope silver-108)	60
Am-241 (isotope Americium-241)	0.7
Am-243 (isotope Americium-243)	0.7
C-14 (isotope carbon-14)	200
Cl-36 (isotope chlorine-36)	100
Co-60 (isotope cobalt-60)	40
Cs-135 (isotope caesium-135)	70
Cs-137 (isotope caesium-137)	10
H-3 (isotope hydrogen-3 [Tritium])	360,000
I-129 (isotope Iodine-129)	1
Mo-93 (isotope molybdenum-93)	40
Nb-94 (isotope Niobium-94)	80
Ni-59 (isotope nickel-59)	2,000
Ni-63 (isotope nickel-63)	900
Np-237 (isotope neptunium-237)	1
Pu-239 (isotope plutonium-239)	0.6
Pu-241 (isotope plutonium-241)	30
Pu-242 (isotope plutonium-242)	0.6
Ra-226 (isotope radium-226)	0.5
Se-79 (isotope selenium-79)	50
Sn-126 (isotope tin-126)	30
Sr-90 (isotope strontium-90)	5
Tc-99 (isotope technetium-99)	200
Th-230 (isotope thorium-230)	0.7

Table 5.7.6-2: Maximum Concentrations of Radionuclides in the Treated Effluent

Radionuclide	Maximum Concentrations in Treated Effluent (Bq/L)[(a)]
Th-232 (isotope thorium-232)	0.6
U-233 (isotope uranium-233)	3
U-234 (isotope uranium-234)	3
U-235 (isotope uranium-235)	3
U-238 (isotope uranium-238)	3
Zr-93 (isotope zirconium-93)	100

Source: CNL 2019d

a) Discharge limit concentration, as an upper bound.

Bq/L = Becquerels per litre.

5.7.6.1.1.2 Post-closure Phase

The main supporting documents for the assessment of environmental media and ecological health in the post-closure phase of the NSDF Project are the PostSA (Arcadis and Quintessa 2020b) and the EcoRA (Arcadis 2020a). A general background of these documents is provided below.

Post-Closure Safety Assessment

The PostSA (Arcadis and Quintessa 2020b) analyzes the long-term implications (i.e., during the institutional control and post-institutional control periods) of the NSDF Project. The purpose of the PostSA is:

- to undertake a quantitative assessment of the radiological (and non-radiological) safety of the NSDF during the post-closure phase;
- to identify those uncertainties that have the greatest potential effect on the long-term performance of the closed facility; and
- to provide necessary information to support an EIS which will address the requirements of the *Canadian Environmental Assessment Act, 2012* and CNSC's *REGDOC-2.11.1, Waste Management, Volume III: Assessing the Long-Term Safety of Radioactive Waste Management* (CNSC 2018).

Evaluating post-closure safety requires projections of the future condition of the NSDF Project and its environment, and how receptors might interact with it. Approaches have been developed to undertake such evaluations, centred on a “system analysis” method. This involves representing the NSDF Project, the facility inventory present and all potentially relevant media, with mathematical models to represent the key processes that may occur (e.g., corrosion of wastes, dissolution into groundwater, uptake by plants). It is essential that the models used are relevant, well grounded and auditable. This is achieved through a systematic approach to safety assessment. The international community has developed best practice guidance on the process, which is documented in a report of the International Atomic Energy Agency’s Improving Safety Assessment Methodologies program (IAEA 2004) and incorporated into a more recent safety guide (IAEA 2012). This process has been applied internationally since its publication, is consistent with CNSC’s *REGDOC-2.11.1, Waste Management,* *Volume III: Assessing the Long-Term Safety of Radioactive Waste Management* (CNSC 2018) and underpins the PostSA analysis.

The PostSA considers three pathways of release of contaminants into the environment:

- Volatiles (e.g., radon, tritium) may be released to air, which can affect ecological health.
- Leachate may be released to soil via overtopping the berm, which can affect ecological health.
- Leachate may be released through the base liner to groundwater, which can affect ecological health.

Gases released above the ECM will diffuse through the soil and into the atmosphere, where they will be dispersed by wind. Some contaminants will be taken up into vegetation and could then be consumed by animals and people.

Contaminants released by overtopping the ECM berm will move through the shallow environment by overland flow and interflow resulting in contamination of surface soils. Exposures can arise by external irradiation, inhalation of dust, inadvertent ingestion and consumption of food stuffs grown in the soil, or consumption of animals that have grazed in the contaminated area.

Contaminants released to groundwater beneath the ECM will move through the geological and hydrogeological environment by advection and dispersion and may sorb to sediments. Once in the aquatic environment, there will be dilution, firstly in Perch Creek and then in the Ottawa River. Contaminants may be taken up by aquatic flora and fauna.

The PostSA considers both radiological and non-radiological contaminants, based on the inventory of the ECM. The radioactive inventory of the ECM includes low-level waste associated with bulk unpackaged wastes as well as wastes in packages. The radionuclide inventory has been screened to reduce the number of radionuclides being considered to those that are relevant for the post-closure phase. Radioactive decay and ingrowth are accounted for during the assessment time frame. The radionuclides assessed in the PostSA are presented in Table 5.7.6-3 (refer to Section 5.7.6.2.1.2 for a description of non-radiological contaminants).

Table 5.7.6-3: Radionuclides Assessed in the PostSA

Radionuclides	
Ag-108m (metastable isotope silver-108)	Pu-239 (isotope plutonium-239)
Am-241 (isotope Americium-241)	Pu-241 (isotope plutonium-241)
Am-243 (isotope Americium-243)	Pu-242 (isotope plutonium-242)
C-14 (isotope carbon-14)	Ra-226 (isotope radium-226)
Cl-36 (isotope chlorine-36)	Sr-90 (isotope strontium-90)
Co-60 (isotope cobalt-60)	Tc-99 (isotope technetium-99)
Cs-135 (isotope caesium-135)	Th-230 (isotope thorium-230)
Cs-137 (isotope caesium-137)	Th-232 (isotope thorium-232)
H-3 (isotope hydrogen-3 (Tritium)	U-233 (isotope uranium-233)
I-129 (isotope Iodine-129)	U-234 (isotope uranium-234)
Nb-94 (isotope Niobium-94)	U-235 (isotope uranium-235)
Ni-59 (isotope nickel-59)	U-238 (isotope uranium-238)
Ni-63 (isotope nickel-63)	Zr-93 (isotope zirconium-93)
Np-237 (isotope neptunium-237)	

The PostSA uses the best available information on the NSDF Project and its surrounding environment to form the basis of the mathematical models developed specifically to represent the system. These have been used to calculate results that can be compared with relevant Canadian criteria and standards, as well as inform on uncertainties and identify the most important aspects of the system. These uncertainties and important aspects are captured using a number of scenarios, which are summarized in the PostSA and within the groupings below:

- Normal Evolution Scenario;
- Disruptive Event Scenarios;
- Defence-in-Depth Cases;
- "What-If" Cases; and
- Sensitivity Analysis Cases.

The **Normal Evolution Scenario** is a description of the most likely, expected, evolution of the ECM and its surrounding environment. The Normal Evolution Scenario accounts for the expected degradation of the engineered barriers over the post-closure phase. It starts immediately following the operations and closure phase, to capture the entire post-closure phase (i.e., institutional control and post-institutional control periods). It is assumed that during the institutional control period (year 2100 to year 2400), the base liner and cover will be functional and no leachate will seep through the base liner.

Disruptive Event Scenarios are variants on the Normal Evolution Scenario, designed to address uncertainties that have arisen during the definition of scenarios and conceptual models. Each is described with scenario-specific assumptions. The following Disruptive Event Scenarios were assessed in the PostSA:

- **Human Intrusion (Borehole):** This scenario assesses the potential of humans drilling, extracting and examining a core sample from the facility, potentially leading to internal or external exposures.
- **Human Intrusion (House with Basement):** In this scenario, a potential basement is constructed on top of the ECM and excavated soil/waste is spread over the garden area.
- **Enhanced Erosion Case:** This scenario investigates the potential faster erosion of the cap such that wastes are exposed at the ground surface and eroded materials spread downslope in the swamp area between the ECM and Perch Creek. This could be caused by seismic events.
- **Localized Cover Failure:** In this scenario, it is assumed that potential high infiltration through a failure in the final cover occurs, resulting in earlier bathtubbing[4] of the ECM (relative to the Normal Evolution Scenario).
- **Localized Liner Failure:** This scenario assesses increased leaching through a potential failure in the base liner, resulting in delayed bathtubbing of the ECM (relative to the Normal Evolution Scenario).
- **Damage to the Berm:** This scenario assesses potential damage to the berm; the reduced height of the berm results in increased flow of water over the berm during bathtubbing and a reduced water level in the wastes.

[4] "Bathtubbing" refers to a process in which waste material degrades, producing voids within a disposal trench followed by subsidence of the overlying soil and the entry of surface water into the trench.

In addition to Normal Evolution Scenario and Disruptive Event Scenarios, the PostSA also considers other types of scenarios, including "What-If" Cases, Defence-in-Depth Cases and Sensitivity Analysis Cases.

- "What-If" Cases represent a deliberately extreme set of assumptions that can be used to understand the absolute limits of safety performance. These have been identified as potentially of interest in the same way as other scenarios, but discounted from the main set of assessment calculations on the basis that they are of very low or negligible likelihood. Nevertheless, they inform on the underlying bounds to post-closure safety and, as such, provide valuable perspective. However, due to their very low likelihood, they are not considered in the identification and assessment of residual effects.
- Defence-in-Depth Cases are aimed at building confidence in the performance of the ECM after closure. These cases examine the extent to which the NSDF Project depends on key engineered barriers and what would happen if those barriers were not present. This group of scenarios therefore involves hypothetical combinations in order to analyze the barriers in the system. Each scenario involves a change in one or more parameters related to a particular barrier; by comparing the results to those of the Normal Evolution Scenario, the influence of the barrier is tested.
- Sensitivity Analysis Cases are used to directly examine the effect of important uncertainties in the models and data used to represent the system. As many modelling aspects can in practice be expressed through parameter values, sensitivity cases focus on using alternative parameter value choices. The alternative parameter values that are assigned need not represent specific bounds on uncertainty (as in some cases these cannot easily be established); in other words, the alternative parameters need not necessarily be the "highest" or "lowest" possible values. Rather, they are used to test the effect of uncertainty; for example, if parameter x is increased by a factor of 10, by what factor does the dose increase?

These cases serve to illustrate the importance of facility design features, address uncertainty in model parameters and provide perspective on the limits of safety performance. They are not relevant for the EIS effects assessment and are therefore not discussed further in this section. Further information on these scenarios and the PostSA calculations and results in general, is available in the PostSA (Arcadis and Quintessa 2020b).

Environmental data from the PostSA was incorporated into the EcoRA (Arcadis 2020a) to assess potential effects to ecological receptors during the post-closure phase.

Ecological Risk Assessment

The EcoRA (Arcadis 2020a) assesses the effects of radiological (and non-radiological) contaminants on ecological receptors during the post-closure phase of the NSDF Project. Other stressors associated with the NSDF Project (e.g., noise, dust, changes in habitat) are assessed directly within the EIS. Following the *CSA N288.6, Environmental Risk Assessment at Class 1 Nuclear Facilities and Uranium Mines and Mills* (CSA Group 2012) process/framework, the EcoRA uses results from the PostSA on contaminant concentrations in various environmental media, to assess ecological risk.

The EcoRA screens the contaminant concentrations calculated in each relevant PostSA scenario against the most conservative available criteria such as the Environmental Media Concentrations (EMCs) from the ERICA Tool (ERICA 2019) and No-Effect Concentrations (NECs) (Arcadis 2019a) where gaps existed, for radiological contaminants. Based on this, aluminum, copper, lead, and uranium were screened into the non-radiological assessment for all scenarios during the post-closure phase. Nine radionuclides (actinium-227, molybdenum-93, niobium-93m, plutonium-242, thorium-229, uranium-233, zirconium-93) were 'screened-in' due to a lack of available screening criteria to screen them out, and not necessarily because they had elevated environmental concentrations. If a contaminant was 'screened in', it was then carried forward for assessment in the EcoRA.

The indicator species selected for inclusion in the EcoRA were chosen based on the VCs defined in this EIS, as well as selection criteria outlined in CSA N288.6 (CSA Group 2012). The VCs and their respective indicator species are provided in Table 5.7.2-1. These indicator species are considered appropriate because they reflect a variety of diets/feeding habits, cover a variety of trophic levels, are representative of the biota expected to be found in the RSA, and are of interest to the facility and stakeholders. In addition to these indicator species, the EcoRA also includes moose as an ecological receptor in response to Indigenous interests.

The indicator species are assessed using assessment endpoints, which are expressions of the actual environmental values to be protected. In general, the assessment endpoints selected in this study were healthy populations of the identified indicator species within the RSA.

The list of indicator species chosen for assessment in the EcoRA included the following species at risk, as defined under the *Species at Risk Act:*

- Canada warbler (*Cardellina canadensis*; Threatened);
- eastern milksnake (*Lampropeltis Triangulum*; Species of Concern);
- eastern whip-poor-will (*Antrostomus vociferous*; Threatened);
- eastern wolf (*Canis lupus lycaon*; Species of Concern);
- little brown myotis (*Myotis lucifugus*; Endangered);
- monarch butterfly (*Danaus plexippus*; Species of Concern); and,
- snapping turtle (*Chelydra serpentine*; Species of Concern).

For example, the snapping turtle is selected as a surrogate for Blanding's turtle exposure. In the EcoRA, potential effects of the NSDF Project on these species at risk were considered on an individual level, rather than population-level effects.

The EcoRA assessed potential effects to ecological receptors for the various scenarios discussed above under the PostSA, such as Normal Evolution Scenario, Disruptive Event scenarios, and others. It is noted that some of the Disruptive Event scenarios do not have relevant pathways to ecological receptors, and as such were not assessed in the EcoRA. The scenarios omitted from the EcoRA are typically Human Intrusion scenarios (e.g., Borehole). Although the Human Intrusion (House with Basement) scenario is included in the EcoRA, because the displacement of waste onto the surface presents a potential pathway to wildlife.

Further information on the EcoRA assumptions, calculations and results is available in the EcoRA.

5.7.6.1.2 Application Case Results

5.7.6.1.2.1 Operations and Closure Phases

This section presents a summary of the assessment of ecological health prior to the post-closure phase (i.e. construction, operations and closure) for the Normal Operations. Anticipated Operational Occurrences, Design Basis Accidents and Beyond Design Basis Accidents are considered in Section 7.0 (Accidents and Malfunctions).

Safety Analysis Report – Atmospheric Emissions

The LLW disposed in the ECM, ECM waste placement activities, and wastewater processing (tank emissions) are the primary sources of the NSDF radiological airborne emissions (CNL 2019c).

Table 5.7.6-4 provides the estimated airborne concentrations of radon, tritium and C-14 in the disposal cell, and the estimated dose to the ECM worker (CNL 2019c). The estimated airborne radon concentration in the disposal cell is 0.5 Bq/m^3, which is lower than the current Canadian guideline of 200 Bq/m^3 for radon in indoor air for dwellings (Health Canada 2017). The dose to the ECM worker dose is negligible from ECM airborne concentrations of radon, tritium and C-14. Since the dose to the ECM worker is negligible, the radiological effect on ecological receptors will also be negligible from ECM airborne concentrations of radon, tritium and C-14.

Table 5.7.6-4: Radionuclide Atmospheric Concentrations and ECM Worker Dose

Radionuclide	Atmospheric Concentration in Disposal Cell (Bq/m^3)	ECM Worker Dose (mSv/year)
Radon	0.5	9.6E-04
Tritium	61	1.6E-05
Carbon-14	0.53	2.2E-06

Source: CNL 2020b.

Airborne emissions from the Equalization Tanks and the WWTP process tanks occur because of evaporative loss of the liquid in storage and as a result of changes in liquid level. The emissions from a single Equalization Tank and the WWTP filter press feed tank were calculated in the SAR (CNL 2020b) and compared to the CRL site Derived Release Limit (DRL) (CNL 2018f). The DRLs represent release rates that correspond to critical groups at the public dose limits. The filter press feed tank emissions were estimated, since this tank has the largest radiological source term of the WWTP process tanks (CNL 2019c). There are no appreciable radiological airborne releases from a single Equalization Tank vent and from the filter press feed tank vent, since the total radioactive material losses are 0.04% and 0.004% of the DRL, respectively (CNL 2019c). The radiological effect on ecological receptors from the NSDF wastewater tanks air emissions is expected negligible, based on the tanks air emissions being a fraction of the CRL site DRLs.

Further radiological doses to ecological receptors arising from exposure to air plumes at the points-of-impingement locations for the principal atmospheric sources at the CRL site such as the NRU Reactor were assessed in the 2005 Ecological Effects Review (EcoMetrix 2005). Dose to terrestrial biota was much less than the benchmark for protection of biota of 9.6 mGy/day (400 µGy/h). Atmospheric emissions from the NSDF Project (ECM and WWTP) will be a small fraction of those from the (now shutdown) NRU Reactor; therefore no further assessment is required.

Waterborne Effluent – Operations Phase

The surface water quality modelling confirms that environmental concentrations of contaminants are below the No Effect concentrations for protection of aquatic biota for radiological contaminants with the exception of one parameter, gross beta as Strontium-90. Existing gross beta concentrations are elevated at East Swamp Stream. The elevated concentrations are associated with an existing Strontium-90 groundwater plume in the area (Section 5.7.4.6). Surface water quality modelling indicates that the impacts on baseline concentrations are negligible (see

Table 5.4.2-14). No further assessment is therefore required. For the methods and numerical results of the surface water modelling, refer to Section 5.4.2.

By ensuring that releases and subsequent environmental concentrations are below the relevant guidelines or are below levels that would result in potential adverse effects on aquatic life, there will be no adverse effects to biota during the operations phase of the NSDF Project. Therefore, a quantitative assessment of radiological dose to biota is not required.

The predicted concentrations for the Ottawa River for each of the radionuclides that screened into the assessment are well below No Effect Concentrations based on 400 uGy/hr radiation benchmark used in the assessment. Accordingly, radiation doses to Aquatic Biota in the Ottawa River are predicted to be well below the Province of Quebec criteria of 10 µGy/hr.

5.7.6.1.2.2 Post-Closure Phase

This section presents results for radiological contaminants in environmental media, as well as radiological dose for ecological receptors for the Normal Evolution Scenario and Disruptive Event Scenarios during the post-closure phase.

Ecological risks are assessed by estimating the total dose rate received by an ecological receptor and comparing it to the selected benchmark values. The recommended radiological dose benchmarks used in the EcoRA are consistent with UNSCEAR (2008) and consist of 100 µGy/hr (2.4 mGy/d) for terrestrial biota and 400 µGy/h (9.6 mGy/d) for aquatic biota. A safety factor of 10 was applied to the selected benchmark values for species at risk to assess risks at the individual as opposed to population level. It is noted that part of the Ottawa River is located in the Province of Quebec, whose criteria for aquatic biota (10 µGy/hr) is 40 times lower than the benchmarks recommended by CSA N288.6-12 (CSA Group 2012). For species located in the Ottawa River, the Quebec benchmark has been applied.

Normal Evolution Scenario

During the post-closure phase, once the cap has degraded and water infiltrates the facility, contaminants are leached from the waste. Water drains through the base liner of the ECM and enters the groundwater pathway to Perch Creek. If the infiltration rate through the cap exceeds the drainage rate through the base liner, then overtopping occurs, with water containing dissolved contaminants being released directly to the ground surface and cap perimeter soils. Rates of infiltration through the cap and drainage through the base liner are calculated in the PostSA (Arcadis and Quintessa 2020b).

The total radioactivity associated with the wastes decreases over time due to radioactive decay. During the first 100 years, the decline is quite rapid as shorter-lived radionuclides decay. Thereafter the decline is much slower, as only longer-lived radionuclides remain.

Environmental contaminant concentrations are presented in detail in the PostSA (Arcadis and Quintessa 2020b). The application case results for radiological contaminants with respect to ecological health is summarized below.

Atmospheric Environment

During the post-closure phase, the gases of interest are radon-222, water vapour labelled with tritium, and methane and carbon dioxide labelled with carbon-14. Radon-220 gas will be generated but is not of interest as it will decay before it migrates through the cap. Radon-222, tritium and carbon-14 labelled gases will only be present in small quantities (i.e., they are trace gases).

The effects in the atmospheric environment during the post-closure phase are assessed with respect to the potential effect on indicator species in the EcoRA (Arcadis 2020a). The EcoRA determined that negligible residual effects were expected.

Geological and Hydrogeological Environment

Contaminants can be released to the geological and hydrogeological environment via:

- Water overtopping the berm will move through the shallow environment by overland flow and interflow resulting in contamination of surface soils. This soil contamination has the potential to effect external irradiation, inhalation of dust and vegetation quality, as well as ecological receptors.
- Leaching to groundwater beneath the ECM, and possible sorption to sediments. Leachate will migrate to the surface water and aquatic environments, where the leachate will be further diluted in Perch Creek and then in the Ottawa River. Contaminants may be taken up by aquatic biota.

The effects in the geological and hydrogeological environment during the post-closure phase are assessed with respect to the potential effect on indicator species in the EcoRA (Arcadis 2020a). The EcoRA determined that negligible residual effects were expected.

Surface Water Environment

As contaminants reach Perch Creek, there will be sorption in creek sediments and dilution in surface water and transport downstream to the Ottawa River. In the Ottawa River there will be significant dilution and transport downstream. The river level can rise following periods of snowmelt and higher rainfall. Under these conditions, suspended sediments, containing absorbed contaminants, may be deposited on the shore.

Peak environmental concentrations in water are low in the context of environmental effects. For example, as calculated in the PostSA (Arcadis and Quintessa 2020b), the peak concentration of tritium in surface water during the post-closure phase is 0.000055 Bq/L, as compared to the Maximum Acceptable Concentration of 7,000 Bq/L of tritium in drinking water (Health Canada 2019).

The potential effects of screened-in radiological contaminants are further assessed with respect to potential effects on indicator species in the EcoRA. As discussed in the Aquatic Environment and Terrestrial Environment below, the EcoRA determined that negligible residual effects were expected.

Aquatic Environment

Using maximum predicted concentrations calculated in the PostSA (Arcadis and Quintessa 2020b), the EcoRA (Arcadis 2020a) assessed the effect of radiological releases on aquatic biota during the post-closure phase.

An SI is the ratio (i.e., unitless) of an estimated exposure level (e.g., estimated environmental concentration) divided by a corresponding toxicity reference value or benchmark value. An SI value greater than 1 indicates the potential for undue effects.

SI values calculated for all radionuclides assessed were below a value of 1 for aquatic receptors. An SI below 1 indicates no undue effects.

Based on the effects assessment undertaken in the EcoRA, negligible residual effects from radiological exposure were predicted for aquatic biota in the post-closure phase.

Terrestrial Environment

Using maximum predicted concentrations calculated in the PostSA (Arcadis and Quintessa 2020b), the EcoRA (Arcadis 2020a) assessed the effect of radiological releases on terrestrial biota during the post-closure phase.

- SI values for all radionuclides were below a value of 1 for terrestrial receptors. An SI below 1 indicates no undue effects.

Based on the effects assessment undertaken in the EcoRA, negligible residual effects from radiological exposure were predicted for terrestrial biota in the post-closure phase.

Overall, negligible residual effects were identified for ambient radioactivity and ecological health for the Normal Evolution Scenario.

Disruptive Event Scenarios

Human Intrusion (House with Basement)

A potential basement is constructed on the top of the ECM and excavated soil/waste is spread over the garden area.

SI values for all radionuclides were below 1, indicating no undue effects to terrestrial or aquatic biota from radiological contaminants. Therefore, negligible residual effects were expected to result from the Human Intrusion (House with Basement) Disruptive Event Scenario.

Enhanced Erosion Case

In the Enhanced Erosion case, the potential faster erosion of the cap such that wastes are exposed at the ground surface and eroded materials spread downslope in the swamp area between the ECM and Perch Creek. Additionally, there is increased suspended sediment loading to Perch Creek. Therefore, potential effects in the geological and hydrogeological environment and the surface water environment are assessed under this scenario.

SI values for all radionuclides were below 1, indicating no undue effects to terrestrial or aquatic biota from radiological contaminants. Therefore, negligible residual effects were expected to result from the Enhanced Erosion Case Disruptive Event Scenario.

Localized Cover Failure

There is initially increased infiltration through the failure in the cap, resulting in earlier bathtubbing of the ECM (relative to the Normal Evolution Scenario). The increased infiltration alters the leachate release to groundwater, swamp soils and eventually Perch Creek. Therefore, potential effects in the geological and hydrogeological environment and the surface water environment are assessed under this case.

SI values for all radionuclides were below 1, indicating no undue effects to terrestrial or aquatic biota from radiological. Therefore, negligible residual effects were expected to result from the Localized Cover Failure Disruptive Event Scenario.

Localized Liner Failure

There is increased leaching through a potential failure in the base liner, resulting in delayed bathtubbing of the ECM (relative to the Normal Evolution Scenario). Therefore, potential effects in the geological and hydrogeological environment and the surface water environment are assessed under this scenario.

SI values for all radionuclides were below 1, indicating no undue effects to terrestrial or aquatic biota from both radiological contaminants. Therefore, negligible residual effects were expected to result from the Localized Liner Failure Disruptive Event Scenario.

Damage to the Berm

The reduced height of the berm results in increased flow of water over the berm during bathtubbing and reduced water level in the wastes. Therefore, potential effects in the geological and hydrogeological environment and the surface water environment are assessed under this scenario.

SI values for all radionuclides were below 1, indicating no undue effects to terrestrial or aquatic biota from radiological contaminants. Therefore, negligible residual effects were expected to result from the Damage to the Berm Disruptive Event Scenario.

Overall, no potential residual effects were identified for ambient radioactivity and ecological health for the Disruptive Event Scenarios.

5.7.6.2 Non-Radiological Exposure Assessment

5.7.6.2.1 Application Case Methods

The majority of the information in the Residual Effects Analysis for the non-radiological exposure assessment is taken from the following sources:

- air quality modeling (Section 5.2.2) presents the analysis and results of non-radiological airborne emissions during the operations phase;
- surface water quality modelling (Section 5.4.2) presents the analysis and results of non-radiological waterborne effluent during the operations phase;
- PostSA (Arcadis and Quintessa 2020b) presents the analysis and results for non-radiological contaminants in environmental media during the post-closure phase; and
- EcoRA (Arcadis 2020a) presents the analysis and results of non-radiological exposure for ecological receptors during the post-closure phase.

The non-radiological exposure assessment considers the ways in which ecological receptors (introduced in Section 5.7.2) could be exposed to contaminants present in the various environmental media.

5.7.6.2.1.1 Operations and Closure Phases

Atmospheric Emissions

Effects to air quality for non-radiological constituents are expected to be not significant (see Section 5.2.1.6) and localized to the LSA for all constituents when considering the conservatism built into the predictive models and the realistic operation of equipment during NSDF Project operations (i.e., that not all equipment would be operating at full capacity all of the time, but would rather be idling for part of the time resulting in lower emissions than predicted). Therefore, impacts on air quality and ecological receptors from non-radiological emissions was not considered further for these phases of the NSDF Project.

Inhalation by wildlife cannot be adequately assessed because there is a relative lack of toxicity data related to inhalation exposure for wildlife. As well, respirable particles (i.e., greater than 5 µm) are most likely ingested as a result of lung clearance rather than being inhaled (Witschi and Last 1996). At equal exposure concentrations, it has been determined that inhalation of contaminants associated with dust particles is expected to contribute less than 0.1% of total risk compared to oral exposure to wildlife (US EPA 2005). As such, inhalation exposure is expected to be minimal, if not negligible, in comparison to the oral route of exposure. Therefore, exposure via inhalation was not assessed.

Waterborne Effluent

For the operations phase of the NSDF Project, the main supporting information is from modelling completed for surface water quality (Section 5.4.2). The non-radiological exposure assessment for ecological health considered the following two model scenarios for surface water environment (described in Section 5.4.2.6.1.2):

- **Scenario 1**: This scenario divides the total annual discharge equally between the exfiltration gallery at East Swamp weir and Perch Lake (direct pumping to Perch Lake via transfer line). The exfiltration gallery is considered to be the downstream portion of East Swamp (upstream of East Swamp weir) and the outfall location is considered to be at the northeastern shoreline of Perch Lake.

- **Scenario 2**: This scenario discharges 100% of the total annual discharge directly into Perch Lake at the northeastern shoreline. Scenario 2 was modelled to examine the "worst case" scenario of projected Perch Lake concentrations (i.e., no available mixing nor dilution upstream of Perch Lake).

The two surface water model scenarios were completed for a selected group of parameters termed constituents of potential concern (COPCs) as defined in Section 5.4.2.6.1.4. Key elements of the COPC selection process included identifying those parameters that were expected to change as a result of the Project, those with available guidelines, those with existing ambient concentrations and those that were expected to be toxic to aquatic organisms (including parameters that characterize general water properties with the potential to modify toxicity). The full list of COPCs is provided in Table 5.4.2-5, and the COPCs forwarded to the aquatic risk assessment include aluminum, barium, copper, iron, lead, manganese, phosphorus, selenium, silver and zinc as these parameters showed exceedances above their respective effluent discharge targets.

5.7.6.2.1.2 Post-Closure Phase

For the assessment of environmental media and ecological health in the post-closure phase of the NSDF Project, the main supporting documents are the PostSA (Arcadis and Quintessa 2020b) and the EcoRA (Arcadis 2020a). A general background of these documents is provided below.

Post-Closure Safety Assessment

The PostSA (Arcadis and Quintessa 2020b) analyzes the long-term implications during the post-closure phase on ecological health of the NSDF Project.

Evaluating post-closure safety requires projections of the future condition of the NSDF Project and its environment, and how receptors might interact with it. Approaches have been developed to undertake such evaluations, centred on a "system analysis" method. This involves representing the NSDF Project, the facility inventory present and all potentially relevant media, with mathematical models to represent the key processes that may occur (e.g., corrosion of wastes, dissolution into groundwater, uptake by plants). It is essential that the models used are relevant, well grounded and auditable. This is achieved through a systematic approach to safety assessment. The international community has developed best practice guidance on the process, which is documented in the International Atomic Energy Agency's report *Improvement of Safety Assessment Methodologies for Near Surface Disposal Facilities* (IAEA 2004) and incorporated into a more recent safety guide (IAEA 2012). This process has been applied internationally since its publication, is consistent with CNSC's *REGDOC-2.11.1, Waste Management, Volume III: Assessing the Long-Term Safety of Radioactive Waste Management* (CNSC 2018) and underpins the PostSA analysis. Although this approach has been developed with radiological contaminants in mind, the same principles are considered to be appropriate for non-radiological contaminants and offers consistency in the approach used to assess both contaminant types for the NSDF Project.

The PostSA considers two primary pathways of release of non-radiological contaminants into the environment:

- leachate may be released to soil via overtopping the berm, which can affect human health; and
- leachate may be released through the base liner to groundwater, which can affect human health.

Contaminants released by overtopping the berm will move through the shallow environment by overland flow and interflow resulting in contamination of surface soils. Exposures can arise by external irradiation, inhalation of dust, inadvertent ingestion and consumption of food stuffs grown in the soil, or consumption of animals that have grazed in the contaminated area.

Contaminants released to groundwater beneath the ECM will move through the geological and hydrogeological environment by advection and dispersion and may sorb to sediments. Once in the aquatic environment, there will be further dilution in Perch Creek and then in the Ottawa River. Contaminants may be taken up by aquatic flora and fauna.

It is noted that release of volatiles to air was not considered a primary pathway for non-radiological contaminants given that no volatile non-radiological contaminants have been identified as COPCs.

As noted in Section 3.3.1.3.1, the NSDF Project will follow the guidelines of Ontario's *Regulation 347, General – Waste Management*, thus constraining the non-radiological inventory and limiting the environmental effects in the post-closure phase of the NSDF Project. However, an estimate on the quantity of discrete metals and organics in the NSDF at closure which is comprised of primarily wood, metals and bulk solid wastes. The non-radionuclides explicitly assessed in the PostSA include:

- aluminum;
- copper;
- lead; and
- uranium.

Similar to the radiological dose assessment, six scenarios were considered for the post-closure phase for the non-radiological exposure assessment. These scenarios are described in Section 5.7.6.1.1.2

Ecological Risk Assessment

The EcoRA (Arcadis 2020a) assesses the effects of chemical (and radiological) contaminants on ecological receptors during the post-closure phase of the Project. Other stressors associated with the NSDF Project (e.g., noise, dust, changes in habitat) are assessed directly within the EIS. Following the *CSA N288.6, Environmental Risk Assessment at Class 1 Nuclear Facilities and Uranium Mines and Mills* (CSA Group 2012) process/framework, the EcoRA uses results from the PostSA on contaminant concentrations in various environmental media, to assess ecological risk.

The EcoRA screens the contaminant concentrations calculated in each relevant PostSA scenario against the most conservative available criteria such as the CCME Canadian Environmental Quality Guidelines for non-radiological contaminants. Based on this, aluminum, copper, lead, and uranium were screened into the non-radiological assessment for all scenarios during the post-closure phase.

The indicator species selected for inclusion in the EcoRA were chosen based on the VCs defined in this EIS, as well as selection criteria outlined in CSA N288.6 (CSA Group 2012). The VCs and their respective indicator species are provided in Table 5.7.2-1. These indicator species are considered appropriate because they reflect a variety of diets/feeding habits, cover a variety of trophic levels, are representative of the biota expected to be found in the RSA, and are of interest to the facility and stakeholders. In addition to these indicator species, the EcoRA also includes moose as an ecological receptor in response to Indigenous interests.

The indicator species are assessed using assessment endpoints, which are expressions of the actual environmental values to be protected. In general, the assessment endpoints selected in this study were healthy populations of the identified indicator species within the RSA.

The list of indicator species chosen for assessment in the EcoRA included the following species at risk, as defined under the *Species at Risk Act:*

- Canada warbler (*Cardellina canadensis*; Threatened);
- eastern milksnake (*Lampropeltis Triangulum*; Species of Concern);
- eastern whip-poor-will (*Antrostomus vociferous*; Threatened);
- eastern wolf (*Canis lupus lycaon*; Species of Concern);
- little brown myotis (*Myotis lucifugus*; Endangered);
- monarch butterfly (*Danaus plexippus*; Species of Concern); and,
- snapping turtle (*Chelydra serpentine*; Species of Concern).

In the EcoRA, potential effects of the NSDF Project on these species at risk were considered on an individual level, rather than population-level effects.

The EcoRA assessed potential effects to ecological receptors for the various scenarios discussed above under the PostSA, such as Normal Evolution Scenario, Disruptive Event scenarios, and others. It is noted that some of the Disruptive Event scenarios do not have relevant pathways to ecological receptors, and as such were not assessed in the EcoRA. The scenarios omitted from the EcoRA are typically Human Intrusion scenarios (e.g., Borehole). Although the Human Intrusion (House with Basement) scenario is included in the EcoRA, because the displacement of waste onto the surface presents a potential pathway to wildlife.

Further information on the EcoRA assumptions, calculations and results is available in the EcoRA.

5.7.6.2.1.3 Guidelines

This section discusses the guidelines that were used to assess the effects from non-radiological elements on ecological receptors.

Guidelines Used in the Operations Phase

The RBs for non-radiological constituents (Table 5.7.6-5 are based on the Lowest Observable Effect Level (LOEL) with acute exposure at which population level effects may occur. They are based on:

- Federal and provincial guidelines for acute exposure; and
- Lowest observable effect concentrations from the literature.

Exceedance of an RB does not necessarily indicate that ecological effects would occur, but instead indicates that there may be some potential for effects (CNL 2019c).

Table 5.7.6-5: Selected Risk Benchmark Values for Non-Radiological Parameters in Surface Water

Parameter	Units	Selected Risk Benchmark Value	Reference
Aluminum	µg/L	100	AESRD (2014)
Barium	µg/L	110	Suter and Tsao (1996)
Copper	µg/L	Narrative[(a)]	AESRD (2014)
Iron	mg/L	3.4	SAVEX (2013)
Lead	µg/L	7	AESRD (2014)
Manganese	µg/L	2,300	Suter and Tsao (1996)
Phosphorus	µg/L	No data	—
Selenium	µg/L	20	Suter and Tsao (1996)
Silver	µg/L	4.1	Suter and Tsao (1996)
Zinc	µg/L	120	Suter and Tsao (1996)

(a) Other factors need to be considered in the risk assessment (e.g., water hardness).

AESRD = Alberta Environment and Sustainable Resource Development; µg/L = micrograms per litre; mg/L = milligrams per litre.

Guidelines Used in the Post-closure Phase

Overall, ecological toxicity benchmark values for non-radiological contaminants were obtained based on a hierarchy of sources which included federal and provincial guidelines such as CCME (1995, 2003, 2019) and MOE (2011) as well as the U.S. EPA ECOTOX Database, U.S. EPA Ecological Soil Screening Levels, Suter and Tsao (1996) and Sample et al. (1996). These hierarchies include credible, recognized references that are used in EcoRAs as common industry practice. The hierarchies generally incorporate CSA N288.6-12 guidance (CSA 2012) but in cases where N288.6-12 sources were considered outdated, values from more recent credible sources were used preferentially (with supporting rationale). More detailed descriptions of the methodologies used in selecting these toxicity benchmark values are presented in the EcoRA.

5.7.6.3 Application Case Results

5.7.6.3.1 Operations and Closure Phases

Aquatic Environment

The predicted non-radiological concentrations of the ten selected COPCs at six water quality nodes for two scenarios are provided in Section 5.4.2.6.2. The predictions were compared to effluent discharge targets and to local background at the six water quality nodes. The predicted concentrations of the 10 selected COPCs exceeded their respective effluent discharge targets and local background concentrations and as such were forwarded for further consideration in the ecological health assessment.

Comparison of the predicted concentrations of the ten COPCs to the selected risk benchmark values as well as the water quality criteria set by the Quebec Ministry of Environment (MELCC) is shown in Table 5.7.6-6.

Table 5.7.6-6: Comparison of Risk Benchmark Values to Maximum Predicted Surface Water Concentrations for Each Parameter for All Modelled Scenarios and Locations

Parameter	Risk Benchmark Values (µg/L)	Quebec Criteria (µg/L)	Maximum (µg/L)	Scenarios with Exceedances	Locations with Exceedances of Risk Benchmark Values
Aluminum	100	100	631	Scenario 1 Scenario 2	▪ East Swamp weir (local ambient, all stats) ▪ Perch Lake Inlet 2 (local ambient, all stats) ▪ Perch Lake (local ambient, all stats) ▪ Perch Creek weir (local ambient, 95th and max) ▪ Ottawa River (local ambient)
Barium	110	38	18.8	None	None
Copper	2	1.3	8.4	Scenario 1 Scenario 2	All nodes (ambient, all stats)
Iron	3,400	**1,300**	2,870	None	None
Lead	7	**0.17**	5.9	None	None
Manganese	120	260	2,300	None	None
Phosphorus	—	—	120	None – phosphorus is considered non-toxic	None – phosphorus is considered non-toxic
Selenium	20	5	1.28	None	None
Silver	4.1	**0.1**	1.047	None	None
Zinc	120	17	7.91	None	None

Bold = Quebec criteria (Gouvernement du Québec. 2020) is more stringent than Risk Benchmark Value
µg/L = micrograms per litre; — = no value.

The predicted concentrations for the non-radiological COPCs in the discharge from the WWTP were compared to the benchmark values derived for the NSDF Project and to local ambient water quality at the six water quality nodes (see Section 5.4.2.6.2). The predicted concentrations of all the parameters measured, with the exception of aluminum and copper, met their respective benchmark values at all sampling nodes. The Quebec guidelines for the compounds assessed in the EIS for the operations and closure phases are equal to or greater than the benchmarks used in the EIS (i.e., aluminum, phosphorus and manganese), or are equal to or greater than the maximum predicted concentrations in surface water (i.e., barium, selenium and zinc), for all compounds except copper, iron, lead, and silver.

As shown in Table 5.4.2-7 (aluminum) and 5.4.2-17 (copper) in Section 5.4.2.6.2, the predicted concentrations of these parameters for both Scenario 1 and Scenario 2 were equal to or less than background at all nodes with the exception of Perch Lake Inlet 2. However, the highest predicted concentrations at this node were within typical measurement error (i.e., 12% for aluminum and 7% for copper) and therefore there is no increase in incremental risk to aquatic life from discharge of these substances. As such, no detailed assessment of risks to ecological receptors is warranted for these substances.

Terrestrial Environment

Effects to the terrestrial environment are not expected. As previously summarized (Section 5.7.6.2.1.1), effects to air quality for non-radiological constituents are expected to be not significant (5.2.1.6) and localized to the LSA for all constituents when considering the conservatism built into the predictive models and the realistic operation of equipment during NSDF Project operations (i.e., that not all equipment would be operating at full capacity all of the time, but would rather be idling for part of the time resulting in lower emissions than predicted). Therefore, impacts on air quality and ecological receptors from non-radiological emissions was not considered further for these phases of the NSDF Project. As a result, the effects of uptake into foodstuffs and consumption of prey by ecological receptors are expected to be similarly negligible. Therefore, residual effects to the terrestrial environment during the operations phase of the NSDF Project are considered to be negligible for ecological health.

5.7.6.3.2 Post-closure Phase

This section presents results for chemical concentrations in environmental media, as well as chemical exposure for ecological receptors for the Normal Evolution Scenario and Disruptive Event Scenarios.

Normal Evolution Scenario

During the 10,000-year assessment timeframe of the PostSA, peak concentrations of copper, lead and uranium are below the corresponding environmental quality criteria (EQS) for soil, sediment and water, except for the concentration of lead in groundwater adjacent to the ECM. The concentration of uranium in groundwater is approaching the EQS, and slightly exceeds the EQS for swamp soils.

Aluminum is a key component of clay minerals in soils and sediments. Therefore, there are not environmental quality standards for aluminum. The peak concentration in groundwater immediately downgradient of the ECM is only slightly elevated above background. However, the concentration is much lower in surface waters. For context, concentrations of aluminum in groundwater and surface water are well below the Health Canada proposed operational guidance value and maximum acceptable concentrations in drinking water (Health Canada 2019). It is noted that these guidance values are not meant for application to environmental concentrations.

Non-radiological contaminants were assessed in the PostSA following a very cautious approach. All non-radiological contaminants were assumed to be readily available for dissolution and leaching upon contact with water, whereas in reality most of the non-radiological inventory will be encased in iron-based matrices. Additionally, as noted in Section 3.3.3.3, the disposal of the remaining small fraction of non-radiological inventory will meet land disposal regulations, which are protective of public health and the environment.

Finally, it is noted that conventional landfills can contain significant quantities of lead. The NSDF ECM meets the design and durability requirements of Ontario landfill regulations and is consistent with best practice for a conventional landfill, and so, in the context of containment of lead, the ECM would provide similar long-term performance to a contemporary conventional landfill.

Therefore, negligible residual effects are expected from non-radiological contaminants associated with the NSDF Project.

Aquatic Environment

Using total concentrations based on maximum predicted incremental concentrations calculated in the PostSA (Arcadis and Quintessa 2020b) combined with background concentrations in environmental media, the EcoRA (Arcadis 2020a) assessed the effect of non-radiological releases on aquatic biota during the post-closure phase.

Screening indices (SI) for copper and lead were above 1 for some aquatic receptors, and below 1 for uranium for all aquatic receptors. An SI is the ratio (i.e., unitless) of an estimated exposure level (e.g., estimated environmental concentration) divided by a corresponding toxicity reference value or benchmark value. An SI value greater than 1 indicates the potential for undue effects. However, the EcoRA determined that these SI exceedances were driven largely by the background concentrations of these contaminants as opposed to contributions from the NSDF Project.

Based on the effects assessment undertaken in the EcoRA, negligible residual effects from non-radiological exposure were predicted for aquatic biota in the post-closure phase.

Terrestrial Environment

Using total concentrations based on maximum predicted incremental concentrations calculated in the PostSA (Arcadis and Quintessa 2020b) combined with background concentrations in environmental media, the EcoRA (Arcadis 2020a) assessed the effect of non-radiological releases on terrestrial biota during the post-closure phase.

- SI values for copper, and uranium were below a value of 1 for terrestrial receptors. An SI below 1 indicates no undue effects. For lead, the SI value was above 1 for the Canada warbler and Eastern whip-poor-will, but these exceedances were driven largely by the background concentrations of the contaminants as opposed to contributions from the NSDF Project.

Based on the effects assessment undertaken in the EcoRA, no potential residual effects from non-radiological exposure were predicted for terrestrial biota in the post-closure phase.

Overall, no potential residual effects were identified for ambient radioactivity and ecological health for the Normal Evolution Scenario.

Disruptive Event Scenarios

Hypothetical disruptive event scenarios were also assessed in the PostSA as mechanisms to test the robustness of the overall waste management system. Non-radiological contaminants were assessed following a very cautious approach. All non-radiological contaminants were assumed to be readily available for dissolution and leaching upon contact with water, whereas in reality most of the non-radiological inventory will be encased in iron-based matrices. Additionally, as noted in Section 3.3.3.3, the disposal of the remaining small fraction of non-radiological inventory will meet land disposal regulations, which are protective of public health and the environment.

For non-radiological contaminants, aluminium, uranium, copper and lead screened in for all disruptive event scenarios. SI values for aluminum and uranium were below a value of 1, indicating no undue effects to terrestrial or aquatic biota. SI values for copper and lead were above 1 similar to the Normal Evolution Scenario exposure assessment. Although an SI value greater than 1 indicates the potential for undue effects, the EcoRA further assessed these contaminants and determined that their corresponding SI exceedances were driven largely by the background concentrations of these contaminants as opposed to contributions from the NSDF Project. In one disruptive event case – namely, the Enhanced Erosion Scenario – the NSDF Project also contributed to the SI value. However, taking the low probability into account, the effective SI would be less than 1, and thus negligible residual effects are anticipated.

Finally, it is again noted that conventional landfills can contain significant quantities of non-radiological contaminants. The NSDF ECM meets the design and durability requirements of Ontario landfill regulations and is consistent with best practice for a conventional landfill, and so, in the context of containment of non-radiological contaminants, the ECM would provide similar long-term performance to a contemporary conventional landfill.

Therefore, negligible residual effects are expected from non-radiological contaminants associated with the NSDF post-closure phase.

5.7.7 Prediction Confidence and Uncertainty

Table 5.7.7-1 describes key uncertainties in assessing residual effects from the NSDF Project on ecological health and how conservatism in the analysis and assumptions addressed these uncertainties.

Table 5.7.7-1: Uncertainties in Ambient Radioactivity and Ecological Health Assessment

Parameter	Uncertainty	Conservatism and Assumptions
Waste inventory	There is uncertainty with regard to the inventory of radionuclides that have been accumulated over the decades of operation of CRL site, as well as the projected inventory of wastes that will be generated in the future.	▪ Both already accumulated wastes and those that will be generated in the future will have to meet NSDF Waste Acceptance Criteria. ▪ The PostSA (Arcadis and Quintessa 2020b) explores the effect of uncertainty in the inventory, in the “Inventory Sensitivity” Sensitivity Analysis Case.
Source term	There is uncertainty associated with airborne and waterborne release rates.	▪ Waterborne releases from the WWTP are assumed to contain contaminants at maximum permissible concentrations.
ECM performance	There is uncertainty with regard to when protective barriers may begin to fail due to erosion or other natural events.	▪ The ECM includes multiple protective barriers in the cover and base liner, designed to isolate the waste even in the event if one or more of the barriers were to fail. ▪ The ECM can be maintained and monitored during the period of institutional control. Any issues identified during this period can be mitigated. ▪ The PostSA considers two conservative scenarios involving premature failures of the cover and base liner.

Table 5.7.7-1: Uncertainties in Ambient Radioactivity and Ecological Health Assessment

Parameter	Uncertainty	Conservatism and Assumptions
Waste package integrity	The current and future integrity of waste packaging is uncertain. Package failure leads to increased leachate concentrations.	▪ For pre-closure design and safety considerations, “Normal” packaged waste is assumed to have an initial failure of 5% upon placement. It is then assumed to fail at a rate of 1% per year. ▪ For post-closure, no credit is given for waste packages or containers. It is assumed that all waste packages have degraded and provide no barrier to the release of contaminants.
Wastewater quantity	The wastewater volumes used in the Leachate and Wastewater Characterization report (AECOM 2018c) are developed for the purpose of determining the long-term average wastewater volumes that are used to establish the flow-rate design capacity of the WWTP. Extreme precipitation events are not considered, as their effects are mitigated by the temporary storage capacity provided by the three EQS.	▪ The pressure boundary failure analysis conservatively assumes that failure occurs when membrane filter feed and process tanks are full. The calculation is, therefore, not affected by changes in wastewater quantity. ▪ The WWTP seismic event analysis conservatively assumes that failure occurs when all three EQS are full (5.6ME+06 L).
Leachate concentration	Uncertainties in the wastewater concentrations include the effects of uncertainties in the contaminant concentrations in the waste, the waste density, moisture content and the distribution coefficients. Contaminant concentrations in waste are defined by the Waste Characterization report (AECOM 2020), which defines the inventories and is consistent with the PostSA inventory. The waste density and moisture content play minor roles in the uncertainty of the wastewater concentrations. Both are confined to relatively small ranges. The average waste density is assumed to be 1.5 g/cm3 but may vary locally in the disposal cell, by perhaps ±20%, from this nominal value. The waste moisture content (0.2181, volumetric basis) is from the Hydrological Evaluation of Landfill Performance model discussed in the Leachate and Wastewater Characterization report (AECOM 2018c). Moisture content may also vary by ±20% from this value during wet and dry periods of the year. The distribution coefficients, taken from Canadian Standards Association N288.1-14 Table G-2 (CSA Group 2014), may also vary, but alternative values have not been evaluated.	▪ A soil to liquid partition model was used to determine leachate concentrations. Average Kd (water-soil distribution coefficient) values for soil (loam) and a waste density of 1.5 g/cm3 were assumed to apply homogeneously to the waste matrix. Compaction procedures and waste processing to minimize void space will ensure that this approximate waste density is maintained. ▪ During normal operations, higher leachate concentrations would have no effect on the public or environment since wastewater is treated at the WWTP. It would increase contaminant concentrations in the WWTP slightly, but the effect on safety would be minimal.

Table 5.7.7-1: Uncertainties in Ambient Radioactivity and Ecological Health Assessment

Parameter	Uncertainty	Conservatism and Assumptions
Environmental transport	Contaminants released to the environment, primarily groundwater and surface water, are transported uniquely, based on their chemical form and specific hydrogeological and hydrological characteristics near the SSA. Some of these characteristics are known from nearby WMAs and recent modelling, albeit with uncertainty.	▪ For the scenario involving waterborne exposure to members of the public, a transit time from the ECM to Perch Creek is not credited. This is conservative given that the groundwater transit time from modelling analysis is expected to be 7 years, which would be applicable to tritium, but conservative for all other radionuclides. No removal of contaminants from groundwater through sedimentation or other processes is assumed. ▪ The PostSA includes a sensitivity analysis case where groundwater transit time to Perch Creek is reduced to 5 and 2 years (from 7 years in the NES).
Conceptual model	This uncertainty is associated with conceptual model for groundwater flow and potential future effects on it resulting from the climate change.	▪ Current groundwater flow and contaminant transport in Perch Lake area are well understood due to decades of data available for the site. ▪ Groundwater flow model was calibrated against the available datasets based on the existing plumes emanating from WMA and LDA. ▪ The PostSA includes a sensitivity analysis case where groundwater transit time to Perch Creek is reduced to 5 years (from 7 years in the Normal Evolution Scenario). ▪ Characterization of the site includes 25 test pits, 70 boreholes and 47 monitoring wells, among other monitoring and testing activities.
Leaching and transport parameters	Parameter uncertainty may lead to underestimation of doses to members of the public and ecological receptors	▪ The site characteristics are well understood owing to many decades of monitoring. In any case, conservative and bounding assumptions were used as described for the conceptual model parameter. ▪ To test the effect of uncertainty in sorption rates, the PostSA includes a sensitivity analysis case that tests the uncertainty of the parameter Kd (water-soil distribution coefficient).

Table 5.7.7-1: Uncertainties in Ambient Radioactivity and Ecological Health Assessment

Parameter	Uncertainty	Conservatism and Assumptions
Future conditions	Due to the timeframe of the PostSA, there is some uncertainty with respect to future conditions at the site, for example, seismicity and climate change.	▪ As part of the NES, the climate is assumed to evolve according to the current scientific interpretation of anthropogenic climate change. Additionally, the PostSA examines the potential for a reduced amount of hydrologically effective rainfall, due to an increase in evapotranspiration. ▪ Although seismic activity is not expected to affect the safety function of the cover, liner, or berm, the PostSA considers the potential for a beyond design-basis earthquake to affect the safety function of these structures, in a number of the PostSA Disruptive Event Scenarios. ▪ In the NES, the PostSA assumes that erosion is balanced by other processes such as deposition. However, the PostSA also examines a case with more severe erosion, e.g., caused by wetter climate, or seismic damage.
Performance of the facility	This uncertainty is related to the degradation of various components of the facility ECM, such as the cover, liner and berm.	▪ The PostSA includes Disruptive Event Scenarios that examine the effect of accelerated degradation of the cover and liner. ▪ Additionally, the PostSA explores the importance of both the cover and liner using two scenarios that assume either the cover or the liner is absent at the time of closure. A third scenario is also included to assess the importance of the berm.
Assessment of doses to non-human biota	There is uncertainty in the modelling parameters for atmospheric and waterborne exposure pathways.	▪ Conservative exposure parameters were used, consistent with the quantitative risk assessment methods described in CSA N288.6 (CSA Group 2012).
Assessment of radiological risks to populations of ecological receptors	There is uncertainty in the dose criteria used for ecological receptors.	▪ While there is a variation of dose benchmarks in various jurisdictions, care should be taken in ensuring that they are fit for use. ▪ In particular a screening level of 10 µGy/hr should be considered as "below concern" based on generic screening calculations. If this level is exceeded, then a more detailed evaluation is required above such levels (Anderson et al. 2009). As such, this is a minimum level, which is not meant to be a limiting criterion. ▪ Benchmarks selected for this assessment are consistent with CSA N288.6 (CSA Group 2012). They are appropriate for the site-specific quantitative ecological risk assessment conducted for the NSDF.

Table 5.7.7-1: Uncertainties in Ambient Radioactivity and Ecological Health Assessment

Parameter	Uncertainty	Conservatism and Assumptions
Modelling tool uncertainty	There is uncertainty associated with conceptual models built within AMBER codes.	▪ The assessment of long-term safety of the NSDF in the PostSA was undertaken in accordance with REGDOC-2.11.1, Waste Management, Volume III: Assessing the Long-Term Safety of Radioactive Waste Management (CNSC 2018) which states: "Due to the uncertainty of predictions made far into the future, the reliability of quantitative predictions diminishes with increasing timescale. The demonstration of safety will rely less on quantitative predictions and more on qualitative arguments as the timescale increases. Long-term quantitative predictions should therefore not be considered as guaranteed impacts, but rather as safety indicators." ▪ It also states that: "uncertainties in the modeling should be addressed by conservatism built into 1. The assessment model; 2. the scenario design; and 3. parameter choice." ▪ As documented within this table, modelling uncertainty is addressed with conservatism built into the model, scenario design and parameters.
Cumulative effect	There is uncertainty associated with the cumulative effect during post-closure, taking into account releases from WMAs and LDAs in the Perch Creek Basin.	▪ CNL is developing an appropriate environmental remediation concept for contaminated areas. The decision-making process is based on radiological effects. ▪ It is expected that, if there is any potential to have cumulative effects exceeding safety objectives, then contaminated land from WMAs and LDAs will be removed prior to the NSDF closure.
Receptor occupancy	There is uncertainty in receptor occupancy at the site (e.g., how long would a migratory bird be on the site?).	▪ The EcoRA (Arcadis 2020a) conservatively assumes that all mobile receptors spend all of their time in the location of maximum predicted concentrations.
Receptor characteristics	There is uncertainty with respect to receptor characteristics (e.g., body weight, intake rates for food, soil, water).	▪ The EcoRA addresses this indirectly, through the use of generally conservative assumptions (e.g., assuming that 100% of intake of the COPC is absorbed into the organism).
Environmental concentrations	Concentrations in environmental media are modelled (i.e., information is not measured).	▪ The EcoRA uses maximum concentrations (predicted in the PostSA). As a result, calculated exposures are likely to be conservatively overestimated.

Table 5.7.7-1: Uncertainties in Ambient Radioactivity and Ecological Health Assessment

Parameter	Uncertainty	Conservatism and Assumptions
Contaminant migration	Contaminant migration through environmental media and biota are either modelled or estimated using literature or food intake calculations (i.e., information is not measured and not site-specific)	▪ There is uncertainty in the transfer of contaminants between environmental media, or from the environment to biota as transfer factors and data are not site specific; however, in the absence of measured data, this approach provides the only method for estimating concentrations and for estimating transfer up the food chain. Uncertainty can be addressed by selecting conservative transfer parameters.
Effects assessment	Toxicity reference values and benchmark values used in the EcoRA are based on reputable sources; however, there is inherent uncertainty associated with the extrapolation of laboratory testing to field conditions.	▪ Despite being obtained from reputable sources, there is uncertainty associated with toxicity reference values from literature, because they were derived from laboratory conditions and species rather than a field environment. ▪ In the EcoRA, toxicity information for a COPC was used regardless of its form in the test procedure, even though this may not be the same form used in the assessment.
Risk characterization	When dealing with multiple contaminants of potential concern, there is the potential for multi-stressor effects (e.g., interaction between contaminants).	▪ When dealing with toxic chemicals, there is potential interaction with other chemicals that may be found at the same location. It is well established that synergism, potentiation, antagonism or additivity of toxic effects occurs in the environment. These potential interactions were not investigated as part of the EcoRA, which may result in an underestimate of the risk for some COPC combinations.

PostSA = Post-Closure Safety Assessment; WWTP = Wastewater Treatment Plant; ECM = engineered containment mound; EQS = Environmental Quality Standard; NES = Normal Evolution Scenario; SSA = Site Study Area; WMA = Waste Management Area; LDA = Liquid Dispersal Area; EcoRA = Ecological Risk Assessment; CNSC = Canadian Nuclear Safety Commission; COPC = constituent of potential concern.

5.7.8 Residual Effects Classification and Determination of Significance

The residual effects analysis methods for the ecological health assessment are different in some notable ways from those used by other VCs. Specifically, the assessment of potential effects to ecological health VCs (i.e., ecological receptors) results in the generation of risk factors that inherently consider the geographic extent, duration, frequency and other characteristics of the predicted changes to the environment that may result from Project activities. As such, these inherent attributes cannot be used to determine environmental significance, as they can with other components. Instead, significance for ecological health is evaluated based on 1) the potential magnitude of the response, as indicated by the comparison to benchmarks, and 2) the degree of conservatism and uncertainty in the analysis.

During the operations and closure phases radiological doses to terrestrial biota are assessed to be well below benchmark values. The predicted radionuclide concentrations in surface water are well below the No Effect Concentrations with one exception; existing concentrations of one radiological parameter (gross beta as strontium-90) has baseline concentrations that are greater than the No Effect Concentrations. The elevated baseline surface water concentrations for gross beta as strontium-90 are localized to a small area. Further, the impact of operations activities on surface water concentrations for this parameter are negligible. As such, residual effects are considered to be negligible for all ecological receptors during the operations and closure phase

Results of the radiological dose assessment for the post-closure phase indicate that doses to ecological receptors are below their respective benchmark values. As such, residual effects are considered to be negligible for all ecological receptors during the operations and post-closure phases.

Although uncertainties in the assessment exist (Section 5.7.7), conservatism has been included in the modelling so that residual effects are not greater than predicted.

The predicted non-radiological concentrations in surface water during operations were less than the selected guidelines for most non-radiological parameters, although some predicted concentrations were greater than their guidelines for some scenarios. However, predicted concentrations did not exceed local ambient concentrations in surface waterbodies and as such, residual effects are considered to be negligible for all ecological receptors during the operations and closure phase.

Results of the non-radiological exposure assessment for the post-closure phase indicate that concentrations are below their respective ecological screening values. Non-radiological contaminants were assessed in the PostSA following a very cautious approach. All non-radiological contaminants were assumed to be readily available for dissolution and leaching upon contact with water, whereas in reality most of the non-radiological inventory will be encased in iron-based matrices. Therefore, following this cautious approach, residual effects are considered to be negligible for all ecological receptors during the post-closure phase.

Although uncertainties in the assessment exist as described above, conservatism has been included in the modelling so that residual effects are not greater than predicted. Additionally, wastes placed into the NSDF will be required to meet the facility’s Waste Acceptance Criteria, which will be developed such that concentrations in the receiving environment do not pose a potential risk to indicator species. As such, residual effects are not significant for all ecological receptors during the operations phase and post-closure phase.

5.7.9 Monitoring and Follow-up

Monitoring of environmental media at the CRL site and surrounding area will proceed as described in alignment with CNL's existing Environmental Monitoring Program. As described in Section 5.7.4.3 Environmental Monitoring Program, this includes sampling and analysis of surface water, groundwater, sediment, soil, vegetation, ambient air, milk, garden produce, game animals, farm animals and fish (CNL 2018a). Sections 5.7.4.4 Radioactivity in the Atmospheric Environment to 5.7.4.10 Radioactivity in Terrestrial Foodstuffs, provide additional details regarding the scope of these programs for monitoring radioactivity in environmental media (CNL 2018a).

Emissions and effluents from the NSDF Project during the construction, operations, closure and the institutional control phase will be managed in accordance with CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018e). This standard defines the key requirements, responsibilities and processes for the management of radioactive and non-radioactive emissions at the NSDF Project. The NSDF *Environmental Protection Plan* (AECOM 2018d) expands on the regulatory requirements of CSA N288.5-11 (CSA Group 2011) for the management of these emissions. For example, operational control monitoring will be completed to confirm emission controls and treatment systems are functioning as intended. In addition, effluent monitoring will be completed to verify that emissions meet effluent discharge targets.

The CRL radiological Effluent Verification Monitoring Program will be established for the monitoring of emissions estimated from the NSDF Project. The Effluent Verification Monitoring Program at the NSDF Project site is required to demonstrate compliance with the No-Effect Concentrations for radiological constituents. For non-radiological contaminants, concentrations are maintained below the CCME's guidance levels for the protection of aquatic biota for the non-radiological contaminants. If the environmental monitoring and follow-up program identifies that adverse environmental effects are greater than predicted, then CNL will evaluate whether they result in changes to the conclusions in this EIS. If changes are confirmed, then CNL will evaluate the need for revised mitigation actions and management practices to manage effects. CNL's evaluation process for monitoring data include environmental performance criteria that are based on statistical measures and ecological health benchmarks. An exceedance of environmental performance criteria triggers CNL's non-conformance and corrective action process and includes notifying management and further investigation. Where the need for revised mitigations is identified they will be developed and implemented. The evaluation process is documented in alignment with CNL's Environmental Monitoring Program procedures (CNL 2018a).

Proposed environmental assessment monitoring and follow-up programs for the NSDF Project are documented in Section 11, including activities related to ambient radioactivity and ecological health:

- air quality (i.e., dust) will be monitored at the SSA and air effluent verification monitoring may be required at the WWTP;
- dust samples collected in the high volume air sampler during construction and operations will be screened for radioactivity;
- treated effluent from the WWTP, storm water pond effluent and surrounding surface water quality will be monitored;
- ambient radioactivity will be measured at the SSA; and
- groundwater monitoring will be performed surrounding the ECM, to confirm groundwater quality and detect potential releases of constituents from the ECM containment area.

These monitoring activities will occur during operations, closure and post-closure (institutional control). The need for and duration of monitoring will be reviewed based on annual review of monitoring data.

5.7.10 Conclusions

For ecological health, representative receptor taxa were selected as VCs, as documented in Section 5.7.2. Assessment endpoints are qualitative expressions used to assess the significance of residual effects on VCs and represent the key properties of the VC that should be protected for future human generations (i.e., incorporates sustainability). The assessment endpoint is the protection of ecological health. Measurement indicators represent properties of the environment, that when changed, could result in or contribute to an effect on an assessment endpoint. Measurement indicators for the ecological health assessment include changes in air quality, groundwater quality and surface water quality.

During the operations and closure phases, airborne emissions are negligible, and waterborne emissions result in environmental concentrations that are below the No-Effect Concentrations for radiological constituents. The predicted radionuclide concentrations in surface water are well below the No Effect Concentrations with one exception; existing concentrations of one radiological parameter (gross beta as strontium-90) has baseline concentrations approximately a factor of two greater than the No Effect Concentrations. The elevated surface water concentrations are localized to a small area. Further the impact of operations activities on surface water concentrations for this parameter are negligible. Therefore, no dose assessment for ecological receptors is required for the operations phase based on the screening process.

For non-radiological contaminants, concentrations are maintained below the CCME's guidance levels for the protection of aquatic biota or are below levels that would result in potential adverse effects on aquatic life. Therefore, an exposure assessment from non-radiological constituents to ecological receptors is not required.

During the post-closure phase, airborne and waterborne releases are modelled in the PostSA to determine environmental concentrations and carry into the EcoRA for assessment of effects on ecological receptors. Results indicate that the predicted doses to all indicator species are below the dose benchmark values during the post-closure period.

Although uncertainties in the assessment exist, conservatism has been included in the modelling so that residual effects are not greater than predicted. As such, residual effects are considered to be not significant for all ecological health VCs during the operations and post-closure phases of the NSDF Project. Monitoring and follow-up programs are described in Section 5.7.9 and include implementation of the existing Effluent Verification Monitoring Program, Groundwater Monitoring Program and Environmental Monitoring Program, as well as NSDF Project-specific environmental monitoring activities. These programs will verify effects predictions for ecological health.

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5.8 Human Health

This section of the Environmental Impact Statement (EIS) for the Canadian Nuclear Laboratories (CNL) Near Surface Disposal Facility (NSDF) Project summarizes the results of the Environmental Risk Assessment (ERA), specifically as it relates to effects to human health from changes in ambient radioactivity and non-radiological substances. Baseline information on radiological parameters in the environment that are relevant to human health are summarized in Section 5.7, and non-radiological parameters are summarized in the discipline-specific sections.

5.8.1 Scope of the Assessment

The human health assessment follows the overall environmental assessment approach and methods described in Section 5.1. The assessment is completed in the following key steps:

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries and assessment cases** for the human health assessment (refer to Sections 5.8.2 Valued Components and Section 5.8.3 Assessment Boundaries). The VCs and measurement indicators used to assess NSDF Project related effects to human health, the spatial and temporal boundaries at which the assessment occurred, and the assessment cases considered are described.
- **Step 2 – Describe the existing conditions** (refer to Section 5.8.4 Description of the Existing Environment). Baseline data collected from Chalk River Laboratories (CRL) existing operations and background levels across Canada are discussed. The existing conditions provide a reference, from which to compare the effects of the NSDF Project to.
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 5.8.5 Project Interactions and Mitigation). Project components and/or activities with the potential to affect human health are identified and mitigation developed to limit or avoid effects are presented. A pathways analysis is then used to focus further assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects are adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects to human health after incorporating mitigation are carried forward to Step 3 for further analysis and residual effects characterization.
- **Step 4 – Present the methods and results of the residual effects analysis** (refer to Section 5.8.6 Residual Effects Analysis). This Section summarizes the methods used to predict and characterize residual effects to human health from primary effects pathways. The results of the human health assessment are presented including the characterization of residual incremental effects of the NSDF Project and the cumulative effects of the NSDF Project in combination with other reasonably foreseeable developments (if applicable).
- **Step 5 – Describe the level of certainty and management of uncertainty** (refer to Section 5.8.7 Prediction Confidence and Uncertainty). Evaluate the available literature, data and models used for the assessment, and describe the level of certainty that can be placed on predicted residual effects. This section will also identify how the uncertainty has been managed so that the effects are not underestimated.

- **Step 6 – Classify and determine the significance of the predicted residual effects** (refer to Section 5.8.8 Residual Effects Classification and Determination of Significance). Residual effects predicted from primary pathways are classified using a common set of criteria: direction, magnitude, geographic extent, duration, reversibility, frequency and likelihood. A determination of the significance of the predicted residual effects of the NSDF Project on human health is made. Relative to other sections, the human health assessment uses a slightly different approach to the classification of residual effects and evaluation of significance, because several of the criteria (e.g., geographical extent, duration, frequency and reversibility) are already incorporated into the risk estimates and, therefore, are not independent variables.
- **Step 7 – Identify monitoring and follow-up** required to confirm effects predictions and address uncertainty (refer to Section 5.8.9 Monitoring and Follow-up).
- **Step 8 – Present a consolidated summary of conclusions** and outcomes of the assessment of residual effects on human and non-human biota (refer to Section 5.8.10 Conclusions).

Information and areas of interest raised by the public, communities of interest, and Indigenous peoples during engagement that influenced the scope of the human health assessment are summarized in Table 5.8.1-1. Other general concerns and questions raised during the engagement that pertain to the human health assessment (if any) are documented in CNL's Indigenous Engagement Report (CNL 2020a) and Stakeholder Activity Reports (CNL 2017a,b, 2019a).

Table 5.8.1-1: Summary of Areas of Interest Raised during Engagement Activities that Influenced the Scope of the Human Health Assessment

Area of Interest	How the Area of Interest Was Included in the Assessment
Effects to fish from potential for contamination in the Ottawa River from the NSDF Project.	The spatial boundaries of the assessment were selected to include consideration of potential effects to the Ottawa River. The human health risk assessment considered potential changes in surface water in Perch Creek. Meeting effluent discharge targets within the Perch Creek and Perch Lake watershed is considered to be protective of the Ottawa River. The RSA was expanded to include a reach of the Ottawa River extending 8 km downstream of CRL in response to comments received from the public.
Potential for radioactivity from gases from the capped facility	Potential changes in air quality from the NSDF Project were evaluated in the human health assessment during the operations phase.
Potential for changes in groundwater quality to affect uses downstream of the ECM	Potential changes in groundwater quality from the NSDF Project were evaluated in the human health risk assessment and included potential changes from treated effluent discharge from the WWTP, and seepage from the ECM during the operations phase and post-closure phase.
Treatment of leachate	Leachate from the ECM will be collected and pumped to the WWTP for treatment prior to discharge.
Potential leakage of leachate from the ECM	Potential leakage of leachate from the ECM during operations will be mitigated through the design and implementation of a composite base liner system, a leachate detection system and a leak collection system. Potential leakage from the ECM during the operations phase and post-closure phase is considered in the human health risk assessment.

RSA = Regional Study Area; ECM = engineered containment mound; WWTP = Wastewater Treatment Plant

5.8.2 Valued Components

Valued components (VCs) refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous peoples, the scientific community or the public (The Agency 2018). The human health risk assessment focused on Nuclear Energy Workers (herein referred to as "worker") and public health. The assessment for public health considered locations where people are known to be present (e.g., local communities, farmers and recreational areas). VCs and rationale for their selection for the human health assessment are provided in Table 5.8.2-1.

Table 5.8.2-1: Valued Components for the Human Health Assessment

Valued Component	Rationale for Selection
Worker	▪ Potential external and internal radionuclide exposure; potential non-radionuclide exposure
Public ▪ Residential ▪ Seasonal	▪ Potential exposure to airborne and waterborne radiological emissions; potential non-radionuclide exposure
Self-Sufficient Indigenous Group	▪ Potential exposure to airborne and waterborne radiological emissions; potential non-radionuclide exposure from the NSDF Project. ▪ This group represents a group of Indigenous peoples, including adults and children, using area that surrounds the ECM, including Perch Creek and the Ottawa River, for hunting and gathering during the post-closure phase. ▪ This receptor was assessed as part of the Sensitivity Analysis Case in the Post-Closure Safety Assessment (Arcadis and Quintessa 2020).

Assessment endpoints are qualitative expressions used to assess the significance of residual effects on VCs and represent the key properties of the VC that should be protected for future human generations (i.e., incorporates sustainability). The assessment endpoint is the protection of human health. Measurement indicators represent properties of the environment, that when changed, could result in or contribute to an effect on an assessment endpoint. The measurement indicators for the human health assessment are outlined in Table 5.8.2-2.

Table 5.8.2-2: Assessment Endpoints and Measurement Indicators for the Human Health Risk Assessment

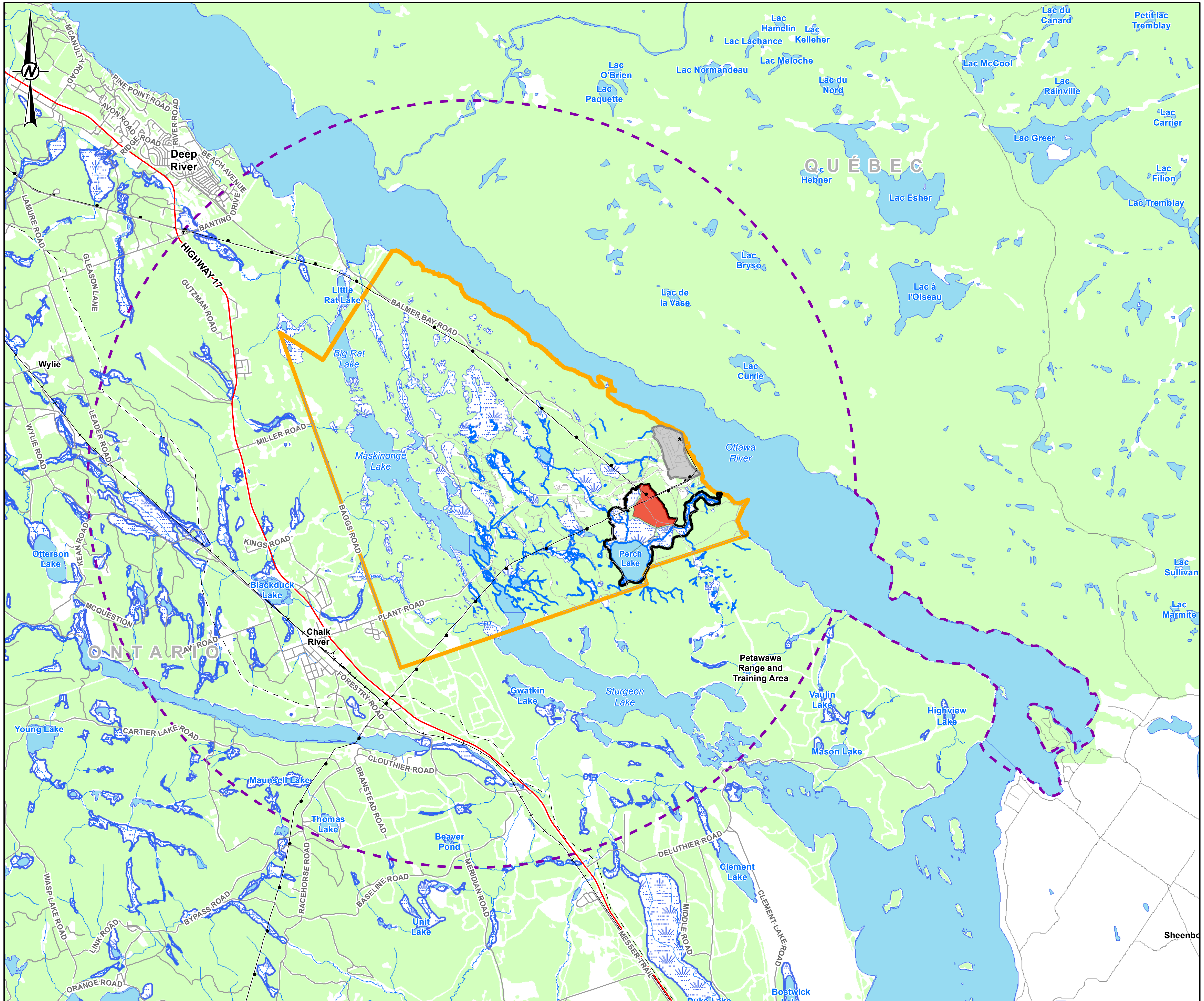
Valued Component	Assessment Endpoint	Measurement Indicators
Worker Public ▪ Residential ▪ Seasonal Indigenous peoples	Protection of human health	▪ Changes to air quality ▪ Changes to groundwater quality ▪ Changes to surface water quality ▪ Changes to sediment quality ▪ Changes to soil quality ▪ Changes to vegetation quality ▪ Changes to food quality

5.8.3 Assessment Boundaries

5.8.3.1 Spatial Boundaries

The spatial boundaries for the human health risk assessment are defined by the boundary of the Regional Study Area (RSA). The Local Study Area (LSA) is an area of greater focus within the RSA (Figure 5.8.3-1). To define the spatial boundaries for human health, the primary pathways that could contribute to residual effects on human health were determined (see Section 5.8.5). Primary pathways were identified from air quality, groundwater water quality and surface water quality. The spatial boundaries for human health were thus selected to incorporate relevant portions of the study areas for air quality, groundwater quality and surface water quality to evaluate the environmental changes that could contribute to effects on human health. The spatial boundaries for the effects assessment are as follows:

- **Site Study Area (SSA):** The SSA is the NSDF Project footprint (i.e., where Project activities would be undertaken including the NSDF Project's proposed facilities, buildings and infrastructure).
- **Local Study Area (LSA):** The LSA is defined as the area within which there is potential for measurable changes to measurement indicators resulting from the proposed NSDF Project activities. The LSA adapted from the groundwater and surface water Local Study Area (LSA) and is designated as the spatial extent of the Perch Creek and Perch Lake Watershed, and includes Perch Lake and its tributaries and Perch Creek. The Ottawa River in the vicinity of the mouth of Perch Creek is also included in the LSA.
- **Regional Study Area:** The RSA is defined as the area within which the potential effects of the NSDF Project may interact with the effects of other existing or reasonably foreseeable projects. Humans in the vicinity of the engineered containment mound (ECM) could be exposed to airborne and waterborne emissions as well as direct gamma radiation from the waste. Therefore, the RSA for human health is a combination of the air quality and aquatic environment RSAs as this is the largest extent of potential cumulative effects on human health. The air quality RSA is defined as an approximate 7.4 kilometre (km) circular radius surrounding the LSA, and the aquatic RSA extends roughly 8 km downstream in the Ottawa River to Harrington Bay.



LEGEND

- HIGHWAY
- ROAD
- RAILWAY
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- SITE STUDY AREA (NSDF PROJECT SITE)
- CRL MAIN CAMPUS
- CRL SITE
- LOCAL STUDY AREA
- REGIONAL STUDY AREA

REFERENCE(S)

1. BASEMAP:SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. HIGHWAYS AND FIRST NATION RESERVES MNRF 2016
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
SPATIAL BOUNDARIES SELECTED FOR THE HUMAN HEALTH ASSESSMENT

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.8.3-1

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5.8.3.2 Temporal Boundaries

Temporal boundaries (i.e., project phases) establish the timeframe during which NSDF Project effects are assessed. The temporal boundary represents the timeframe during which project activities are actively occurring, and does include the duration of predicted residual effects. The duration of an effect is defined as the amount of time between the start and end of a Project activity or stressor (which is related to the project phases) plus the time required for the residual effect to be reversed. In some cases, a residual effect may be irreversible within the temporal boundaries of the Project (e.g., residual effect lasts for thousands of years). The following phases were identified for the NSDF Project and considered in the assessment:

- **Construction Phase**: includes site preparation and all activities associated with the construction of the NSDF Project. This phase includes activities such as installing the necessary supporting and/or ancillary facilities and infrastructure to facilitate NSDF Project operations, inactive commissioning and systems testing, and transportation of construction materials. Construction activities are expected take place from 2021 to 2023.
- **Operations Phase**: includes all activities associated with waste placement, water management, water management, Wastewater Treatment Plant (WWTP) operations, vehicle movements into and from the SSA and maintenance activities. Operations activities are expected to last approximately 50 years (i.e., 2024 to 2070).
- **Closure Phase:** includes activities necessary to complete the installation of the final cover and implementation of long-term monitoring. Closure activities are expected to start in 2070 and continue through to 2100, after which the NSDF Project will transfer into the post-closure phase.
- **Post-closure Phase:** has two discrete periods: institutional control and post-institutional control. The Institutional Control period includes implementation of controls to 2400 (i.e., 300 years). During institutional control, groundwater monitoring and groundwater quality management will continue to demonstrate compliance with the post-closure safety assessment assumptions. Post-institutional control occurs after year 2400 and continues indefinitely. The *Post-Closure Safety Assessment* (PostSA; Arcadis and Quintessa 2020), which supports the assessment, includes consideration of effects of the NSDF Project for 10,000 years post-closure phase.

5.8.3.3 Assessment Cases

The assessment cases considered in the human health assessment include the Base Case and Application Case:

- **Base Case –** This scenario represents existing conditions and characterizes combined effects from previous and existing developments and activities. The Base Case reflects the effects of existing disturbances, such as forestry, transportation, agricultural, mining and residential and recreational development. Current effects from the existing CRL facilities and operations, for example, are considered part of the Base Case.
- **Application Case –** This scenario represents predictions of the effects of the Base Case combined with the effects that may result from the NSDF Project. The Application Case considers potential effects from the NSDF Project during the operations phase and the post-closure phase.

- **Reasonably Foreseeable Developments (RFD) Case –** This scenario represents predictions of the cumulative effects of the Application Case, which includes the Base Case, plus projects that are currently under application review or that have officially entered a regulatory application process and are therefore considered reasonably foreseeable. Because RFDs will either have no spatial overlap in effects or are likely to positively affect human health, an RFD Case is not presented as part of this assessment. RFDs within the CRL site (i.e., the RSA) include only the new or upgrades to research and development facilities, construction and operations of the SMR, new support infrastructure, and on-going decommissioning and environmental remediation activities. Revitalization projects at the CRL site (i.e., new or upgrades to research and development facilities, new support infrastructure) and decommissioning include several small projects staged over a 10-year period where best practices, mitigation and monitoring for management of emissions will be followed. No process intakes of water from or discharges to surface or groundwater, or releases to air beyond the potential for a limited amount of steam from dry cooling towers, are identified in the description of the planned SMR (Global First Power 2019). During normal operations, the SMR will introduce a very small radiological exposure to workers or members of the public near the plant, within the CRL site (Global First Power 2019). The incremental radiological (in proximity to SMR) and non-radiological emissions from RFD Projects at any one time are expected to be small, distributed across the CRL site and removed from the more intensive activities within the SSA (i.e., the NSDF Project footprint).

The NSDF Project will enable the remediation of contaminated lands and legacy waste management areas, and decommissioning of outdated infrastructure at the CRL site and CNL's other business locations to support future CNL missions. The end-state plan for the CRL site will be to return lands disturbed by site activities to a condition that is physically stable and safe in keeping with the land use and landscape of the day. Therefore, decommissioning and environmental remediation activities are anticipated to positively affect human health.

5.8.4 Description of the Existing Environment

Background radiation dose from natural and anthropogenic sources and historical radiation dose from CRL operations is used to establish a baseline characterization of radiation dose for human health assessment prior to the NSDF Project.

5.8.4.1 Background Sources of Radiation and Radioactivity

This section describes the background radiation and radioactivity that is present in the environment due to natural and anthropogenic sources independent of CRL operations. The magnitude of radiation dose from natural sources varies greatly, both spatially and temporally. The main natural sources of radiation are cosmic rays; naturally occurring radionuclides in air, water and food; and naturally occurring radionuclides in the soil, rocks and building materials used in homes (CNSC 2013).

Cosmic radiation originates from celestial events and the sun. This cosmic radiation and the secondary particles produced penetrate the Earth's atmosphere and give an external radiation dose at the Earth's surface.

- Naturally occurring radionuclides are also incorporated into plants, animals and water from surrounding soils and rocks. Humans ingest these foodstuffs and receive an internal radiation dose. Radon gas, a product of the decay of uranium in soil, is inhaled and contributes to the internal radiation dose.
- Consumer products and services contribute a relatively low amount to the total dose. Naturally occurring radionuclides such as uranium, potassium and thorium are present in soils, rocks and building materials. These naturally occurring radionuclides also contribute to the external gamma radiation dose. Medical diagnostic procedures (such as x-rays) contribute to the external dose.

The average annual doses in Canada are shown on Figure 5.8.4-1; the total annual dose from natural background radiation is approximately 1.8 millisieverts (mSv) (CNSC 2013).

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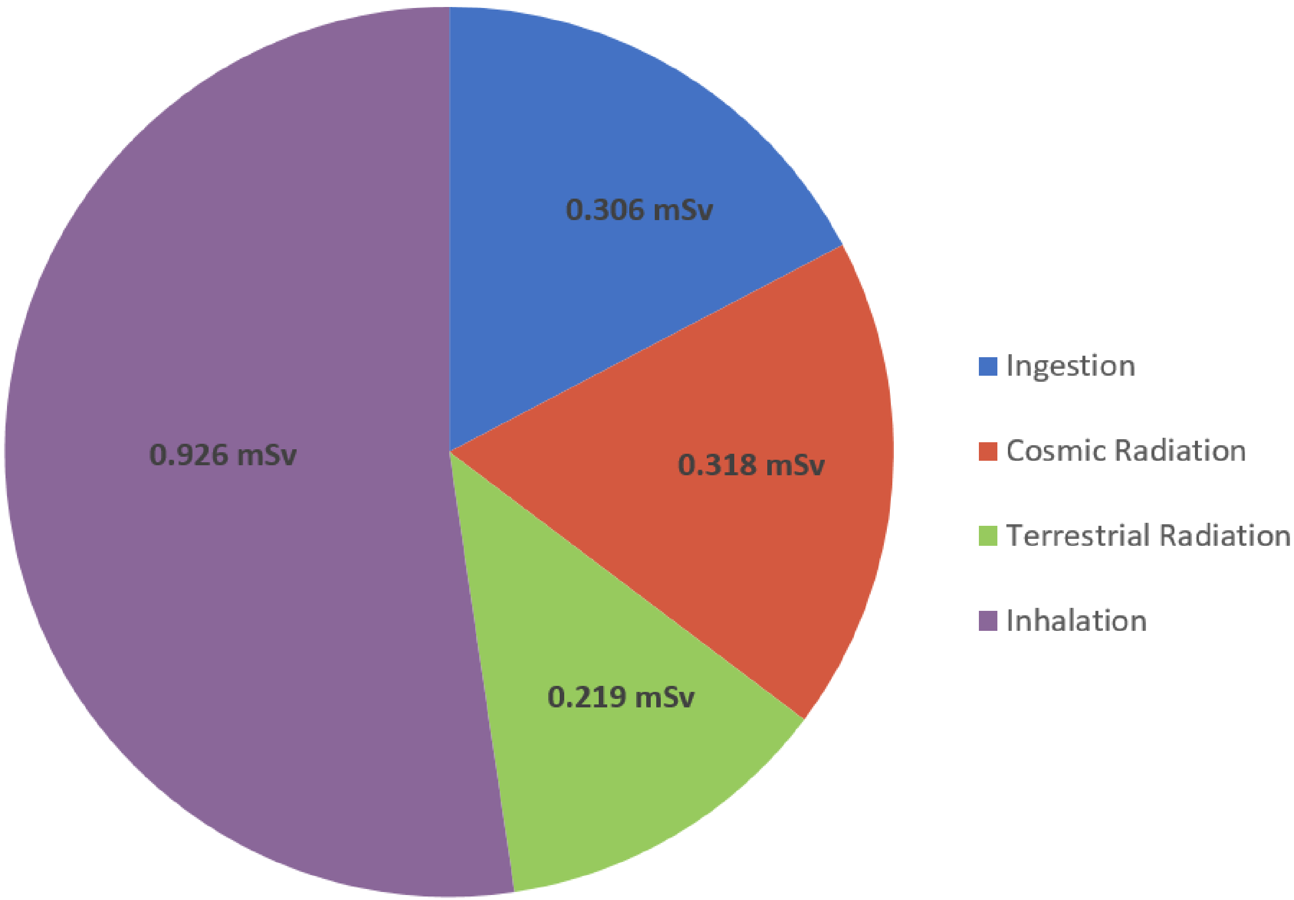

NOTE(S)

CLIENT
CANADIAN NUCLEAR LABORATORIES

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	PR
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT

TITLE
AVERAGE BACKGROUND RADIATION DOSES IN CANADA (MSV/YR) (CNSC 2013)

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	**5.8.4-1**

5.8.4.2 Radiation Dose from CRL Operations

CNL reports the results of the CRL Environmental Monitoring Program each year to the Canadian Nuclear Safety Commission (CNSC). The Environmental Monitoring Program data are collected to verify that radiation doses to members of the public as a result of the operations of the CRL site remain As Low As Reasonably Achievable (ALARA). The calculated radiation dose to members of the public from CRL operations is shown in Table 5.8.4-1, and represents the Base Case radiation dose from CRL prior to the NSDF Project. The 2018 dose assessment showed that highest adult radiation dose to the public from CRL operations was 0.032 millisieverts per year (mSv/yr), representing 3.2% of the regulatory dose limit of 1 mSv/yr for members of the public. The 5-year average adult dose from 2014 to 2018 is 0.065 mSv/yr (CNL 2019b). The dose to members of the public is predominantly from airborne emissions.

Table 5.8.4-1: Total Dose to Critical Groups Outside the Chalk River Laboratories Boundary Based on Environmental Monitoring Results – 2014-2018

Year	Airborne Effluent Pathway – Adult Dose (mSv/yr)	Waterborne Effluent Pathway – Adult Dose (mSv/yr)
2018	0.036	0.00016
2017	0.086	0.00042
2016	0.077	0.00052
2015	0.082	0.001
2014	0.060	0.00028
5 Year Average (2014-2018)	**0.065**	**0.00047**

Source: CNL 2016; 2017c, 2018a, 2019b.

mSv/yr = millisieverts per year.

5.8.5 Project Interactions and Mitigation

5.8.5.1 Methods

This section describes the process by which interactions between NSDF Project components and activities and human health were identified and evaluated. Potential effects pathways related to ecological health are discussed in Section 5.7. Potential effects pathways are identified and mitigation developed to eliminate and/or reduce effects is presented. A pathways analysis is then used to focus the assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects will be adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects after incorporation of mitigation are further characterized in subsequent subsections of the assessment. As such the Project Interactions and Mitigations’ section helps to focus the remainder of the assessment on those interactions (effects pathways) with the potential to result in residual adverse effects.

The first part of the analysis was to identify the potential effects pathways for all stages of the NSDF Project. The next step in the analysis was the development of environmental design features and mitigation that could be incorporated into the NSDF Project to eliminate and/or reduce adverse effects to human health. Environmental design features included project design elements, environmental best practices and management policies and procedures. Environmental design features and mitigation were developed through an iterative process between the NSDF Project’s engineering and environmental teams, combined with input from Project-specific or regional engagement with other interested parties. The design features and/or mitigation were selected considering their effectiveness for implementation and maintenance, and their appropriateness within the context of the identified effects pathways.

After incorporation of mitigation, potential pathways were evaluated into the following categories using scientific knowledge, logic, experience with similar developments and the effectiveness of environmental design features and mitigation:

- **No linkage:** The pathway is removed by environmental design features or mitigation such that the NSDF Project would not be expected to result in a measurable environmental change relative to Base Case values and therefore would have no residual effects to human health.
- **Secondary pathway:** The pathway could result in a measurable minor environmental change, but would have a negligible residual effect to human health relative to Base Case (or guideline values) and is not expected to contribute cumulatively to other Project effects or to the effects of other previous, existing or reasonably foreseeable developments to cause a significant effect.
- **Primary pathway:** The pathway is likely to result in an environmental change to measurement indicators identified for human health VCs relative to the Base Case that could contribute to residual effects to human health.

Environmental design features and mitigation that could be incorporated into the NSDF Project to eliminate and/or reduce adverse effects to human health were considered. Potential pathways that were completely removed due to implementation of environmental design or mitigation were not assessed further. Pathways that were assessed to be secondary and demonstrated to have a negligible residual effect to human health VCs through qualitative or quantitative evaluation of the pathway were also not advanced for further assessment.

Primary pathways were carried forward for more detailed quantitative and qualitative effects analysis to characterize the residual effects of the NSDF Project on human health VCs.

5.8.5.2 Results

The pathways analysis for human health VC is provided in Table 5.8.5-1. There will be no exposure to construction workers during the construction phase; therefore, no pathways related to construction workers are listed in Table 5.8.5-1. Any accidents and malfunctions during the construction phase are assessed in Section 7.0.

Table 5.8.5-1: Pathways Analysis for Human Health Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
▪ Project activities during the operations and closure phase: ▪ Phased development of disposal cells in the ECM ▪ On-site transportation of waste and placement in the ECM ▪ Progressive closure of disposal cells and installation of final cover ▪ Surface water management ▪ Operation of the WWTP ▪ Discharge of treated effluent from the WWTP	▪ Dust may be created during handling of bulk materials and emissions of gases may be released during storage and disposal of radioactive materials, which can affect human health. ▪ Emissions may be released from the WWTP to air during operations, which can affect human health.	▪ All activities will be covered by either CNL's work permits with completed Radiological Safety Assessments, as required, or by approved work procedures. ▪ CNL's procedure for Management and Monitoring of Emissions (CNL 2018b), which includes operational control monitoring and verification monitoring, will be implemented. ▪ The buildup of gas emissions from waste in closed cells is mitigated by gas venting in the final cover. ▪ The Dust Management Plan (AECOM 2018a) for the NSDF Project will include: ▪ restricting or suspending activities if unacceptable amounts of dust are generated due to winds or other site conditions; ▪ use of water spraying or misting techniques (e.g., water trucks) as the primary dust control method; ▪ use of fixatives (e.g., chemical suppressant) for dust control, and for use as daily/interim cover; ▪ suspension of excavating, loading, hauling and disposal operations when wind speeds exceed the specified criterion; and ▪ vehicles that have come into contact with contamination will be required to pass through the vehicle decontamination facility ▪ Processed wastewater will not be heated within the WWTP (raising the temperature increases potential release rates). ▪ There is active ventilation within the WWTP building and active ventilation exhaust will be filtered through HEPA prior to release.	Primary
	▪ Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) may cause changes to surface water quality, which can affect human health.	▪ All activities will be covered by either CNL's work permits with completed Radiological Safety Assessments, as required, or by approved work procedures. ▪ The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses best available technology that is economically achievable and capable of meeting regulatory requirements. ▪ Effluent discharge targets for wastewater discharges are protective of the environment and human health. ▪ Discharge targets for non-radiological contaminants are sourced from federal and provincial guidelines for protection of aquatic biota. ▪ Discharge targets for radionuclides are the Canadian Drinking Water Guidelines, with the exception of tritium for which a site-specific target is developed (Section 3.4.2.5.1). ▪ Treated effluent will be sampled to confirm that it meets effluent discharge targets before release to the environment. ▪ When applied, the proposed exfiltration gallery will promote the exfiltration of treated water into the local groundwater regime where further retention of radioactivity by the geosphere is anticipated. ▪ The Perch Lake diffuser design provides additional dilution of treated effluent at the point of release ▪ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water quality. ▪ Appropriate procedures will be in place to effectively identify spill occurrences in the event treated effluent is released to areas other than directly to the exfiltration gallery and initiate appropriate emergency responses.	Primary
▪ Project activities during the operations and closure phase: ▪ Surface water management ▪ Operation of the WWTP ▪ Discharge of treated effluent from the WWTP	▪ Leakage of leachate from the ECM during operations and closure may cause changes to surface water quality, which can affect human health.	▪ Design of the ECM includes base grading configured in a herringbone pattern with ridges and valleys to promote leachate transport to the leachate collection system for removal. ▪ The base liner design includes primary and secondary liner systems designed to have redundancy in case of premature failure and are a combination of natural and synthetic barrier systems. These include a compacted clay liner (CCL), two geosynthetic clay liners (GCL) and an HDPE geomembrane. ▪ Clay materials were selected for the CCL and GCL components of the liner system as these materials are anticipated to maintain their function as hydraulic barriers throughout and beyond the design life of the disposal facility (i.e., 550 years). ▪ The HDPE geomembrane design for the liner will be compatible with the leachate generated by the waste and provide a long service life. ▪ The base liner system will include an underlying compacted clay liner to supplement the primary and secondary liner system. ▪ The leachate collection system design will provide accessible access points for inspections, maintenance, repairs, and replacements. ▪ Appropriate responses to leachate leakage and contamination will be implemented as described in the Operations and Maintenance Plan (AECOM 2019).	No Linkage

Table 5.8.5-1: Pathways Analysis for Human Health Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
▪ Project activities during the post-closure phase: ▪ On-going long-term performance monitoring, transfer of NSDF Project into the post-institutional control period	▪ Volatiles (e.g., radon, tritium) may be released to air, which can affect human health	▪ A passive landfill gas venting system will be constructed at the same time as installation of the ECM final cover system. ▪ The landfill gas monitoring probes will also be installed around the perimeter of the ECM to detect evidence of potential landfill gas migration away from the ECM.	Primary
	▪ Leachate may be released to soil via overtopping the berm, which can affect human health	▪ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound, and minimize leachate generation. ▪ The cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity. ▪ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. ▪ The ECM final grading and drainage plan includes collection ditches along the top of the ECM berm road to collect side slope drainage. ▪ Environmental monitoring will be completed as required during the institutional control period for the NSDF Project to confirm that the final cover is functioning as intended	Primary
	Leachate may be released through the base liner to groundwater, which can affect human health	The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the ECM and minimize leachate generation. The cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity. The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. The ECM final grading and drainage plan includes collection ditches along the top of the ECM berm road to collect side slope drainage. The design life for the ECM is 550 years to meet the required time period to allow for radioactive decay of the waste placed in the facility (i.e., until it has decayed to levels that do not present a risk to the public and environment). The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water and groundwater quality.	Primary

ECM = engineered containment mound; CRL = Chalk River Laboratories; WWTP = Wastewater Treatment Plant; LLW = low-level waste.

5.8.5.2.1 No Linkage Pathways

The following pathway was assessed as having no measurable environmental change and hence, no linkage to residual effects on human health VCs.

- **Leakage of leachate from the ECM during operations and closure may cause changes to surface water quality, which can affect human health.**

Design of the ECM includes base contours that have been developed using a herringbone pattern with ridges and valleys to promote leachate transport to the leachate collection system for removal. The base liner design includes both primary and secondary liner systems that are designed to have redundancy in case of premature failure and are a combination of natural and synthetic barrier systems. The primary liner will include a leachate collection system with the secondary liner housing a leak detection system. The composite base liner will contain perforated high-density polyethylene (HDPE) collection and transfer line. The HDPE geomembrane was selected as it is compatible with the leachate generated by the waste and is expected to perform as an effective hydraulic and diffusion barrier over the 550-year design life (i.e., 50 years of operations and 500 years post-closure, see Section 3.4.1.4). The base liner system will include an underlying compacted clay liner to supplement the primary and secondary liner system. The leachate collection system design will provide accessible access points for inspections, maintenance, repairs and replacements.

The primary liner system will contain the leachate collection system and will convey leachate to a single collection point for removal from the ECM, for transfer to the WWTP for treatment. The primary liner system serves as the primary source of protection for the natural environment below the ECM from leachate migration. The secondary liner system will contain the leak detection system, which will be used to detect leaks in the unlikely event that the primary liner system fails. Leachate collected by the leachate collection system will be pumped to the on-site WWTP for treatment.

Perimeter berms consist of three main geotechnical elements, or layers, each contributing to the soundness and integrity of the berm itself and the whole ECM. A *Slope Stability Analysis* (AECOM 2018b) was completed to provide the information needed to support the design of the base slopes, sidewalls and side slopes of the ECM. The *Slope Stability Analysis* addresses the range of anticipated loading conditions, under both short-term and long-term scenarios, to confirm that the slope designs will satisfy minimum factor-of-safety requirements for stability. Size and shape of the berms and each of the elements and layers were determined using a seismic design basis, including the *National Building Code of Canada 2015* (NRCC 2015).

The implementation of the design of the ECM, the liner systems, and the perimeter berms will reduce the potential for changes to groundwater and surface water quality from the NSDF Project site. As such, this pathway was determined to have no linkage to effects on human health.

5.8.5.2.2 Secondary Pathways

No secondary pathways were identified as having residual effects on human health.

5.8.5.2.3 Primary Pathways

Primary pathways identified for human health that are evaluated in the residual effects analysis (Section 5.8.6) include:

During the operations and closure phases:

- **Dust may be created during handling of bulk materials and emissions of gases may be released during storage and disposal of radioactive materials, which can affect human health.**
- **Emissions may be released from the WWTP to air during operations and closure, which can affect human health.**
- **Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) can cause changes to surface water quality, which can affect human health.**

During the post-closure phase:

- **Volatiles (e.g., radon, tritium) may be released to air, which can affect human health.**
- **Leachate may be released to soil via overtopping the berm, which can affect human health.**
- **Leachate may be released through the base liner to groundwater, which can affect human health.**

5.8.6 Residual Effects Analysis

This section describes the specific methods used to assess the residual effects on human health for the NSDF Project activities and pathways identified as primary in Table 5.8.5-1. The approach used to predict residual effects is described below, along with the scenarios, models, policies, guidelines and standards considered in the analysis. The radiological dose assessment is discussed Section 5.8.6.1 and the non-radiological exposure assessment is discussed in Section 5.8.6.2.

5.8.6.1 Radiological Dose Assessment

5.8.6.1.1 Application Case Methods

Radiological dose to workers (i.e., Nuclear Energy Workers) in the SSA may result from external exposure to radiation emitted from radioactive waste or wastewater, or inhalation of radioactive contaminants in the ECM, WWTP or support buildings (e.g., vehicle decontamination facility). Dose to workers will be monitored and managed as part of the NSDF *Radiation Protection Plan* (AECOM 2018c), which is in accordance with CNL's site-wide Radiation Protection Program. As a result of the implementation of the NSDF *Radiation Protection Plan*, doses to workers will be kept as low as reasonably achievable, and below the effective dose limit of 100 mSv over five years and below 50 mSv in any single year. Worker dose consequences will be also kept below the CNL Radiation Protection Action Levels, which are lower than the regulatory limits listed in the preceding sentence. Worker dose during operations is assessed as part of the NSDF *Safety Analysis Report* (SAR) (CNL 2020b).

Radiological dose to members of the public from the NSDF Project may result from waterborne or airborne emissions. Dose to members of the public from waterborne emissions is assessed during the operations phase, as well as during the post-closure phase. It is assumed that during the institutional control period (year 2100 to year 2400), the base liner and cover will be functional and no leachate will seep through the base liner however other migration pathways of contaminants are taken into account in the pathways analysis. This assumption is consistent with the 550-year design life of the engineered barriers.

Radiological dose to members of the public from airborne emissions is assessed for the operations phase of the NSDF Project as part of the SAR (CNL 2020b). This represents a bounding case for the closure phase (i.e. 2070-2100), since it is expected that with the installation of the final cover, doses to members of the public during the closure would be less than the operations phase. Radiological dose to members of the public from airborne emissions during the post-closure phase of the NSDF Project as part of the PostSA (Arcadis and Quintessa 2020).

This EIS relies upon supporting documents, as noted, for the prediction and assessment of potential radiological effects on human receptors.

5.8.6.1.1.1 Operations and Closure Phase

For the assessment of human health in the operations and closure phases of the NSDF Project, the main supporting document is the SAR (CNL 2020b). A general background of the methods of the SAR is provided as follows:

Safety Analysis Report

The SAR describes the design of the facility, and subsequently analyzes the hazards and potential consequences present in the operations of the facility. The purpose of the SAR is:

- to demonstrate the adequacy of the NSDF design in support of the licensing process;
- to demonstrate that the proposed design of the facility conforms to CNSC regulatory requirements and guidance provided by the International Atomic Energy Agency, and will provide for safe operation over the operational life;
- to identify the hazards, describe how hazards are controlled and/or mitigated, and describe the management system in place to ensure the controls are effectively and consistently applied;
- to undertake a quantitative and qualitative assessment of the radiological and non-radiological safety of the NSDF Project during the operations and closure phases;
- to undertake a quantitative and qualitative assessment of the radiological and non-radiological safety of the NSDF Project during the operations and closure phases; and
- to provide necessary information to support an EIS which will address the requirements of the *Canadian Environmental Assessment Act, 2012* (CEAA 2012) and *REGDOC-2.11.1 Waste Management, Volume III: Assessing the Long-Term Safety of Radioactive Waste Management* (Vol. III; CNSC 2018).

The scope of the SAR is to present the operational safety analysis of the NSDF Project based on the detailed design package, proposed operations and identified hazards. The SAR uses the most up-to-date information about the NSDF Project design to form the basis of the assessment. In the SAR, nuclear safety is assessed for normal operations as well as accident conditions for on- and off-site human receptors and the environment. The timeframe assessed includes the construction period, approximate 50-year operations period, and 30-year closure period.

Normal Operations refers to the most likely, expected process and work tasks that take place on a day-to-day basis. The assessment of Normal Operations assumes that all processes and procedures are followed, that workers are properly trained, and that all CNL compliance programs are being adhered to.

For Normal Operations, the dose constraint for workers is 20 mSv/yr and for the public a dose constraint of 0.3 mSv/yr is applied in accordance with the CRL Licence Conditions Handbook (CNSC 2019). The dose constraint for the public is achieved by ensuring that off-site radionuclide releases are well below Derived Release Limits (DRL) for the CRL site (CNL 2018d). The NSDF Project is designed so the potential release of radionuclides during normal operations is less than a target of 1% of the corresponding release limits and DRL.

Accident conditions are separated into three categories based on frequency of occurrence, and are evaluated further in Section 7.0:

- Anticipated Operational Occurrence: An event that deviates from normal operations and is expected to occur once to several times during the operating lifetime of the facility. An Anticipated Operational Occurrence does not result in significant damage.
- Design Basis Accident: A rare event that is expected to occur once in 10,000 years, but much less frequently than an Anticipated Operational Occurrence. The NSDF Project is designed to perform under the conditions of a Design Basis Accident.
- Beyond Design Basis Accident: A very rare event that has more severe consequences, but occurs less frequently than a Design Basis Accident. A Beyond Design Basis Accident is expected to occur less than once in 10,000 years.

The objectives of the safety analysis are to demonstrate the following requirements under normal operations, Anticipated Operational Occurrences, Design Basis Accidents and Beyond Design Basis Accidents in the NSDF Project:

- the safety of the off-site public and on-site workers is protected;
- the dose acceptance criteria are met;
- there are no significant adverse effects on the environment;
- the adequacy of the NSDF Project design; and
- the proposed design of the NSDF Project conforms to regulatory requirements and guidance provided by the CNSC and the International Atomic Energy Agency (IAEA).

The SAR considers the following primary pathways in the evaluation of dose to persons on-site (workers) and off-site (public):

- Dust may be created during handling of bulk materials and emissions of gases may be released during storage and disposal of radioactive materials, which can affect human health.
- Emissions may be released from the WWTP to air during operations, which can affect human health.

Gases and dust released from the ECM or WWTP can diffuse into the environment where they will be dispersed by wind. Some contaminants will be absorbed by vegetation which could then be consumed by animals and people. Workers in proximity to the waste or WWTP processes will be exposed to radiation. Pathways include external exposure and inhalation of dust.

Contaminants released through the treated effluent will reach Perch Lake. Once in the aquatic environment, there will be further dilution in Perch Creek and then in the Ottawa River. Contaminants may be taken up by aquatic flora and fauna. However, given that the effluent discharge meets applicable discharge requirements, exposure to humans and biota through this pathway are considered negligible during the operations and closure phase.

The human receptors assessed in the SAR are discussed in Section 5.8.6.1.1.3.

The radiological inventory of the ECM includes low-level waste associated with bulk unpackaged wastes and packaged wastes. The radionuclides assessed in the SAR are presented in Table 5.8.6-1.

Table 5.8.6-1: Radionuclides Assessed in the Safety Analysis Report

Radionuclides	
Ag-108m (metastable isotope silver-108)	Pu-239 (isotope plutonium-239)
Am-241 (isotope Americium-241)	Pu-241 (isotope plutonium-241)
Am-243 (isotope Americium-243)	Pu-242 (isotope plutonium-242)
C-14 (isotope carbon-14)	Ra-226 (isotope radium-226)
Cl-36 (isotope chlorine-36)	Se-79 (isotope selenium-79)
Co-60 (isotope cobalt-60)	Sn-126(isotope tin-126)
Cs-135 (isotope caesium-135)	Sr-90 (isotope strontium-90)
Cs-137 (isotope caesium-137)	Tc-99 (isotope technetium-99)
H-3 (isotope hydrogen-3 [Tritium])	Th-230 (isotope thorium-230)
I-129 (isotope Iodine-129)	Th-232 (isotope thorium-232)
Mo-93 (isotope molybdenum-93)	U-233 (isotope uranium-233)
Nb-94 (isotope Niobium-94)	U-234 (isotope uranium-234)
Ni-59 (isotope nickel-59)	U-235 (isotope uranium-235)
Ni-63 (isotope nickel-63)	U-238 (isotope uranium-238)
Np-237 (isotope neptunium-237)	Zr-93 (isotope zirconium-93)

Source: CNL 2020b

The SAR examines the potential hazards that could result from normal operations and the consequences of abnormal events and accidents. The SAR uses a systematic and comprehensive method to identify all hazards and accident scenarios which includes:

- hazard identification;
- identification of major hazards and postulated initiating events associated with the NSDF Project design and operations;
- hazard analysis of the consolidated list of major hazards and postulated initiating events for the NSDF Project facilities;
- failure mode, effects and criticality analysis (FMECA) of the WWTP; and

- safety analysis of normal operation, Anticipated Operational Occurrences, Design Basis Accidents and Beyond Design Basis Accidents using credible/relevant scenarios.

The hazard identification was conducted early in the design process (AECOM 2016). The objective of the hazard identification was to list characteristics associated with systems, structures and components with the potential for radiological or chemical harm to people or the environment.

The hazards posed by the NSDF Project, with the exception of the WWTP, were identified based on the safety analysts' engineering judgement, and were recorded on the Safety Hazards Checklist and documented in Hazard Identification (AECOM 2016). The Safety Hazards Checklist was used to record relevant details and safeguards for the identified hazards.

The WWTP hazard identification involved completing a preliminary failure modes and effects analysis (FMEA) for the WWTP components and subcomponents based on the 30% design piping and instrumentation diagrams (AECOM 2016). The preliminary FMEA for the WWTP components was developed to identify failure modes and effects based on the safety analysts' engineering judgement. The WWTP preliminary FMEA is documented in Hazard Identification (AECOM 2016).

Waterborne Effluent – Operations Phase

The total average annual volume of leachate, contact stormwater and decontamination water under this operating scenario is 13,320 m^3/yr. This operating scenario represents the anticipated wastewater generated over approximately 50 years of the ECM for one active cell and nine filled (closed) cells based on:

- two weeks of 22.5 m^3/hr discharge (8 hr/day) corresponding to a storm event (i.e. 2,520 m^3); and
- 120 days of 11.25 m^3/hr discharge (8 hr/day) corresponding to normal operations (i.e. 10,800 m^3).

This single annual effluent flow of 13,320 m^3/yr is discharged under two receiving environment scenarios:

- Scenario 1: 50% of WWTP effluent discharges to an exfiltration gallery ultimately leading to the East Swamp Wetland and the remaining 50% directly discharges to Perch Lake via an end-of-pipe diffuser.
- Scenario 2: 100% of WWTP effluent discharges directly to Perch Lake via an end-of-pipe diffuser.

For the operations phase modelling, it is conservatively assumed that no dilution occurs along the groundwater flow-path from the WWTP effluent discharge to the East Swamp Stream. The annual average flow rate of the East Swamp Stream, which drains the wetland, is 72,000 m^3/yr. Average annual outflow from this wetland is via East Swamp Stream to Perch Lake, which discharges to the Ottawa River via Perch Creek at approximately 2,200,000 m^3/yr.

The treated effluent will contain small quantities of residual contaminants. The effluent discharge targets for radionuclides are the Canadian Drinking Water guidelines, with the exception of tritium. The tritium effluent discharge target is a site-specific target which will ensure that tritium concentrations in Perch Creek which discharges to the Ottawa River do not exceed the drinking water guideline of 7,000 Bq/L. The concentrations of radionuclides in the treated effluent are assumed to equal the effluent discharge targets and are presented in Table 5.8.6-2.

There is no public access to the CRL site including the Perch Creek and Perch Lake Watershed where treated effluent is discharged. Radionuclide releases from the treated effluent discharges will be negligible compared to the site Derived Release Limits. Radiation doses to off-site members of the public located downstream of the CRL site will be well below the regulatory limits.

Table 5.8.6-2: Maximum Concentrations of Radionuclides in the Treated Effluent

Radionuclide	Maximum Concentrations in Treated Effluent (Bq/L)[(a)]
Ag-108m (metastable isotope silver-108)	60
Am-241 (isotope Americium-241)	0.7
Am-243 (isotope Americium-243)	0.7
C-14 (isotope carbon-14)	200
Cl-36 (isotope chlorine-36)	100
Co-60 (isotope cobalt-60)	40
Cs-135 (isotope caesium-135)	70
Cs-137 (isotope caesium-137)	10
H-3 (isotope hydrogen-3 [Tritium])	360,000
I-129 (isotope Iodine-129)	1
Mo-93 (isotope molybdenum-93)	40
Nb-94 (isotope Niobium-94)	80
Ni-59 (isotope nickel-59)	2,000
Ni-63 (isotope nickel-63)	900
Np-237 (isotope neptunium-237)	1
Pu-239 (isotope plutonium-239)	0.6
Pu-241 (isotope plutonium-241)	30
Pu-242 (isotope plutonium-242)	0.6
Ra-226 (isotope radium-226)	0.5
Se-79 (isotope selenium-79)	50
Sn-126(isotope tin-126)	30
Sr-90 (isotope strontium-90)	5
Tc-99 (isotope technetium-99)	200
Th-230 (isotope thorium-230)	0.7
Th-232 (isotope thorium-232)	0.6
U-233 (isotope uranium-233)	3
U-234 (isotope uranium-234)	3
U-235 (isotope uranium-235)	3
U-238 (isotope uranium-238)	3

Table 5.8.6-2: Maximum Concentrations of Radionuclides in the Treated Effluent

Radionuclide	Maximum Concentrations in Treated Effluent (Bq/L)[(a)]
Zr-93 (isotope zirconium-93)	100

Source: CNL 2020b

a) Effluent discharge target concentration, as an upper bound.

Bq/L = Becquerels per litre.

Airborne Releases – Operations Phase

During operations, the ECM may emit airborne radionuclide releases (AECOM 2018d). Potential discharges include emissions of radioactive dust during handling of bulk materials and gaseous emissions during storage and disposal of radioactive materials. The expected gaseous radionuclide releases are:

- tritium in the form of tritium oxide;
- gases containing carbon-14; and
- radon-222 released due to the decay of radium-226, plutonium-242, uranium-234 and uranium-238.

The concentrations of radon, tritium, and carbon-14 in air near the surface of the ECM, as well as the resulting dose to the worker, are presented in Table 5.8.6-3 below. Doses to off-site receptors (public) would be several orders of magnitude less, due to the separation distance of a few kilometers.

Table 5.8.6-3: Radioactive Gas Generation Rates and Worker Doses during Normal Operations

Parameter	Value
Radon gas production rate	3.0×10^{-8} Bq/cm^3-sec
Radon flux to atmosphere, no cover	2.9×10^{-2} Bq/m^2/sec
Radon flux to atmosphere, final cover	6.4×10^{-3} Bq/m^2/sec
Radon concentration in NSDF cell	0.50 Bq/m^3
Radon dose to worker	9.6×10^{-4} mSv/yr
Tritium concentration in air	61 Bq/m^3
Tritium dose to worker	1.6×10^{-5} mSv/yr
Carbon-14 concentration in air	0.53 Bq/m^3
Carbon-14 dose to worker	2.2×10^{-6} mSv/yr

There will also be airborne emissions from the WWTP. The emission rates for radionuclides were calculated in the SAR (CNL 2020b). The highest emission rates were for americium-241, cobalt-60 and tritium, at about 0.04% of the CRL Derived Release Limits (DRL). The rest of the radionuclides were below 0.001% of the DRL. The dose to members of the public is therefore predicted to be well below regulatory limits.

5.8.6.1.1.2 Post-Closure Phase

For the assessment of human health in the post-closure phase of the NSDF Project, the main supporting document is the PostSA (Arcadis and Quintessa 2020). A general background of the radiological methods of the PostSA is provided below.

Post-Closure Safety Assessment (PostSA)

The PostSA (Arcadis and Quintessa 2020) analyzes the long-term implications (i.e., during the institutional control and post-institutional control periods) of the NSDF Project. The purpose of the PostSA is:

- to undertake a quantitative assessment of the radiological and non-radiological safety of the NSDF Project during the post-closure phase;
- to identify those uncertainties that have the greatest potential effect on the long-term performance of the decommissioned facility; and
- to provide necessary information to support an EIS which will address the requirements of CEAA 2012 and REGDOC-2.11.1 Vol. III (CNSC 2018).

Evaluating post-closure safety requires projections of the future condition of the NSDF Project and its environment, and how receptors might interact with it. Approaches have been developed to undertake such evaluations, centred on a “system analysis” method. This involves representing the NSDF Project, the facility inventory present and all potentially relevant media (e.g., groundwater, soil, surface water and sediment), with mathematical models to represent the key processes that may occur (e.g., corrosion of wastes, dissolution into groundwater, uptake by plants). It is essential that the models used are relevant, well grounded and auditable. This is achieved through a systematic approach to safety assessment. The international community has developed best practice guidance on the process, which is documented in a report of the IAEA ISAM programme (IAEA 2004) and incorporated into a more recent safety guide (IAEA 2012). This process has been applied internationally since its publication, is consistent with REGDOC 2.11.1 Vol. III (CNSC 2018) and underpins the PostSA analysis.

The PostSA considers three primary pathways of release of contaminants into the environment:

- volatiles (e.g., radon, tritium) may be released to air, which can affect human health;
- leachate may be released to soil via overtopping the berm, which can affect human health; and
- leachate may be released through the base liner to groundwater, which can affect human health.

Gases released above the ECM will diffuse through the soil and into the atmosphere where they will be dispersed by wind. Some contaminants will be absorbed by vegetation which could then be consumed by animals and people.

Contaminants released by overtopping the berm will move through the shallow environment by overland flow and interflow resulting in contamination of surface soils. Exposures can arise by external irradiation, inhalation of dust, inadvertent ingestion and consumption of food stuffs grown in the soil, or consumption of animals that have grazed in the contaminated area.

Contaminants released to groundwater beneath the ECM will move through the geological and hydrogeological environment by advection and dispersion and may sorb to sediments. Once in the aquatic environment, there will be further dilution in Perch Creek and then in the Ottawa River. Contaminants may be taken up by aquatic flora and fauna.

The human receptors assessed in the PostSA are discussed in Section 5.8.6.1.1.3. The radioactive inventory of the ECM includes low-level waste associated with bulk unpackaged wastes and packaged wastes.
The radionuclide inventory has been screened to reduce the number of radionuclides being considered to those that are relevant for the post-closure phase. Radioactive decay and ingrowth are accounted for during the assessment time frame. The radionuclides assessed in the PostSA are presented in Table 5.8.6-4.

Table 5.8.6-4: Radionuclides Assessed in the PostSA

Radionuclides	
Ag-108m (metastable isotope silver-108)	Pu-239 (isotope plutonium-239)
Am-241 (isotope Americium-241)	Pu-241 (isotope plutonium-241)
Am-243 (isotope Americium-243)	Pu-242 (isotope plutonium-242)
C-14 (isotope carbon-14)	Ra-226 (isotope radium-226)
Cl-36 (isotope chlorine-36)	Se-79 (isotope selenium-79)
Co-60 (isotope cobalt-60)	Sn-126(isotope tin-126)
Cs-135 (isotope caesium-135)	Sr-90 (isotope strontium-90)
Cs-137 (isotope caesium-137)	Tc-99 (isotope technetium-99)
H-3 (isotope hydrogen-3 [Tritium])	Th-230 (isotope thorium-230)
I-129 (isotope Iodine-129)	Th-232 (isotope thorium-232)
Mo-93 (isotope molybdenum-93)	U-233 (isotope uranium-233)
Nb-94 (isotope Niobium-94)	U-234 (isotope uranium-234)
Ni-59 (isotope nickel-59)	U-235 (isotope uranium-235)
Ni-63 (isotope nickel-63)	U-238 (isotope uranium-238)
Np-237 (isotope neptunium-237)	Zr-93 (isotope zirconium-93)

Source: Arcadis and Quintessa 2020

In the PostSA, human health acceptance criteria have been defined according to REGDOC-2.11.1 Vol. III (CNSC 2018) which requires reasonable assurance that:

- the regulatory dose limit for public exposure (1 mSv/yr) will not be exceeded;
- the possibility of exposure to multiple sources is allowed for; and
- doses are ALARA.

The human health acceptance criteria to assess the potential impacts from radon gas is the Health Canada guideline for radon in household air of 200 Bq/m^3.

The specific criteria adopted for each scenario are outlined in the Assessment Context section of the PostSA.

The PostSA uses the best available information on the NSDF Project and its surrounding environment to form the basis of the mathematical models developed specifically to represent the system. These have been used to calculate results that can be compared with relevant Canadian criteria and standards, as well as inform on uncertainties and identify the most important aspects of the system. These uncertainties and important aspects are captured using a number of scenarios, which are summarized in the PostSA and within the groupings below:

- Normal Evolution Scenario;
- Disruptive Event Scenarios;
- Defence-in-Depth Cases;
- "What-If" Cases; and
- Sensitivity Analysis Cases.

The **Normal Evolution Scenario** is a description of the most likely, expected, evolution of the ECM and its surrounding environment. The Normal Evolution Scenario accounts for the expected degradation of the engineered barriers over the post-closure phase. It starts immediately following the operations phase, to capture the entire post-closure phase (i.e., institutional control and post-institutional control periods). It is assumed that during the institutional control period (year 2100 to year 2400), the base liner and cover will be functional and no leachate will seep through the base liner. The PostSA estimates doses to humans during the post-closure phase.

Disruptive Event Scenarios are variants on the Normal Evolution Scenario, designed to address uncertainties that have arisen during the definition of scenarios and conceptual models. Each is described with scenario-specific assumptions. The following Disruptive Event Scenarios were assessed in the PostSA:

- **Human Intrusion (Borehole):** This scenario assesses the potential of humans drilling, extracting and examining a core sample from the facility, potentially leading to internal or external exposures.
- **Human Intrusion (House with Basement):** In this scenario, a potential basement is constructed on top of the ECM and excavated soil/waste is spread over the garden area.
- **Enhanced Erosion Case:** This scenario investigates the potential faster erosion of the cap such that wastes are exposed at the ground surface and eroded materials spread downslope in the swamp area between the ECM and Perch Creek. This could be caused by seismic events.
- **Localized Cover Failure:** In this scenario, it is assumed that potential localised high infiltration through a failure in the cap, resulting in earlier bathtubbing of the ECM (relative to the Normal Evolution Scenario).
- **Localized Liner Failure:** This scenario assesses there is increased leaching through a potential failure in the base liner, resulting in delayed bathtubbing of the ECM (relative to the Normal Evolution Scenario).
- **Damage to the Berm:** This scenario assesses potential damage to the berm; the reduced height of the berm results in increased flow of water over the berm during bathtubbing and reduced the water level in the wastes.

In addition to Normal Evolution Scenario and Disruptive Event Scenarios, the PostSA also considers other types of scenarios, including "What-If" Cases, Defence-in-Depth Cases and Sensitivity Analysis Cases.

- "What-If" Cases represent a deliberately extreme set of assumptions that can be used to understand the absolute limits of safety performance. These have been identified as potentially of interest in the same way as other scenarios, but discounted from the main set of assessment calculations on the basis that they are of very low or negligible likelihood. Nevertheless, they inform on the underlying bounds to post-closure safety and, as such, provide valuable perspective. However, due to their very low likelihood they are not included in consideration for the identification and assessment of residual effects.
- Defence-in-Depth Cases are aimed at building confidence in the performance of the NSDF after closure. These cases examine the extent to which the NSDF Project depends on key engineered barriers and what would happen if those barriers were not present. This group of scenarios therefore involves hypothetical combinations in order to analyze the barriers in the system. Each scenario involves a change in one or more parameters related to a particular barrier; by comparing the results to those of the Normal Evolution Scenario, the influence of the barrier is shown.
- Sensitivity Analysis Cases are used to directly examine the effect of important uncertainties in the models and data used to represent the system. As many modelling aspects can in practice be expressed through parameter values, sensitivity cases focus on using alternative parameter value choices. The alternative parameter values that are assigned need not represent specific bounds on uncertainty (as in some cases these cannot easily be established); in other words, the alternative parameters need not necessarily be the 'highest' or 'lowest' possible values. Rather, they are used to test the effect of uncertainty; for example, if parameter x is increased by a factor of 10, by what factor does the dose increase?

These cases serve to illustrate the importance of facility design features, address uncertainty in model parameters and provide perspective on the limits of safety performance. These scenarios are not relevant for the EIS effects assessment and are therefore not discussed further in this report. In general, the EIS only restates necessary information from the PostSA. Further information on scenarios, receptors, calculations and results in general, is available in the PostSA (Arcadis and Quintessa 2020).

5.8.6.1.1.3 Receptor Selection

Operations and Closure Phases

For normal operations, the dose to the worker is quantitatively assessed. The dose to an off-site receptor (member of the public) is confirmed to be acceptable by meeting the air and water release limits as prescribed in the CRL License Conditions Handbook (CNSC 2019) and by the criteria set out in the Derived Release Limits (DRL) for CNL's Chalk River Laboratories (CNL 2018d). The NSDF Project is designed so that the potential release of radionuclides during normal operation is less than a target of 1% of the corresponding release limits and DRL.

The on-site receptors are workers and include both the NSDF Project worker and a representative CNL employee at a central location on-site. The closest public receptor was chosen to represent the off-site dose. This receptor is the Quebec cottager/resident across the Ottawa River, approximately 3 km from the SSA. Traditionally, cottagers are assumed to spend 8% of their time in the cottage area, for the purposes of dose calculations. CNL received feedback from a nearby cottage resident which indicated that the cottage was being used as a full-time residence. As a result, the cottage resident is treated as having the same occupancy factor as any other Potential Critical Group, which is conservatively assumed to be 100%. Local food and water consumption rates are based on the Canadian Standards Association (CSA) N288.1-14 (CSA Group 2014).

Post-closure Phase

The PostSA identifies two potential exposure groups conceived for the Normal Evolution Scenario:

- Resident/Farmer: A small household (comprising two adults, a child and an infant) above the ECM footprint. The household raises chickens, are assumed to grow a portion of their fruits and vegetables in the garden, as well as raise cattle in the affected swamp area. It is assumed that 100% of the family receptors' occupancy time occurs within the contaminated area. The house does not have a basement, but there is potential exposure from radon-222.
- Hunting/Recreational: This group is represented by a small number of adults and children making hunting and/or recreational use of the area surrounding the ECM, including Perch Creek and the Ottawa River. This group occasionally drinks water from the Perch Creek and eats deer hunted from the CRL site.

The PostSA also assesses other receptors as part of the Sensitivity Analysis Case. Two receptor types were chosen:

- Self-Sufficient Indigenous Group: This group represents a group of Indigenous peoples, including adults and children, using area that surrounds the ECM, including Perch Creek and the Ottawa River, for hunting and gathering. Individuals in this group are assumed to obtain all of their food through hunting and gathering in the area. It is assumed that this group would have increased consumption of fish and wild game. Furthermore, this group is assumed to gather local mushrooms and berries.
- Public Interest Receptor: This group is represented by resident receptors that obtain their drinking and bathing water from the Ottawa River, downstream from the NSDF Project. Specifically, these receptors represent the Sheenboro and Ottawa/Gatineau communities. The inclusion of these receptors was driven by public interest.

There is also a driller receptor in the Human Intrusion (Borehole) scenario and Human Intrusion (House with Basement) scenario. This driller is exposed to waste while drilling or excavating the basement.

The PostSA does not calculate the dose to an on-site worker who performs maintenance on the NSDF Project during the institutional control period. This worker's exposure is bounded by the ECM worker during operations who works directly with low-level waste, before the final cover is installed (which acts as a shield).

Table 5.8.6-5 provides a comparison of the key exposure characteristics of the Normal Evolution Scenario receptors.

Table 5.8.6-5: Receptors and Exposure Characteristics

Receptor Group	Lives On site	External Exposure	Inhalation[(a)]	Drinks from Deep Well	Drinks from Perch Creek	Drinks from Ottawa River	Grows Food On-site	Grows Food Off-site[(b)]	Raises Chickens	Raises cattle	Gathers Local Food	Collects Honey	Hunts Local Game	Fishes in Ottawa River	Uses Land for Recreation
Resident/Farmer	✓	✓		✓	✓		✓		✓	✓				✓	✓
Hunter/Recreational		✓			✓							✓	✓	✓	✓
Self-Sufficient Indigenous		✓			✓						✓	✓	✓	✓	✓
Public Interest Receptor						✓								✓	

a) Inhalation is assessed for human intrusion scenarios (disruptive event)

b) Off-site receptors who many grow food off site are evaluated as a sensitivity analysis

5.8.6.1.2 Application Case Results

5.8.6.1.2.1 Operations and Closure Phases

This section presents a summary of the estimated radiological dose results for human receptors in the pre-closure phase (i.e., construction, operations and closure) for the Normal Operations. Anticipated Operational Occurrences, Design Basis Accidents and Beyond Design Basis Accidents are considered in Section 7.0 (Accidents and Malfunctions). For further detail on these results, the reader is directed to the SAR (CNL 2020b).

The criterion used for public radiological exposure as a result of CRL site operations will be ALARA, and subject to the dose constraint of 0.3 mSv/yr for the public (CNSC 2019).

Normal Operations – On-site (Worker) Doses

Doses to the representative NSDF Project workers for normal operations were calculated and shown in Table 5.8.6-6. The peak calculated dose is to an ECM worker performing the task of macro-encapsulation of drummed wastes and is 10.4 mSv/yr. This dose is below CNL's Action Level of 20 mSv/yr, and represents 20.8% of the 50 mSv/yr limit for Nuclear Energy Workers.

Table 5.8.6-6: Doses to Representative NSDF Project Workers for Normal Operations

NSDF Project Worker Type	Effective Dose per Year (mSv/yr)
WWTP worker	5.21
ECM worker tasks:	
▪ Macro-encapsulation of drummed waste	10.4
▪ Normal ECM work	6.37

mSv/yr = millisieverts per year; WWTP = Wastewater Treatment Plant; ECM = engineered containment mound.

Normal Operations – Off-site (Public) Doses

The nearest off-site receptors are located at the Quebec cottages, approximately 3 km from the CRL site, and Chalk River, approximately 7 km west of the CRL site. The primary dose pathways for the off-site receptor are inhalation of airborne contaminants and ingestion of drinking water. Cloudshine and groundshine of the waste placed in the ECM will have a negligible effect on the off-site receptors due to the separation distance (i.e., closest receptor is approximately 3 km from the CRL site).

The effluent discharge targets for radionuclides are based on Canadian Drinking Water Guidelines with the exception of tritium for which a site-specific target is developed (Section 3.4.2.5.1). During normal operations, only the discharge of treated effluent meeting the effluent discharge targets (CNL 2019c) is expected. Therefore, the off-site receptor ingestion dose consequence will be much lower than the dose constraint of 0.3 mSv/yr for the public.

The off-site receptor inhalation dose consequence is expected to very low based on:

- The air emissions from the WWTP process tanks are a fraction of the CRL site DRLs.
- The off-site receptor inhalation dose rate is much lower than that of the ECM worker who is in direct contact with the waste (i.e., closest off-site receptor is approximately 3 km from the CRL site).

Airborne releases of contaminants during normal operations are expected to occur during:

- waste placement and compaction activities in the ECM;
- filling and draining of WWTP tanks; and
- operation of the WWTP active ventilation.

During ECM operations, dust will be controlled following the *Dust Management Plan* (AECOM 2018a), mitigating the airborne releases. During WWTP operations where there is potential for airborne releases, the active ventilation system is implemented to control the spread of contamination and gaseous effluents are directed through HEPA filters to abate particulate discharges.

The dose consequences to the off-site receptors during normal operations are expected to be much lower than the 0.3 mSv/yr dose constraint thus negligible residual effects are expected on human health from radioactivity associated with the NSDF Project during the operations and closure phase.

5.8.6.1.2.2 Post-Closure Phase

This section presents a summary of the estimated radiological dose results for human receptors in the post-closure phase for the Normal Evolution Scenario and Disruptive Event Scenarios as assessed in the PostSA. For further detail on these results, the reader is directed to the PostSA (Arcadis and Quintessa 2020).

Human health criteria for public radiological dose are as follows:

- The criterion used for public radiological exposure as a result of the Normal Evolution Scenario is that the dose to the public will be ALARA and subject to a dose constraint of 0.3 mSv/yr.
- For Disruptive Event Scenarios, the probability of exposure is considered during the scenario definition process. A regulatory dose limit of 1 mSv/yr is used for radiation exposure of humans for unlikely but credible scenarios. If the calculated dose exceeds 1 mSv/yr, the scenario is examined on a case-by-case basis, taking into account the likelihood and nature of the exposure, conservatism and uncertainty in the assessment and conservatism in the regulatory dose limit.
- Radon-222, given its source as a naturally occurring radioactive material, will be compared against a complementary safety criterion. Predicted radon-222 concentrations for relevant scenarios (i.e., within the house on the disposal facility) will be compared against the Health Canada guideline (Health Canada 2014a) for radon in household air (200 Bq/m^3), as well as against the average Ontario and Canada wide household air concentrations, 38.7 Bq/m^3 and 45.5 Bq/m^3 respectively (CNSC 2011). Furthermore, the annual effective dose in Canada for radon is around 1 mSv (CNSC 2011), and predicted radon doses can be compared to this value.

Normal Evolution Scenario

The highest calculated dose rate to any receptor in the normal evolution scenario is 0.015 mSv/y, which is 20 times lower than the dose constraint of 0.3 mSv/yr. This peak dose is received by the on-site resident/farmer adult. The peak occurs around 4,100 years after closure.

The key radionuclides and pathways for doses to the adult on-site resident/farmer are:

- external irradiation from niobium-94 and thorium-228; and
- ingestion of carbon-14 from crops and beef.

The highest calculated dose rate (0.012 mSv/yr) to the hunter/recreation receptor in the normal evolution scenario is received by the adult. This dose rate is 25 times lower than the dose constraint of 0.3 mSv/yr. The peak occurs around 650 years after closure.

The key radionuclides and pathways for doses to the adult on hunter/recreational receptor are:

- ingestion of carbon-14 from game;
- external irradiation from thorium-228, niobium-94, radium-228, radium-226; and
- ingestion of plutonium-239 from fish.

The low peak dose relative to the dose constraint implies that there are negligible residual effects expected on human health from radioactivity associated with the NSDF Project during the post-closure phase.

Any radon that may accumulate in a house potentially built on top of the NSDF Project in the post-closure phase for the NES will have a maximum concentration of 2.9 Bq/m^3, far below Health Canada guidance level of 200 Bq/m^3. This is also far below average values of radon in Ontario houses 38.7 Bq/m^3. This implies that there are negligible residual effects expected on human health due to radon buildup associated with the NSDF Project.

Receptors of public interest were also assessed. These include residents in Sheenboro and Ottawa-Gatineau drawing water from the Ottawa River. The maximum peak dose for these residents was over 70,000 times lower than the dose constraint.

Additionally, a Self-Sufficient Indigenous receptor was assessed in the PostSA. The results for this receptor are discussed in Section 6.6 of this EIS.

Disruptive Event Scenarios

Human Intrusion (Borehole)

The peak annual dose calculated for Human Intrusion (Borehole) is 0.00065 mSv and is received by the driller receptor. This peak dose rate is the highest estimated dose rate within the assessment timeframe and is over 1,500 times lower than the regulatory dose limit of 1 mSv/yr. The peak occurs around 300 years (the end of institutional control) after closure.

The key radionuclides and pathways for doses to the driller are:

- inhalation of americium-241 and its progeny thorium-228 and radium-228 from dust.

The low dose relative to the regulatory dose limit implies there are negligible residual effects expected on human health associated with the NSDF Project for the Human Intrusion Borehole Case.

Human Intrusion (House with Basement)

The peak annual dose calculated for Human Intrusion (House with Basement) is received by the on-site resident/farmer. The calculated peak dose rate is 0.017 mSv/yr, compared to the regulatory dose limit of 1 mSv/yr. This peak dose rate is over 50 times lower than the regulatory dose limit. The peak occurs around 2,900 years after closure.

The key radionuclides and pathways for doses to the on-site resident/farmer adult are:

- ingestion of carbon-14 from beef; and
- external exposure of thorium-228, niobium-94, radium-228, and radium-226 from swamp area.

The low dose relative to the regulatory dose limit implies there are negligible residual effects expected on human health associated with the NSDF Project for the Human Intrusion Basement Case.

Any radon that may accumulate in a house, potentially built on top of the NSDF Project in the post-closure period for the Human Intrusion (House with Basement) will have a maximum concentration of 10.7 Bq/m^3, far below Health Canada guidance level of 200 Bq/m^3. This is also below average values of radon in Ontario houses 38.7 Bq/m^3. This implies that there are negligible residual effects expected on human health due to radon buildup associated with the NSDF Project for the H.I. Basement Case.

Enhanced Erosion Case

The highest peak annual dose rate calculated for the Enhanced Erosion Scenario is 0.14 mSv/yr, compared to a regulatory dose limit of 1 mSv/yr. This peak dose is received by the on-site resident/farmer child receptor. This peak dose rate is 6 times lower than the regulatory dose limit. The peak occurs around 7,650 years after closure.

The key radionuclides and pathways for doses to the on-site resident/farmer child are:

- ingestion of radium-228 from foodstuffs.

The low dose relative to the regulatory dose limit implies there are negligible residual effects expected on human health associated with the NSDF Project for the Enhanced Erosion Scenario.

Localized Cover Failure

The peak annual dose rate calculated for the Localized Cover Failure Scenario is 0.017 mSv/yr, and is received by the on-site resident/farmer adult. This peak dose is over 50 times lower than the regulatory dose limit of 1 mSv/yr. The peak occurs around 2,900 years after closure.

The key radionuclides and pathways for doses to the on-site resident/farmer adult are:

- external irradiation of thorium-228, niobium-94, radium-228, and radium-226 from soil; and
- ingestion of carbon-14 from foodstuffs.

The low dose relative to the regulatory dose limit implies there are negligible residual effects expected on human health associated with the NSDF Project for the Localized Cover Failure Scenario.

Localized Liner Failure

The peak annual dose calculated for the Localized Liner Failure Scenario is estimated to be 0.01 mSv/yr, 100 times lower than the regulatory dose limit of 1 mSv/yr. This peak dose is received by both the on-site resident farmer and hunter receptors. The peaks occur around 2,600 years and 650 years after closure for the on-site resident farmer and hunter receptors respectively.

The key radionuclides and pathways for doses to the on-site resident/farmer adult are:

- External irradiation of thorium-228, niobium-94, radium-228, and radium-226 from soil; and
- Ingestion of carbon-14 from foodstuffs.

The key radionuclides and pathways for doses to the hunter/recreational adult are:

- Ingestion of carbon-14 from game;
- External irradiation of thorium-228, niobium-94, radium228, and radium-226 from soil; and
- Ingestion of plutonium-239 from fish.

The low dose relative to the regulatory dose limit implies there are negligible residual effects expected on human health associated with the NSDF Project for the Localized Liner Failure Scenario.

Damage to the Berm

The peak annual dose rate calculated for the Damage to Berm Scenario is 0.02 mSv/yr, and is received by both the on-site resident/farmer adult and hunter/recreational adult receptors. This peak dose is lower than the annual regulatory dose limit of 1 mSv/yr by 2 orders of magnitude. The peak occurs around 3,600 years and 700 years after closure for the on-site resident farmer and hunter/recreational adult receptors respectively.

The key radionuclides and pathways for doses to the on-site resident/farmer adult are:

- External irradiation of thorium-228, niobium-94, radium228, and radium-226 from soil; and
- Ingestion of carbon-14 from foodstuffs.

The key radionuclides and pathways for doses to the hunter/recreational adult are:

- Ingestion of carbon-14 from game; and
- External irradiation of thorium-228 from soil.

The low dose relative to the regulatory dose limit implies there are negligible residual effects expected on human health associated with the NSDF Project for the Damage to Berm Scenario.

5.8.6.2 Non-radiological Exposure Assessment

5.8.6.2.1 Application Case Methods

The non-radiological exposure assessment considers the ways in which human receptors (introduced in Section 5.8.2) could be exposed to contaminants present in the various environmental media. In general, human receptors may come into contact with contaminants through four primary exposure routes: dermal exposure, incidental ingestion (e.g., of soil), ingestion of contaminated food and inhalation.

This EIS relies upon supporting documents for the prediction and assessment of potential non-radiological effects on human receptors.

5.8.6.2.1.1 Operations and Closure Phases

For the Operations phase of the NSDF Project, the main supporting information is from modelling completed for surface water quality (Section 5.4.2). The non-radiological exposure assessment considered the following two scenarios for the surface water environment (described in Section 5.4.2.6.1.2):

- Scenario 1: This scenario divides the total annual discharge equally between the exfiltration gallery at East Swamp weir and Perch Lake (direct pumping to Perch Lake via transfer line). Scenario 1 was modelled to examine if an exfiltration gallery approach resulted in any measurable decrease in projected Perch Lake concentrations (i.e., some degree of mixing and dilution of WWTP effluent with ambient concentrations anticipated upstream of Perch Lake).
- Scenario 2: This scenario discharges 100% of the total annual discharge directly into Perch Lake at the northeastern shoreline. Scenario 2 was modelled to examine the “worst case” scenario of projected Perch Lake concentrations (i.e., no available mixing nor dilution upstream of Perch Lake).

The two surface water model scenarios were completed for a select group of parameters termed constituents of potential concern (COPCs). Key elements of the COPC selection process included identifying those parameters that were expected to change as a result of the NSDF Project, those with available guidelines and those that were expected to be toxic to aquatic organisms. The ten selected COPCs were aluminum, barium, copper, iron, lead, manganese, phosphorus, selenium, silver, and zinc.

A preliminary screening was completed as shown in Section 5.4.2.6.1.4, wherein predicted concentrations of parameters in untreated effluent were compared to effluent discharge targets. The effluent discharge targets (see Table 3.4.2-3) are generally based on aquatic guidelines from a variety of sources including Canadian Council of Ministers of the Environment (CCME), United States (US) Environmental Protection Agency (EPA), US Department of Energy and others. However, to ensure that human health is adequately protected, predicted concentrations of non-radiological parameters were compared to federal guidelines that are protective of human health. Where federal guidelines were not available, provincial guidelines that are similarly protective of human health were consulted. In the absence of both federal and provincial guidelines, alternate guidelines from other jurisdictions were used. The selected guidelines are described below (see Section 5.8.6.2.1.3).

It is noted that the air quality discipline assessed the predicted non-radiological concentrations in air emissions during the operations phase of the NSDF Project. Predicted concentrations for the Application Case during both construction and operations phases are below applicable air quality guidelines and/or standards with the exception of nitrogen dioxide, that will not meet the 2020 1-hour Canadian Ambient Air Quality Standards (Section 5.2.1.6.2, Table 5.2.1-14). The contributing factor to the high magnitude nitrogen dioxide emissions is the heavy-duty construction equipment and the conservative assumption that all equipment will run simultaneously and continuously during working hours. In reality, individual equipment will be idling or off for varying parts of the workday that can not be predicted but will result in lower emissions than currently estimated. The likelihood that all equipment operates simultaneously for an hour or more along with unfavourable weather conditions to produce the maximum concentrations modelled is very low. With the implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018b) and through the implementation of the *Dust Management Plan* (AECOM 2018a) for the NSDF Project, residual effects from the NSDF Project on air quality are predicted to be not significant. Consequently, non-radiological concentrations in air emissions during the operation phase were not considered for human health.

5.8.6.2.1.2 Post-Closure Phase

For the assessment of human health in the post-closure phase of the NSDF Project, the main supporting document is the PostSA (Arcadis and Quintessa 2020). A general background of the non-radiological methods of the PostSA is provided as follows:

Post-Closure Safety Assessment (PostSA)

The PostSA (Arcadis and Quintessa 2020) analyzes the long-term implications (i.e., during the institutional control and post-institutional control periods) on human health of the NSDF Project.

Evaluating post-closure safety requires projections of the future condition of the NSDF Project and its environment, and how receptors might interact with it. Approaches have been developed to undertake such evaluations, centred on a "system analysis" method. This involves representing the NSDF Project, the facility inventory present and all potentially relevant media, with mathematical models to represent the key processes that may occur (e.g., corrosion of wastes, dissolution into groundwater, uptake by plants). It is essential that the models used are relevant, well-grounded and auditable. This is achieved through a systematic approach to safety assessment. The international community has developed best practice guidance on the process, which is documented in a report of the IAEA ISAM programme (IAEA 2004) and incorporated into a more recent safety guide (IAEA 2012). This process has been applied internationally since its publication, is consistent with REGDOC 2.11.1 Vol. III (CNSC 2018), and underpins the PostSA analysis. Although this approach has been developed with radiological contaminants in mind, the same principles are considered to be appropriate for non-radiological contaminants and offers consistency in the approach used to assess both contaminant types for the NSDF Project.

The PostSA considers two primary pathways of release of non-radiological contaminants into the environment:

- leachate may be released to soil via overtopping the berm, which can affect human health; and
- leachate may be released through the base liner to groundwater, which can affect human health.

Contaminants released by overtopping the berm will move through the shallow environment by overland flow and interflow resulting in contamination of surface soils. Exposures can arise by external irradiation, inhalation of dust, inadvertent ingestion and consumption of food stuffs grown in the soil, or consumption of animals that have grazed in the contaminated area.

Contaminants released to groundwater beneath the ECM will move through the geological and hydrogeological environment by advection and dispersion and may sorb to sediments. Once in the aquatic environment, there will be further dilution in Perch Creek and then in the Ottawa River. Contaminants may be taken up by aquatic flora and fauna.

It is noted that release of volatiles to air was not considered a primary pathway for non-radiological contaminants given that no volatile non-radiological contaminants have been identified as COPCs.

As noted in Section 3.3.1.3.1, the NSDF Project will follow the guidelines of Ontario's *Regulation 347, General – Waste Management*, thus constraining the non-radiological inventory and limiting the environmental effects in the post-closure phase of the NSDF Project. However, an estimate on the quantity of discrete metals and organics in the NSDF at closure which is comprised of primarily wood, metals and bulk solid wastes. The non-radionuclides explicitly assessed in the PostSA include:

- aluminum;
- copper;
- lead; and
- uranium.

Similar to the radiological dose assessment, six scenarios were considered for the post-closure phase for the non-radiological exposure assessment. These scenarios are described in Section 5.8.6.1.1.2

5.8.6.2.1.3 Guidelines

This section discusses the guidelines that were used to assess the effects from non-radiological elements on human receptors.

Guidelines Used in the Operations Phase

In the operations phase, federal and provincial health-based surface water guidelines were used, as follows.

Federal Guidelines

The federal guidelines include those published by the CCME and Health Canada:

- The Health Canada Guidelines for Canadian Drinking Water Quality are based on health effects, aesthetic effects and operational considerations for drinking water (Health Canada 2014b). Health-based standards are listed as maximum acceptable concentrations and are established based on comprehensive review of known health effects, exposure levels and the availability of treatment and analytical technologies. If no health-based standard was available for a given chemical, then an aesthetic objective or operational guideline was used. Aesthetic objectives (i.e., taste and odour) are established based on whether people will consider the water drinkable. Operational guideline values are established based on levels that may interfere or impair water treatment processes or technology or adversely affect drinking water infrastructure. If health-based guidelines were not available from another source, then the aesthetic/operational values were selected for use in the assessment.

Provincial Guidelines

The provincial guidelines include those published by the Ministry of the Environment, Conservation and Parks:

- The Provincial Water Quality Objectives (PWQOs) are intended to be protective of aquatic life and recreational uses of surface waters (MOEE 1994). The PWQOs represent a desirable level of water quality strived to be maintained in the province. While these objectives are intended for protection of aquatic life, it is considered that they are also protective of human and wildlife health because PWQOs are typically much lower than drinking water guidelines and livestock watering guidelines. Where the PWQOs are explicitly based upon an aquatic endpoint, an alternate health-based guideline from another jurisdiction was selected if available.
- The primary purpose of the Ontario Drinking Water Standards (O. Reg. 169/03) is to protect public health through the provision of safe drinking water. The standards are protective against unsafe concentrations of toxic metals, radioactive substances and disease-causing organisms. Like the drinking water quality standards from Health Canada (i.e., Canadian Drinking Water Quality), Ontario Drinking Water Standards are presented as maximum acceptable concentrations above which there are known or suspected adverse health effects. Standards can also be based on aesthetic objectives, including taste, odour, turbidity and colour, or operational guidelines, including corrosiveness.

Alternate Guidelines

For parameters for which federal and/or provincial guidelines were not health-based (i.e., operational guidelines or aesthetic objectives from Health Canada or based on aquatic life for the PWQOs), alternate guidelines were also considered. Alternate guidelines were sourced from the US EPA. The US EPA provides a similar level of review of the available scientific literature and a similar approach to setting water quality guidelines as Health Canada and Ontario to be protective of human health and the environment. The selected health-based guidelines are shown below in Table 5.8.6-7.

Table 5.8.6-7: Selection of Health-Based Guidelines for Non-Radiological Parameters in Surface Water

Parameter	Federal Guidelines	Provincial Guidelines		Alternate Guidelines
	Health Canada[a] (µg/L)	PWQO[b] (µg/L)	ODWS[c] or GW1[d] (µg/L)	US EPA Tap Water[e,f] (µg/L)
Aluminum	100 (OG)	15	NV	4,000
Barium	1,000	NV	NV	NV
Copper	1,000 (AO)	1	NV	160
Iron	300 (AO)	300	NV	2,800
Lead	10	1	NV	NV
Manganese	120[g]	NV	NV	NV
Phosphorus	NV	NV[h]	NV	NV
Selenium	50	1	NV	NV
Silver	NV	0.1	100	NV
Zinc	5,000 (AO)	30	NV	1,200

Note: Selected health-based guidelines are shown with grey shading.

(a) Health Canada 2014b.

(b) MOEE 1994.

(c) O. Reg.. 169/03.

(d) MOE 2011.

(e) US EPA 2016.

(f) The US EPA Tap Water Regional Screening Levels (RSLs) were derived considering a target Hazard Quotient of 0.1 and Incremental Lifetime Cancer Risk of one in a million. The values presented in this table reflect a target Hazard Quotient of 0.2 (to be consistent with Ontario).

(g) Health Canada 2019.

(h) A PWQO is available for total phosphorus of 10 µg/L, which is based upon algal growth. There are no health-based drinking water guidelines available for phosphorus, as it is generally considered to be non-toxic at environmental concentrations. It is an essential element for human nutrition at upper limit daily intakes of 3 to 4 grams per day (Institute of Medicine 1997).

PWQO = Ontario Provincial Water Quality Objective; ODWS = Ontario Drinking Water Standard; GW1 = Groundwater component value protective of drinking by humans; US EPA = United States Environmental Protection Agency; OG = operational guidelines; AO = aesthetic objective; NV = No Value; µg/L = micrograms per litre.

The selected health-based guidelines are considered to be protective of members of the public (including sensitive receptors such as the very young, elderly, women of child-bearing age and those with pre-existing conditions) that rely on surface water for drinking and bathing. For the purposes of this assessment, it has been assumed that there are no restrictions on members of the public obtaining their potable water from the surface water nodes that may be affected by the NSDF Project during the operations phase. This is a conservative assumption as no water intakes are known to exist in any of the affected waterbodies and none of the areas around the waterbodies are populated.

Guidelines Used in the Post-closure Phase

In the post-closure phase, Environmental Quality Standard (EQS) criteria for groundwater, soil, sediment and surface water were used as guidelines for assessing the potential for adverse effects due to exposure by food chain and/or other pathways. The EQS guideline values, described in the Assessment Context section of the PostSA (Arcadis and Quintessa 2020), are presented as concentrations in environmental media. Consequently, the explicit assessment of the uptake of these substances into biota is not required; for example, exposure via drinking water intake does not need to be calculated if the drinking water concentration is below the EQS. If a contaminant concentration exceeds the EQS in any of the media, these species were further assessed using more detailed, more realistic risk assessment models. The EQS values are based on federal and provincial guideline concentrations for groundwater, surface water, soil and sediment, as follows:

- Guideline concentrations for groundwater, soil and sediment were taken primarily from MOE (2011), since these are the most conservative.
- For surface water, the most conservative guideline concentration values between MOEE (1994) and CCME (2019) were selected.
- For several elements of potential interest, no criteria were provided in MOEE (1994), CCME (2019) or MOE (2011). In these cases, surface water criteria were taken from Sneller et al. (2000), Suter and Tsao (1996), ODEQ (2001) and CCOHS (2009).

5.8.6.2.2 Application Case Results

5.8.6.2.2.1 Operations

The predicted concentrations for the non-radiological COPCs in the discharge from the WWTP were compared to the effluent discharge targets for the NSDF Project and to local ambient water quality at the six water quality nodes (see surface water quality modelling results in Section 5.4.2.6.2). The predicted concentrations of all the parameters measured, with the exception of aluminum, barium, copper, iron, lead, manganese, phosphorus, selenium, silver and zinc, met the effluent discharge criteria at all sampling nodes (while phosphorus concentrations exceeded the effluent limit, phosphorus is considered non-toxic to humans). Concentrations of aluminum, barium, copper, iron, lead, manganese, phosphorus, selenium, silver and zinc exceeded the effluent limits at one or more of the water quality nodes, but were generally at or below local ambient concentrations at these nodes.

Comparison of the predicted concentrations to the selected health-based guidelines is shown in Table 5.8.6-8.

Table 5.8.6-8: Comparison of Health-Based Guidelines to Maximum Predicted Surface Water Concentrations for each Parameter for All Modelled Scenarios and Locations

Parameter	Health-Based Guidelines (µg/L)	Maximum (µg/L)	Scenarios with Exceedances	Locations with Exceedances
Aluminum	4,000	665	None	None
Barium	760	18.8	None	None
Copper	160	8.4	None	None
Iron	2,800	2,867	Scenario 1 Scenario 2	East Swamp weir (local ambient, 95th and max)
Lead	5	5.2	Scenario 1 Scenario 2	Ottawa River (local ambient)
Manganese	120	130	None	Perch Creek weir (local ambient)
Phosphorus	No Value	62	None	None
Selenium	50	1.28	None	None
Silver	100	1.047	None	None
Zinc	5,000	6.59	None	None

µg/L = micrograms per litre.

The predicted concentrations for all modelled parameters for Scenarios 1 and 2 (i.e., operations phase when leaching will be treated at the WWTP prior to discharge) met their respective health-based guidelines with the exception of iron, lead and manganese.

The maximum predicted iron, lead and manganese concentrations at select nodes slightly exceeded their respective health-based guidelines primarily due to existing ambient concentrations.

Considering the conservative assumptions related to the non-radiological concentrations in the waste material and the conservative assumptions in the water quality modelling (Section 5.4.2), and considering that wastes will be required to meet the facility's Waste Acceptance Criteria, risks associated with these parameters and phases are likely negligible. Therefore, with additional information related to water hardness, risks associated with these parameters and phases can be refined.

The peak generation rates of landfill gases occur at the time, 1 year after closure of the ECM (year 51), and the landfill gases and peak generation rates are (AECOM 2018d):

- The total Landfill gases generation rate is 251,700 m^3/yr out of which:
  - Methane generation rate is 125,800 m^3/yr.
  - Carbon dioxide generation rate is 125,800 m^3/yr.

The values stated above are conservative because the rates were determined based on wastes under conditions ideal for the decomposition where all of the organic material in the waste could be completely decomposed. Conditions for the NSDF will not be ideal for waste decomposition as the design and operating practices will result in an in-place waste mass that is too dry to support optimal decomposition.

To address the unlikely event that higher ECM landfill gases generation rates are higher than are currently anticipated, the final cover system design includes landfill gas vents to mitigate against potential future buildup of gas pressures within the ECM after closure.

5.8.6.2.2.2 Post-closure

This section presents results for human health related to non-radiological contaminants for the Normal Evolution Scenario and Disruptive Event Scenarios. Additional details are provided in the PostSA (Arcadis and Quintessa 2020).

Normal Evolution Scenario

During the 10,000-year assessment timeframe of the PostSA, peak concentrations of copper, lead and uranium are below the corresponding environmental quality criteria (EQS) for soil, sediment and water, except for the concentration of lead in groundwater adjacent to the ECM. The concentration of uranium in groundwater is approaching the EQS, and slightly exceeds the EQS for the swamp soils.

Aluminum is a key component of clay minerals in soils and sediments. Therefore, there are not environmental quality standards for aluminum. The peak concentration in groundwater immediately downgradient of the ECM is only slightly elevated above background. However, the concentration is much lower in surface waters. For context, concentrations of aluminum in groundwater and surface water are well below the Health Canada proposed operational guidance value and maximum acceptable concentrations in drinking water (Health Canada 2019). It is noted that these guidance values are not meant for application to environmental concentrations.

Non-radiological contaminants were assessed in the PostSA following a very cautious approach. All non-radiological contaminants were assumed to be readily available for dissolution and leaching upon contact with water, whereas in reality most of the non-radiological inventory will be encased in iron-based matrices. Additionally, as noted in Section 3.3.3.3, the disposal of the remaining small fraction of non-radiological inventory will meet land disposal regulations, which are protective of public health and the environment. Therefore, there are negligible residual effects are expected from non-radiological contaminants associated with the NSDF Project.

Disruptive Event Scenarios

The PostSA model calculates some exceedances for lead, aluminum, copper, and uranium for disruptive events. As discussed for the normal evolution scenario above, the modelling assumptions are conservative, and do not take into account the containment of metal-based matrices or land disposal regulation requirements. Therefore, there are negligible residual effects are expected from non-radiological contaminants associated with the NSDF Project for Disruptive Event scenarios.

5.8.7 Prediction Confidence and Uncertainty

Table 5.8.7-1 describes key uncertainties in assessing residual effects from the NSDF Project on human health and how conservatism in the analysis and assumptions addressed these uncertainties.

Table 5.8.7-1: Uncertainties in the Human Health Assessment

Parameter	Uncertainty	Conservatism and Assumptions
Waste Inventory (radiological)	There is uncertainty with regards to the inventory of radionuclides that have been accumulated over the decades of operation of CRL site, as well as the projected inventory of wastes that will be generated in the future.	- Both already accumulated wastes and those that will be generated in the future will have to meet NSDF Waste Acceptance Criteria. - The effect of uncertainty in the radiological inventory is explored in 'Sensitivity Analysis Case - Inventory Sensitivity' for the post-closure phase.
Waste Inventory (non-radiological)	There is uncertainty with regards to the inventory of hazardous wastes (i.e., non-radionuclides) that have been accumulated over the decades of operation of the CRL site, as well as the project inventory of hazardous wastes (i.e., non-radionuclides) that will be generated in the future.	- Both already accumulated wastes and those that will be generated in the future will have to meet NSDF Waste Acceptance Criteria.
ECM Performance	There is uncertainty with regards to when protective barriers may begin to fail due to erosion or other natural events.	- The ECM includes multiple protective barriers in the cover and base liner, designed to isolate the waste even in the event if one or more of the barriers were to fail. - The ECM can be maintained and monitored during the period of institutional control. Any issues identified during - this period can be mitigated. - The PostSA considers two conservative scenarios involving premature failures of the cover and base liner.
Source term	There is uncertainty associated with airborne and waterborne release rates.	- Waterborne releases from the WWTP are assumed to contain contaminants at maximum permissible concentrations. This is a bounding assumption; in most cases concentrations will be a minor fraction of maximum permissible concentrations. - Airborne releases from the ECM are based on empirical data for carbon-14 and tritium oxide and on a conservative model for radon-222. - In the PostSA, water release from overtopping the berm is assumed to begin earlier than it would realistically be expected to occur, i.e., it does not account for the time required for the water level in the ECM to rise above the level of the berm. - The generation rate of bulk gases will heavily depend on the nature and quantity of organic and metal wastes, which are currently not well-defined for the ECM. - Accumulation of radon-222 was calculated using an approach that typically overestimates the radon-222 concentrations found in buildings. - Carbon-14-labelled gases are assumed to be released to the surface at the rate they are generated.

Table 5.8.7-1: Uncertainties in the Human Health Assessment

Parameter	Uncertainty	Conservatism and Assumptions
Human habits	It is uncertain that future populations will maintain current habits, consumption rates, and that the location of population centers will not change.	▪ The PostSA (Normal Evolution Scenario) makes conservative assumptions about future land use, using different human receptor groups, such as a resident/farmer household living on the ECM footprint, growing fruits and vegetables, and raising poultry and cattle. ▪ To investigate sensitivity to changes in future human habits and location of potential exposure groups, the PostSA considers scenarios involving borehole drilling, and a house with a basement on the ECM.
Conceptual model	This uncertainty is associated with conceptual model for groundwater flow and potential future effects on it resulting from the climate change.	▪ Current groundwater flow and contaminant transport in Perch Lake area are well understood due to decades of data available for the site. ▪ Groundwater flow model (Golder 2019) was calibrated against the available datasets based on the existing plumes emanating from WMAs and LDAs. ▪ The PostSA includes a Sensitivity Analysis Case where groundwater transit time to Perch Creek is reduced to 5 years (from 7 years in the Normal Evolution Scenario). ▪ Characterization of the site includes 25 test pits, 70 boreholes, and 47 monitoring wells, among other monitoring and testing activities.
Assessment of radiological doses to members of the public	There is uncertainty in modelling parameters used for the assessment of radiological dose to members of the public	▪ In the PostSA, assumptions for dispersion, consumption and intake rate parameters are mainly based on CSA N288.1 (CSA Group 2014). ▪ Conservative values are chosen for occupancy and other human exposure factors in the PostSA. ▪ Estimated radiological doses represent a very minor fraction of the limit.
Leaching and Transport parameters	Parameter uncertainty may lead to underestimation of radiological doses to members of the public and non-human biota	▪ The site characteristics are well understood, owing to many decades of monitoring. ▪ To test the effect of uncertainty in sorption rates, the PostSA includes a Sensitivity Analysis Case where a lower water-soil distribution coefficient (K_d) was assumed. A lower K_d would result in more rapid release and more rapid transport in groundwater.
Effect of Environment on ECM	Performance of the ECM barriers could be impeded by natural events, such as floods, weathering, animal borrowing and fires destroying vegetative cover.	▪ To address uncertainty in the performance of the cover and liner during the post-closure phase, the PostSA examines the effect of accelerated degradation of these barriers (relative to their design life). ▪ Additionally, the PostSA explores the importance of both the cover and liner using two scenarios that assume either the cover or the liner is absent at the time of closure. A third scenario is also included to assess the importance of the berm.

Table 5.8.7-1: Uncertainties in the Human Health Assessment

Parameter	Uncertainty	Conservatism and Assumptions
Modelling Tool uncertainty	Uncertainty associated with conceptual models built within AMBER codes	▪ The models used in the PostSA calculations (e.g., AMBER) have undergone model validation for the relevant pathways and exposure scenarios. ▪ The assessment of long-term safety of the NSDF in the PostSA was undertaken in accordance with Canadian Nuclear Safety Commission REGDOC-2.11.1, Vol. III (CNSC 2018), which states: ▪ *"Due to the uncertainty of predictions made far into the future, the reliability of quantitative predictions diminishes with increasing timescale. The demonstration of safety will rely less on quantitative predictions and more on qualitative arguments as the timescale increases. Long-term quantitative predictions should therefore not be considered as guaranteed impacts, but rather as safety indicators."* ▪ It also states that: ▪ *"uncertainties in the modeling should be addressed by conservatism built into: 1. the assessment model; 2. the scenario design; and 3. parameter choice."* ▪ As documented within this table, modelling uncertainty is addressed with conservatism built into the model, scenario design, and parameters.
Cumulative Effect	Uncertainty associated with the cumulative effect during post-closure, taking into account releases from WMAs and LDAs in the Perch Creek Basin.	▪ Canadian Nuclear Laboratories is developing an appropriate environmental remediation concept for contaminated areas. The decision-making process is based on radiological effects. ▪ It is expected that, if there is any potential to have cumulative effects exceeding safety objectives, then contaminated land from WMAs and LDAs will be removed prior to the NSDF closure.

ECM = engineered containment mound; WMA = Waste Management Area; LDS = Liquid Dispersal Area; PostSA = Post-closure Safety Assessment.

5.8.8 Residual Effects Classification and Determination of Significance

The residual effects analysis methods for the human health assessment are different in some notable ways from those used by other VCs. Specifically, the assessment of potential effects to human health VCs results in the generation of risk factors that inherently consider the geographic extent, duration, frequency and other characteristics of the predicted changes to the environment that may result from Project activities. As such, these inherent attributes cannot be used to determine environmental significance, as they can with other components. Instead, significance for human health is evaluated based on: (i) the potential magnitude of the response, as indicated by the comparison to dose limits (for radionuclides) or risk benchmark values (for non-radionuclides) and (ii) the degree of conservatism and uncertainty in the analysis.

Results of the radiological dose assessment for the operations phase and post-closure phase indicates that doses to human health VCs are below their respective dose limits or risk benchmark values. In addition, all predicted non-radiological concentrations were less than their selected guidelines or alternate benchmarks. Although uncertainties in the assessment exist (Section 5.8.7), conservatism has been included in the modelling so that residual effects are not greater than predicted. As such, residual effects are not significant for all human health VCs.

5.8.9 Monitoring and Follow-up

Monitoring of environmental media at the CRL site and surrounding area will proceed in alignment with CNL's existing Environmental Monitoring Program. This includes sampling and analysis of surface water, groundwater, sediment, soil, vegetation, ambient air, milk, garden produce, game animals, farm animals and fish (CNL 2018c). Section 5.7.4 provides additional details regarding the scope of these programs for monitoring radioactivity in environmental media. CNL's Environmental Monitoring Program includes assessment of dose to members of the public based on emissions monitoring and measurements in environmental media (CNL 2018c). Additionally, the dose to workers at CRL is monitored and reported to the CNSC annually.

Emissions and effluents from the NSDF Project during the construction, operations and closure phases and institutional control period will be managed in accordance with CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018b). This standard defines the key requirements, responsibilities and processes for the management of radioactive and non-radioactive emissions at the NSDF Project. The NSDF *Environmental Protection Plan* (AECOM 2018e) expands on the regulatory requirements of CSA N288.5 (CSA Group 2011) for the management of these emissions. For example, operational control monitoring will be completed to confirm emission controls and treatment systems are functioning as intended. In addition, effluent monitoring will be completed to verify that emissions meet effluent discharge targets.

The CRL Effluent Verification Monitoring Program will be established for the monitoring of emissions estimated from the NSDF Project. The Effluent Verification Monitoring Program at the NSDF Project site is required to demonstrate compliance with the dose constraint of 0.3 mSv/yr for the public.

Proposed environmental assessment monitoring and follow-up programs for the NSDF Project are documented in Section 11, including activities related to human health:

- air quality (i.e., dust) will be monitored at the SSA and air effluent verification monitoring will be performed at the WWTP;
- dust samples collected in the high-volume air sampler during construction and operations will be screened for radioactivity;
- treated effluent from the WWTP, stormwater pond effluent and surrounding surface water quality will be monitored;
- ambient radioactivity will be measured at the SSA; and
- groundwater monitoring will be performed surrounding the ECM, to confirm groundwater quality and detect potential releases of constituents from the ECM containment area.

These monitoring activities will occur during operations, closure and post-closure. The need for and duration of monitoring will be reviewed based on annual review of monitoring data.

5.8.10 Conclusions

Valued components refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community or the public (The Agency 2018). The human health risk assessment focused on worker and public health. Assessment endpoints are qualitative expressions used to assess the significance of residual effects on VCs and represent the key properties of the VC that should be protected for future human generations (i.e., incorporates sustainability). The assessment endpoint is the protection of human health. Measurement indicators represent properties of the environment, that when changed, could result in or contribute to an effect on an assessment endpoint. Measurement indicators for the human health assessment include changes in air quality, groundwater quality and surface water quality.

Radiological dose to humans may result from waterborne or airborne emissions from the NSDF Project. Dose to humans from waterborne emissions is calculated during the operations phase, as well as during the post-closure phase for the NSDF Project. The peak calculated doses for all scenarios and sensitivity cases are summarized in Figure 5.8.10-1. The doses are compared against the 0.3 mSv/y dose constraint for the normal evolution scenario, the 1.0 mSv/yr regulatory dose limit for disruptive events, and the average background radiation dose in Canada of 1.8 mSv/yr. For the on-site (worker), the maximum dose during normal operations is calculated to be 10.4 mSv/yr. During the institutional control period, the on-site worker dose is bounded by the operational phase results.

For off-site receptors during the operational phase, there are two radiological dose exposure pathways: airborne and waterborne releases. The effluent discharge targets for radionuclides are based on Canadian Drinking Water Guidelines with the exception of tritium for which a site-specific target is developed (Section 3.4.2.5.1). During normal operations, only the discharge of treated effluent meeting the effluent discharge targets (CNL 2019c), is expected. Therefore, the off-site receptor ingestion dose consequence will be much lower than the dose constraint of 0.3 mSv/yr for the public. Airborne releases of dust are controlled during operations, mitigating airborne releases. The dose consequences to the off-site receptors during normal operations are expected to be negligible and much lower than the 0.3 mSv/yr dose constraint.

During the post-closure phase, the maximum calculated dose during the Normal Evolution Scenario is to the on-site resident/farmer adult, and is 0.015 mSv/y, which is 20 times lower than the annual dose constraint of 0.3 mSv/yr. For Disruptive Events, the maximum dose is 0.14 mSv/yr as a result of the Enhanced Erosion Case, which is 6 times lower than the criterion.

Non-radiological chemicals were screened by comparing concentrations to the federal guidelines that are protective of human health. The predicted concentrations for all modelled parameters for Scenarios 1 and 2 (i.e., operations phase when leachate will be treated at the WWTP prior to discharge) met their respective health-based guidelines. Therefore, there are no anticipated risks to human health due to the modeled non-radiological parameters during the operations phase of the Project.

Although uncertainties in the assessment exist, conservatism has been included in the modelling so that residual effects are not greater than predicted. As such, residual effects are not significant for all human health VCs during the operations phase and the post-closure phase. Monitoring and follow-up programs are described in Section 5.8.9 and include implementation of the existing Effluent Verification Monitoring Program, Groundwater Monitoring Program and Environmental Monitoring Program, as well as NSDF-specific environmental monitoring activities. These activities will verify effects predictions for human health.

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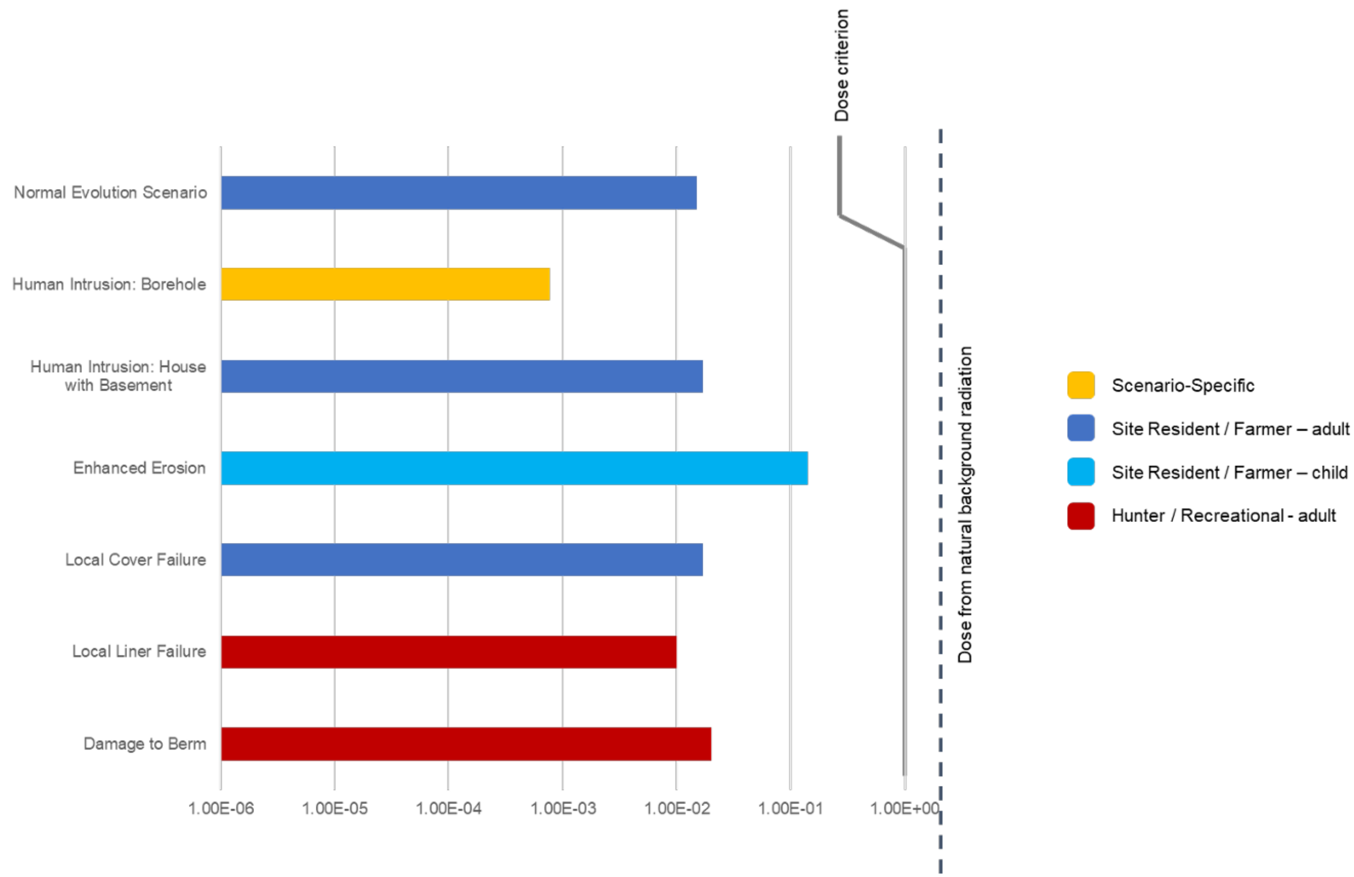

REFERENCE(S)
1. ARCADIS 2019

CLIENT
CANADIAN NUCLEAR LABORATORIES

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	PR
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT

TITLE
PEAK CALCULATED DOSES AND ASSOCIATED POTENTIALLY EXPOSED GROUPS

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	**5.8.10-1**

5.9 Land and Resource Use

Section 5.9 of the Environmental Impact Statement (EIS) for the Canadian Nuclear Laboratories (CNL) Near Surface Disposal Facility (NSDF) Project seeks to understand and characterize the potential residual effects of the NSDF Project and previous, existing and reasonably foreseeable developments on land and resource use. The land and resource assessment considers outdoor recreation and tourism, land tenure, and archaeology. Traditional land and resource use by Indigenous peoples is considered in Section 6.4.

The assessment of effects on land and resources identifies linkages between the NSDF Project activities and current environment, to determine the residual effects of the NSDF Project on land and resource use. Residual effects (i.e., those effects remaining after the implementation of all mitigation) are placed in the context of the cumulative effects of previous, existing and future projects.

5.9.1 Scope of the Assessment

The land and resource use assessment follows the overall environmental assessment approach and methods described in Section 5.1 Environmental Assessment Approach. The assessment is completed following the key steps listed below:

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries and assessment cases** for the land and resource use assessment (refer to Sections 5.9.2 Valued Components and Section 5.9.3 Assessment Boundaries). The VCs, assessment endpoints and measurement indicators used to assess Project-related changes to the land and resource use are described; along with the spatial and temporal boundaries at which the assessment occurred; and the assessment cases considered.
- **Step 2 – Describe the existing conditions** (refer to Section 5.9.4 Description of the Environment). Existing conditions in the local and regional areas are described, including the combined effects of previous and existing developments (Base Case). The existing environment represents the historical and current environmental pressures that have shaped the observed patterns in the land and resource use environment. The existing conditions provide a reference to which the effects of the NSDF Project can be compared.
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 5.9.5 Project Interactions and Mitigation). Project components and/or activities with the potential to affect land and resource use are identified and mitigation developed to limit or avoid effects is presented. A pathways analysis is then used to focus further assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects are adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated.
- **Step 4 – Present the methods and results of the residual effects analysis**. This step was not required as no primary pathways were identified in the land and resource use assessment.
- **Step 5 – Describe the level of certainty and management of uncertainty.** This step was not required as no primary pathways were identified in the land and resource use assessment.
- **Step 6 – Classify and determine the significance of the predicted residual effects**. This step was not required as no residual adverse effects were identified in the land and resource use assessment.

- **Step 7 – Identifying monitoring and follow-up** required to confirm effects predictions and address uncertainty (refer to Section 5.9.6 Monitoring and Follow-up).
- **Step 8 – Present a consolidated summary of conclusions and outcomes of the assessment** of residual effects on land and resource use (refer to Section 5.9.7 Conclusions).

Information and areas of interest raised by stakeholders and Indigenous peoples during engagement that influenced the scope of the land and resource use assessment are summarized in Table 5.9.1-1. A full record of engagement activities is available in Section 4.3.1. Other general areas of interests and questions raised during the engagement that pertain to the land and resource use assessment (if any) are documented CNL's Indigenous Engagement Report (CNL 2020) and CNL's Stakeholder's Activity Reports (CNL 2017a,b, 2019).

Table 5.9.1-1: Summary of Area of Interest Raised during Engagement Activities that Influenced the Scope of the Land and Resource Use Assessment

Area of Interest	How the Area of Interest Was Included in the Land and Resource Use Assessment
Interest expressed in relation to potential effects on fish and fish harvesting due to concerns of potential contamination or radioactive seepage into Perch Creek, the Ottawa River and other waterbodies from the NSDF Project.	The spatial boundaries of the land use assessment were selected to include consideration of potential effects on water quality and include the aquatics study areas. CNL continues to monitor the aquatic environment extensively, specifically Perch Creek. The NSDF Project has used recent modelling to understand the potential for effects within the Perch Creek and Perch Lake watershed. Existing land use with regards to fishing is described in Section 5.9.4.1.3.2 (outdoor tourism and recreation) and existing traditional land use with regard to fishing is described in Section 6.4.4.1.2.3. Potential effects on these VCs are assessed in Section 5.9.5 and Section 6.4.5. CNL conducts monitoring of fish in the Ottawa River for radioactive contamination as part of its Environmental Monitoring Program. The spatial boundaries for the land use assessment were expanded to include reach of the Ottawa River extending 8 km downstream from CRL site.
Interest expressed in relation to potential effects on recreational activities (i.e., boating and swimming) due to concerns of potential contamination or radioactive seepage into the Ottawa River and other waterbodies from the NSDF Project.	The land use assessment included outdoor tourism and recreation as a VC. The spatial boundaries for the land use assessment include consideration of potential effects to the aquatic environment, and specifically include the aquatics study areas. CNL continues to monitor the aquatic environment extensively. The NSDF Project has used recent modelling to understand the potential for effects within the Perch Creek and Perch Lake watershed. CNL conducts environmental monitoring for tritium and other radionuclides in environmental media including fish from the Ottawa River. Outdoor tourism and recreation is addressed in Section 5.9.4.1.3. The spatial boundaries for the land use assessment were expanded to include reach of the Ottawa River extending 8 km downstream from CRL site.

VC = valued component; EIS = Environmental Impact Statement; SSA = Site Study Area.

The information in Table 5.9.1-1 was used to frame the scope of the assessment and identify VCs (Section 5.9.2). This assessment considers changes in wildlife harvesting and angling, outdoor tourism and recreation opportunities and other resource uses identified during the collection of baseline information at the local and regional scales. CNL has and will continue to meet with interested stakeholders and Indigenous peoples to receive input on the NSDF Project. The objectives of these meetings are to understand the priorities and interests of recreational and traditional users and to review potential mitigation to reduce or eliminate the effects of the NSDF Project.

5.9.2 Valued Components

Valued Components (VCs) refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous peoples, the scientific community or the public (The Agency 2018). Land and resource use VCs were selected based on the potential for the NSDF Project to interact with these features or activities of the land and resource use environment.

The VCs selected for assessing potential effects on land and resource use conditions are presented in Table 5.9.2-1.

Table 5.9.2-1: Valued Components For The Land And Resource Use Assessment

Valued Component	Rationale for Selection
Land and Resource Tenures and Other Registered Interests	▪ Project construction and operation must demonstrate compatibility with existing land use direction as expressed by responsible authorities based on a qualitative comparison of the Project with established land and resource designations in plans, policies and bylaws. ▪ Land users and responsible authorities need to understand if the NSDF Project will affect access routes / access to commercial land and resource use areas (e.g., for existing mining, forestry and agriculture). ▪ Land users and responsible authorities need to understand if the NSDF Project will affect the availability of commercial land and resource use opportunities.
Outdoor Tourism and Recreation	▪ The NSDF Project has the potential to affect access to outdoor tourism and recreational land and resource use opportunities associated with parks and protected areas, fishing, hunting, trapping and non-consumptive tourism and recreation. ▪ The NSDF Project has the potential to affect the quality and quantity of outdoor tourism and recreation land use opportunities.
Archaeological Sites	▪ Archaeological sites are an important aspect of Indigenous peoples. Archaeological sites are the focus of the archaeology discipline as archaeological sites are identified and protected by the Ontario Heritage Act.

Assessment endpoints are qualitative expressions used to assess the significance of residual effects on VCs and represent the key properties of the VC that should be protected for future generations. Measurement indicators represent properties of the environment and VCs that, when changed, could result in or contribute to an effect on a VC. Measurement indicators can be used to monitor the success of mitigation and management programs. The assessment endpoints and measurement indicators identified for the land and resource use VCs are presented in Table 5.9.2-2.

Table 5.9.2-2: Assessment Endpoints and Measurement Indicators for the Land and Resource Use Assessment

Valued Component	Sub-component	Assessment Endpoints	Measurement Indicators
Land and Resource Tenures and Other Registered Interests	Land use designations	Maintenance of compatibility with federal, provincial, regional and municipal land use designations	▪ Compatibility of the NSDF Project with existing land use designations.
	Mining and aggregates	Continued land and resource use opportunities	▪ Changes in access to land use areas and access routes used for land and resource tenures and other registered interests. ▪ Changes in the availability of tenured land use opportunities and other registered interests.
	Forestry		
	Agriculture		
Outdoor Tourism and Recreation	Parks and protected areas	Continued land and resource use opportunities	▪ Changes in access to outdoor tourism and recreation activities. ▪ Changes in quality and quantity of outdoor tourism and recreation opportunities.
	Fishing		
	Hunting		
	Trapping		
	Non-consumptive tourism and recreation		
Archaeological Sites	Not applicable	Management of cultural and archaeological sites	▪ Number, type and locations of archaeological materials or features that would contribute to an archaeological site and ability to recover archaeological materials or protect archaeological features.

5.9.3 Assessment Boundaries

5.9.3.1 Spatial Boundaries

The spatial boundaries selected for the land and resource use assessment were chosen because they permit a description of existing conditions in sufficient detail to enable potential project-VC interactions and effects to be identified, understood and assessed, including the contribution of the NSDF Project to cumulative effects.

The spatial boundaries selected for the land and resource use assessment are presented on Figure 5.9.3-1 and are described as following.

- **Site Study Area (SSA):** The SSA is the NSDF Project footprint (i.e., where Project activities would be undertaken, including the project's proposed facilities, buildings and infrastructure). The SSA covers an area of approximately 37 ha (Figure 5.9.3-1). The SSA falls within the Chalk River Laboratories (CRL) site boundary.
- **Local Study Area (LSA):** The LSA is selected in consideration of the NSDF Project footprint and the spatial extent of potential direct effects of the Project on the VCs. The land and resource use LSA corresponds with the combined area of the terrestrial and aquatics LSAs used for the assessment of the groundwater and surface water environment, aquatic biodiversity and terrestrial biodiversity, and covers approximately 226 ha (Figure 5.9.3-1). The aquatics, terrestrial, biophysical LSAs are defined in Sections 5.2 through 5.6.

  The LSA is defined to capture both direct and indirect effects on the terrestrial and aquatic environments as a result of the NSDF Project (e.g., changes in groundwater and surface water quality, habitat loss and changes in abundance, distribution and disturbances to wildlife and fish) as these effects have the potential to result in subsequent effects on land and resource use. The LSA falls within the CRL site boundary.

  No land and resource use tenures, outdoor tourism or recreation activities occur within the CRL site boundary.
- **Regional Study Area (RSA):** The RSA is defined as the area within which the potential effects of the NSDF Project may interact with the effects of other existing or reasonably foreseeable developments. The land and resource use RSA is the combined area of the air quality, terrestrial and aquatics RSAs, which have been used for the assessment of the air quality, groundwater, surface water, aquatic and terrestrial environments (Figure 5.9.3-1). The RSA is defined to capture effects on the terrestrial and aquatic environments as a result of the NSDF Project (e.g., habitat loss, sensory disturbance for wildlife and changes to habitat from air quality and surface water quality, changes in groundwater and surface water quality, habitat loss and changes in abundance, distribution and disturbances to wildlife and fish), as these effects have the potential to result in subsequent effects on land and resource use. Therefore, the RSA for land and resource use is a combination of the air quality and aquatic environment RSAs as this is the largest extent of potential cumulative effects on land and resource use. The air quality RSA is defined as an approximate 7.4 kilometre (km) circular radius surrounding the LSA, and the aquatic RSA includes the outlet of Perch Creek to the Ottawa River and extends roughly 8 km downstream in the Ottawa River to Harrington Bay. While there are no land and resource use tenures, or outdoor tourism or recreation activities occurring within the CRL site boundary, there may be some trapping occurring in Garrison Petawawa and in the RSA. The Ottawa River where it overlaps with the RSA boundaries would also most likely be used for some outdoor tourism and recreation.

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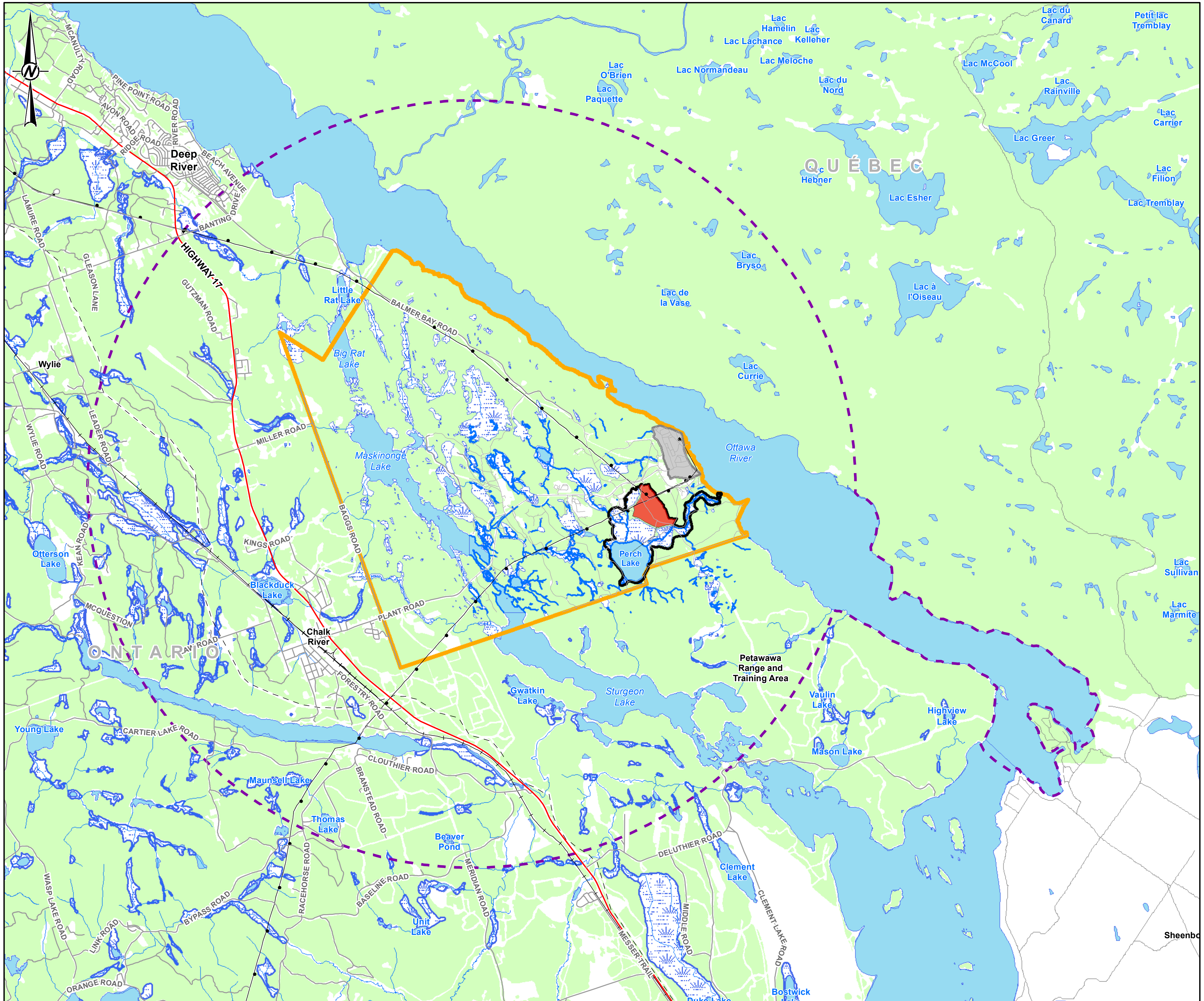

LEGEND

- HIGHWAY
- ROAD
- RAILWAY
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- SITE STUDY AREA (NSDF PROJECT SITE)
- CRL MAIN CAMPUS
- CRL SITE
- LOCAL STUDY AREA
- REGIONAL STUDY AREA

2.5 0 2.5

1:75,000 KILOMETRES

REFERENCE(S)

1. BASEMAP:SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. HIGHWAYS AND FIRST NATION RESERVES MNRF 2016
4 PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
SPATIAL BOUNDARIES SELECTED FOR THE LAND AND RESOURCE USE ASSESSMENT

CONSULTANT: GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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5.9.3.2 Temporal Boundaries

Temporal boundaries (i.e., project phases) establish the timeframe during which project effects are assessed. The temporal boundary represents the timeframe during which project activities are actively occurring, and considers the duration of predicted residual effects. The duration of an effect is defined as the amount of time between the start and end of a project activity or stressor (which is related to the project phases) plus the time required for the residual effect to be reversed. In some cases, residual effects may be irreversible within the temporal boundaries of the project or if the effects were predicted to last so far into the future that they could not be predicted with any level of certainty (e.g., residual effect lasts for thousands of years). The following phases were identified for the NSDF Project.

- **Construction phase**: This phase includes site preparation and all activities associated with the construction of the NSDF Project. This phase includes activities such as installing the necessary supporting and/or ancillary facilities and infrastructure to facilitate NSDF Project operations, inactive commissioning and systems testing, and transportation of construction materials. Construction activities are expected take place from 2021 to 2023.
- **Operations phase**: This phase includes all activities associated with waste placement, water management, Wastewater Treatment Plant (WWTP) operations, vehicle movements into and from the SSA and maintenance activities. Operations activities are expected to last approximately 50 years (i.e., 2024 to 2070).
- **Closure phase:** This phase includes activities necessary to complete the installation of the final cover and implementation of long-term monitoring. Closure activities are expected to start in 2070 and continue through to 2100, after which the NSDF Project will transfer into the post-closure phase.
- **Post-closure phase:** This phase has two discrete periods: institutional control and post-institutional control. The institutional control period includes implementation of controls throughout 2100 to 2400 (i.e., 300 years). During institutional control, environmental monitoring will continue to demonstrate compliance with the environmental assessment conditions. Post-institutional control occurs after year 2400 and continues indefinitely.

The temporal boundaries for the land and resource use assessment include consideration of effects of the NSDF Project from construction through to the end of post-closure.

5.9.3.3 Assessment Cases

The assessment cases considered in the in the land and resource use assessment, including the Base Case, Application Case and the Reasonably Foreseeable Development (RFD) Case.

- **Base Case –** This scenario represents existing conditions and characterizes effects from previous and existing developments and activities. The Base Case reflects the effects of existing land and resource uses in the area, such as hunting, fishing, trapping, forestry, agriculture, mining and recreational use. Current effects from the existing CRL facilities and operations are considered part of the Base Case.
- **Application Case –** This scenario represents the effects of the Base Case combined with the predicted effects from the NSDF Project. The Application Case considers effects from the NSDF Project during construction through to post-closure.

- **Reasonably Foreseeable Development (RFD) Case –** This scenario represents the effects of residual adverse effects of the Application case combined with other reasonably foreseeable projects in the land and resource use RSA. Because RFDs will not have any spatial overlap or are likely to positively affect the land and resource use, an RFD Case is not presented as part of this assessment. No cumulative effects with RFDs were identified in Sections 5.5 Aquatic Environment and 5.6 Terrestrial Environment that could potentially introduce indirect effects to land and resource use. Similarly, of the RFDs identified (see Section 8.2), none will result in change in broad land use category, use or access to land outside of the CRL site. As such, potential effects from RFDs are not expected to spatially overlap with potential effects to land and resource use from the NSDF Project.

5.9.4 Description of the Environment

This section describes the setting and characterization for land and resource use, including land and resource tenures, outdoor recreation and tourism, and archaeological sites, as relevant for the assessment of the NSDF Project. It describes the existing conditions (i.e., Base Case) against which potential changes from the NSDF Project are compared and evaluated.

5.9.4.1 Land and Resource Tenures and Outdoor Recreation and Tourism

5.9.4.1.1 Methods

Baseline information was collected from a range of information sources and analyzed to submit a profile for the land and resource use conditions in the LSA and RSA. Baseline information was collected from the following sources:

- regional and local land use Official Plans and Zoning By-laws, as applicable;
- the Ministry of Natural Resources and Forestry's (MNRF) Land Information Ontario (LIO) spatial land use database (MNRF 2016a);
- Natural Resources Canada's (NRCan's) CANVEC spatial land use database;
- municipal and regionally-based outdoor tourism, recreation and economic development webpages and reports;
- information on parks and protected areas available through Ontario Parks and Parks Canada; and
- publicly available wildlife harvesting data available through the MNRF.

5.9.4.1.2 Land and Resource Tenures and Other Registered Interests Results

5.9.4.1.2.1 Land Use Designations

The SSA is located entirely within the CRL site boundary, in the Town of Deep River (a lower-tier municipality), which forms part of Renfrew County (an upper-tier municipality). The SSA is bordered by the remaining CRL site to the north, east and west, the Garrison Petawawa to the south, and the Ottawa River to the southeast. The Town of Laurentian Hills lies adjacent to the CRL site boundary.

County of Renfrew Official Plan

The SSA falls within the County of Renfrew (see Figure 1 in Appendix 5.9-1). Last consolidated in 2014, the 2003 Official Plan for the County of Renfrew sought to manage land use planning for the rural communities within its jurisdiction, but still provided each municipality with the opportunity to develop their own Official Plan if desired (County of Renfrew 2003). The Official Plan addresses land use for ten lower-tier municipalities in the County of Renfrew, but does not include the Town of Deep River (which opted to maintain its own Official Plan). Under Schedule A (Map 1 of 2) of the County of Renfrew Official Plan, the SSA is simply identified as "Non-County Areas"; consequently, the County of Renfrew Official Plan does not apply to the NSDF Project. The NSDF Project is not be subject to land use designation provisions or restrictions under the County of Renfrew Official Plan.

Town of Deep River Official Plan

The SSA is located in the Town of Deep River (see Figure 2 in Appendix 5.9-1). The currently approved version of the Official Plan (CRPD 2017) identifies that the presence of the largest nuclear research facility in Canada exerts a dominant influence on the Town of Deep River (CRPD 2017). Section 1.1 of the Official Plan (CRPD 2017) states that the Official Plan applies to lands within the corporate limits of the Town of Deep River, but identifies that the remaining lands are in federal ownership and control in conjunction with Atomic Energy of Canada Limited (CRPD 2017. Consequently, the NSDF Project is not subject to land use designation provisions or restrictions under the Town of Deep River Official Plan.

Town of Laurentian Hills Official Plan

The Town of Laurentian Hills is directly adjacent to the CRL site boundary (see Figure 3 in Appendix 5.9-1). The SSA does not overlap the Town of Laurentian Hills, therefore the NSDF Project is not subject to provisions under the 2010 Official Plan. However, the Land Use Plan Schedule 'A1' still presents and considers the CRL site and consequently, the SSA. In the Schedule A1 land use designation map, the Town of Laurentian Hills identifies the SSA, LSA and RSA as 'Restricted Access Crown Land.'

The presence of Crown land is not uncommon in the Town of Laurentian Hills; as identified in Section 2.6 of the Town's Official Plan. A large proportion of the Town's land base (51.8%) is made up of federal/Crown land, which are not subject to municipal land use controls. In accordance with Section 5.12 of the Town's Official Plan:

> "The Municipality recognizes that there are no provisions in the *Planning Act* which binds the Federal Crown in the administration and use of its lands. Section 6 (2) of the *Planning Act* requires the Ministries and agencies of the Ontario government…as set out in Sections 3, 6, 48 and 62 of the *Planning Act*, shall have regard to the Municipality's planning policies and consult with the Municipality before carrying out or authorizing any undertaking considered to affect the Municipality. Council's intent is to ensure that the planning process be applied to changes of use that may arise."
>
> (Town of Laurentian Hills 2010).

Crown Land Designations

The SSA is located in Crown land, subject to federal jurisdiction. According to spatial data sourced from the MNRF LIO database and CNL, the SSA is comprised entirely of Patented Land, External (e.g., lands held in title to other provincial or federal government agencies or sold by the Crown), as is the vast majority of the LSA (Table 5.9.4-1). A negligible 0.1 ha of the LSA and 18.1 ha of the RSA are considered to be unpatented Crown land (i.e., lands that remain under the Crown and have never been transferred to a private owner). The southern portion of the RSA also overlaps 84.6 ha of lands attributed to Garrison Petawawa.

Table 5.9.4-1: Crown Land Designations in the Site Study Area and Regional and Local Study Areas

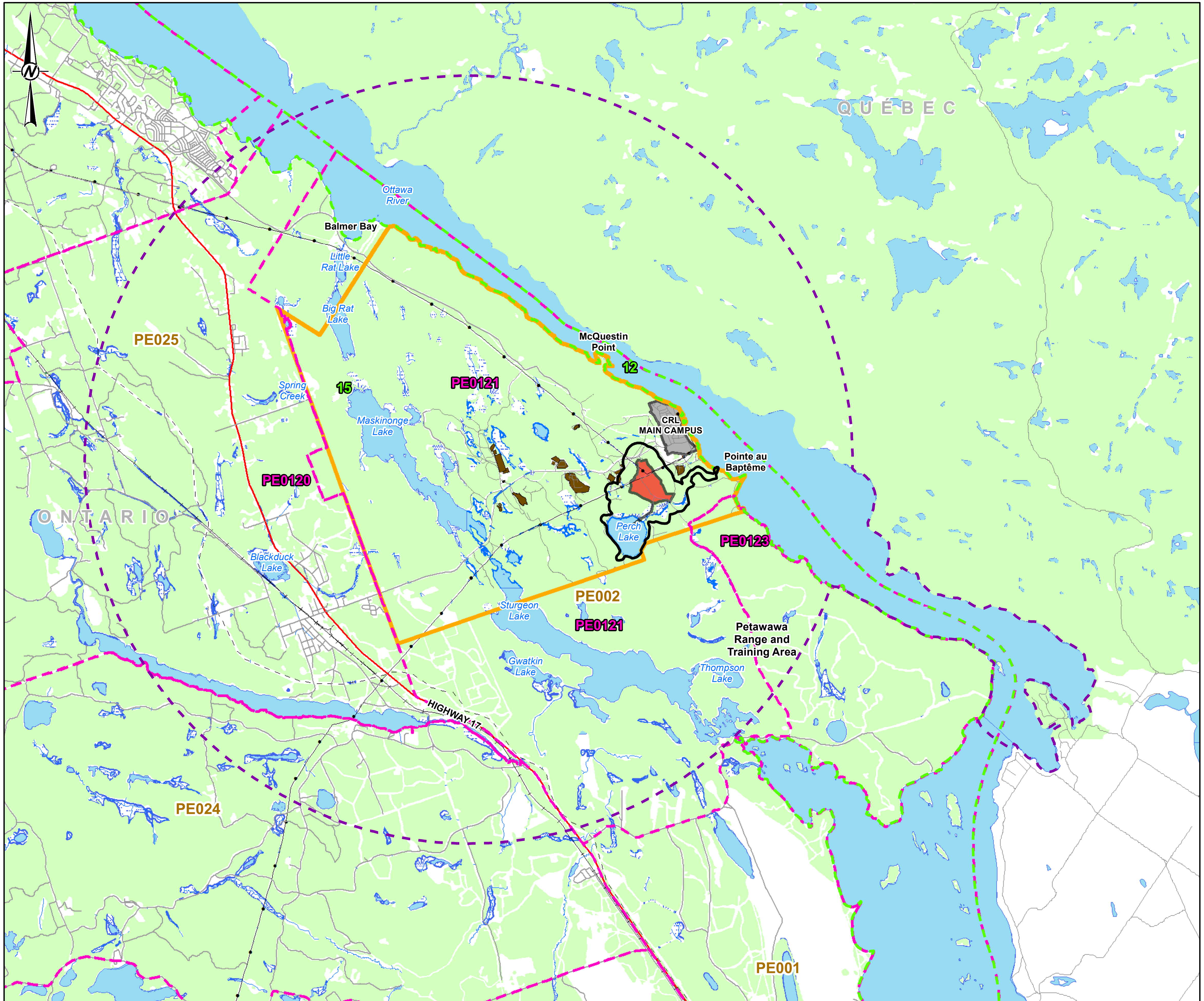
Crown Land Use Category	Description	SSA (ha)	LSA (ha)	RSA (ha)
Unpatented Crown Land	Lands that have never been patented (i.e., transferred to a private owner) by the Crown, or patented lands that have been forfeited back to the Crown.	0.0	0.1	5,814.9
Garrison Petawawa	Garrison Petawawa – approximate boundary	0.0	0.0	4,059.6
Patented Land External (Federal Government)	Lands which have been sold by the Crown. May include lands in title to other provincial or federal government agencies or mining patents.	37.1	225.6	3,861.4

Source: MNRF 2016a.

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

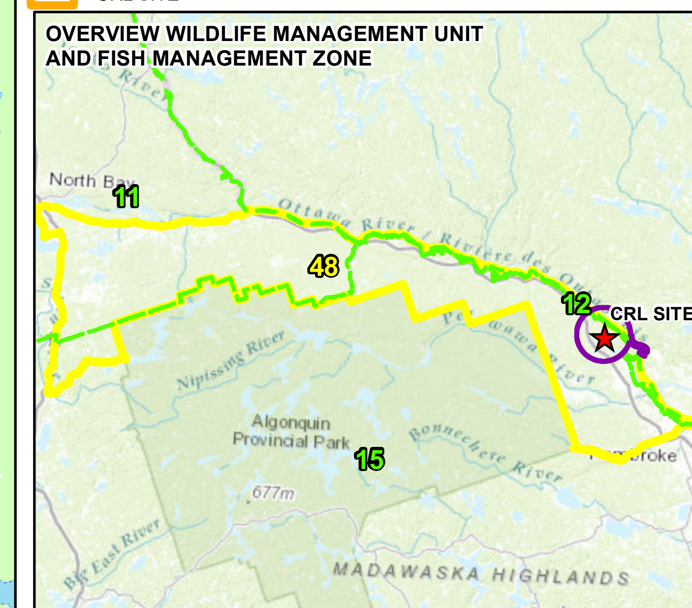
5.9.4.1.2.2 Mining and Aggregates

Aggregate resources are regulated under the Ontario *Aggregate Resources Act* on Crown lands and most private lands (MNR 2012). The MNRF manages aggregate resources in collaboration with the Ministry of Northern Development and Mines and the Ontario Aggregate Resources Corporation. There are no active Authorized Aggregate Sites (i.e., licenced and permitted pits and quarries) in the land and resource use LSA or RSA. The RSA overlaps one Aggregate Designated Area, which prohibits the extraction of aggregates on these private lands without a licence. Aggregate Designated Area boundaries are presented on Figure 5.9.4-1 (MNRF 2016a). There are no existing mine sites, active mining claims, pending mine claims, active dispositions or active withdraws in the LSA or RSA (MNRF 2016a).



LEGEND

- HIGHWAY
- ROAD
- RAILWAY
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- UNKNOWN TRANSMISSION LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- CRL MAIN CAMPUS
- SITE STUDY AREA (NSDF PROJECT SITE)
- WASTE MANAGEMENT AREA (WMA)[1]
- CRL SITE
- LOCAL STUDY AREA
- REGIONAL STUDY AREA
- BAIT HARVEST AREA
- FISH MANAGEMENT ZONE
- TRAPLINE AREA
- WILDLIFE MANAGEMENT UNIT



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REFERENCE(S)
1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT CHALK RIVER, ONTARIO

TITLE
HUNTING, FISHING AND TRAPPING IN THE LAND AND RESOURCE USE LOCAL AND REGIONAL STUDY AREAS

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

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5.9.4.1.2.3 Forestry

The MNRF is responsible for the long-term health of Ontario's Crown forests. Where active forestry is desired, the MNRF shares this responsibility with forest product companies through forest management planning guided by the *Crown Forest Sustainability Act, 1994* and the Ontario *Environmental Assessment Act*. Approximately 44% of Ontario's Crown forests are managed forests, divided into forest management units (FMUs; MNRF 2016b).

These FMUs are managed by various Indigenous and non-Indigenous companies through forest management plans. The MNRF requires forest management plans to be developed prior to any forestry activity within these FMUs. The forest management plans determine where and how much harvesting can occur, where roads can be built and how much forest will be renewed. These plans are prepared by registered professional foresters with input from Indigenous peoples, stakeholders and other members of the public, to ensure sustainability while finding a balance of economic, social and environmental values (MNRF 2016b). The forest management plans are approved for 10-year terms.

The RSA overlaps the Ottawa Valley Forest FMU, licensed to and managed by Ottawa Valley Forest Inc. (MNRF 2016a). The RSA includes small parcels of Crown land to the west of CRL under licence to the Ottawa Valley FMU area and therefore subject to the forest management plan activities mentioned above. There are no agreement forest area or forest processing facilities in the LSA or RSA.

In the western region of the SSA, approximately 2.6 ha of land is still identified as part of the Petawawa Research Forest plantation. The plantation was established in 1956 to determine the resistance of Norway spruce (*Picea abies*) trees to frost and white pine (*Pinus strobus*) weevil. The plantation was abandoned in the 1980s, and personnel with the Petawawa Research Forest have confirmed this plantation is no longer required for research purposes.

A comprehensive Sustainable Forest Management Plan is being developed for the CRL site, with an objective to ensure the long-term retention of trees serving as maternity roosts for bat species.

5.9.4.1.2.4 Agriculture

The NSDF Project is located in a northern region of Ontario, which has a less prominent history of agriculture than southern parts of the province. Consequently, the spatial provincial Agricultural Resource Inventory, which identifies and characterizes agricultural resources in the Province of Ontario, does not extend into the LSA or RSA (Ministry of Agriculture, Food and Rural Affairs 2016). The RSA is restricted to the CRL site and a small portion of the Garrison Petawawa property. Agricultural use of these properties is prohibited due to restricted public access.

5.9.4.1.3 Outdoor Tourism and Recreation Results

This subsection describes the non-traditional outdoor tourism and recreation activities occurring in the land and resource use LSA and RSA (e.g., parks and protected areas, fishing, hunting, trapping and non-consumptive tourism and recreation activities and features), as well as the legislated harvesting and tenure requirements for non-traditional land users. Use of these resources by Indigenous peoples is addressed in Section 6.4.4.1.2.

5.9.4.1.3.1 Parks and Protected Areas

The LSA and RSA do not overlap any parks and protected areas, including municipal parks, provincial parks, national parks, conservation reserves, non-governmental organizations, Nature Reserves, Natural Heritage System Areas, Significant Ecological Areas, Heritage River Systems or Areas of Natural and Scientific Interest (MNRF 2016a). No Ontario Conservation Authorities maintain jurisdiction over the LSA or RSA, nor do the LSA and RSA overlap any conservation areas (Conservation Ontario 2019).

5.9.4.1.3.2 Fishing

In the Province of Ontario, fishing is managed through fisheries management zones (FMZs) used by the MNRF to establish zone-specific limits and seasons to protect vulnerable fisheries, re-establish fish populations, adjust fishing seasons for different climates and allow more fishing in thriving fishery zones (MNRF 2016c). These are administered under the *Fish and Wildlife Conservation Act, 1997*. The LSA and RSA overlap FMZs 12 and 15, while the SSA only transects FMZ 15.

FMZ 12 is located along the Ontario/Quebec border. It is a large and diverse fishery, valuable for the recreational and tourism-based fishing industries (MNRF 2016d). It represents an important Eastern Ontario fishery for Walleye (*Sander vitreus*), Sauger (*Sander canadensis*), Northern Pike (*Esox Lucius*), Muskellunge (*Esox masquinongy*), Largemouth Bass (*Micropterus salmoides*) and Smallmouth Bass (*Micropterus dolomieu*; MNRF 2016d). It includes the Ontario portions of Lake Temiskaming and the Ottawa River, and the Madawaska and Mississippi Rivers upstream to the first dam (MNRF 2016d). As this FMZ is located on the Ontario/Quebec border, the MNRF has dictated that anglers can fish in the Ontario waters of the Ottawa River and Lake Temiskaming with a resident fishing licence from either Ontario or Quebec (MNRF 2016d).

FMZ 15 is located in central Ontario. This large zone has numerous natural lake and brook trout lakes, a well-developed road network and moderate angling effort, includes fishing opportunities in Algonquin Provincial Park, and represents an important recreational fishery for Lake Trout (*Salvelinus namaycush*), Brook Trout (*Salvelinus fontinalis*), Walleye, Northern Pike and Smallmouth Bass. The FMZ is stocked with Lake Trout and Brook Trout to increase angling opportunities (MNRF 2016e). It extends from Georgian Bay in the west to the Ottawa River in the east (MNRF 2016e).

As with other harvesting activities, the MNRF regulates fishing by establishing permitted seasons and limits in each FMZ. For some species, fishing seasons are open all year, whereas others face more restrictions. These fishing seasons influence levels of fishing activity in the SSA, LSA and RSA as presented in Table 5.9.4-2.

Table 5.9.4-2: Fishing Seasons by Fisheries Management Zone in the Local and Regional Study Areas (2019)

Fish Species	Open Fishing Season	
	FMZ 12	FMZ 15
Walleye and Sauger	January 1 to March 31 and Friday before the third Saturday in May to December 31	January 1 to March 15 and the third Saturday in May to December 31
Largemouth and Smallmouth Bass	Friday before the fourth Saturday in June to November 30	The fourth Saturday in June to November 30
Northern Pike	January 1 to March 31 and Friday before the third Saturday in May to December 31	January 1 to March 31 and the third Saturday in May to December 31
Muskellunge	Friday before the third Saturday in June to December 15	First Saturday in June to December 15
Yellow Perch	Open all year	Open all year
Crappie	Open all year	Open all year
Sunfish	Open all year	Open all year
Brook Trout	Friday before the fourth Saturday in April to September 30	January 1 to September 30
Brown Trout and Rainbow Trout	Friday before the fourth Saturday in April to September 30	Open all year
Lake Trout	Friday before the fourth Saturday in April to September 30	January 1 to September 30
Splake	Friday before the fourth Saturday in April to September 30	Open all year
Atlantic Salmon	Friday before 4th Saturday in April to September 30	Closed all year
Lake Whitefish	Open all year	Open all year
Lake Sturgeon	Closed all year	Closed all year
Channel Catfish	Open all year	Open all year
Pacific Salmon	No information publicly available through the MNRF	Open all year

Source: MNRF 2019a.

The use of live organisms as bait remains common among anglers and bait types vary depending on the species of fish being sought (Kerr 2012). Surveys suggest that almost 80% of Ontario anglers use live bait (e.g., worms, baitfish, frogs and/or crayfish) (Kerr 2012). Ontario anglers can choose to harvest or purchase bait (Kerr 2012). Commercial bait harvesting on Ontario is licenced through bait harvesting areas. Bait harvesters pay approximately $300 per year for the exclusive rights to each bait harvesting area. The land and resource use RSA overlaps six bait harvesting areas (PEO118, PE0119, PE0120, PE0121, PE0123 and PE0124). The SSA and LSA only overlap PE0121 (approximately 37 ha and 226 ha, respectively) (MNRF 2016a). There are no fishing access points identified by the MNRF in the LSA or RSA (MNRF 2016a).

5.9.4.1.3.3 Hunting

The MNRF manages hunting activities in Ontario through 95 regulated wildlife management units (WMUs). Each WMU has customized restrictions for the types of game that can be hunted, open season dates and hunting methods permitted (MNRF 2015). The SSA, LSA and RSA are located within WMU 48.

To effectively balance wildlife populations with the demands of harvesting activities, the MNRF establishes seasonal dates where hunting by local residents and non-residents is permitted in the WMU. Hunting seasons are adjusted every year as necessary. The presentation of baseline conditions focuses on moose (*Alces alces*), white-tailed deer (*Odocoileus virginianus*) and black bear (*Ursus americanus*), three indicator species considered important to recreational hunting in Central and Eastern Ontario. Moose, deer and bear hunting seasons in WMU 48 for residents and non-residents are presented in Table 5.9.4-3.

Table 5.9.4-3: Firearm Hunting Seasons for Resident Hunters in Wildlife Management Unit 48 (2019-2020)

Species	WMU 48	
	Resident Hunters	Non-Resident Hunters
Moose	October 19 to October 25	No Season
Deer	November 4 to November 17	November 4 to November 17
Black Bear	September 1 to November 30	September 1 to November 30

Source: MNRF 2019b.

The MNRF also monitors harvest data to establish sustainable hunting seasons year over year and to assess levels of hunting activity in each WMU. The most recent, publicly available hunter and harvest data for moose in the WMU overlapping the SSA, LSA and RSA is presented in Table 5.9.4-4. In 2017, approximately 1,211 hunters were active in WMU 48 in 2017, harvesting a total of 53 moose.

Table 5.9.4-4: Resident Moose Hunter and Harvest Data for Wildlife Management Unit 48 (2008-2017)

WMU	Year	Estimated Active Resident Moose Hunters	Estimated Total Moose Harvest by Resident Hunters
48	2008	803	26
	2009	1,007	44
	2010	1,059	75
	2011	1,182	54
	2012	1,092	60
	2013	948	53
	2014	1,229	68
	2015	1,100	79
	2016	1,263	59
	2017	1,211	53

Source: MNRF 2018a.

The most recent, publicly available hunter and harvest data for white-tailed deer in WMU 48 is presented in Table 5.9.4-5. The number of resident white-tailed deer hunters active in WMU 48 varied between 2008 and 2017, with a peak of 3,067 licensed hunters active in 2015. The number of deer harvested has declined since 2013 with a peak of 948 deer harvested in 2013 to only 577 deer harvested in 2018 (a decrease of 39%; MNRF 2018b).

Table 5.9.4-5: Resident Deer Hunter and Harvest Data in Wildlife Management Unit 48 (2008-2017)

WMU	Year	Estimated Active Resident Deer Hunters	Estimated Total Deer Harvest by Resident Hunters
48	2008	2,621	767
	2009	2,698	716
	2010	2,010	639
	2011	2,994	775
	2012	3,026	805
	2013	2,862	948
	2014	2,611	825
	2015	3,067	692
	2016	3,030	675
	2017	2,896	577

Source: MNRF 2018b.

The most recent, publicly available hunter and harvest data for bear in WMU 48 is presented in Table 5.9.4-6. The number of bear hunters and bears harvested rose between 2013 and 2016 and then started to decline in 2018. There are no Bear Management Areas[1] or Crown Game Preserves overlapping the SSA, LSA or RSA.

Table 5.9.4-6: Resident and Non-Resident Bear Hunters and Harvests in Wildlife Management Unit 48 (2012 to 2017)

WMU	Year	Resident and Non-Resident Bear Hunters	Bear Harvest
48	2012	464	55
	2013	365	37
	2014	398	78
	2015	567	149
	2016	639	168
	2017	627	109

Source: MNRF 2018c.

[1] Bear Management Areas (BMAs) are areas of Crown land licenced annually to a tourist operator for providing bear hunting services to non-resident clients. Some BMAs can completely surround private or patent land. Bear hunting services can occur on these lands provided that the licenced tourist operator allocated the BMA has obtained permission of the land owner to provide bear hunting services on the property.

5.9.4.1.3.4 Trapping

In the Province of Ontario, trapping is regulated under the *Fish and Wildlife Conservation Act, 1997,* administered by the MNRF (MNRF 2016f). Individuals must hold trapping licences to harvest fur, identifying where each individual can trap, in order to monitor furbearer populations and regulate trapping activities through seasons and harvest quotas (MNRF 2016f). Trapline tenures are gained by obtaining licences from the MNRF, which can be secured by proving Canadian citizenship, holding a valid hunting/fishing Outdoors Card, and successfully completing the MNRF's Fur Harvest, Fur Management and Conservation course (MNRF 2016f). The SSA, LSA and RSA all overlap the active PE002 trapline area. Trapline areas PE025 and PE024 also overlap the western section of the RSA. While trapping is prohibited in the LSA and most areas of the RSA due to restricted public access within the CRL site boundary (see Figure 5.9.4-1)[2], results of consultation and engagement have identified that there may be some limited trapping activities at the southern portion of the RSA, beyond the CRL site boundary, on the Garrison Petawawa property.

5.9.4.1.3.5 Non-consumptive Tourism and Recreation

While tourism and recreation opportunities exist in the County of Renfrew and the Town of Deep River, tourism and recreational opportunities are non-existent in the LSA and very limited in the RSA. According to the MNRF LIO data, there are no formal access points, boat caches (private or commercial), boathouses, club houses, designated camping sites, recreation camps[3], tourism establishment areas[4], potential tourism establishment areas, beaches, golf courses, resting areas, trailheads or Ontario Trail Network trails in the LSA or RSA (MNRF 2016a). There is snowmobile and all-terrain vehicle use, including a trail along the north-western side of the CRL site within the RSA. Potential disturbance through existing traffic noise to people, including tourists and recreational site users, within the RSA is characterized in Section 5.10.4.2.10, with low levels of disturbance identified.

Recreational boaters do traverse the Ottawa River within the RSA. The Pointe au Baptême represents a site of importance not within the footprint of the NSDF Project, but within the RSA on the CRL site. (Figure 5.9.3-1). Recreational boaters on the Ottawa River frequently use Pointe au Baptême as a picnic stop.

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[2] It is noted that CNL contracts a trapper for managing nuisance beavers on the CRL site.

[3] A Recreation Camp is a polygon feature that identifies an area used for commercial tourist operations with a focus on outdoor activities other than hunting and fishing (MNRF no date [a]).

[4] A Tourism Establishment Area is a polygon feature that identifies an area containing facilities and services for tourists (MNRF no date [b]).

5.9.4.2 Archaeological Environment

5.9.4.2.1 Archaeological Context

In 2008, CNL developed an Archaeological Master Plan that resulted in a formal Cultural Resource Management (CRM) Program at CNL. The CRM Program includes an archaeological potential model which assists in locating areas of archaeological potential and a robust cultural resource inventory of heritage sites. To date, the CRM Program at CRL has identified over 50 archeological sites that are registered with the Ontario Ministry of Tourism, Culture and Sport within the CRL site. According to the Borden (1952) system of archaeological site registration (Borden 1952, as cited in Swayze and Cameron 2016, the CRL site is in the CaGi "Borden Block" (a rectangular area, about 13 km by 19 km) that straddles both sides of the Ottawa River. Six archaeological sites were previously recorded within 1 km of the SSA. Each of these sites are described below.

- CaGi-54 South Shore Site is a small early postglacial Pre-Contact Period site discovered on the edge of the D6 115 kV hydro corridor at 181 to 183 metres above sea level (masl) (Swayze 2008, as cited in Swayze and Cameron 2016). Stage 3 test excavations were carried out at CaGi-54 in 2010 to collect a larger artifact sample and to determine the nature and condition of the deposit. Ten 1 m units were excavated and a total of 135 stone tools were recovered. The raw material consists of quartz and metamorphic rock available in the till. No formal artifacts or exotic material occurred. The excavation of an additional 35 test pits determined that the deposit was isolated in the hydro corridor, but it continued for some extent to the north. In terms of cultural affiliation, CaGi-54 is consistent with the Gulf of Main Archaic Tradition (Robinson 1992, as cited in Swayze and Cameron 2016) even though it probably dates to the Palaeo-Indian time period (Swayze 2009; Swayze and McGhee 2011; as cited in Swayze and Cameron 2016).
- CaGi-52 Communications Tower Site is an early postglacial Pre-Contact Period site that was recorded in 2008 during a Stage 2 assessment of the footprint for the communication tower (Swayze 2010, as cited in Swayze and Cameron 2016). A collection of 52 stone artifacts, similar to the artifacts recovered from CaGi-54, was obtained from nine positive Stage 2 test pits, which were expanded into Stage 3 test units. Similar to the South Shore site, CaGi-52 is consistent with the Gulf of Maine Archaic Tradition, even though the 180 m strand it is associated with pre-dates the earliest maritime sites.
- Pole 191 Stack Road Site was recorded during a Stage 2 assessment of wood pole replacements along the D6 115 kV hydro corridor and was assigned the temporary designation Borden Number CaGi-G (Swayze 2012, as cited in Swayze and Cameron 2016). Eleven test pits were excavated around this pole structure and there were three positive results. Test units were excavated around each positive test pit but in total, only nine stone artifacts were discovered. The recovered stone artifacts are consistent with the Gulf of Maine Archaic Tradition.
- CaGi-37 Blimkie Farm Site originally consisted of a two room, two storey log house with stone and cement foundations, three outbuildings and a laneway. Much of this archaeological site has been disturbed by road and fence construction in the area. Artifacts on the surface include mower and sleigh parts, ceramics and glass[5].

[5] During the Stage 2 assessment, the Blimkie Farm archaeological site (CaGi-37) was identified to be within the CRL site. The Project chose to preserve the site by modifying the footprint boundary. As a result, this site is no longer within 1 km of the current SSA.

- CaGi-40 Parking Lot Site is an Early Archaic site under a new parking lot. It was found in 2007 with assistance of the Stewardship Rangers and the Earthwalkers of Pikwakanagan. The site was along the relic shoreline of the recessional Champlain Sea.
- CaGi-53 Parking Lot was discovered in 2008. The site consists of expedient stone tools associated with an early postglacial low water event. The deposit was subsequently inundated and buried under riverine sediments, which have affected the condition of the artifacts.

In 1955, the National Research Universal heritage site was discovered in a sand deposit, approximately 3 m above the waterline, near the National Research Universal reactor. The site was not registered with the Borden system and the disposition of the artifacts is uncertain, although some are believed to be stored at the Canadian Museum of History in Ottawa. Bone, pottery sherds and Chert chips were found in an area approximately 15 m by 60 m. Most artifacts were disturbed, although one intact refuse pit was excavated. The pottery was determined to match Middle Woodland (Point Peninsula) activity from approximately 2,000 years ago.

The *Canadian Environmental Assessment Act, 2012* requires a designated project to consider whether changes to the environment caused by project activities will adversely affect cultural heritage resources. Archaeological assessments in Ontario are completed in accordance with the *Standards and Guidelines for Consultant Archaeologists* (the Guidelines; OMTC 2011). These standards and guidelines identify four main stages for completing archaeology assessments. The purpose of the four stages is to:

- discover any archaeological resources on the lands that are being developed;
- determine the degree of cultural heritage value of any archaeological resources found on the property;
- recommend the most appropriate strategies for conserving archaeological sites prior to land development activities; and
- implement recommendations for long-term protection strategies for archaeological sites to be affected by the project, or if protection of the site is not a viable option, conduct archaeological excavation to document the site and remove artifacts before construction begins.

Following the guidance provided in the *Reference Guide on Physical and Cultural Heritage Resources* (The Agency 1996), an archaeological assessment was completed for the NSDF Project (Swayze and Cameron 2016) in accordance with the *Standards and Guidelines for Consultant Archaeologists* (OMTC 2011). This assessment was submitted to the Ministry of Tourism and Culture in 2017 as a condition of licensing, in accordance with the *Ontario Heritage Act*.

Section 5.9.4.2.2 summarizes the findings of the archaeological assessment completed for the NSDF Project, titled Cultural Resource Management At Canadian Nuclear Laboratories, 2016 Stage 1, 2 & 3 Archaeological Assessments At The Near Surface Disposal Facility (NSDF) On Part Of Lots 20-23 Ranges A & B Buchanan Township (Geo.), Renfrew County (Swayze and Cameron 2016), and Stage 4 Archaeological Assessment. Proposed Near Surface Disposal Facility - EMR Site. 232-509213-REPT-003 (Kinickinick Heritage Consulting and Cameron Heritage Consulting Inc. 2018).

5.9.4.2.2 Archaeological Assessment

5.9.4.2.2.1 Methods

Licenced by the Ontario Ministry of Tourism, Culture and Sport (formerly the Ontario Ministry of Tourism and Culture), the consultant archaeologist conducted the Archaeological Assessments in accordance with the Guidelines (OMTC 2011). These standards and guidelines identify four main stages for completing archaeology assessments. The four stages are:

1) Background Study and Property Inspection;
2) Property Assessment;
3) Site-specific Assessment; and
4) Mitigation of development impacts.

CNL contracted Kinickinick Heritage Consulting and Cameron Heritage Consulting to complete the Archaeological Assessment for the NSDF Project. The following sections are based on information provided in the reports prepared by Swayze and Cameron (2016) and Kinickinick Heritage Consulting and Cameron Heritage Consulting Inc. (2018). A complete Archaeological Assessment Report was submitted to the Ontario Ministry of Tourism, Culture and Sport in 2017. All of the reports have been made available for review by Indigenous peoples and stakeholders. Engagement related to archeological assessment with Indigenous peoples is further discussed in Section 6.2.4.

Stage 1 Assessment

Under the *Standards and Guidelines for Consultant Archaeologists* (OMTC 2011), it is recognized that much of northern Ontario and the Canadian Shield present obstacles to archaeological assessment including less detailed mapping and difficulties of access. The Guidelines (OMTC 2011) make allowances for assessments carried out in these areas where the bedrock is Pre-Cambrian Canadian Shield.

A desktop assessment (Stage 1 Background Study and Property Inspection) was completed to identify areas where potential archaeological resources may exist. The desktop assessment focused on the underlying principles of archaeological resource prediction, particularly of a hunter-gatherer society, including the proximity to water and the association of archaeological sites with certain landforms. The first assumes that human habitation is dependent upon potable water and that economic activity will occur most frequently on the shores of major bodies of water that offer biodiversity and biomass and act as communication and transportation corridors. The second assumes that the physical site and setting of human activity will not occur randomly on the terrain, but will reflect a choice of soil, drainage and landform that reflect economic decisions. A desktop review of historical geologic maps was completed to identify areas of archaeological potential, in particular, relic shorelines created over the millennia through glaciation.

Stage 2 Assessment

Stage 2 (Property Assessment) begins with test pit surveys completed in areas where archaeological potential was identified during the background study and property inspection (Stage 1). Test pit surveys were completed over the entire property, digging at two intervals: every 5 m within 100 m of each major relic shore and every 10 m within 101 to 150 m above the former waterline.

Test pits were approximately 30 cm by 30 cm in size and were excavated by hand with a shovel and masonry trowel to a depth at least 5 cm into the parent material. Given the shallow nature of the soil, some test pits met this condition at 15 to 20 cm below surface; however, most test pits were excavated to 30 cm depth and frequently as deep as 40 cm. The back dirt was passed through a 6 mm mesh and the screen inspected carefully for artifacts or samples of potential artifacts.

The second phase of Stage 2 involved “infilling” where further excavation was completed at each positive test pit to determine if further inspection of the area was necessary. The procedure consisted of excavating infill test units around the positive test pit, in a “compass rose” pattern, at 2.5 m distance, as well as the excavation of a 1 m by 1 m unit over the discovery spot. The infill excavation methods were identical to that described above for the test pit survey. Artifact samples from infill test pits were tagged and bagged according to date, excavator, sequential number and infill unit location.

Stage 3 Assessment

The Stage 3 component of the Archaeology Assessment is a site-specific assessment and involves controlled surface pick up of material and text unit excavation determining the location and number of significant test pits. To accomplish this, test excavations were carried out wherever five or more artifacts of any kind were recorded during Stage 2, and within any area (i.e., a 10 m by 10 m area). The procedure consisted of establishing a permanent datum at each cluster of positive test pits and superimposing a 1 m grid over the area to be tested. Grid units were then excavated out at 5 m intervals over the prescribed area. An additional 20% of units were then placed at selected areas where artifact concentrations might be expected. These grid units were excavated by hand with a shovel and trowel to at least 5 cm depth into the parent material. The back dirt was passed through a 6 mm screen and the rock samples in it were carefully examined for archaeological material. In accordance with the Guidelines (OMTC 2011), when dealing with Early Archaic archaeological sites, 20% of the back dirt from the grid units was passed through a 3 mm screen to determine if there were any tiny retouch flakes or beads, that could slip through the standards screen.

Stage 4 Assessment

Stage 4 in an Archaeological Assessment involves implementing long-term management strategies for those sites recommended for mitigation in Stage 3. Stage 4 entails either preservation and protection (the preferred choice when possible) or controlled excavation to remove the deposit. Stage 4 controlled excavation entails excavating eight grid units around the significant Stage 3 unit. If any of these exceed 10 artifacts of any kind then 1 m by 1 m units will be excavated around it. The excavations continue until the artifact frequency remains consistently below the threshold.

5.9.4.2.2.2 Results and Recommendations

Stage 1 Assessment

The desktop review (Stage 1 Background Study and Property Inspection) determined that the majority of the SSA had some level of archaeological potential (Figure 4 of Swayze and Cameron 2016). In general, the areas of archaeological potential include:

- within a 150 m buffer above the elevation of a relic shoreline;
- within a 100 m buffer above a major waterbody, such as the shoreline of a lake or river;

- within a 50 m buffer around secondary areas of archaeological interest (e.g., the shorelines of streams, wetlands and intermittent creeks and landforms like lookouts, rock-faces, or sources of suitable rocks for tool manufacture); and
- within a 50 m buffer on each side of historical roads.

Large areas of high archaeological potential were identified due to proximity to a relic shoreline or the historical Mattawa Road. The relic shorelines are associated with the creation of the Champlain Sea and its regression over several millennia. Relic shorelines of the Champlain Sea within the SSA are located at 180, 170 and 159 masl, at which the elevation of the former sea level stayed for several centuries at a time. Areas of high archaeological potential were identified as 100 m above each relic shoreline. Areas of moderate potential were identified as above 101 to 150 m of each relic shoreline. Low potential terrain within the SSA consists of organic terrain that cannot be tested because of standing water or water saturated soil conditions.

Stage 2 Assessment

Approximately 9,000 test pits have been excavated with only 337 of these identified as positive test pits (approximately 3.7%). The positive test pits above 180 masl were assigned the Borden Number CaGi-65; while those between 170 and 179 were designated CaGi-66; and those between 159 and 169 are designated CaGi-67 (Figure 5 of Swayze and Cameron 2016). In total, approximately 450 artifacts were discovered, usually only one or two artifacts per test pit. During the Stage 2 assessment, the Blimkie Farm archaeological site (CaGi-37, see Section 5.9.4.2.1) was identified to be within the CRL site. The Project chose to preserve the site by modifying the footprint boundary.

As a result of infill excavations, 117 of the original 337 positive test were determined to be insignificant and are no longer of any heritage concern. However, 53 test pits are now “areas” (10 m by 10 m area) containing more than five artifacts of any kind and warrant test excavation on a grid. Most of these test pits were incorporated into existing test excavation areas, although a few are small 25 m² outliers. The infill excavation added approximately 400 artifacts to the collections.

Stage 3 Assessment

Based on the Stage 2 assessment a total of 68 locations were recommended for Stage 3 site assessment. Results of the Stage 3 assessment identified 19 units that contained cultural heritage value or interest in seven areas of concentration within the boundaries of the NSDF site. None of these areas were able to be avoided and protected and, therefore, all 19 units were recommended for Stage 4 assessment.

Stage 4 Assessment

Stage 4 entails either preservation and protection (the preferred choice when possible) or controlled excavation to remove the deposit.

Within CaGi-65 there were five 1m by 1 m units in three areas of concentration that contained sufficient cultural heritage value or interest to require Stage 4 mitigation. Fieldwork was conducted between August 10 and November 1, 2017. A total of 118 m² were excavated within three areas of concentration within CaGi-65. A total of 2,787 lithic artifacts were recovered and all but 15 were from local sources. The artifacts and their distribution throughout CaGi-65 indicates that this site consists of a general lithic workshop/quarry area.

Within CaGi-66 there were five 1 m by 1 m units in one area of concentration that contained sufficient cultural heritage value or interest to require Stage 4 mitigation. Fieldwork was conducted between October 19 and October 26, 2017. A total of 33 m² was excavated within one area of concentration within CaGi-66. A total of 198 lithic artifacts were recovered and all were from local sources. The artifacts and their distribution throughout CaGi-66 indicates that this site consists of a general lithic workshop/quarry area.

Within CaGi-67 there were nine 1 m by 1 m units in three areas of concentration that contained sufficient cultural heritage value or interest to require Stage 4 mitigation. Fieldwork was conducted between August 10 and November 1, 2017. A total of 130 m² were excavated within three areas of concentration within CaGi-67. A total of 1,978 lithic artifacts were recovered and all but 25 were from local sources. The artifacts and their distribution throughout CaGi-67 indicates that this site consists of a general lithic workshop/quarry area.

Site Analysis and Results

Indicators of an archaeological site's significance and importance include representativeness, site type or function, age, rarity, depositional integrity, preservation of organics, artifact and feature frequency and density, the presence or absence of human remains and burials, and deeply buried archaeological material (OMTC 2011). The cultural heritage and scientific value, as well as the potential value to a community or as a public resource are also considered (OMTC 2011). These criteria are discussed below in terms of how they apply, generally and specifically, to the NSDF Project archaeological material (Swayze and Cameron 2016).

Representativeness (i.e., is this type of site typical or unusual) – In the consultant's opinion, the archaeological materials assessed are typical or representative of small and large diffuse lithic scatters. Given that stone technology creates a great deal of detritus over time, one should not be surprised to find some indication of it anywhere on relic shorelines in this region.

Site Type/Function – The sites are situated on former shorelines and are probably campsites and/or workshops.

Age – The association of these sites with the earliest postglacial relict shoreline suggests a geochronological date of 8,500 to 10,500 BP.

Rarity – The early postglacial time period is poorly known everywhere in Ontario, in part because the early postglacial Great Lakes shorelines are now submerged. In the Ottawa Valley, on the other hand, the major shorelines of the Champlain Sea and the ancestral Ottawa River are available for sampling as "relic shorelines" and "fossil islands". Although systematic survey in the Ottawa Valley is relatively recent, similar lithic scatters were encountered on all the major relic shorelines, where sampled. Although all archaeological deposits are rare phenomena (and older deposits are more rarely preserved than recent ones) sites like those encountered in the SSA, may not be especially rare in this region, only rarely recorded.

Depositional Integrity – Sites with good depositional integrity exhibit buried cultural features (e.g., hearths, pits and post molds) and artifacts remains that are, more-or-less, left as they were. At the excavations on the SSA, however, there were no buried cultural features and no apparent pattern in the horizontal or vertical distribution of the artifacts. The parent material throughout is deep deltaic sand, stony and rocky in places, and "pit and hummock" terrain is common. As a result, there has been considerable surface mixture.

Preservation of Organics – No organic materials or cultural features were observed, which is not surprising given the age of the deposit and the acidic and excessively well-drained nature of the soil. Bones from food remains do not preserve well in such conditions and are rarely preserved in Archaic period sites.

Artifact and Feature Frequency and Density – The frequency and density of artifacts is generally low, with the exception of the concentrations where test excavations are under way. There are no chronologically diagnostic artifacts present. The artifact assemblage consists of expedient or informal tools made from locally available raw material.

Human Remains and Burials – None were observed. One would not expect bones or burials to be preserved in these conditions.

Deeply Buried Archaeological Material – Excavations units are assessed in the upper 10 to 15 cm of soil during Stage 2 assessment to a depth of 100 cm during Stage 4 assessment. There is a chance that archaeological material may be deeply buried.

The Guidelines present criteria and indicators to evaluate cultural heritage value and interest (OMTC 2011:60-61, Table 3.2). These guidelines are described as follows as to their applicability to the SSA.

Cultural Heritage Value – The archaeological deposits at the SSA provide some information to advance our knowledge of settlement patterns during the early postglacial period and they provide a glimpse into the material culture of the ancestors of modern Indigenous peoples, specifically the Anishinaabe. Algonquin oral history is based on a concept of the postglacial period and these sites are associated with “fossil islands” (Swayze and Cameron 2016).

Scientific Value – The sites in the vicinity of the NSDF Project have scientific value, because of their rarity and age (Swayze and Cameron 2016). Nevertheless, their scientific value is compromised by: poor depositional integrity, lack of organic artifact and cultural feature preservation, low artifact productivity and absence of diagnostic artifacts. On the other hand, recent advances in lithic artifact study have found that use wear studies of stone tool collections can provide insight into past activities. High magnification surface analysis of stone tools is now advanced enough that organic residues such as lipids or resins have been found on the stone artifact surfaces and organic samples as small as a single spore have been radiocarbon dated.

Value to a Community – Different communities may perceive the cultural value or interest of an archaeological site in various ways. Thus, it can be expected that Indigenous peoples would perceive these sites and artifact collections to have cultural value and interest (Swayze and Cameron 2016).

Value as a Public Resource – This refers to the ability of an archaeological resource to enhance the public’s understanding and appreciation of Ontario’s past. The criteria include potential for public use for education, recreation or tourism and the indicators of a suitable archaeological site are that it can be made accessible to tourists, local residents or school groups, and can be incorporated into local education, recreation or tourism strategies and initiatives. The sites in the vicinity of the NSDF Project have no potential in this respect because Stage 4 protection is not a realistic expectation. However, there may be places in CRL where these kinds of programs could be carried out in partnership with Indigenous peoples (Swayze and Cameron 2016).

In summary, the archaeological sites encountered in the SSA, may not be especially rare in this region, only rarely recorded. There are no chronologically diagnostic artifacts or human remains or burials present. However, it can be expected that Indigenous peoples would perceive these sites and artifact collections to have cultural value and interest. Based on the Stage 4 assessment, CaGi-65, CaGi-66 and CaGi-67 have been fully excavated and documented to the extent required under the *Standards and Guidelines for Consultant Archaeologists* (OMTC 2011). No cultural heritage value or interest remains and the locations have been fully documented and the information is preserved for future study; therefore, no further archaeological work was recommended for the NSDF Project.

5.9.5 Project Interactions and Mitigation

5.9.5.1 Methods

This section describes the process by which interactions between NSDF Project components and activities and the land and resource use VCs were identified and evaluated. Potential effects pathways are identified and mitigations have been developed to eliminate and/or reduce potential adverse project effects. A pathways analysis is used to focus the assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential for residual effects. Where effects will be adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects after incorporation of mitigation are further characterized in subsequent subsections of the assessment. As such the 'Project Interactions and Mitigations' section helps to focus the remainder of the assessment on those interactions (effects pathways) likely to result in residual adverse effects.

The first part of the analysis is to identify the potential effects pathways for all stages of the NSDF Project. The next step in the analysis is the development of environmental design features and mitigation practices that could be incorporated into the NSDF Project to eliminate and/or reduce effects to land and resource use VCs. These measures include environmental design features, environmental best practices and management policies and procedures. Environmental design features and mitigation were developed through an iterative process between the engineering and environmental teams, combined with input from Project-specific engagement with other interested parties. The design features and/or mitigation activities were selected considering their effectiveness for implementation and maintenance, and their appropriateness within the context of the identified effect pathways.

After incorporation of mitigation, potential pathways were evaluated into the following categories using scientific knowledge, logic, experience with similar developments, and the effectiveness of environmental design features and mitigation:

- **No linkage:** The pathway is removed by environmental design features or mitigation such that the NSDF Project would not be expected to result in a measurable environmental change to measurement indicators identified for land and resource use VCs relative to Base Case values, and therefore, would have no residual effects to land and resource use VCs.
- **Secondary pathway:** The pathway could result in a measurable minor change to measurement indicators identified for land and resource use VCs, but would have a negligible residual effect on land and resource use VCs relative to Base Case values and is not expected to contribute cumulatively to other NSDF Project effects or to the effects of other previous, existing or reasonably foreseeable developments to cause a significant effect.
- **Primary pathway:** The pathway is likely to result in an environmental change to measurement indicators identified for land and resource use VCs relative to the Base Case that could contribute to residual effects to socio-economic VCs.

Environmental design features and mitigation that could be incorporated into the NSDF Project to eliminate and/or reduce adverse effects to land and resource use VCs were considered. Potential pathways that were completely removed due to implementation of environmental design or mitigation were not assessed further. Pathways that were assessed to be secondary and demonstrated to have a negligible residual effect to land and resource use VCs through quantitative and qualitative evaluation of the pathway were also not advanced for further assessment. Primary pathways are carried forward for more detailed quantitative and qualitative effects analysis to characterize the residual effects of the NSDF Project on land and resource use VCs.

5.9.5.2 Results

The pathways analysis for the land and resource use VCs is presented in Table 5.9.5-1.

Table 5.9.5-1: Pathways Analysis for the Land and Resource Use Valued Components

Project Activity	Valued Component	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Construction, operations, closure, post-closure	Land and Resource Tenures and Other Registered Interests (i.e., land use designations, mining and aggregates, forestry and agriculture.	Change in access to or availability of tenured land use opportunities and other registered interests.	▪ Access to the LSA is restricted; therefore, no mining, aggregate, forestry, or agricultural activity will be affected by the NSDF Project.	No Linkage
Construction and operations, closure, post-closure (institutional control)	Outdoor Tourism and Recreation (i.e., parks and protected areas, fishing, hunting, trapping and non-consumptive tourism and recreation).	Changes in access to or quality and quantity of outdoor tourism and recreation activities (except trapping).	▪ Access to the LSA is restricted; therefore, no parks or protected areas will be affected by the NSDF Project. ▪ Terrestrial effects are limited to the CRL site, which encompasses the LSA and is restricted access; therefore, no hunting activities will be affected by the NSDF Project. ▪ The RSA overlaps the mouth of Perch Creek and a small portion of the Ottawa River where fishing activities may take place. Results of the surface water quality assessment identify there is no residual effect as there are no measurable concentrations of indicator compounds predicted and therefore fishing will not be affected by the NSDF Project.	No Linkage
		Changes in access to or quality and quantity of trapping opportunities	▪ There is trapping identified in the southern portion of the RSA in the Garrison Petawawa property and two trapline areas in the western portion of the RSA. ▪ While terrestrial effects are limited to the CRL site, which is restricted access, CNL will work to consult with the trappers to understand any remaining concerns.	Secondary

Table 5.9.5-1: Pathways Analysis for the Land and Resource Use Valued Components

Project Activity	Valued Component	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Post-closure (post-institutional control)	Outdoor Tourism and Recreation (i.e., fishing, hunting, trapping and non-consumptive tourism and recreation).	Changes in access to or the quality and quantity of outdoor tourism and recreation activities.	▪ Environmental monitoring will be completed as required during the institutional control period for the NSDF Project to confirm that the final cover is functioning as intended.	Secondary
Construction	Archaeological Sites	Ground disturbance from the NSDF Project during construction may cause disturbance or destruction to archaeological sites.	▪ Implementation of CNL's Archaeological Master Plan and CRM Program. ▪ Should previously undocumented archaeological resources be discovered, CNL will suspend construction immediately and will engage a licensed consultant to carry out archaeological fieldwork, in compliance with Sec. 48 (1) of the Ontario Heritage Act. ▪ If any human remains are identified during construction, CNL will immediately notify the police or coroner, and the Registrar of Cemeteries, MTCS, and applicable Indigenous communities or groups.	No Linkage

RSA = regional study area; CNL = Canadian Nuclear Laboratories; CRM = Cultural Resource Management; CFB = Canadian Forces Base.

5.9.5.2.1 No Linkage Pathways

An interaction may have no linkage to environmental effects if the activity does not occur, or if the interaction is removed by mitigation so that the NSDF Project results in no detectable change in measurement endpoints, and subsequently, no residual effect to land and resource use VCs. The following pathways are anticipated to have no linkage to residual effects to land and resource use VCs, and will not be carried through the residual effects assessment.

- **Change in access to or availability of tenured land use opportunities and other registered interests**
- **Changes in access to or quality and quantity of outdoor tourism and recreation activities (except trapping)**

Although the engagement activities have identified concerns from stakeholders and Indigenous peoples extending beyond the RSA (Table 5.9.1-1), there is no evidence to suggest that there is potential for the terrestrial environment to be adversely affected by the NSDF Project outside of the CRL site (which encompasses the LSA), as discussed Section 5.6. Further, the RSA overlaps a small portion of the Ottawa River; however, results of the surface water quality assessment identifies no residual effect as there are no measurable concentrations of indicator compounds predicted in the Ottawa River. Therefore, no pathway to affect outdoor tourism/recreation activities or uses of the Ottawa River are identified as a result of the NSDF Project. No biophysical effects are expected beyond the CRL site from project-environment interactions with the atmospheric environment and groundwater. This is reflective of the design of the NSDF Project, which includes multiple barriers of protection against effects on the environment.

Beyond the RSA, a transportation route may affect the experience of recreation users via nuisance effects due to increased truck traffic. Section 5.10.5.2.2 provides a qualitative assessment of noise effects including the transportation route. This assessment determined that the effect of increased traffic on noise levels is considered to be a slight but discernible change when compared to existing levels of traffic from current employees and operations at CRL. Transportation of site preparation and construction equipment, and construction materials will be scheduled to reduce noise and traffic volumes and limit inconvenience to local residents. As such, this potential project-environment interaction is considered to have a negligible residual effect on quality of life and subsequently not predicted to affect land and resource use.

The health and safety of tenure holders and recreational and tourism land users (except trappers) to actively participate in commercial and recreational land use activities and resource harvesting is not predicted to be affected outside of the CRL site. Further, access to these land use areas and the quality or quantity of these land use areas are not predicted to be affected outside the CRL site, as described below.

The LSA is located entirely within restricted federal lands (i.e., the CRL site). Aside from the operations and activities undertaken by CNL, other land uses of the CRL site are prohibited due to restricted public access. Tenured, registered and outdoor tourism and recreation land uses within the terrestrial and aquatic areas potentially affected by the NSDF Project do not currently exist, in order to protect land users from existing activities in the SSA. The Comprehensive Preliminary Decommissioning Plan (CPDP) for the CRL site recognizes that the CRL site will be maintained under institutional control for at least 300 years. Where the continued land use designation of the LSA during post-closure is as a monitored site with restricted assess, the presence of the NSDF will continue to be aligned, with no pathway to affect other land uses within the SSA.

With respect to changes in access to, or availability of, tenured land use opportunities and other registered interests, although the NSDF Project overlaps the Ottawa Valley Forest FMU, the RSA does not overlap any active agreement forest areas. Moreover, there are no active mine sites, active mining claims, active dispositions or active withdraws in the RSA, nor is there any permitted agricultural use. Consequently, there are no mining, aggregate, or agricultural activities occurring within the RSA that have the potential to be disturbed.

With respect to outdoor tourism and recreation, there are no municipal, provincial or national parks or conservation reserves, Areas of Natural and Scientific Interest or natural heritage systems or tourism establishment areas located within the land and resource use RSA where users' access will be reduced, or where users will face disturbances that could be perceived to reduce the quality of tourism or recreational opportunities. The SSA is comprised of federal lands intended for nuclear-related activities and is not subject to municipal land use plan designations; therefore, there are no predicted NSDF Project effects related to land use planning.

Although the NSDF Project overlaps large FMZ, WMU, trapline and baitfish harvest areas where hunting, trapping and fishing take place, the LSA is located within federal lands with restricted use, where consumptive and non-commercial land and resource use (i.e., outdoor tourism and recreational activities) is prohibited.
The NSDF Project will have no interaction with recreational activities (e.g., boating) taking place on the adjacent Ottawa River, as the NSDF Project will occur within a restricted area. However, the NSDF Project is not predicted to have any terrestrial effects beyond the CRL site, and results of the aquatic environment assessment identify that measurable residual effects on aquatic biodiversity VCs are not predicted as a result of the NSDF Project. Therefore, no effects on land users are expected.

Overall, there are no anticipated residual effects on continued land and resource opportunities. No further assessment or characterization of residual effects is undertaken for the land and resource use VCs.

However, in order to address stakeholder and Indigenous peoples concerns with regards to perceived risks on the safety and quality of lands and waters currently used for commercial and recreational land and resource use activities, considerations for monitoring and follow-up programs are provided in Section 5.9.6.

- **Ground disturbance from the NSDF Project during construction may cause disturbance or destruction to archaeological sites.**

There are no effects anticipated to archaeological resources as most mitigation for archaeological resources are applied and completed in advance of ground disturbance activities. Further, based on the archaeological assessments completed to date, potential archaeological sites within the SSA have been fully excavated and documented to the extent required under the Standards and Guidelines (OMTC 2011). No cultural heritage value or interest remains and the locations have been fully documented and the information is preserved for future study; therefore, no further archaeological work was recommended for the NSDF Project.

In 2008, CNL developed an Archaeological Master Plan that resulted in a formal CRM Program at CNL. The CRM Program includes an archaeological potential model which assists in locating areas of archaeological potential and a robust cultural resource inventory of heritage sites. To date, the CRM Program at CRL has identified over 50 heritage sites that are registered with the MTCS, within the CRL site. There are six archaeological sites previously recorded within 1 km of SSA, but none are located directly within the NSDF CRL site.

The CRM Program will be used to identify unanticipated archaeological resources and implement adaptive management. The archaeological assessment was submitted to the Minister of Tourism, Culture and Sport as a condition of licensing in accordance with the *Ontario Heritage Act*. Should previously undocumented archaeological resources be discovered, CNL will suspend construction immediately and will engage a licensed consultant to carry out archaeological fieldwork, in compliance with Sec. 48 (1) of the *Ontario Heritage Act*. If any human remains are identified during construction, CNL will immediately notify the police or coroner and the Registrar of Cemeteries, Ministry of Small Business and Consumer Services and Indigenous peoples. Consequently, this pathway was identified as having no linkage to effects on archaeological resources and is not evaluated further in this assessment.

5.9.5.2.2 Secondary Pathways

Two secondary pathways were identified as having a linkage to the Outdoor Tourism and Recreation VC. These secondary pathways have been identified for changes in access to or quality and quantity of trapping opportunities for land and resource users.

- **Changes in access to or quality and quantity of trapping opportunities**

The results of research identified that there may be a very limited amount of trapping occurring on Garrison Petawawa property. A portion of the RSA extends in to the Garrison Petawawa property and trapline PE002 is located on the Garrison Petawawa property (see Figure 5.9.4-1). Also, two trapline areas (PE025 and PE024) are located in the western portion of the RSA. However, the NSDF Project is not predicted to have any terrestrial effects beyond the CRL site and results of the aquatic biodiversity assessment identified only negligible residual effects on aquatic biodiversity VCs as a result of the NSDF Project. Further, there is a substantial amount of Crown and private land available for trapping outside the CRL site, but in the vicinity of the NSDF Project.

CNL will work with Garrison Petawawa to consult with trappers about their use of the Garrison Petawawa property for trapping activities. CNL will also consult with trappers in the western portion of the RSA to understand any concerns; however, given the distance from the NSDF Project and that terrestrial effects are limited to the CRL site, no effects to trapping in these areas are anticipated.

No further assessment or characterization of residual effects is undertaken for this VC.

One pathway was identified as having a linkage to the Outdoor Tourism and Recreation VC related to hunting, trapping, fishing and some forms of non-consumptive tourism and recreation during the post-closure (post-institutional control). This secondary pathway has been identified for changes in access to or quality and quantity of these outdoor tourism and recreation activities.

- **Changes in access to in access to or quality and quantity of outdoor tourism and recreation activities**

There are no outdoor tourism and recreation activities occurring presently in either the SSA or LSA, as this is a restricted access area. This restricted access will be maintained until the end of institutional control, after which access within these areas may be re-established. Outdoor tourism and recreation activities likely did occur within the LSA and SSA prior to federal control of the CRL site and may again occur post-institutional control. This represents a potential beneficial change to access for outdoor tourism and recreation activities including hunting, trapping and fishing with access to any resources that may occur at that time. However, given the limited areas of the LSA (226 ha) or SSA (37 ha) that may become accessible, this is anticipated to represent a negligible change to the total area within which outdoor tourism is practiced. Access to fishing areas on the Ottawa River will not be restricted due to the NSDF Project during any project phase.

Quality and quantity of hunting, trapping and fishing consider the health and well-being of users, as well as ecological health. The effect of radiological and non-radiological releases on terrestrial and aquatic biota during the post-closure phase is assessed in the *Post-Closure Safety Assessment* (Arcadis and Quintessa 2020b) and the Ecological Risk Assessment (Arcadis 2020a), summarized in the assessment of effects of ambient radioactivity and ecological health in Section 5.7. No significant residual effects were identified for ambient radioactivity and ecological health during the post-closure phase. As well, the *Post-Closure Safety Assessment* (Arcadis and Quintessa 2020b) models potential effects of radiological and non-radiological releases on human health, using varying scenarios. Section 5.8 reports these findings as part of the assessment of effects to human health. The peak radiological dose for the Normal Evolution Scenario is 20 times lower than the annual dose criterion. The predicted concentrations for all modelled non-radiological chemical contaminants met their respective health-based guidelines.

As no significant residual effects were identified to the health of terrestrial or aquatic biota, or to human health, no change to outdoor tourism and recreation activities during the post-closure phase is anticipated.

5.9.5.2.3 Primary Pathways

No pathways were identified as having a primary linkage to land and resource use VCs. Therefore, the assessment has concluded that no residual effects on land and resource use are anticipated as a result of the NSDF Project. As such, a residual effects analysis and assessment of significance is not required for land and resource use VCs.

5.9.6 Monitoring and Follow-up

As part of CNL's Public Information Program, CNL will continue to engage with local communities, municipalities and Indigenous peoples, and share the results of the monitoring and follow-up programs recommended for air quality, surface water quality and groundwater quality data through an accessible format (e.g., NSDF Project website), a recognized best practice used by projects with high levels of perceived risk that may have the potential to alter or reduce land and resource use activity without primary or secondary pathways.

The relevant monitoring and follow-up programs identified above do not directly monitor indicators for land and resource use VCs; rather, monitoring for environmental pathways (i.e., for air quality, surface water quality and groundwater quality) will be implemented to verify effects predictions for land and resource use VCs, and to promote land user comfort around the safety of the LSA, RSA and surrounding areas for land and resource use, outdoor tourism and recreation, and commercial (i.e., tenured) land use activities. Monitoring to verify effects predictions will be on-going during operations, closure and post-closure (institutional control) phases, and the need for and duration of monitoring will be reviewed based on an annual review of monitoring data. This monitoring will be integrated into the CNL Environmental Monitoring Program.

Follow-up programs for archaeological resources are anticipated to be minimal as most mitigation for archaeological resources are applied and completed in advance of ground disturbance activities. Monitoring will be used to identify unanticipated archaeological resources and apply adaptive management through the implementation of the CNL Archaeological Master Plan and Cultural Resource Management Program (AECOM 2018). Should previously undocumented archaeological resources be discovered, CNL will suspend construction immediately and will engage a licensed consultant to carry out archaeological fieldwork, in compliance with Section 48(1) of the *Ontario Heritage Act* (AECOM 2018).

5.9.7 Conclusions

Valued Components refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community or the public (The Agency 2018). Land and resource use VCs were selected based on the potential for the NSDF Project to interact with the features of the land and resource use environment.

Land and resource VCs selected for this assessment include:

- land and resource tenures and other registered interests (land use designations, mining and aggregates, forestry and agriculture);
- outdoor tourism and recreation (parks and protected areas, fishing, hunting, trapping, non-consumptive tourism and recreation); and
- archaeological sites.

The NSDF Project SSA and LSA are located entirely within the CRL site boundary, on federal lands. Therefore, aside from the operations and activities undertaken by CNL, other land uses of the CRL site are prohibited due to restricted public access, which will continue into institutional control. The lands of the RSA also extend into Garrison Petawawa, other federal lands with restricted public access. As such, there are limited land and resource use tenures, other registered interests, or outdoor tourism and recreational areas occurring within the RSA that have the potential to be disturbed by the NSDF Project. Land users have been identified as potentially trapping in the southern and western portions of the RSA, which overlaps the land and resource use RSA. However, the NSDF Project is not predicted to have any terrestrial effects beyond the CRL site, and results of the aquatic environment assessment identified only negligible residual effects on aquatic biodiversity VCs as a result of the NSDF Project. No pathway to affect quality of life including noise were identified to socio-economic VCs as a result of the Project. Access to the Pointe au Baptême site along the Ottawa River will continue to occur and not be restricted because of the NSDF Project. No pathway to affect archaeological resources is identified as most mitigation for archaeological resources are applied and completed in advance of ground disturbance activities. The CRM Program will be used to identify unanticipated archaeological resources and implement adaptive management. Consequently, the NSDF Project is not predicted to have any residual effects to the land and resource VCs.

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5.10 Socio-economic Environment

Section 5.10 of the Environmental Impact Statement for the Canadian Nuclear Laboratories (CNL) Near Surface Disposal Facility (NSDF) Project seeks to understand and characterize the potential residual effects of the NSDF Project and previous, existing and reasonably foreseeable developments on the socio-economic environment. Potential effects on human health are described in Section 5.8 and potential effects on archaeology and cultural heritage are described in Section 5.9 Land and Resource Use. This section presents the assessment of socio-economic effects of the NSDF Project.

5.10.1 Scope of the Assessment

The socio-economic assessment follows the overall environmental assessment approach and methods described in Section 5.1 Environmental Assessment Approach. The assessment was completed following the key steps listed below.

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries and assessment cases** for the socio-economic assessment (refer to Sections 5.10.2 Valued Components and Section 5.10.3 Assessment Boundaries). The VCs and measurement indicators used to assess Project-related changes to socio-economics are described, along with the spatial and temporal boundaries at which the assessment occurred and the assessment cases considered.
- **Step 2 – Describe the existing conditions** (refer to Section 5.10.4 Description of the Environment). Existing conditions in the local and regional areas are described, including the combined effects of previous and existing developments (Base Case). The existing environment represents the historical and current socio-community characteristics, including non-tangible features and the “built” environment. The existing conditions provide a reference to the effects of the NSDF Project can be compared.
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 5.10.5 Project Interactions and Mitigation). Project components and/or activities with the potential to affect socio-economics are identified and mitigation developed to limit or avoid negative effects, or to maximize benefits is presented. A pathways analysis is then used to focus further assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects are adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects to socio-economics after incorporating mitigation are carried forward to Step 4 for further analysis and residual effects characterization.
- **Step 4 – Present the methods and results of the residual effects analysis** (refer to Section 5.10.6 Residual Effects Analysis). This section outlines the methods used to predict and characterize residual effects to socio-economics from primary effects pathways. The analysis results are also presented including the characterization of incremental effects from the NSDF Project, as well as cumulative effects of the NSDF Project in combination with other reasonably foreseeable developments (if applicable).

- **Step 5 – Describe the level of certainty and management of uncertainty** (refer to Section 5.10.7 Prediction Confidence and Uncertainty). This purpose of this section is to evaluate the available literature and data used for the assessment, and describe the level of certainty that can be placed on predicted residual effects. This section will also identify how the uncertainty has been managed so that the effects are not underestimated.
- **Step 6 – Classify and determine the significance of the predicted residual effects** (refer to Section 5.10.8 Residual Effects Classification and Determination of Significance). Residual effects predicted from primary pathways are classified using a common set of criteria: direction, magnitude, geographic extent, duration, reversibility, frequency and likelihood. A determination of the significance of the predicted residual effects from NSDF Project for the socio-economics VCs is made.
- **Step 7 – Identifying monitoring and follow-up** required to confirm effects predictions and address uncertainty (refer to Section 5.10.9 Monitoring and Follow-up).
- **Step 8 – Present a consolidated summary of conclusions and outcomes of the assessment** of residual effects on socio-economics (refer to Section 5.10.10 Conclusions).

Information and areas of interest raised by the public, communities of interest, and Indigenous peoples during engagement that influenced the scope of the socio-economic assessment are summarized in Table 5.10.1-1. Other general areas of interest and questions raised during the engagement that pertain to the socio-economics assessment (if any) are documented in CNL's Indigenous Engagement Report (CNL 2020a) and CNL's Stakeholder's Activity Reports (CNL 2017a,b, 2019).

Table 5.10.1-1: Summary of Areas of Interest Raised during Engagement Activities that Influenced the Scope of the Socio economic Assessment

Area of Interest	How the Area of Interest Was Included in the Assessment
Will consideration be given to provide jobs or buy material, such as sand that could be delivered by barge, to the closest full-time residents to the site, in Sheenboro QC?	▪ Industries throughout the County of Renfrew and the Ottawa area in Ontario and the Region of Outouais in Quebec, are anticipated to supply the NSDF Project with many of the required goods and services (e.g., manufacturing, wholesale, transport). CNL will competitively procure material and services for the NSDF Project (see Section 5.10.6.2.1). ▪ The construction workforce is anticipated to be sourced from firms within the County of Renfrew and the Ottawa area in Ontario and the Region of Outaouais (which includes the Municipality of Sheenboro and City of Gatineau) in Quebec. Canadian Nuclear Laboratories employment opportunities that may arise due to NSDF Project activities will be posted on the vendor portal at www.cnl.ca website (see Section 5.10.6.2.1).

5.10.2 Valued Components

Valued Components (VCs) refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous peoples, the scientific community or the public (The Agency 2018). Socio-economic VCs were selected based on the potential for the NSDF Project to interact with the features of the socio-economic environment. The VCs selected for assessing potential effects on socio-economic conditions are presented in Table 5.10.2-1.

Table 5.10.2-1: Valued Components for Socio economic Assessment

Valued Component	Rationale for Selection
Labour Market	▪ Local workforce and communities are interested in long-term employment opportunities that will be generated through the NSDF Project. ▪ Income generation is perceived as a Project benefit by local workforce, businesses and communities.
Economic Development	▪ The NSDF Project will contribute to local and regional economies, through direct procurement, as well as indirect investment in other business activities.
Government Finances	▪ The NSDF Project will generate incremental tax revenues for all levels of government.
Housing and Accommodations	▪ Potential in-migration of workers (and families) for the NSDF Project could increase the demand for permanent housing or temporary accommodations.
Services and Infrastructure	▪ Potential in-migration of workers (and families) for the NSDF Project could increase the demand for community services (i.e., schools, community health, protection and emergency services) and community infrastructure (i.e., water supply and traffic).
Quality of Life	▪ Project activities (i.e., changes in air quality, ambient noise, increases in traffic volume and visual disturbances) could affect worker and local public quality of life[1].
Public Safety	▪ Public safety is a concern near the NSDF Project. Hazards include transport of heavy equipment and supplies to the site and other hazards typical of industrial facilities.

Assessment endpoints are qualitative expressions used to assess the significance of residual effects on VCs and represent the key properties of the VC that should be protected for future generations. Measurement indicators represent properties of the environment and VCs that, when changed, could result in or contribute to an effect on a VC. Measurement indicators can be used to monitor the success of mitigation and management programs. The assessment endpoints and measurement indicators associated with the socio-economic assessment are outlined in Table 5.10.2-2.

[1] See Section 5.8 Human Health for assessment of effects to human health from Project-related changes in ambient radioactivity and non-radiological substances.

Table 5.10.2-2: Assessment Endpoints and Measurement Indicators for the Socio economic Assessment

Valued Component	Assessment Endpoints	Measurement Indicators
Labour Market	Employment opportunities and income generation	▪ Direct, indirect and induced employment ▪ Income generation ▪ Training and skill development opportunities
Economic Development	Business and economic development opportunities	▪ Direct goods and services purchased by types and number of suppliers and their location ▪ Indirect supplier industry expenditures and output ▪ Induced expenditures and output generated associated with household spending
Government Finances	Contribution to Government finances	▪ Government revenue generation
Housing and Accommodations	Housing and accommodation availability	▪ Number of residents in local communities ▪ Housing demand and supply
Services and Infrastructure	Community services and infrastructure availability and access	▪ Education, health, protective and emergency services demand, use and supply
Quality of Life	Contribution to quality of life	▪ Quality of Life can be indirectly affected by changes in air quality, ambient noise, increases in traffic volume and visual disturbances (nuisance effects)
Public Safety	Protection of Public	▪ Public exposure to physical hazards (note that chemical hazards and potential effects on human health are evaluated in Section 5.7 Ambient Radioactivity and Ecological Health, and Section 5.8 Human Health)

Assessment endpoints and associated measurement indicators for each socio-economic VC are further discussed as following.

- **Labour Market:** The assessment endpoint of continuation of employment opportunities and income generation pertains to the incremental change that the NSDF Project will have on both direct local and regional income through direct employment and purchase of goods and services. It also considers the availability of persons with the required skills to satisfy the NSDF Project's labour needs during all project phases. The assessment endpoint will be influenced by the number of direct construction and operational positions required for the NSDF Project and the average wage/salary levels of these positions. The NSDF Project will also generate employment in goods and services supply (indirect employment) and may possibly lead to a small amount of induced employment from NSDF Project workforce expenditures. Training and skill development opportunities provided by the NSDF Project to the workforce and contractors/suppliers can contribute to the local labour force and local business community's skills and capacity.
- **Economic Development:** The assessment endpoint considers incremental expenditures for procurement requirements created by the NSDF Project and implications to the existing industry and business profile in the regional and local study areas. The measurement indicators used are the types and amount of goods and services required by the NSDF Project, and opportunities provided to local businesses.

- **Government Finances:** The NSDF Project will generate taxes in the form of personal and corporate income taxes, property taxes and various consumption taxes. These fiscal benefits generated by the NSDF Project can be compared to government revenue streams. The assessment endpoint of continuation of government finances will be influenced by the tax generation associated with the NSDF Project.
- **Housing and Accommodations:** Project-related effects on availability of housing and temporary accommodation are driven by potential project-induced changes in the size of local population and population characteristics (i.e., effect of population change on housing supply and demand). New NSDF contract employees (and in some cases their families) may require access to local housing and/or temporary accommodation during the construction phase.
- **Services and Infrastructure:** Project-related effects on availability of community services and infrastructure are driven by potential project-induced changes in the size of local population and population characteristics (i.e., effect of population change on demand of community services and infrastructure). The NSDF Project's effects on services and infrastructure are linked to Project-related direct use of services during construction and operational activities (e.g., transportation network). The NSDF Project's effects are also linked to incremental demand, the available capacity to accommodate additional pressure placed on services due to population growth, the ability of these services to meet the demands of the local population and the potential requirement for additional capital investment in services and infrastructure.
- **Quality of Life:** Project-related effects on quality of life are driven by potential project-induced changes in environment (i.e., changes in air quality, ambient noise, increases in traffic volume and visual disturbances).
- **Public Safety:** The assessment endpoint for public safety addresses concerns related to hazards associated with the NSDF Project site during construction, operations, closure and post-closure activities.

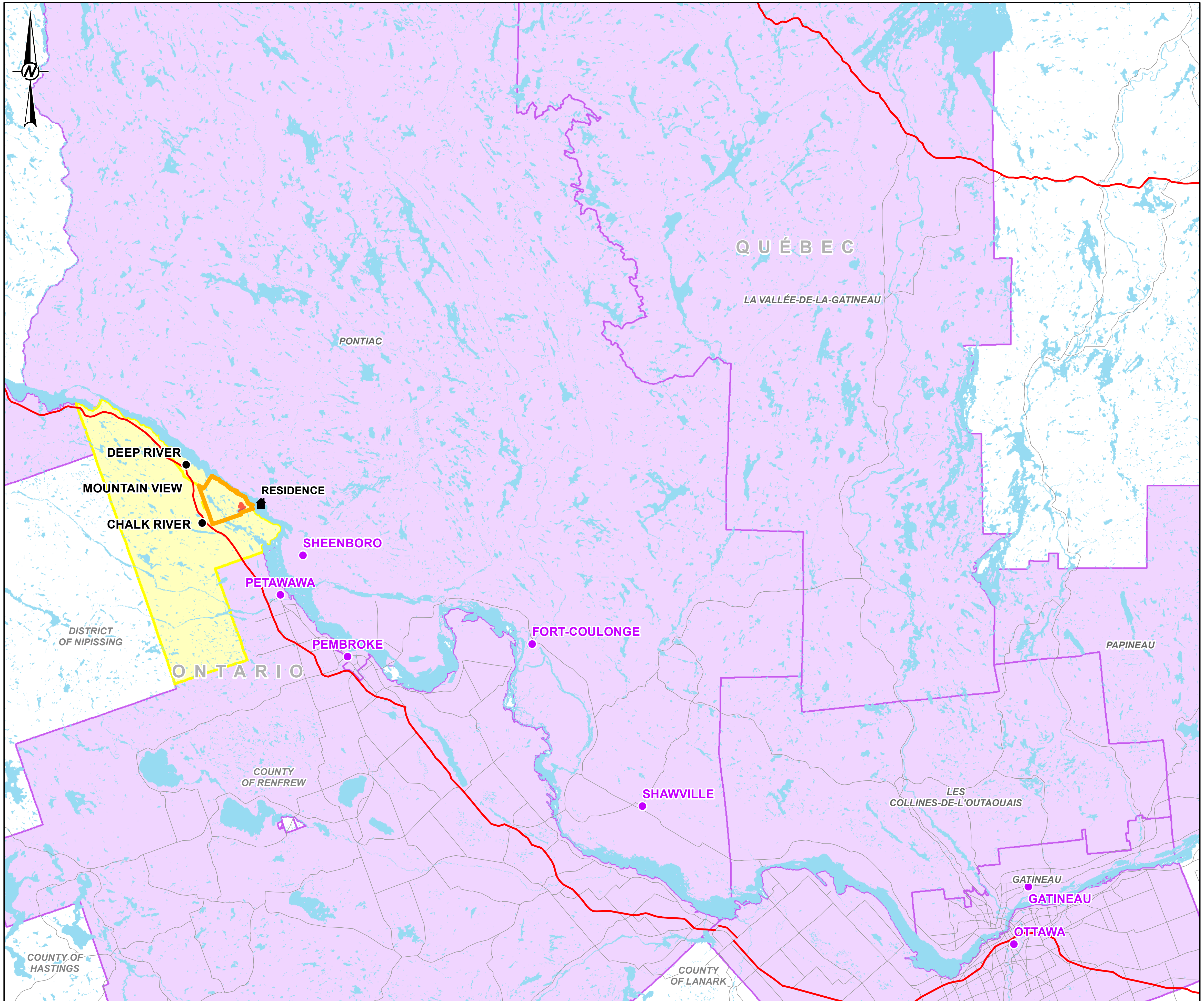
5.10.3 Assessment Boundaries

5.10.3.1 Spatial Boundaries

The spatial boundaries for the socio-economic assessment are defined below. These spatial boundaries were chosen because they permit description of existing conditions in sufficient detail to enable potential VC-project interactions and effects to be identified, understood and assessed, including understanding and assessing the contribution of the NSDF Project to cumulative effects. The spatial boundaries for the socio-economic assessment are presented on Figure 5.10.3-1 and described as follows:

- **Site Study Area (SSA):** The SSA is the NSDF Project footprint (i.e., where Project activities would be undertaken, including the proposed facilities, buildings and infrastructure).
- **Local Study Area (LSA)**: The LSA is defined as the area within which there is potential for measurable changes to socio-economic VC measurement indicators resulting from the proposed NSDF Project activities. The LSA includes the closest communities to the NSDF Project, specifically the Village of Chalk River located 7 km west of the Chalk River Laboratories (CRL) site, and the Town of Deep River located 9 km northwest of the CRL site (Figure 5.10.3-1). Mountain View, a settlement within the Municipality of Laurentian Hills, lies between Chalk River and Deep River, off Highway 17. Wylie, a settlement that constitutes part of the Municipality of Laurentian Hills, is located 12 km northwest of the NSDF Project, near Mountain View. Wylie and Mountain View were not included in the assessment as data for these settlements are not available due to their small populations.

- **Regional Study Area (RSA): The RSA** is defined as the area within which the potential effects of the NSDF Project may interact with the effects of other existing or reasonably foreseeable developments. The RSA is defined to include the communities of Petawawa and Pembroke located approximately 20 km and 34 km southeast of the CRL site, respectively, as it is anticipated that workforce and business opportunities within these communities may overlap with those required for CNL's Nuclear Power Demonstration (NPD) Closure Project. It is also expected that workforce and business opportunities may be sourced from the City of Ottawa and the Province of Quebec. The RSA therefore includes the City of Ottawa and the Region of Outaouais (Quebec), which encompasses the Pontiac Regional County Municipality (closest regional municipality to the NSDF Project) and the urban centre of Gatineau. Data on Ottawa and Gatineau is included when applicable reflecting the consideration of these areas as sources of labour and materials.



LEGEND

- RESIDENCE
- HIGHWAY
- MAIN ROAD
- RIVER/STREAM
- WATERBODY
- SITE STUDY AREA (NSDF PROJECT SITE)
- CRL MAIN CAMPUS
- CRL SITE
- LOCAL STUDY AREA
- REGIONAL STUDY AREA
- LOCAL STUDY AREA COMMUNITY
- REGIONAL STUDY AREA COMMUNITY

10 0 10 20 30

1:650,000 KILOMETRES

REFERENCE(S)

1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, QUÉBEC MRNF 2016 AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE

SPATIAL BOUNDARIES SELECTED FOR THE SOCIO-ECONOMIC ASSESSMENT

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO/PR
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0009	FINAL 2	5.10.3-1

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5.10.3.2 Temporal Boundaries

Temporal boundaries (i.e., project phases) establish the timeframe during which NSDF Project effects are assessed. The temporal boundary represents the timeframe during which project activities are actively occurring, and does include the duration of predicted residual effects. The duration of an effect is defined as the amount of time between the start and end of a project activity or stressor (which is related to the project phases) plus the time required for the residual effect to be reversed. In some cases, a residual effect may be irreversible within the temporal boundaries of the Project (e.g., residual effect lasts for thousands of years). The following phases were identified for the NSDF Project.

- **Construction phase**: This phase includes site preparation and all activities associated with the construction of the NSDF Project. This phase includes activities such as installing the necessary supporting and/or ancillary facilities and infrastructure to facilitate NSDF Project operations, inactive commissioning and systems testing, and transportation of construction materials. Construction activities are expected take place from 2021 to 2023. The construction phase will require an average of 225 full-time equivalents, with a peak workforce of approximately 300 personnel.
- **Operations phase**: This phase includes all activities associated with waste placement, water management, Wastewater Treatment Plant (WWTP) operations, vehicle movements into and from the NSDF Project site, and maintenance activities. The operations phase is expected to last approximately 50 years (i.e., 2024 to 2070) with an average labour force of 65 full-time equivalents (although this will be adjusted based on operational demand), which is expected to be drawn from the existing CRL workforce.
- **Closure phase:** This phase includes activities necessary to complete the installation of the final cover and implementation of long-term monitoring. Closure activities are expected to start in 2070 and continue through to 2100, after which the NSDF Project will transfer into the post-closure phase.
- **Post-closure phase:** The phase has two discrete periods: institutional control and post-institutional control. The institutional control period includes implementation of controls throughout 2100 to 2400 (i.e., 300 years). During institutional control, environmental monitoring will continue to demonstrate compliance with the environmental assessment conditions. Post-institutional control occurs after year 2400 and continues indefinitely.

For the purposes of the socio-economic assessment, effects during the construction phase are expected to have the greatest magnitude; as such project-related effects are assessed for the construction phase only. Effects to the socio-economic VCs during the operations, closure and post-closure phases are expected to be less than effects predicted during the construction phase of the NSDF Project.

5.10.3.3 Assessment Cases

The assessment cases considered in the socio-economic assessment are the Base Case, the Application Case and the Reasonably Foreseeable Developments Case.

- **Base Case:** This scenario represents existing conditions and characterizes effects from previous and existing developments and activities. The Base Case reflects the effects of existing infrastructure and services in the area, such as forestry, transportation, agricultural, mining, and residential and recreational development. Current effects from the existing CRL facilities and operations are considered part of the Base Case.

- **Application Case:** This scenario represents predictions of the effects of the Base Case combined with the effects that may result from the NSDF Project. The Application Case considers potential effects from the NSDF Project from the construction phase through the post-closure phase. The workforce is the largest during the construction phase, and although the operations phase is expected to last approximately 50 years the operations labor force is expected to be drawn from the existing CRL workforce. As such, the Application Case only considers the construction phase as the bounding phase for socio-economic effects of the NSDF Project.
- **Reasonably Foreseeable Developments (RFD) Case:** This scenario represents the effects of residual adverse effects of the Application case combined with other reasonably foreseeable projects in the socio-economic RSA. Reasonably foreseeable developments in the RSA that are anticipated to overlap with the NSDF Project include new/upgrades to research and development facilities, construction and operation of a small modular reactor, new support infrastructure, on-going decommissioning and environmental remediation activities on the CRL site and the NPD Closure Project. As well, there may be overlap of the construction period with limited construction at the neighbouring Garrison Petawawa. Additional details on these proposed activities are provided in Section 8.0.

5.10.4 Description of the Existing Environment

This section presents an overview of the socio-economic setting as relevant for the assessment of the NSDF Project. It describes the existing conditions (i.e., Base Case) against which potential changes from the NSDF Project are compared and evaluated.

5.10.4.1 Methods

Baseline information was collected from a range of information sources and analyzed to submit a profile for the social and economic conditions in the LSA and RSA. Baseline information was collected from the following sources:

- Statistics Canada census;
- municipal and provincial government websites;
- local service provider websites;
- regional tourism authority sources; and
- email and telephone communications with key informants (e.g., Fire Chiefs).

Existing socio-economic conditions in the LSA and RSA are described, as relevant for the assessment of potential NSDF Project effects on:

- socio-community characteristics (e.g., existing and projected population and demographic data, housing and accommodation, services and infrastructure, and quality of life);
- economic characteristics (e.g., labour market, economic development and government finances); and
- land used by businesses (e.g., existing land developments, outdoor recreation).

5.10.4.2 Results of Socio-community Characteristics

The NSDF Project is located on the CRL site in Renfrew County, approximately 12 km southeast of the Town of Deep River, 9 km northwest of the Garrison Petawawa, and 7 km east of the Village of Chalk River (Figure 5.10.31). The land is characterized by deciduous and coniferous forest and the Ottawa River, which forms the northeastern boundary of the Town of Deep River. The CRL site is located in the Allumette Lake and Lac Coulonge reach of the Ottawa River, which extends approximately 90 km between La Passe and the Des-Joachims hydroelectric dam. The distance from the centre of the NSDF Project site to the closest point on the Ottawa River shoreline is approximately 1.1 km. The following descriptions are based on the most recently available data.

The Village of Chalk River is approximately 7 km southwest across Highway 17. The village is part of the amalgamation of communities that form the Municipality of Laurentian Hills, and is connected directly to the CRL site through Plant Road off Highway 17 (County of Renfrew 2016a). The majority of the population of the Municipality of Laurentian Hills resides in the urban settlement areas of Chalk River, Rolphton and Point Alexander along the Highway 17 corridor (Laurentian Hills 2010).

The Town of Deep River is the largest community near the NSDF Project site, approximately 9 km northwest of the CRL site. Established as a company town for Atomic Energy of Canada Limited in the 1940s, Deep River is the location of the largest nuclear research facility[2] in Canada (CRPD 2017). The Town of Deep River contains the built-up town site, the CRL site and federally-owned forested lands. As the second largest employer in the County of Renfrew, behind the Garrison Petawawa, CNL provides large public-sector employment with above average wages for the area (CRPD 2017). In 2013, CRL employed approximately 2,850 people and Garrison Petawawa employed around 7,000, with base personnel becoming an important source of new residents for the community. The Pembroke Census Agglomeration (CA) is approximately 34 km southeast of the CRL site, and is the largest community and the administrative headquarters of Renfrew County. Pembroke is the largest commercial centre between Ottawa and North Bay and provides many commercial services to local area residents in the Ottawa Valley and surrounding regions (City of Pembroke 2016).

The Region of Outaouais is composed of five regional county municipalities: Gatineau, Papineau, Les Collines-de-l'Outaouais, La Vallee-de-la-Gatineau and Pontiac (Government of Quebec 2017). The largest city in the Region of Outaouais is Gatineau (Government of Quebec 2017). The Municipality of Sheenboro, in the Pontiac Regional County Municipality is the closest municipality to the NSDF Project site in the Province of Quebec. It is located approximately 16 km southeast of Chalk River across the Ottawa River. To travel by road from Chalk River to Sheenboro is approximately 80 km. Sheenboro is a small town of less than 800 citizens with primary industries of logging and farming. Sheenboro is also a popular tourist destination (Municipality of Sheenboro 2011).

[2] All licences for the operation of Chalk River Laboratories were transferred from Atomic Energy of Canada Limited to Canadian Nuclear Laboratories Ltd on November 3, 2014 (CNSC 2017).

5.10.4.2.1 Population, Demographics and Mobility

Between 2011 and 2016, the population in the Town of Deep River (4,109) had a slight decrease (2.0%) while the population in the Municipality of Laurentian Hills (2,961) increased during the same period (5.3%), as shown in Table 5.10.4-1. The Town of Deep River had an almost equal number of males and females, with 2,065 males and 2,040 females in 2016. The Municipality of Laurentian Hills had slightly more males than females, with 1,510 males and 1,450 females (Statistics Canada 2017a,b).

Deep River has a considerably older median age of 47.6 compared to the 41.3 median age of Municipality of Laurentian Hills and 40.4 median age for the province of Ontario (Statistics Canada 2017a,b). The Town of Deep River reported that most retirees remain in the town and replacement workers come from outside the community (CRPD 2017). Both communities experienced greater numbers of intraprovincial migration within the last five years, compared to interprovincial migration, which is likely due to the highly specialized workforce needed for CRL. In 2011, the Town of Deep River and the Village of Chalk River housed the two largest populations of employees from CRL (893 and 190 respectively; County of Renfrew 2011). The skilled workforce required in the nuclear industry is based predominantly in Ontario as most of Canada's nuclear reactors currently in full commercial operation, are in Ontario (NRCan 2016).

The population of Deep River has declined since 1991 when the population was 4,571 (County of Renfrew 2017). Like the aging trends seen in the County of Renfrew and the Province of Ontario, the Town of Deep River is aging as a result of the "baby boom". Between 2001 and 2011, all age categories in the town, except for the under-45 category, increased (Jp2g Consultants 2015a). The highest rate of growth in that period was seen in the 50 to 54 and 55 to 59 age ranges (16.7% and 25.7%), while the under 45 age range decreased (-7.4%).

A greater proportion of the Municipality of Laurentian Hills identified as Indigenous peoples (13.4%) compared to the Town of Deep River (6.7%). For both communities, this is well above the provincial average (Statistics Canada 2017c). Table 5.10.4-1 presents the population and demographic characteristics of the LSA.

In the RSA, the Petawawa CA[3] had a population of 17,187 and the Pembroke CA[4] had a population of 23,269 in 2011. The population of Petawawa grew by 7.5% between 2011 and 2016. The high rate of population growth in Petawawa is due to increased personnel at Garrison Petawawa, with soldiers returning from missions abroad with the end of active combat in Afghanistan (Butler 2012; Chase 2014). The presence of a large number of military personnel and their families also provides an explanation for the lower median age of 30.8 years, which is lower than the other LSA and RSA communities, and the Province. Similarly, both interprovincial and intraprovincial migration was higher in Petawawa, as military personnel come from across the province and Canada. There is also a relatively high self-identifying Aboriginal[5] population of 8.4% living in Petawawa (Statistics Canada 2017d).

[3] The Petawawa Census Agglomeration (CA) is defined by Statistics Canada as being the Town of Petawawa, Garrison Petawawa and surrounding areas. Data provided in this report are for the Petawawa CA.

[4] Pembroke Census Agglomeration (CA) is defined by Statistics Canada as being the City of Pembroke and surrounding regions. Data provided in this report are for the Pembroke CA.

[5] Throughout the EIS, the terms Aboriginal, Indigenous, First Nations, and Métis have been used, consistent with the source from which the term is drawn. The source of this information (Statistics Canada 2017d) uses the term Aboriginal.

Pembroke's 3.1% population decline was the third largest population decline in an Ontario urban area between 2011 and 2016 (Norris 2017). In Pembroke, intraprovincial migration was in line with trends seen in Laurentian Hills, Deep River and the Province. There are more women than men in Pembroke, which is common in RSA communities but not LSA communities. Pembroke's 11.1% Aboriginal population is much larger than the provincial average which is inline with communities across the LSA and northern areas of the RSA.

The Region of Outaouais has a population of 382,604 with a median age of 41.2, slightly below the provincial average. The population of the Region of Outaouais has grown 3.6% between 2011 and 2016, slightly above the provincial average of 3.3%. Approximately 5.5% of the population identifies as being of Aboriginal identity, higher than the average for the province which is 2.3%.

Within the Region of Outaouais, the Municipal Region County (MRC) Pontiac has a population of 14,251 and a median age of 50.4, which is higher than both the provincial average (42.5) and that of Outaouais (41.2). The population of MRC Pontiac has remained consistent between 2011 and 2016 with a slight decrease of less than 1%. The proportion of the population in MRC Pontiac identifying as being Aboriginal is approximately 18% which is significantly higher than the average for the province and the Region of Outaouais (Statistics Canada 2017i).

A 2017 paper regarding the economic landscape of MRC Pontiac noted that the area has been in decline for a number of years where youth migrate out of the area due to a lack of a post-secondary school and skilled employment opportunities and an out migration of senior citizens dues to a lack of local facilities and services to meet their needs (Pontiac Regional County Municipality 2017).

The City of Ottawa has a population of 934,243 with a median age of 40.1, slightly below the provincial average. The population of the City of Ottawa has grown 5.8% between 2011 and 2016, above the provincial average of 4.6%. Most of the population growth can be attributed to immigration with almost 32,325 migrants entering City of Ottawa between 2011 and 2016 (Statistics Canada 2017e). Approximately 2.5% of the population identifies as being of Aboriginal identity, lower than the average for Ontario of 2.8%.

Table 5.10.4-1: Population and Demographic Characteristics of the LSA, RSA and the Provinces of Ontario and Quebec

	Municipality of Laurentian Hills	Town of Deep River	Petawawa CA	Pembroke CA	City of Ottawa	Province of Ontario[(a)]	Region of Outaouais	MRC Pontiac	Province of Quebec[(a)]
Total Population 2016	2,961	4,109	17,187	23,269	934,243	13,448,494	382,604	14,251	8,164,361
Total Population 2011	2,811	4,193	15,988	24,017	883,391	12,851,821	369,171	14,358	7,903,001
2011 to 2016 population change (%)	5.3	-2.0	7.5	-3.1	5.8	4.6	3.6	-0.7	3.3
Median Age of the population	41.3	47.6	30.8	46.2	40.1	41.3	41.2	50.4	42.5
Males	1,510	2,065	9,265	11,160	453,875	6,559,390	188,195	7,100	4,016,760
Females	1,450	2,040	7,925	12,105	480,370	6,889,105	194,410	7,145	4,147,605
% of population with Aboriginal identity	13.4	6.7	8.4	11.1	2.5	2.8	5.5	18.1	2.3
Intraprovincial migrants within the last 5 years	530	550	3,360	2,150	42,440	1,380,900	30,095	1,165	893,800
Interprovincial migrants within the last 5 years	180	100	1,825	555	32,325	181,480	12,515	660	55,370

Source: Statistics Canada 2017a,b,c,d,e,f,g,h, i

(a) Data for the provinces of Ontario and Quebec are provided for comparison purposes

CA = Census Agglomeration.

5.10.4.2.2 Education

The population in the LSA are a highly educated and skilled workforce. In 2016, approximately two-fifths (39.9%) of the population of Deep River reported that they had attained a university level education or above, which was higher than the rates for the county and the Province of Ontario (10.1% and 20.9%; Statistics Canada 2017b,c). Approximately a quarter (27.3%) of the population in Deep River reported that they had attained a college or other non-university level certificate or diploma. In the Municipality of Laurentian Hills, approximately one-third (30.5%) had attained a high school certificate as their highest level of educational attainment (Statistics Canada 2017a). In comparison, 11.2% and 5.0% in the Municipality of Laurentian Hills and the Town of Deep River, respectively, had attained an apprenticeship, trades certificate or diploma (Statistics Canada 2017a,b).

In the RSA, approximately 35.2% of the population in Petawawa and 30.2% of the population in Pembroke had a high school certificate or equivalent as their highest level of education achieved. While the percentage of the population with a university degree or equivalent was lower than the provincial average, a larger percentage of people (26.4% in Petawawa CA and 26.3% in Pembroke CA) from these communities had attained a college or non-university certificate or diploma than the provincial average (18.4% in Ontario) (Statistics Canada 2017d,f).

In City of Ottawa, the rate of attaining college, CEGEP or other non-university certificates or diplomas as the highest level of education achieved is 20.0% and the rate of attaining a university certificate or diploma as the highest level of education achieved is greater than the provincial average (37.7% compared to 26.0%; Statistics Canada 2017e).

In the Region of Outaouais, the rate of attaining college, CEGEP or other non-university certificates or diplomas as the highest level of education achieved is slightly more than the provincial average (17.7% compared to 17.6%) and the rate of attaining a university certificate or diploma as the highest level of education achieved is also greater than the provincial average (21.7% compared to 20.5%; Statistics Canada 2017g). Approximately 22.5% of the population of Outaouais has their high school certificate or equivalent as their highest level of education achieved, similar to the provincial average for Quebec (21.5%). In Pontiac, the closest Regional County Municipality to the NSDF Project, 26.7% of the population have completed high school; 20.5% have completed college, CEGEP or other non-university certificate; and 14.1% have completed university at a bachelor level or above as their highest level of education achieved (Statistics Canada 2017i).

5.10.4.2.3 Land Use

The majority of land in the Town of Deep River's municipal boundary is owned by CNL, which falls under federal jurisdiction. Deep River is currently composed of a downtown core (i.e., commercial, institutional, high density residential), including:

- the marina and public waterfront;
- stable residential areas;
- the Highway 17 commercial corridor;
- large-lot estate residential;
- a large open space and parkland network (including the Four Seasons Conservancy trail system); and
- undeveloped areas to the west and east of the developed portion of the Town (Jp2g Consultants 2015a).

With the exception of existing operations and activities undertaken by CNL, other land uses of the CRL site are prohibited due to restricted public access. Limited trapping may occur along the southern portion of the RSA as described in Section 5.9 in the area surrounding the CRL site. The nearest area of notable agriculture and dairy farming is located within the RSA, 15 km southeast on the Quebec side of the Ottawa River and 35 km southeast on the Ontario side.

The Municipality of Laurentian Hills is a sparsely populated area. Outside of the village and hamlet settlement areas, most land within the municipality is rural land (Laurentian Hills 2010). With a population density of 4.6 people per km^2, the majority of residents in the municipality reside along the Highway 17 corridor and along the shoreline of the Ottawa River (Statistics Canada 2017a; Laurentian Hills 2010). A business park of approximately 9.7 ha of vacant lands is located at the southeast end of Chalk River (Laurentian Hills 2010).

Outdoor recreational activities in the Municipality of Laurentian Hills and the Town of Deep River include hiking, biking, snowmobiling and skiing trails as well as swimming, sport fishing and boating along the Ottawa River (Ottawa Valley 2016; Laurentian Hills 2016a). Of particular note is the 400-ha area located east of the Town of Deep River, the Four Seasons Conservation area, which is highly valued by the town's residents for outdoor recreation (Deep River 2013).

In the RSA, both the Municipality of Petawawa and the City of Pembroke are urban centres that are more densely populated than the LSA (Statistics Canada 2017a,b,d,f). The Garrison Petawawa is located in the northwest quadrant of Petawawa's central business district and provides retail services to military personnel and their families. The City of Pembroke is also a services and retail hub to nearby suburbs and communities. In the Region of Outaouais, much of the territory is used for agriculture with beef, dairy, market gardening and small berry production predominant in the region (Government of Quebec 2017). Recreational activities such as cycling and water-based activities take place in communities along the shores of the Ottawa River by residents and tourists from Ontario and Quebec (Petawawa 2016a; Pembroke 2016a; Outaouais Tourism 2017).

The MRC Pontiac is sparsely populated with a population density of 1.1 per km^2 (Statistics Canada 2017i), the majority of the population is found in the southern portion of the region. Further north the landscape is characterized by large open spaces with a number of lakes and rivers. There are few access roads with the main access to the southern portion of the region being via the Chemin du Bois Franc which runs north to south. This area is utilized for outdoor pursuits. Within the region is the ZEC (zone d'exploitation contrôlée) Pontiac, which is a Controlled Exploitation Zone on provincial land managed by a non-profit organization and offers services related to the practice of forest recreations such as fishing, hunting and camping (ZEC Pontiac 2020). The town of Campbell's Bay is the County seat and features a small number of community resources such as shops, churches, recreation facilities and schools.

5.10.4.2.4 Labour Market

The two largest employers within the vicinity of the NSDF Project are Garrison Petawawa and CNL (CRPD 2017). Garrison Petawawa is located in the RSA near the Town of Petawawa and employs nearly 7,000 military and civilian personnel (CRPD 2017). Chalk River Laboratories (i.e., CNL, as operator for the Atomic Energy of Canada Limited's) is the second largest employer in the region. As of May 2019, CRL employed approximately 2,850 employees. In addition, some of the historically larger employers in the region such as the Government of Canada's Petawawa Research Forest, located east of Chalk River between CRL and Garrison Petawawa, have ramped down operations and employment in the region (Forest Research Partnership 2016).

Between 2011 and 2016, the Municipality of Laurentian Hills's unemployment rate increased from 2.6% to 7.3% (Table 5.10.4-2). While this is a large change, it is likely a market correction as the 2016 rate of unemployment is aligned with the Ontario average (Statistics Canada 2017a,c). During the same period, the Town of Deep River's unemployment rate increased slightly (from 5.2% in 2011 to 5.9% in 2016). Based on the most recent data available, the Town of Deep River has a low unemployment rate (5.9%) while the Municipality of Laurentian Hills has a typical unemployment rate (7.3%) compared to the County of Renfrew (7.3%) and the Province of Ontario (7.4%; Statistics Canada 2017a,b,c,j). While the LSA communities' participation rates were slightly lower than the provincial rate, this is likely due to the higher median ages found in the LSA communities, which indicates a larger percentage of retirees present.

Table 5.10.4-2: Select Labour Market Characteristics (2016)

Community	Population Age 15 and Over	In the Labour Force	Employed	Unemployed	Participation Rate (%)	Unemployment Rate (%)
Municipality of Laurentian Hills	2,435	1,505	1,400	110	61.6	7.3
Town of Deep River	3,395	1,865	1,755	110	54.9	5.9
Petawawa CA	12,520	9,285	8,875	405	74.2	4.4
Pembroke CA	18,960	11,120	10,315	810	58.6	7.3
County of Renfrew	82,830	51,230	47,510	3,715	61.1	7.3
City of Ottawa	761,420	513,655	476,540	37,120	67.5	7.2
Province of Ontario[(a)]	11,038,440	7,141,675	6,612,150	529,525	64.7	7.4
Region of Outaouais	309,055	203,860	189,605	14,255	66.0	7.0
MRC Pontiac	11,985	6,295	5,630	660	52.5	10.5
Province of Quebec[(a)]	6,634,280	4,255,500	3,949,325	306,170	64.1	7.2

Source: Statistics Canada 2017a,b,c,d,e,f,h,I,i,j.

(a) Data for the provinces of Ontario and Quebec are provided for comparison purposes.

CA = Census Agglomeration

An economic overview for Deep River found that in 2014, a large proportion (41% or 1,061 out of 2,574 jobs) of the town's employment base was in the professional, scientific and technical services industry, followed by retail, accommodations and food services, and health care and social assistance (Jp2g Consultants 2015a). While the highest growth is anticipated in the service industries, growth in the professional, scientific and technical industries is largely linked to the operations of CNL, its contractors and other businesses that provide services directly to the company. The Town of Deep River strategized that diversification of this industry to other sources of businesses will benefit the local economy and make it more resilient in the event of organizational and operational changes at CNL (Jp2g Consultants 2015a). This is relatively aligned with the current occupations of Deep River's labour force where 32% of the labour force is employed in the professional, scientific or technical service sector (Statistics Canada 2017b).

There is a very limited number of construction firms in the Town of Deep River and Municipality of Laurentian Hills. In 2014, only 38 out of 2,574 jobs (1.5%) in Deep River were in the construction industry (Jp2g Consultants 2015a). The labour force in Deep River and Laurentian Hills also does not contain many construction workers with only 2.4% and 6% of community members employed in construction respectively (Statistics Canada 2017a,b). This is well below the Ontario provincial average of 6.7% (Statistics Canada 2017c). The few construction companies that do operate in the LSA communities focus primarily on home renovation (Yellow Pages 2016a,b).

In Petawawa, the labour force participation rate is higher (74.2%) than the provincial average and the unemployment rate (4.4%) is lower than the provincial average (Statistics Canada 2017c,d). The Garrison Petawawa employees and the population employed through the demand for goods and services spurred by the base, account for high employment levels and low number of job seekers in the community (Statistics Canada 2017d). Pembroke's labour force participation and unemployment indicators (58.6% and 7.3%%) more closely resemble a larger more diversified economy and are similar to those of Renfrew County (61.1% and 7.3%) and the Province of Ontario (64.7% and 7.4%; Statistics Canada 2017c,f,j). Approximately 9% of the available labour force in Pembroke is employed in the construction industry. This is slightly higher than the Ontario provincial average of 6.7% (Statistics Canada 2017c,f). There are 53 construction firms listed in Pembroke Ontario, and include contractors specialized in excavation, industrial buildings and project management (Yellow Pages 2016c). The 2015 Renfrew County labour market planning report identifies that construction is one of the five top industries of growth and identifies that there are 81 registered heavy construction and civil engineering firms in the county. The report also identifies that the number one industry for job seekers to find employment in is the construction industry, followed by retail and customer services/information jobs (Workforce Planning Ontario 2015). This report also identifies speciality trade contractors as the highest absolute employment growth sector between 2013 and 2014 (Workforce Planning Ontario 2015). Many of the speciality trade contractors operate small to medium sized businesses with one large business identified (Workforce Planning Ontario 2015).

In the Region of Outaouais, the labour force participation rate of 66.0% is 1.3% higher than the Ontario provincial average of 64.7%. The unemployment rate is also 0.4% lower than the provincial average of 7.4% in the Region of Outaouais at 7.0% (Statistics Canada 2017g). Public administration employs approximately 21.5% of the workers in the Region of Outaouais and represents the most prevalent form of employment. The employment in public service is well above the provincial rate of 5.8%. Manufacturing accounts for approximately 3.5% of the jobs in the Region of Outaouais which is below the Ontario provincial average of 9.6%. In all other listed industries, the Region of Outaouais is within 3% of the provincial average (Statistics Canada 2017g). Approximately 8.0% of the workforce is employed in the construction sector with 263 building contractors listed within the region (Statistics Canada 2017g; Yellow Pages 2017a).

In the MRC Pontiac, the labour force participation rate is 52.5% which is lower than the average for the province of Quebec (64.1%). The unemployment rate of 10.5% is higher than the provincial average of 7.2%. *Trades, transport and equipment operators and related occupations* is the most common occupation category for the municipality (22.3%) followed by *sales and service occupations* (21.3%) (Statistics Canada 2017i).

In the City of Ottawa, the labour force participation rate of 67.5% is 2.8% higher than the Ontario provincial average of 64.7%. The unemployment rate is also 0.2% lower than the provincial average of 7.4% in the City of Ottawa at 7.2% (Statistics Canada 2017e). Approximately 4.5% of the workforce is employed in the construction sector with 92 building contractors listed within the region (Statistics Canada 2017e; Yellow Pages 2017b).

5.10.4.2.5 Income

Table 5.10.4-3 presents the selected individual and family incomes by income source in the Municipality of Laurentian Hills, the Town of Deep River, Petawawa CA, Pembroke CA, the County of Renfrew and the Province of Ontario in 2015. Median income, average income and median family income in both LSA communities were higher than the Pembroke, County of Renfrew and Province of Ontario (Table 5.10.4-3). The Town of Deep River in particular had a median income ($48,717) that was approximately $15,000 above the provincial median income (Statistics Canada 2017b); this is most likely due to the number of residents who are employed at CRL, or who are retired and in receipt of a company pension. Similarly, Petawawa's high median income is due to a large portion of the population being employed by the military.

The median income in the Region of Outaouais is approximately $4,000 higher than the median income for Quebec. Those who live in the Region of Outaouais also capture approximately 2% more of their income through employment. The Region of Outaouais' higher than provincial average income is likely due to the high proportion of the population in the public administration sector (Government of Quebec 2017). The City of Ottawa had a median income roughly $8,000 higher than the provincial average.

Within the MRC Pontiac, the median income in 2016 was $26,490, which was lower than the provincial average of $32,975. The proportion of residents who receive their income through employment is lower compared to the rest of Quebec (59% compared to 68.4%), consequently the number of people receiving government transfers is higher (24.2% compared to 15.5%) (Statistics Canada 2017i).

Table 5.10.4-3: Selected Individual and Family Income by Income Source (2015)

	Municipality of Laurentian Hills	Town of Deep River	Petawawa CA	Pembroke CA	County of Renfrew	City of Ottawa	Province of Ontario[b]	Region of Outaouais	MRC Pontiac	Province of Quebec[b]
Median Income ($)	44,160	48,717	50,371	32,161	34,237	41,857	33,539	37,195	26,490	32,975
Average Income ($)	48,306	56,009	49,420	41,744	42,424	54,605	47,915	44,868	35,665	42,546
Market Income[a]	88.7%	90.4%	91.8%	83.6%	84.7%	91.4%	88.9%	85.9%	75.8%	84.4%
Employment Income	67.5%	65.2%	81.4%	66.8%	67.4%	72.8%	72.9%	70.3%	59%	68.4%
Government Transfer Payments	11.4%	9.8%	8.1%	16.4%	15.3%	8.6%	11.1%	14.1%	24.2%	15.6%
Median Household Income ($)	79,411	90,321	86,048	61,511	67,421	85,981	74,287	67,230	50,567	59,822

Source: Statistics Canada 2017a,b,c,d,e,g,h,i,j.

a) Market income is the sum of employment income (wages, salaries and commissions, net self-employment income from farm or non-farm unincorporated business and/or professional practice), investment income, private retirement income (retirement pensions, superannuation and annuities, including those from registered retirement savings plans [RRSPs] and registered retirement income funds [RRIFs]) and other money income from market sources during the reference period. It is equivalent to total income minus government transfers. It is also referred to as income before transfers and taxes.

(b) Data for the provinces of Ontario and Quebec are provided for comparison purposes.

CA = Census agglomeration.

5.10.4.2.6 Economic Development

Future economic growth and development opportunities are a key concern for the communities in the LSA and RSA. For instance, the Town of Deep River has identified that they are concerned with the changing demographics (fewer young people and families and a growing senior population) and the perceived difficulty in retaining young people and young families within the community (Jp2g Consultants 2015a). A Strengths-Weaknesses-Opportunities-Threats analysis completed for the Town of Deep River also identified a need to diversify the local economy to reduce dependence on a single employer (Jp2g Consultants 2015a).

Deep River's Strategic Plan aims to promote economic development and in-migration of newcomers to the community through attracting business and people to the community (Deep River 2019). The Town of Deep River established an economic development advisory committee in 2015 with the aim of having an annual economic development forum to bring local business leaders together to attract investment and retain business. In addition, Deep River revised its Official Plan in 2017 to identify new employment lands, set appropriate targets to increase ratio of jobs per population and establish growth plan targets for the community.

The town has developed a population growth target that would see approximately 10% more employees from CNL and Garrison Petawawa living in Deep River by 2036 through employment growth and attracting a higher proportion of existing employees (Jp2g Consultants 2015a). Three strategies for economic development that have been proposed in Deep River are using the community's natural assets to promote sustainable tourism, diversifying the housing stock and developing long-term care services for the elderly (Jp2g Consultants 2015b, 2016).

Similarly, the Municipality of Laurentian Hills are also pursuing economic development opportunities to encourage positive population growth rates than can be achieved by “a significant change in the economic circumstances of the Municipality leading to in-migration” (Laurentian Hills 2010). The municipality has established the Chalk River Business Park where approximately 9.7 ha of land is available for new business and industrial development.

In Petawawa, the military is still driving investment and growth in the economy. The community has, however, identified a need to diversify its economy and attract non-military driven economic development opportunities and have zoned land for industrial and commercial developments (Petawawa 2016b). In 2015, the Government of Canada committed $20 million dollars as investment for Garrison Petawawa to improve infrastructure, including roads and military housing at the Petawawa base, and to help create local jobs in the community of Petawawa (Government of Canada 2015).

The largest sectors operating in Pembroke include health care, retail and manufacturing (including wood product manufacturing). The community is also actively encouraging the growth of new business opportunities and has established an economic development strategy and advisory committee that aims to expand and retain industrial and small business ventures. Several parcels of land have been slated for commercial opportunities, including two business parks (Pembroke 2016b).

The economy of the Region of Outaouais is predominantly based on tourism, forestry, agri-food and government administration (Government of Canada 2014). In the early 1990s, an economic diversification process was initiated which has resulted in the development of the information technology and agri-food sectors (Government of Quebec 2017). The information technology niche that has expanded most over the years has been software engineering (Government of Quebec 2017).

The MRC Pontiac published their strategic plan in 2010 that outlines five key sectors for development and growth: tourism, social, cultural and community, business and industry, forestry and natural environments, agriculture and agri-foods (Pontiac Regional County Municipality 2010). This document identifies tourism as the “cornerstone of economic development”. A survey with Pontiac business owners in 2017 identified that Pontiac businesses and private and public organizations mainly come from the retail trade (14.4%), agriculture, forestry, fishing and hunting (11.8%), and accommodation and food services (9.9%) sectors (Zins Beauchesne et Associés 2017).

5.10.4.2.7 Government Finances

Tax revenues reflect the economic vitality of a community, in terms of business activity, local incomes and property values. Tax expenditures help identify key areas of public service and community need. Recent municipal revenues and expenditures in the LSA are presented in Table 5.10.4-4. The NSDF Project will be located on land owned by Atomic Energy of Canada Limited, a federal Crown corporation. As the land is Crown property, the company makes payments in lieu of taxes to local governments (Government of Canada 2016). Top revenue sources for the communities in the LSA include municipal and property taxation and user charges. Top expenditures were most often related to protection services and environmental services (Table 5.10.4-4). Table 5.10.4-4 presents municipal government expenditures and revenues for LSA and RSA communities in Ontario and Quebec. Information on Sheenboro is presented as it is the closest municipality to the Project in the Province of Quebec.

Table 5.10.4-4: Government Expenditures and Revenues in the Local Study Area (Years)

Community (Year)	Total Expenditures ($)	Top Expenditure ($)	Total Revenue ($)	Top Revenue Source ($)	End of Year Financial Position[a,b] ($)
Town of Deep River (2013)	10,389,500	Protection Services, Environmental Services, Recreation and Cultural Services	9,343,330	Taxation, user charges, government transfers	▪ Annual Deficit = (1,046,170) ▪ Accumulated Surplus = 21,945,004
Municipality of Laurentian Hills (2014)	3,663,244	Environmental Services, Transportation Services, Protection Services	4,340,609	Property taxes, governments transfers, sewer and water service charges	▪ Annual Surplus = 677,365 ▪ Accumulated Surplus = 10,036,152
Municipality of Petawawa (2014)	18,133,789	Environmental Services, Recreation and Cultural Services, Protection Services	20,533,756	User charges, payments in lieu of taxes, Property taxation, Gas Tax Funding	▪ Annual Surplus = 2,399,967 ▪ Accumulated Surplus = 84,701,438
City of Pembroke (2013)	33,825,939	Protection Services, Environmental Services, Transportation Services, Recreational Services	35,456,823	Taxation and Payments in Lieu, User Charges, Government Transfers	▪ Annual Surplus = 1,630,884 ▪ Accumulated Surplus = 102,919,067
Municipality of Sheenboro (2014)[c]	693,866	Transportation Services, General Administration, Public Security	687,768	Taxation and Grants	▪ Annual Deficit = (6,098) ▪ Accumulated Surplus = 1,629,602

Source: Deep River (2014), Laurentian Hills (2015).

(a) Annual Surplus/Deficit is the difference between Annual Revenue and Expenditures for a given financial year.

(b) Accumulated Surplus/Accumulated Deficit refers to the municipalities overall financial position at the end of the fiscal year.

(c) No taxation records available for the Region of Outaouais, the closest community is being used as a proxy.

5.10.4.2.8 Housing and Accommodations

In the Town of Deep River, there is a relative shortage of medium to high density housing, with single detached homes comprising most of the housing in the town (CRPD 2017; Jp2g Consultants 2015a). The town has identified a need for more varied and smaller housing forms. In 2016, of the 1,825 total private dwellings, 76% were single detached houses, 12% were semi-detached houses, and 12% were units in apartment buildings (Statistics Canada 2017b). The town strategized that broadening the types of tenure and housing available to residents will make the community more attractive to live in. The vacancy rate, as reported by local real estate agents, is reported to be very close to zero (Town of Deep River 2015).

Similarly, most of the housing in the Municipality of Laurentian Hills is also single-detached homes. In 2016, 92% of the 1,190 private dwellings in the municipality were single-detached- homes (Statistics Canada 2017a). Other housing available in the town are 10 semi-detached houses, five row houses, 50 mobile homes and 30 units in an apartment building.

Approximately 70% of the 6,335 houses in Petawawa are single-detached homes. The remaining homes include semi-detached houses (6.8%), row houses (13.8%) and low-rise apartment buildings (8.8%) (Statistics Canada 2017d). In Pembroke, 71.8% of the almost 10,000 housing units in the community are single detached houses. Low storey apartment buildings account for about 16.7% of all available stock, with the rest being made up of semi-detached and row houses (Statistics Canada 2017f). In the Region of Outaouais, approximately 52.4% of the occupied private dwellings are single detached houses (Statistics Canada 2017g). Remaining homes include apartment dwellings (22.2%), movable dwellings (0.3%), semi-detached houses (11%) and row houses (4.5%; Statistics Canada 2017g). In the MRC Pontiac there are 6,205 homes, 88.2% of which are single-detached homes while 2.7% are semi detached houses, 1% are row homes and the remaining houses are low storey apartments or duplexes and mobile homes (Statistics Canada 2017i).

Hotel accommodations are available in the Town of Deep River. There is one hotel and five motels in the Town of Deep River, and there are no hotels in the Municipality of Laurentian Hills (Laurentian Hills 2016b). Ten motels are available for temporary accommodation in Petawawa (Hotel Guides 2016). In the City of Pembroke and the surrounding area, there are approximately 39 temporary accommodations available (Expedia 2016). Hotel accommodations are available at 236 locations in the Region of Outaouais (Expedia 2017).

5.10.4.2.9 Services and Infrastructure

Traffic and Transportation

The major arterial Highway that connects the NSDF Project to the LSA communities and other regions of Ontario is Highway 17. Highway 17 is the longest highway in Ontario, spanning 1,964 km in a southeasterly direction from Kenora to Arnprior, Ontario. In 2016, annual average daily traffic counts found that traffic levels between the Village of Chalk River and Deep River were 7,950 vehicles per day (MTO 2016). Traffic volumes further south along Highway 17 around Petawawa and Pembroke ranged from 7,300 to 8,750 vehicles per day (MTO 2016). Traffic volumes increase beyond Pembroke towards Ottawa.

From Sheenboro, the primary route to the NSDF Project site is travelling along the Chemin de Chapeau Sheenboro Road, Quebec’s Highway 148 and Ontario’s Highway 17. The distance from Sheenboro to the NSDF Project site is approximately 85 km and is a one-hour travel with normal traffic (Google Maps 2017). Along the preferred route on Highway 17, the traffic volume ranged between 7,100 and 8,750 vehicles per day (MTO 2016). Along the preferred route on Highway 148 traffic levels ranged from 5,900 to 12,300 vehicles per day (MTO 2016). Data is not available for traffic volume on Chemin de Chapeau Sheenboro.

Existing traffic to and from the site was studied by Stantec (CNL 2017c). The morning peak hour inbound traffic was 724 vehicles while the afternoon peak hour outbound traffic was 787 vehicles (CNL 2017c). Overall, the annual average daily traffic count is calculated to be 8,210 at the existing site for eastbound and westbound traffic.

Waste and Water Management

Chalk River Laboratories has solid waste and wastewater facilities on-site that are able to process uncontaminated, contaminated and radioactive waste. On-site waste facilities include landfills for solid waste, such as office garbage and/or waste rock or fill from construction and operation activities. Chalk River Laboratories also collects food waste for disposal at an off-site composting facility. Chalk River Laboratories has on-site wastewater facilities including a septic system and a sewage treatment plant. The NSDF Project facilities also include the development of a WWTP, which will be dedicated to servicing the NSDF Project. There will be a sanitary sewage system at the NSDF Project site. The grey water and sanitary sewage will be transferred by a gravity sewer network to two septic sewage systems; one located on the north end of the site and the second located on the south end of the site.

The Town of Deep River and the Municipality of Laurentian Hills jointly operate the North Renfrew Waste Disposal Site (Baggs Road Landfill) for household waste located just outside of the CRL site. As well, the Town of Deep River operates the Miller's Road Landfill for construction and demolition waste.

Potable water for most of the population in the region is sourced from the Ottawa River. The communities of Deep River, Petawawa and Pembroke each have water treatment plants and receive their water from the Ottawa River. The Village of Chalk River receives its water from Corry Lake, an inland lake located south of Chalk River.

An estimate of the number of residents using groundwater as their source of potable water was determined from a review of database of water supply wells in the province maintained by the Ontario Ministry of the Environment and Climate Change. The review identified 1,902 water wells in the region between Rolphton and Quebec.

Emergency and Protective Services

Fire Services

Chalk River Laboratories has its own full-time fire service that is staffed 24/7 with 40 full time firefighters, up to 6 casual firefighters, and a 10-member Fire Emergency Response Group. The department delivers fire and emergency services utilising 2 pumpers, an aerial, a pumper/tanker and other ancillary vehicles and equipment. The CRL fire department is comprised of a 4-platoon rotational staffing system with 10 firefighters (two officers and eight firefighters) assigned to each platoon and it is structured to provide emergency services with a minimum of eight firefighters on duty at any given time. CRL has established a reciprocal mutual fire aid agreement with fire services in the communities nearest to the NSDF Project site. The community may be able to provide additional resources upon request if they are not committed to an emergency in their own municipality. CNL and the Town of Deep River signed a Fire Protection Service Agreement, effective as of June 1, 2018. CNL Fire Operations now provides a Fire Chief, Deputy Fire Chief, a Fire Prevention Officer, CNL Officer Firefighters, and CNL Firefighters to the Town to an annual maximum of 14,000 personnel hours. This agreement supports a return to 24/7 on-duty coverage in the Deep River fire hall.

As noted, in the LSA, the Town of Deep River and the Municipality of Laurentian Hills have their own fire departments. The Town of Deep River is comprised of a composite fire department utilising full time and volunteer firefighters (approximately 25 members) whereas the Laurentian Hills fire department is solely comprised of approximately 40 volunteer firefighters. No capacity issues such as staffing, equipment or training have been identified in the LSA (Dillon Consulting 2013).

Additionally, CRL has a formal reciprocal mutual fire aid agreement with the Garrison Petawawa fire department and is eligible to request additional firefighters and/or fire apparatus during an emergency. The Garrison Petawawa fire department may be able to provide additional resources upon request if they are not committed to an emergency in their own area.

In the RSA, the Town of Petawawa has a fire department that has two stations serving the community (Petawawa 2016c). The City of Pembroke also has a composite fire department that currently operates out of one station (Pembroke 2016c,d). Pontiac Regional County Municipality, within the Region of Outaouais, contains eighteen municipalities all offering fire services (Pontiac Regional County Municipality 2011).

Emergency Medical Services

Chalk River Laboratories does not have its own emergency medical services. The County of Renfrew Paramedic Services provides paramedic assistance to communities within the County of Renfrew. Every request for paramedic assistance dispatched through the 9-1-1 system or the Community Paramedic Referral Program is responded to by a qualified Paramedic. Of the two LSA communities, only Deep River has an ambulance base. In the RSA, there are ambulance bases in both Petawawa and Pembroke (County of Renfrew 2016b).

In 2016, the County had 133 front-line paramedics, 67 of those were full-time and 66 are part-time paramedics. There are 47 advanced care paramedics and 86 primary care paramedics. The County has a total fleet of 25 ambulances. Seven ambulance vehicles provide 24-hour coverage seven days a week and 10 ambulances provide 12-hour coverage 7 nights per week throughout the county. There is one emergency response vehicle that operates 24 hours per day, 7 days a week and 5 community paramedic response units, operating 12 hours a day, 7 days a week. The average response time for the Renfrew County emergency medical services is approximately 9 minutes.

County representatives note that a challenge they face is that that they serve a large rural county with long distances between communities. There is currently no service agreement in place between the County of Renfrew's emergency medical services and CRL. The County notes that it would be good to have improved interagency operability between different jurisdictions to improve emergency medical services capabilities. The nearest hospital to the CRL site is the Deep River and District Hospital located in Deep River. The Deep River and District Hospital offers emergency care, acute inpatient care, diagnostic imagery, laboratory service and physiotherapy (Deep River and District Hospital 2011a). There are sixteen beds within the hospital and one emergency care physician is on-call or on site (Deep River and District Hospital 2011b,c). The nearest full-service hospital to the NSDF Project site is the Pembroke Regional Hospital, located south of Chalk River in the Municipality of Pembroke (Pembroke Regional Hospital 2016).

Protective Services

Chalk River Laboratories has a security service which provides site access control and conventional security to the CRL site. The Deep River Police Service provides policing services to CRL for any criminal charges and/or motor vehicle accidents that happen on site. The Ontario Provincial Police are responsible for policing the Municipality of Laurentian Hills (i.e., Town of Laurentian Hill and Village of Chalk River). The Ontario Provincial Police also patrols Highway 17.

5.10.4.2.10 Quality of Life

This section presents a description of the existing conditions relating to quality of life for residents living within the LSA. For the purposes of environmental assessment, quality of life is assessed as changes in air quality, ambient noise, increases in traffic volume and visual disturbances (nuisance effects).

Baseline air quality conditions in the air emissions LSA are described in Section 5.2.1 (Air Quality). The primary source of sulphur dioxide and nitrogen oxides in the region is the combustion of fossil fuels, including from the operation of stationary sources, as well as from mobile sources such as vehicles and other equipment. Between 2009 and 2013, no exceedances of the 1-hour or 24-hour Ambient Air Quality Objectives for sulphur dioxide and nitrogen oxides were recorded at the Ottawa Downtown monitoring station[6]. Levels of 24-hour particulate matter less than 2.5 microns in diameter that can affect air quality for humans by aggravating existing lung or heart conditions, have not been exceeded at the Petawawa or Ottawa Station.

Existing traffic volumes are described in Infrastructure and Services (Section 5.10.4.2.9). In 2014, there were 107,028 motor vehicles registered in the County of Renfrew. Most accidents occurred on Highway 17, with 515 total collisions (MTO 2014). Within the county, there were higher numbers of total collisions in the more populated urban communities, with the Municipality of Petawawa having 138 collisions and City of Pembroke registering 206 collisions in 2014. The LSA communities had notably lower number of total collisions, with 10 collisions occurring in the Municipality of Laurentian Hills and 14 collisions in the Town of Deep River in 2013 (MTO 2014).

Baseline data on existing traffic levels were collected on public transportation routes (i.e., Plant Road) used to access CNL’s CRL site from the Village of Chalk River as part of the NSDF Traffic Study (CNL 2017b). Existing traffic levels along Highway 17 were taken from published MTO 2016 traffic volumes presented in Section 5.10.4.2.9. To understand approximate noise impacts as a result of these traffic levels, published literature for typical traffic flows along different types of roads was used to develop assumptions. Using these assumptions, the results of *Noise Impact Study of CNL NSDF Project Construction-Related Road Traffic on Human Receptors* (Golder 2020) indicate that at the existing traffic levels, the percentage of people classified as “highly annoyed[7]” is 9.7% at a distance of 15 m from Plant Road and 24.7% at a distance of 20 m from Highway 17. The distances of 15 m and 20 m correspond to the minimum distances between the nearest identified noise-sensitive receptor and Plant Road and Highway 17, respectively. At a distance of 60 m, the percentage of people in the community classified as highly annoyed due to existing road traffic is 2.9% on Plant Road and 10.9% on Highway 17 (Golder 2020).

6 Nitrogen oxides and sulphur dioxide monitoring was not available at the Petawawa station.

7 High annoyance has been widely used as one way to estimate a community response to noise levels (Health Canada 2017).

5.10.4.2.11 Public Safety

The NSDF Project will be located entirely on the CRL site. The NSDF Project will follow the CRL security requirements, physical security plans, and health and safety programs. Access to the NSDF Project site is exclusively from within the CRL site boundary and access to the CRL site is strictly controlled by security personnel. Section 3.4.4.3 more fully describes access control, security management, and health and safety plans for the NSDF Project.

5.10.5 Project Interactions and Mitigation

5.10.5.1 Methods

This section describes the process by which interactions between NSDF Project components and activities and socio-economic VCs were identified and evaluated. Potential effects pathways are identified and mitigation developed to eliminate and/or reduce effects is presented. A pathways analysis is then used to focus the assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects will be adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects after incorporation of mitigation are further characterized in subsequent subsections of the assessment. As such, this section helps to focus the remainder of the assessment on those interactions (effects pathways) likely to result in residual adverse effects.

The first part of the analysis was to identify the potential effects pathways for all stages of the NSDF Project. The next step in the analysis was the development of environmental design features and mitigation practices that could be incorporated into the NSDF Project to eliminate and/or reduce effects to socioeconomic VCs. Environmental design features included design elements, environmental best practices and management policies and procedures. Environmental design features and mitigation were developed through an iterative process between the engineering and environmental teams, combined with input from project-specific or regional engagement with other interested parties. The design features and/or mitigation activities were selected considering their effectiveness for implementation and maintenance, and their appropriateness within the context of the identified effects pathways.

After incorporation of mitigation, potential pathways were evaluated into the following categories using scientific knowledge, logic, experience with similar developments, and the effectiveness of environmental design features and mitigation.

- **No linkage:** The pathway is removed by environmental design features or mitigation such that the NSDF Project would not be expected to result in a measurable environmental change to measurement indicators identified for socio-economic VCs relative to Base Case values, and therefore would have no residual effects to socio-economic VCs.
- **Secondary pathway:** The pathway could result in a measurable minor change to measurement indicators identified for socio-economic VCs, but would have a negligible residual effect on socio-economic VCs relative to Base Case values and is not expected to contribute cumulatively to other NSDF Project effects or to the effects of other previous, existing or reasonably foreseeable developments to cause a significant direct or indirect effect.

- **Primary pathway:** The pathway is likely to result in an environmental change to measurement indicators identified for socio-economic VCs relative to the Base Case that could contribute to residual direct or indirect effects on socio-economic VCs.

Environmental design features and mitigation that have been or could be incorporated into the NSDF Project to eliminate and/or reduce adverse effects to socio-economic VCs were considered. Potential pathways that were completely removed due to implementation of environmental design or mitigation were not assessed further. Pathways that were assessed to be secondary and demonstrated to have a negligible residual effect to socioeconomic VCs through simple qualitative or semi-quantitative evaluation of the pathway were also not advanced for further assessment. These effects can be considered either direct or indirect in nature e.g., effects on residents' quality of life may occur as a consequence of an increase in nuisance effects that may occur from increases in noise or dust as a direct result of project works. Primary pathways were carried forward for more detailed quantitative and qualitative effects analysis to characterize the residual effects of the NSDF Project on socio-economic VCs (Section 5.10.6).

5.10.5.2 Results

The results of the pathways analysis are summarized in Table 5.10.5-1. Environmental design features and management policies implemented to reduce potential effects are also described.

Table 5.10.5-1: Pathways Analysis for Socio economic Valued Components

Project Activity	Valued Component	Effects Pathways	Project Design Features and Policies	Pathway Assessment
Employment of personnel, procurement of goods and services, and expenditures from the NSDF Project	Labour Force	▪ Direct and indirect employment requirements may affect employment and income with the local and regional study areas. ▪ The NSDF Project may provide contracting and supplier opportunities to Indigenous local and regional businesses.	▪ CNL employment opportunities that may arise due to Project activities will be posted on the vendor portal on www.cnl.ca website. ▪ CNL is working with Indigenous communities on employment and contracting opportunities.	Primary (Potential socio-economic effects are not related to a change from the Project on the environment)
	Economic Development	▪ The NSDF Project may provide contracting and supplier opportunities to local and regional businesses. ▪ The NSDF Project may provide contracting and supplier opportunities to Indigenous local and regional businesses.	▪ CNL will competitively procure material and services for the NSDF Project. ▪ CNL is working with Indigenous communities on employment and contracting opportunities.	Primary (Potential socio-economic effects are not related to a change from the Project on the environment.)
	Government Finances	The NSDF Project may contribute to government finances through the payment of property taxes.	▪ Payment of taxes.	No Linkage
Employment of personnel, use of services and infrastructure for NSDF Project	Housing and Accommodations	The NSDF Project could increase pressure on commercial accommodations.	▪ None	Primary (Potential socio-economic effects are not related to a change from the Project on the environment).
		Changes in housing demand with respect to LSA housing supply and capacity to meet demand.	▪ The construction workforce will be housed in accommodations in the Town of Deep River and the surrounding areas.	No Linkage
	Services and Infrastructure	Changes in demand for community services (health, education, protective and emergency services) with respect to the capacity of LSA services to meet the demand.	▪ Continued implementation and maintenance of compliance with all applicable health and safety standards and CNL's existing environmental, safety and security programs.	Primary (Potential socio-economic effects are not related to a change from the Project on the environment)

Table 5.10.5-1: Pathways Analysis for Socio economic Valued Components

Project Activity	Valued Component	Effects Pathways	Project Design Features and Policies	Pathway Assessment
Employment of personnel, use of services and infrastructure for NSDF Project (cont'd)	Services and Infrastructure (cont'd)	Changes in demand for community infrastructure (e.g., domestic waste management) with respect to capacity of infrastructure to meet demand.	▪ Use of existing waste management infrastructure and facilities on the CRL site where possible. Disposal of materials at appropriate licensed waste management facilities with capacity where off-site disposal of contractor construction waste is required.	Secondary (Potential indirect socio-economic effects could occur as a result of changes not related to the environment).
		The NSDF Project could increase road degradation due to increased traffic volume from the transportation of workers, supplies and equipment.	▪ Coordinate transportation of equipment and materials during construction to avoid peak traffic times to the extent possible.	Primary (Potential socio-economic effects are not related to a change from the Project on the environment)
	Quality of Life	The NSDF Project could affect air quality through the generation of emissions and fugitive dust.	▪ Implementation of CNL's procedure for Management and Monitoring of Emissions, which includes operational control monitoring and verification monitoring. ▪ Implementation of the Dust Management Plan developed for the NSDF Project, which includes appropriate management techniques to control dust generated by the NSDF Project.	Secondary (Potential indirect socio-economic effects could occur as a result of a change from the Project on the environment [i.e., dust])
		The NSDF Project could affect ambient noise levels due to construction traffic.	▪ A maximum of 40 shipments per day will occur during the nighttime period (i.e., 10 pm to 7 am).	Secondary (Potential indirect socio-economic effects could occur as a result of a change from the Project on the environment [i.e., noise])

Table 5.10.5-1: Pathways Analysis for Socio economic Valued Components

Project Activity	Valued Component	Effects Pathways	Project Design Features and Policies	Pathway Assessment
Employment of personnel, use of services and infrastructure for NSDF Project (cont'd)	Quality of Life (cont'd)	The NSDF Project could affect ambient noise levels due to blasting activities.	▪ Blasting activities will be done by a qualified person and in accordance with the Blasting Plan to be developed by the contractor, indicating the type of explosives used and the method of detonation.	Secondary (Potential indirect socio-economic effects could occur as a result of a change from the Project on the environment [i.e., noise])
		The NSDF Project could have a negative effect on visual aesthetics.	▪ The visual effect of the NSDF Project site will be limited as the line of sight will be obscured by hilly topography and the surrounding tree line.	Secondary (Potential indirect socio-economic effects could occur as a result of a change from the Project on the environment [i.e., effects to the visual landscape])
	Public Safety	Public's potential exposure to physical hazards associated with the NSDF Project.	▪ The NSDF Project will follow the CRL security requirements, physical security plans, and health and safety programs.	No Linkage

LSA = Local Study Area.

5.10.5.2.1 No Linkage Pathways

An interaction may have no linkage to environmental effects if the activity does not occur, or if the interaction is removed by mitigation so that the NSDF Project results in no detectable change in measurement endpoints, and subsequently, no residual effect to socio-economic VCs. The following pathways are anticipated to have no linkage to residual effects to socio-economic VCs, and will not be carried through the residual effects assessment in Section 5.10.6.

- **The NSDF Project may contribute to government finances through the payment of property taxes.**

As the NSDF Project will be built on CNL's existing CRL site, which is located on federal land, no additional property taxes are required. Payment in lieu of taxes will continue to be paid to the Town of Deep River. This potential project-environment interaction has therefore been assessed as resulting in no change from existing conditions.

- **Public's potential exposure to physical hazards associated with the NSDF Project.**

The NSDF Project security will follow CRL's site security requirements and physical security plans (Section 3.5.2.7). Access to the NSDF Project site is exclusively from within the CRL site boundary and access to the CRL site is strictly controlled by security personnel. In addition, a security fence will be installed around the entire perimeter of the engineered containment mound to prohibit unauthorized personal from entering, and to limit animal injury and contact during construction and waste placement operations. As well, CNL's Occupational Safety and Health Program is designed to provide for the protection of workers and public health and safety in relation to CNL activities. CNL and its contactors will meet all applicable health and safety legislative requirements. CNL has a Transportation of Dangerous Goods Program that applies to all modes of transport and all locations where CNL is responsible as the consignor (shipper), consignee (receiver), carrier or material owner of dangerous goods off-site. Section 3.5.2 describes access control, security management plans, health and safety programs, and transportation of dangerous goods for the NSDF Project. As security measures to limit access to the NSDF will be put in place, as well as safety measures to protect workers and the public, this potential Project-environment interaction has been assessed as having no linkage to residual effects to public safety.

- **Changes in housing demand with respect to LSA housing supply and capacity to meet demand.**

Residential housing in the LSA is not expected to be affected by the temporary presence of NSDF Project construction workers. NSDF Project employment during the construction phase will be temporary in nature, and filled largely by contractors from the LSA and RSA, although some may also be out of area. Temporary workers from outside of the LSA will be housed in existing accommodations and are not expected to relocate permanently to the LSA due to the temporary nature of employment. Given that no project in-migration is expected and workers will be housed in existing accommodations (e.g., hotels), an increased demand for housing is not expected. As such, this potential Project-environment interaction has therefore been assessed as having no linkage to residual effects to local housing and accommodations.

5.10.5.2.2 Secondary Pathways

In some cases, an interaction may exist, but since the change caused by the NSDF Project is anticipated to be negligible, it has no measurable or detectable effect on socio-economic VCs relative to baseline conditions. The following pathway is expected to be secondary and will not be carried through the residual effects assessment in Section 5.10.6.

- **The NSDF Project could affect air quality through the generation of emissions and fugitive dust.**

The construction and operations phases of the NSDF Project will generate non-radiological air and dust emissions such as carbon monoxide, oxides of sulphur (includes sulphur dioxide), oxides of nitrogen (includes nitrogen dioxide), particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) and suspended particulate matter (SPM). Air emissions can result from the use of fossil fuels in generators, vehicles and machinery. Vehicle exhaust and fugitive dust from unpaved and paved roads is the largest contributor to particulate matter (SPM, PM_{10} and $PM_{2.5}$) during both construction and operations (see Section 5.2.1.6.2).

Mitigation measures to be implemented to limit predicted residual effects from NSDF Project emissions to air quality include meeting Tier 2[8] emission standards for on-site vehicles and equipment engines, use of vehicles that are maintained in good working order and idling of vehicles on site will be limited consistent with CNL's Environmental Protection Program. Dust control will be conducted to support waste placement operations in accordance with the *Dust Management Plan* (AECOM 2018) during loading, transportation, placement and compaction operations. Work areas that have the potential for generating dust will require implementation of dust suppression technique. The primary dust control method will include water spraying or misting techniques (e.g., water trucks). Water application is controlled to avoid generation of free liquids. Fixatives (e.g., chemical suppressant) may also be used for dust control and for use as daily ECM cover. The use of fixatives is reviewed prior to application for potential effects on leachate and surface water runoff generated by the ECM.

Predicted concentrations for the Application Case during both construction and operations phases are below applicable air quality guidelines and/or standards with the exception of nitrogen dioxide, that will not meet the 2020 1-hour CAAQS (Section 5.2.1.6.2, Table 5.2.1-14). The contributing factor to the high magnitude nitrogen dioxide emissions is the heavy-duty construction equipment and the conservative assumption that all equipment will run simultaneously and continuously during working hours. In reality, individual equipment will be idling or off for varying parts of the workday that cannot be predicted but will result in lower emissions than currently estimated. The likelihood that all equipment operates simultaneously for an hour or more along with unfavourable weather conditions to produce the maximum concentrations modelled is very low. With the implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018) and through the implementation of the *Dust Management Plan* (AECOM 2018) for the NSDF Project, the residual effects from the NSDF Project on air quality was predicted to be not significant. Consequently, this potential Project-environment interaction is considered to have a negligible residual effect on quality of life.

8 These regulations set performance-based emission standards for air pollutants and toxic substances from new off-road diesel engines such as those typically found in construction, mining, farming, and forestry machines. Increasing Tier levels indicate stricter emission standards required at the time of manufacture.

- **The NSDF Project could affect ambient noise levels due to construction traffic.**

Noise propagation will be mitigated by the topography as the NSDF Project is situated on the lower side of the hill adjacent to East Mattawa Road (Figure 3.1.1-1 NSDF Site Layout). Changes in ambient noise levels from activities on the NSDF Project site are not expected to be detected in the LSA communities, due to the distance from the NSDF Project site (i.e., Village of Chalk River is the nearest local community and is located 7 km west of the NSDF site).

Noise-level changes often considered in an environmental assessment include noise-induced sleep disturbance, noise complaints and long-term high annoyance. For the NSDF Project, a qualitative assessment of the acoustic environment was carried out based on the separation distance between the NSDF Project site and the nearest dwelling. In accordance with the Ontario Ministry of Environment, Conservation and Parks guideline NPC 300 (MOE 2013), dwellings include permanent and/or seasonal residences. Communities in the vicinity of the NSDF Project site are shown on Figure 5.10.3-1, which includes the nearest residences on the Quebec side of the Ottawa River, approximately 3 km from the NSDF Project site. Based on this separation distance, a detailed assessment is not typically required by the Ontario Ministry of the Environment and Climate Change. In addition, based on the Health Canada guidance (Health Canada 2011), a less extensive assessment may be warranted if noise levels at all receptors are not expected to result in a change in long-term high annoyance exceeding 6.5%.

The haulage route for transportation of site preparation and construction equipment, and construction materials will be via public roads to the CRL site (e.g., Highway 17 and Plant Road). Plant Road is a two lane paved road, primarily used as a conduit for employee traffic to the CRL site as it is the only access route. As discussed in Section 5.10.4.2, CRL employs approximately 2,850 employees and there are also contractors working on-site and daily deliveries to and from the CRL site. There is a community of approximately 35 buildings on Plant Road, including both residences and businesses, between Highway 17 and the CRL site, with no other types of noise sensitive receptors (i.e., schools, hospitals). There is also traffic associated with a small municipal landfill accessed from a side road just before the CRL site.

The hours of operation for truck transport is typically 6 days per week, with 16-hour days but may vary between 12 and 18 hours per day depending on Project activities. Based on estimates of truck deliveries to the NSDF Project site during the 24-month construction period, it is anticipated there will be approximately an additional 200 shipments per day during the 9-month construction season. This represents an increase of approximately 5% to 6% (assuming each inbound trip results in an outbound trip) over existing traffic volumes on Highway 17 at Deep River. The additional construction personnel requirements are expected to result in an additional 300 inbound and outbound trips to the site daily. It is estimated that there will be 10 trucks per day during operations (i.e., less than 1 truck per hour).

In addition, it is assumed that construction workers will travel to the NSDF Project site from the local commercial accommodations using their own personal vehicles. The transport vehicles will pass through the Town of Chalk River. This level of activity is not expected to result in a change in long-term high annoyance exceeding 6.5%. Similarly, the noise levels associated with these truck movements are not expected to increase day-night noise levels (L_{dn}) above 75 dBA (the level at which noise complaints may include strong appeals to authorities to stop noise [Health Canada 2017]). Transportation of equipment and construction materials will be scheduled during normal business and daylight hours to the greatest extent possible to limit inconvenience to local residents. In addition, notifications of peak traffic periods will be distributed to local residents in the Village of Chalk River. In the noise assessment, it was assumed that up to 40 of the 200 shipments could occur during the nighttime period (i.e., 10 pm to 7 am).

Overall, the increase in transport vehicles is considered negligible in comparison to current traffic levels on the roads (personal vehicle traffic for over 2,000 employees and transport vehicles) to support operation of the CRL site. The change in long-term high annoyance is between 6.2% at 15 m and 2.3% at 60 m along Plant Road and 4.7% at 20 m and 2.7% at 60 m along Highway 17. The effect of increased traffic on noise levels at receptors along Highway 17 and Plant Road is considered to result in a small but noticeable change when compared to existing levels of traffic from current employees and operations at CRL. The predicted change in %HA is less than 6.5% and as such, this potential project-environment interaction is considered to have a negligible residual effect on quality of life. The detailed results of the noise effect study are presented in *Noise Impact Study of CNL NSDF Project Construction-Related Road Traffic on Human Receptors* (Golder 2020).

Canadian Nuclear Laboratories (CNL) is committed to organizational transparency, ensuring that Indigenous peoples, the general public, local communities, elected and appointed government officials and other industry stakeholders are properly informed about activities carried out at CNL sites. This commitment is met through the company's Public Information Program (CNL 2020b), a communications program that was developed to build public awareness and trust, and to encourage transparent and proactive communication with its various stakeholders. CNL's Public Information Program includes specific communications to stakeholders, public access to information related to routine activities, radiological and non-radiological emissions, and non-routine items or events at the different sites managed by CNL. Accordingly, CNL will notify local communities of the start of NSDF Project construction.

CNL proactively provides information regarding business activities and environmental remediation management projects. Notification is done through email, letter and face-to-face meetings to ensure appropriate distribution of information.

- **The NSDF Project could affect ambient noise levels due to blasting activities.**

Rock blasting will be required to complete site preparation activities for the NSDF Project site. Blasting activities will be done by a qualified person and in accordance with the Blasting Plan to be developed by the contractor, indicating the type of explosives used and the method of detonation. Additional guidance for the NSDF Project blasting limits will be obtained from the Ontario Provincial Standard Specification in the document *OPSS 120 – General Specification for the Use of Explosives* (OPSS 2014). Blasting activities will follow industry standard best management practices and applicable federal regulations, including the *Explosives Act*.

Communities in the vicinity of the NSDF Project site are shown on Figure 5.10.3-1 (i.e., nearest community is the Village of Chalk River located 7 km away), which includes the nearest residences on the Quebec side of the Ottawa River, approximately 3 km from the NSDF Project site. Given this distance from the site, noise and vibrations from blasting activities are not anticipated to be noticeable to these residents. Blasting activities would be completed during the construction phase only and would be infrequent for a short period of time. In addition, blasting noise and vibrations will be mitigated by the topography as the NSDF Project site is situated on the lower side of the hill adjacent to East Mattawa Road. Overall, the infrequent and short-term blasting activities are considered to have a negligible residual effect on quality of life of local residents.

- **The NSDF Project could have a negative effect on visual aesthetics.**

The visual effect of the NSDF Project site will be limited, as the line of sight will be obscured by hilly topography and the surrounding tree line. The NSDF Project is not expected to be visible to the local public.

- **The NSDF Project could change demand for community infrastructure (e.g., domestic waste management) with respect to capacity of infrastructure to meet demand**

All of the waste that arises as a result of the construction, operations and closure phases will be safely managed and in accordance with CNL's Waste Management Program. The CNL Waste Management Program prescribes that management of solid waste at CNL-operated sites is completed in a safe and environmentally responsible manner that meets or exceeds applicable regulations and standards, and limits current and future environmental effects and liabilities. Facilities and activities within these sites are planned, developed and operated or conducted in a manner that reduces both the volume and the level of hazard of all wastes that are generated during the entire life cycle of the facility or activity. Under the Waste Management Program, wastes are managed in accordance with CNL's Management of Solid Waste and Management of Liquid Waste documents, and CNL's Waste Generation and Handling Standards.

Conventional waste generated during the construction and operations phases will comprise of consumables and sanitary waste. Conventional (non-radiological) waste generated from the NSDF Project during construction will be managed by the contractor. Types of consumables include non-reusable/recyclable construction materials and other regular waste generated at an industrial work site. Each contractor on site will be responsible for their own housekeeping and waste handling/disposal. Standard mitigation will be implemented for storage of conventional waste at the site (e.g., collection and storage in appropriate wildlife-resistant containers), prior to disposal at landfill, which may include off site licenced waste management facilities with capacity to accept it. Construction materials will be reused or recycled, if possible.

Hazardous (non-radiological) materials generated during the construction and operations phases will be typical of those generated for construction of large industrial facilities and will include solvents, chemicals, cleaners, aerosol cans, compressed gases, oils and lubricants. These materials will be managed, including storage, use and disposal, in compliance with applicable legislation, codes and CNL's Waste Generation and Handling Standards. Once collected by a licensed hazardous waste disposal company, these wastes will be transferred off site to licensed waste management facilities for treatment and/or disposal.

During site preparation and construction, waste management includes managing conventional wastes that are generated as part of the work activities. Any radioactive waste that is generated during site preparation and construction activities will be separated and managed according to existing procedures established for all CNL operated sites, which are consistent with applicable regulations.

Grey water and sanitary sewage generated at the NSDF Project site will be managed on the NSDF Project site. The grey water and sanitary sewage will be transferred by a gravity sewer network to two septic sewage systems; one located on the north end of the site and the second located on the south end of the site.

The NSDF Project is expected to require the use of off site waste management facilities including in the nearby communities of Deep River and Chalk River only for contractor-generated non-radiological wastes during construction, as there is existing infrastructure and facilities available on CNL's existing CRL site for other types of waste and infrastructure needs. As a limited amount of construction waste may potentially need to be disposed of at licenced waste management sites with capacity to accept it, this waste disposal activity is considered to have a negligible residual effect on availability of services and infrastructure.

5.10.5.2.3 Primary Pathways

The primary pathways listed below were identified as having a residual effect on socio-economic VCs and have been carried forward to the residual effects analysis. These pathways relate to changes in the socio-economic environment from the NSDF Project and are not indirect effects related to changes in the environment.

- **direct and indirect employment requirements may affect employment and income within the local and regional study areas;**
- **the NSDF Project will extend contracting and supplier opportunities to local, regional and Indigenous businesses;**
- **the NSDF Project could increase pressure on commercial accommodations;**
- **changes in demand for community services (health, education, protective and emergency services) with respect to the capacity of LSA services to meet the demand; and**
- **the NSDF Project could increase road degradation due to increased traffic volume from the transportation of workers, supplies and equipment.**

5.10.6 Residual Effects Analysis

5.10.6.1 Methods

This section builds on the environmental assessment approach outlined in Section 5.1 and will describe the specific methods used to predict changes to socio-economic VCs and assess the residual effects. Residual effects will be evaluated for the Application Case and RFD Case. Only primary pathways identified in Section 5.10.5 Project Interactions and Mitigation are included in the residual effects analysis.

5.10.6.2 Application Case Results

This section describes the residual effects of the NSDF Project on the socio-economic VCs for primary pathways (Table 5.10.5-1). The section also describes the appropriate mitigations for each effect and characterizes the residual effect from the NSDF Project after mitigations have been applied.

5.10.6.2.1 Labour Market and Economic Development

The NSDF Project is expected to be constructed between 2021 and 2023. The key surface structures that will be constructed for the NSDF Project are the engineered containment mound, WWTP, access roads and support facilities and infrastructure. The construction phase will require an average of 225 full-time equivalents, with a peak workforce of approximately 300 personnel. The labour force is expected to be variable depending on the number of parallel activities being performed. Limited maintenance and inspection will occur in off-shift hours. Labour force requirements during the operations, closure and post-closure phases are expected to be less than requirements for the construction phase. Given the nature of the NSDF Project construction activities, it is expected that the construction workforce will be sourced from both local public firms and Indigenous firms within the LSA and RSA (throughout the County of Renfrew and the Ottawa area in Ontario and the Region of Outouais in Quebec). CNL employment opportunities that may arise due to NSDF Project activities will be posted on the vendor portal on the www.cnl.ca website.

Industries in the RSA (throughout the County of Renfrew and the Ottawa area in Ontario and the Region of Outouais in Quebec) are anticipated to supply the NSDF Project with many of the required goods and services (e.g., manufacturing, wholesale, transport). Economic opportunities arising from the NSDF Project will be extended to Indigenous companies. The construction workforce will, therefore, either already live in the RSA or may come from out of area and require temporary residence in the Town of Deep River, the Municipality of Petawawa and the City of Pembroke. The potential exists for a modest increase of expensed meals and accommodations due to the construction workforce which has a peak employment of 300 workers, who may seek to temporarily reside in the LSA and RSA during the construction phase.

Overall, the NSDF project may result in small positive effects to local Indigenous peoples through potential contracting or employment opportunities. Indigenous people have expressed an interest in potential opportunities and CNL will continue to engage with Indigenous peoples on potential employment and contracting opportunities for the NSDF Project.

5.10.6.2.2 Service and Infrastructure

Transportation and Traffic

The haulage route for transportation of site preparation and construction equipment and construction materials will be via public roads to the CRL site (e.g., Highway 17). Transportation of equipment and materials during construction will be scheduled to avoid peak traffic times where possible, to minimize contribution to peak noise and traffic volumes, and limit inconvenience to local residents. Construction materials (e.g., processed granular materials and gravel, geosynthetic products and clay) will be transported to the NSDF Project site using standard highway haul vehicles. It is estimated that there will be approximately 200 trucks per day during construction (based on a construction season of 9 months) and 10 trucks per day during operations. This results in approximately 15 trucks per hour during construction and less than 1 truck per hour during operations for the daytime period. In addition, it is assumed that construction workers will travel to the NSDF Project site from the local commercial accommodations using their own personal vehicles. Within the CRL site, transport of site preparation and construction equipment and construction materials to the NSDF Project site will be by the Plant Road, which leads to the main site access road. This increase in traffic from the transportation of workers, supplies and equipment for the NSDF Project is expected to result in degradation of public transportation infrastructure.

Emergency and Protective Services

Emergency and protective services at CRL rely on CRL's own internal capacity as the first responder to incidents at the NSDF Project site. For more serious incidents, CRL may rely on the County of Renfrew and the Town of Deep River, respectively. As there are no mutual aid agreements in place beyond those related to fire protection services, the NSDF Project may potentially increase demand for emergency and protective services in neighbouring municipalities or in the County due to the need to respond to project-related incidents.

During all phases of the NSDF Project, several strategies will be in place to reduce the likelihood of an incident occurring and to avoid the requirement for community emergency services. Additional mitigation includes operating in compliance with all applicable federal and provincial health and safety standards and CNL's existing Health, Safety, Security and Environmental programs (Section 3.5.2).

5.10.6.2.3 Housing and Accommodations

It is anticipated that the out-of-area construction workforce will be housed in hotels in the Town of Deep River, Municipality of Petawawa, City of Pembroke and the Ottawa Valley (i.e., LSA and RSA in Ontario). This use may slightly increase the demand on commercial accommodations (i.e., hotels) within the RSA during the construction phase of the Project.

5.10.6.3 Reasonably Foreseeable Development Case Results

This section describes the residual effects of the NSDF Project on the socio-economic VCs in consideration of other reasonably foreseeable developments that may overlap spatially and temporally with the NSDF Project. Reasonably foreseeable developments in the RSA that are anticipated to overlap with the NSDF Project include new/upgrades to research and development facilities, construction and operations of the SMR, new support infrastructure and on-going decommissioning and environmental remediation activities on the CRL site and the NPD Closure Project. As well, there may be overlap of the Construction Phase with limited construction at neighbouring Garrison Petawawa. The following sub-sections describes the predicted cumulative residual effects for the RFD Case.

5.10.6.3.1 Labour Market and Economic Development

Atomic Energy of Canada Limited and the Government of Canada are investing $1.2 billion for new and renewed science and site support infrastructure in order to revitalize the CRL site. Over the period 2016 to 2026, CNL is decommissioning more than 100 buildings and structures to make room for new, renovated and repurposed facilities to transform the site into a world-class, nuclear science and technology campus. CNL has consulted with local companies to inform them of revitalization program, CNL's contracting strategy and procurement processes. On-going decommissioning and environmental remediation activities on the CRL site are focusing on early reduction of liabilities. CNL is performing most of the decommissioning activities to gain efficiencies and reduce risks associated with redundant, high-hazard facilities (CNL 2017d). This approach supports the acceptance and adaptation of site-wide program controls to enable an accelerated decommissioning schedule. Additionally, development of a core team and capabilities will reduce incidents and costs, particularly those associated with multiple subcontractors trying to perform multiple scopes of work on congested site amid other on-going work (CNL 2017d). International decommissioning experience gained on multiple sites has demonstrated that the development of a trained and experienced workforce with flexibility to move between buildings as conditions require, is a key step in safely accelerating decommissioning activities.

CNL is planning new nuclear research facilities and support buildings to revitalize the CRL site. The revitalization of the CRL site is planned to occur over the 10-year period 2016-2026. The workforce required for site revitalization activities at any point is expected to be maintain a similar rate to the workforce on-site supporting those activities at present, captured as part of existing conditions. This workforce is anticipated to be approximately equal to that required for the construction of the NSDF Project. CNL will continue to provide updated information to interested contractors and suppliers on work packages as they develop. Nonetheless, the business prospective of the NSDF Project has motivated prospective contractors to engage local and Indigenous companies. A specific new research and development project announced in 2019 is the proposal by Global First Power to build and operate a small modular reactor at the CRL site. Based on the small scale of the development, labour resources for construction will be small compared to that required for the NSDF Project and negligible compared to on-going CRL site operations.

CNL's proposed NPD Closure Project is expected to be executed over a two-year period from 2021 to 2023. It will employ an average of 40 people (approximately 30 existing CNL employees and 10 external contractors). External contractors that may be sourced from the LSA and RSA communities, with possibly some specialized contractors coming from Ottawa and beyond. The peak workforce is expected to be approximately 340 workers in RFD Case (300 peak workforce for the NSDF Project and approximately 40-person workforce for the NPD Closure Project).

Decommissioning of eight buildings, renovation of three and construction of a new 9,900 m facility for the Royal Dragoons planned within the built-up area at Garrison Petawawa (approximately 10 km south of the SSA) in 2020 to 2021 may require labour resources for construction from within the RSA.

Given the size of the labour force in the LSA and RSA in 2016 of approximately 3,370 and 791,985 respectively, with an unemployment rate of 6.6% for both the LSA and RSA (Statistics Canada 2017a,b,f,g), it is not expected that local labour will be constrained in consideration of the demand for labour from the RFD Case.

5.10.6.3.2 Services and Infrastructure

Transportation and Traffic

It is anticipated that there will be additional traffic associated with an estimated average of 225 full time equivalent workers commuting to and from the CRL site each day for the NSDF Project. CNL is planning new nuclear research facilities and support buildings to revitalize the CRL site. The revitalization of the CRL site is planned to occur over the 10-year period 2016-2026. The workforce required for site revitalization activities at any point is expected to be maintain a similar rate to the workforce on-site supporting those activities at present, captured as part of traffic monitoring to characterize existing conditions. This workforce is anticipated to be approximately equal to that required for the construction of the NSDF Project. On-going decommissioning and environmental remediation activities on the CRL site will primarily be completed by CNL employees.

Traffic generated for construction and operations of the SMR, as well as for limited construction at Garrison Petawawa will be small compared to that required for NSDF and negligible compared to on-going CRL site operations.

The NPD Closure Project is not expected to require regular transportation to and from the CRL site. The NPD Closure Project is projected to increase traffic on local roads including Highway 17 by approximately 70 trips per day delivering materials, personnel and services to the CNL NPD site (approximately 30 trips a day for raw materials and 40 trips per day for personnel travel).

Overall, if there is temporal overlap of the NSDF Project, NPD Closure Project and the CNL site revitalization projects, this could result in an average additional 265 workers (225 for the NSDF Project and 40 for the NPD Closure Project) commuting in the region, with approximately 225 of these additional workers commuting to the CRL site. As well, based on estimates of truck deliveries to the NSDF Project site during the 24-month construction period, approximately 200 shipments per day are anticipated during the nine-month construction season.

In consideration of the increased traffic from the NSDF Project and applicable RFD Projects, and the annual average daily traffic levels in the LSA and RSA, which range from 6,700 to 12,300 vehicles per day, the cumulative effects of traffic from the RFD Case may slightly increase traffic levels during the morning and evening commutes.

The increase in traffic from the transportation of workers, supplies and equipment for the NSDF Project and applicable RFD projects is expected to result in degradation of public transportation infrastructure.
The incremental increase in traffic expected from applicable RFD Projects is small, when considered with the NSDF Project during construction.

Emergency and Protective Services

Emergency and protective services at CRL generally rely on CRL's own internal capacity. For medical emergencies, trained CNL personnel will conduct initial evaluation and assistance, and will request external EMS, as required. Chalk River Laboratories' existing emergency and protective services at the CRL site are expected to be sufficient for the NSDF Project, construction and operations of the SMR, on-going decommissioning and revitalization projects. Existing emergency and protective services around the NPD site are also expected to be sufficient for the NPD Closure project activities. There may be a potential increase in demand for emergency and protective services in the LSA and RSA communities, as well as the County of Renfrew, due to the need to support more serious project-related incidents (e.g., incidents requiring hospitalization). However, the predicted residual effect is expected to be limited due to the size of the workforces at any one time for the RFD projects.

5.10.6.3.3 Housing and Accommodation

Similar to the NSDF Project, it is expected that a portion of the RFD project workforce would come from the LSA and RSA and, therefore, already be residents of the area and not require temporary accommodation. In addition, not all of the RFD projects would occur at the same time. For example, the NPD Closure Project is anticipated to occur over a two-year period from 2021 to 2023 whereas revitalization and decommissioning activities at the CRL site will occur progressively over the 10-year period 2016 to 2026. The construction of the SMR may overlap with the construction of the NSDF Project; however, based on the small scale of the development, labour resources for construction will be small compared to that required for the NSDF Project. Based on the small scale of the development and short timeline for construction, labour requiring temporary accommodation will be small compared to that required for the NSDF Project. Limited construction at neighboring Garrison Petawawa is planned in between 2020 and 2021. When considered with the NSDF Project temporary accommodation requirements, and the availability of hotels, motels and other accommodation in the LSA and RSA, it is not expected that the combined effects of the RFD projects will place considerable constraints on temporary accommodation in LSA and/or RSA communities.

5.10.7 Prediction Confidence and Uncertainty

Predictions of the NSDF Project's effects on socio-economics carry an element of uncertainty because many factors will affect the future, including how individuals' choices will affect their personal and community circumstances. For example, the proportion of workers who live in the local communities may continue to be the same, but it is also possible that more workers will choose to live elsewhere and commute into the area for their work shift. The NSDF Project's effects will also be influenced by economic conditions and broad factors affecting societal change within the communities affected by the NSDF Project.

Confidence in the prediction of the effects of the NSDF Project on the socio-economics of the local communities is based on a number of assumptions of future conditions, including the following:

- workers' skill requirements will be similar to those existing at CRL;
- working conditions (e.g., shift schedules) will be the same;
- most workers at the NSDF Project during the operations phase will be employed by CRL; and
- employees will continue to live in the same communities.

The confidence in the effects assessment for socio-economics is considered to be moderate.

A second key source of uncertainty is related to the RFD Case and the contribution to residual effects from the CRL site revitalization outlined in the Site Master Plan. Although specific contractor opportunities and supplier requirements are unknown at this time; there is uncertainty in the combined effects for the RFD Case. However, it is expected that effects from these activities will largely be positive.

Mitigation proposed in the assessment is based on accepted and proven best management practices that are well-understood and have been applied to numerous construction projects throughout Canada. Uncertainty in the assessment has been reduced by making conservative assumptions, planned implementation of known effective mitigation and monitoring, and available adaptive management measures to address unforeseen circumstances should they arise.

Certainty of the predicted effects for commercial accommodation is high, given the effectiveness of the mitigation to be implemented and knowledge of the NSDF Project design and schedule. However, events that may require emergency and protective services are difficult to predict. Mitigation regarding best practices and emergency response are reliably effective and have been or are currently being used pursuant to the *Nuclear Safety and Control Act* and CNL's existing Health, Safety, Security and Environmental programs (Section 3.5.2).

5.10.8 Residual Effects Classification and Determination of Significance

This section classifies the residual effects from cumulative changes to measurement indicators for the Application Case and presents a determination of significance for each socio-economic VC that was predicted to be affected by a primary pathway. Although the positive and neutral residual effects associated with the NSDF Project are reported in this section, they are not assessed for significance.

5.10.8.1 Residual Effects Classification

Effects from adverse residual changes to measurement indicators were classified using a categorical scale and common words to facilitate the determination of significance. The purpose of categorical classification is to provide definitions that permit a clear, thorough and unambiguous classification of residual effects such that reviewers and readers can follow and apply the logic used in the assessment and reach the same classification for a given residual effect.

All primary pathways affecting each measurement indicator were combined for the residual effects classification such that one classification is provided for each measurement indicator. Changes to measurement indicators are classified for each VC, for the Application Case. The classification is based on the residual effects analysis provided in Section 5.10.6.

Magnitude, geographic extent and duration are the principal factors considered to predict significance (Table 5.10.8-1). Magnitude refers to the degree of change in the measurement indicator. Magnitude may be low, moderate or high. Economic effects were assigned magnitude qualitatively based on levels of concern, analysis of the existing economic environment and projected future changes as they affect economic sustainability. Geographic extent refers to the area affected and is categorized into three scales: local, regional and beyond regional. Local effects are those confined to the communities in the LSA. Regional effects include the LSA, but do not extend beyond the RSA. Beyond regional refers to effects that extend beyond the region and throughout the province of Ontario or even farther. Duration is defined as the amount of time from the beginning of an effect when the effect on a VC has ended or dissipated to the point of not being detectable and is expressed relative to project phases.

Direction indicates whether an effect is considered negative (i.e., less favourable) or positive (i.e., beneficial). While the focus of the effects assessment is to predict whether the development is likely to cause significant adverse effects on the environment or cause public concern, the positive and neutral changes associated with the Project are reported. Some effects may have both positive and negative dimensions. For example, although increased income from employment can increase spending in local communities, there is also a cost associated with the management of an out of area workforce by municipalities and infrastructure and service providers.

Table 5.10.8-1: Assessment Criteria for Classifying Predicted Residual Adverse Effects to the Socio economic Valued Components

Direction	Magnitude	Geographic Extent	Duration
Positive: An improvement over Base Case values or conditions. **Neutral:** No change to measurement indicators over Base Case values or conditions. **Negative:** A less favourable change to measurement indicators relative to Base Case values or conditions.	**Negligible:** No discernible change is expected from Base Case values or conditions. **Low:** A slight, but discernible change to measurement indicators from Base Case conditions, but within the capacity of the system. **Moderate:** The change to measurement indicators is detectable, but still remains within historical system capacity or market capacity for response. **High:** The change to measurement indicators is beyond historical norms or existing system or market capacity for effective response.	**Local:** The change to the measurement indicator will not extend beyond communities in the LSA. **Regional:** The change to the measurement indicator will affect the Regional Study Area and LSA (where the changes are more widespread, but still detectable). **Beyond Regional:** The change to measurement indicators will extend beyond the RSA into other areas of the Province.	**Short-term:** The change to measurement indicators occurs during construction, but ends before the end of construction; or occurs during active closure stage only, but ends before final closure. **Medium-term:** The change to measurement indicators occurs throughout operations phase and ends before or near the end of the operations phase. **Long-term:** The change to measurement indicators will extend beyond the operational life of the NSDF Project.

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

Some of the criteria used to determine significance in other sections of the EIS have limited or no application to the socio-economic assessment and include the following criteria.

- **Frequency** refers to number of times an effect is expected to occur over a given period. Although there are isolated exceptions, most economic effects are experienced continuously and are cumulative (i.e., they interact and are directed and shaped by the broader continuously evolving economic environment). Thus, frequency generally is not deemed an applicable criterion for the socio-economic assessment.
- **Reversibility** is defined as the probability and time required to return to a state that is similar to baseline or comparable to similar environments not affected by the NSDF Project. Socio-economic effects associated with a project are typically part of an on-going process of interdependent economic, social and cultural changes extending into the future, which generally cannot be reversed to return to the pre-development conditions. For example, although most employment will come to end at retirement, job experience and training will have enhanced capacity of individuals to find other employment, with lifelong implications (i.e., the employment effect will not be reversed fully).
- **Likelihood** of the predicted NSDF Project effects are all assumed to be high (i.e., occurring) if the NSDF Project proceeds for the purpose of the assessment.

5.10.8.2 Determination of Significance

The classification of primary pathways and the associated predicted changes in measurement indicators provide the foundation for determining the significance of effects from the NSDF Project on the socio-economic VCs. Effect criteria of magnitude, duration and geographical extent are discussed in the context of the changes to the socio-economic measurement indicators from the NSDF Project to the existing environment. As previously mentioned, positive and neutral residual effects associated with the NSDF Project are not assessed for significance.

For socio-economic VCs, an adverse effect was considered significant if it was predicted to have an effect of high magnitude at the local, regional or provincial geographic extent with a long-term duration. When considering a high magnitude rating, an adverse socio-economic effect was considered significant if the effect was predicted to result in the capacity of the system being exceeded on an on-going and consistent basis and the system is unlikely to be able to respond in a timely manner. As part of the determination of significance, confidence in the assessment identified in Section 5.10.7 was considered for each VC.

5.10.8.2.1 Labour Market and Economic Development

Residual effects from the NSDF Project on the labour market and economic development are predicted to be positive. The effects are predicted to be local, regional and beyond regional as is expected that the construction workforce will be sourced from the LSA, RSA which includes the County of Renfrew and the Ottawa area in Ontario and the Region of Outouais in Quebec. The effect is considered medium-term (i.e., during the construction and operations phases).

An increase in procurement of goods and services from local and regional contractors and businesses is expected during the NSDF Project construction (i.e., positive effect). Procurement of construction goods and services is expected to be regional due to the lack of suitable construction firms and associated industries in the LSA. The construction workforce is expected to reside temporarily in the Town of Deep River, the Municipality of Petawawa and City of Pembroke; therefore, the increase in meals and accommodations during construction is expected to be low relative to the size of the local economy, local in geographic extent and short-term in duration (Table 5.10.8-2).

Table 5.10.8-2: Evaluation of Predicted Residual Effects on Labour Market and Economic Development for the Application Case

Indicators	Direction	Magnitude	Geographic Extent	Duration	Significance
Employment opportunities and income generation	Positive	Low	Local to Beyond Regional	Medium-term	Not applicable (significance is not determined for positive effects)

The predicted residual effect of the NSDF Project, in combination with the RFD projects, are expected to result in a detectable increase in labour requirements; therefore, the magnitude of the cumulative residual effect on employment opportunities is predicted to be moderate in magnitude, local to beyond regional in geographic extent and medium-term in duration (Table 5.10.8-3).

Table 5.10.8-3: Evaluation of Predicted Residual Effects on Labour Market and Economic Development for the RFD Case

Indicators	Direction	Magnitude	Geographic Extent	Duration	Significance
Employment opportunities and income generation	Positive	Moderate	Local to Beyond Regional	Medium-term	Not applicable (significance is not determined for positive effects)

5.10.8.2.2 Housing and Accommodations

There may be limited amounts of increased pressure on commercial accommodations during construction of the NSDF Project. The predicted residual effect of construction activities on the availability of commercial accommodations can be positive for business owners and the local economy for increasing accommodation rates, or can be negative in direction because it has the potential to reduce availability of temporary accommodation during periods of high demand, such as peak tourism periods. Given the available hotel capacity in the Town of Deep River, Municipality of Petawawa and City of Pembroke (one hotel and five motels in Deep River and additional hotels in the Municipality of Petawawa and City of Pembroke) and the expected peak construction workforce of 300 personnel, the NSDF Project is expected to have a slight, but discernible effect on commercial accommodation availability (i.e., low magnitude). Overall, the negative residual effect of the NSDF Project on commercial accommodation availability is determined to be not significant (Table 5.10.8-4).

Table 5.10.8-4: Evaluation of Predicted Residual Effects on Commercial Accommodations for the Application Case

Indicators	Direction	Magnitude	Geographic Extent	Duration	Significance
Increased pressure on commercial accommodations	Positive and Negative	Low	Local to Regional	Short-term	▪ Not Significant (where direction is negative) ▪ Not applicable (where direction is positive, as significance is not determined for positive effects)

When considered with the NSDF Project temporary accommodation requirements, and the availability of hotels, motels and other accommodation in the LSA and RSA, it is not expected that the combined effects of the RFD projects will place considerable benefit to or constraints on temporary accommodation in LSA and/or RSA communities. Therefore, the cumulative residual effect on commercial accommodation availability from the NSDF Project combined with the RFD projects is predicted to be of low magnitude, local to regional in extent and medium-term in duration. Overall, the negative cumulative residual effect on commercial accommodation availability is predicted to be not significant for the RFD Case (Table 5.10.8-5).

Table 5.10.8-5: Evaluation of Predicted Residual Effects on Commercial Accommodations for the RFD Case

Indicators	Direction	Magnitude	Geographic Extent	Duration	Significance
Increased pressure on commercial accommodations	Positive or Negative	Low	Local to Regional	Medium-term	▪ Not Significant (where direction is negative) ▪ Not applicable (where direction is positive, as significance is not determined for positive effects)

5.10.8.2.3 Service and Infrastructure

Transportation and Traffic

Increased road degradation due to increased traffic volume on highways and local roads used to access the NSDF Project is predicted during construction. The predicted residual effect of construction activities on highways and local roads used to access the NSDF Project is negative in direction because the increase of traffic for the NSDF Project will place increased pressure on road infrastructure in the LSA and RSA. It is considered short-term in duration because the measurable increase in traffic volume will occur only during NSDF Project construction. The effect of increased traffic on road conditions is considered to be a slight but discernible change (i.e., low magnitude) when compared to existing levels of traffic from current employees and operations at CRL. The effect is considered beyond regional as traffic is expected to come from outside the RSA on Plant Road and Highway 17. Overall, the NSDF Project's residual effect on transportation and traffic is determined to be not significant (Table 5.10.8-6).

Table 5.10.8-6: Evaluation of Predicted Residual Effects on Transportation and Traffic for the Application Case

Indicators	Direction	Magnitude	Geographic Extent	Duration	Significance
Increased road degradation due to increased traffic volume from the transportation of workers, supplies and equipment.	Negative	Low	Beyond Regional	Short-term	Not Significant

In consideration of the increased traffic from the NSDF Project, and the average annual daily traffic levels in the LSA and RSA, the cumulative effects of traffic from the RFD Case may slightly increase traffic levels during the morning and evening commutes. There is a small incremental increase in traffic expected from applicable RFD Projects. The increased levels of traffic from the RFD projects are considered to be low in magnitude when considered with the effects of the NSDF Project. Increased traffic for the RFD Case is expected to occur beyond regional and medium-term in duration. Overall, the cumulative residual effect of road degradation due to increased traffic volume on transportation and traffic is predicted to be not significant for the RFD Case (Table 5.10.8-7).

Table 5.10.8-7: Evaluation of Predicted Residual Effects on Transportation and Traffic for the RFD Case

Indicators	Direction	Magnitude	Geographic Extent	Duration	Significance
Increased road degradation due to increased traffic volume from the transportation of workers, supplies and equipment.	Negative	Low	Beyond Regional	Medium-term	Not Significant

Emergency Services

The NSDF Project will have a residual effect on the demand for emergency services during the construction and operations phases. The predicted residual effect of the NSDF Project on the provision of emergency services is negative in direction because of the potential increased demand on a limited service. The effect is regional in extent because emergency services operate at a regional level in the LSA and RSA. A minor incident could result in personal injury requiring minimal emergency medical care, while a major incident could result in the need for substantial emergency medical care.

While the risk of a major incident is low and made even less likely by CRL's internal capacity and project-related mitigations, accidents by their very nature are unpredictable, as are their outcomes. The added demand associated with the NSDF Project will not lead to unmanageable service requirements or delivery due to the excess of capacity generally. Therefore, the NSDF Project's residual effect on emergency services is assessed to be of negligible to moderate magnitude. Due to the nature of the Project, the predicted residual effect is considered long-term as the risk of project-related accidents could occur during the construction, operations and closure phases. The NSDF Project's residual effect on emergency services is determined to be not significant (Table 5.10.8-8).

The predicted residual effect of construction activities on the provision of protective services is negative in direction because of the potential increased demand on a limited service. As with demand for emergency services, it is not known with any certainty whether or not the NSDF Project will bring about increased demand for protective services. Regular, planned construction activities are not expected to place demand on police services in the LSA or RSA. As all workers are expected to abide by CNL's environmental, safety and security policies and programs, the magnitude of this effect on service provision is considered to be negligible as it is expected that the protective services in the LSA would have sufficient capacity to respond to the incident. As this effect will persist only through construction, and would likely be felt in communities where the construction workforce will reside, it is considered short-term and regional in extent as workers may reside outside of the LSA in the Municipality of Petawawa and City of Pembroke. The NSDF Project's residual effect on protective services is determined to be not significant (Table 5.10.8-8).

Table 5.10.8-8: Evaluation of Predicted Residual Effects on Emergency Services on the Application Case

Indicators	Direction	Magnitude	Geographic Extent	Duration	Significance
Increased demand for emergency services	Negative	Negligible to Moderate	Regional	Short-term to Long-term	Not Significant
Increased demand for protective services	Negative	Negligible	Regional	Short-term	Not Significant

The demand for emergency services will continue to depend on the occurrence and severity of an accident, which is unplanned by its nature. In consideration of the RFD projects, the demand for emergency services will be negative in direction, negligible to moderate in magnitude and regional in geographic extent. As the revitalization and decommissioning activities of the CRL site are for a 10-year period and operations at the SMR are planned for 20 years, the duration of the cumulative residual effect is predicated to be medium-term. The cumulative residual effect on emergency services for the RFD case determined to be not significant (Table 5.10.8-9).

The predicted cumulative residual effect of the RFD case on protective services is assessed to be negative in direction and negligible in magnitude due to the small workforce and implementation of CNL's environmental, safety and security policy and programs. The effect will be regional in geographic extent and short-term in duration, only taking place during the construction phase of the NSDF Project. The cumulative residual effect on protective services in consideration of the RFD case is determined to be not significant (Table 5.10.8-9).

Table 5.10.8-9: Evaluation of Predicted Residual Effects on Emergency Services on the RFD Case

Indicators	Direction	Magnitude	Geographic Extent	Duration	Significance
Increased demand for emergency services	Negative	Negligible to Moderate	Regional	Medium-term	Not Significant
Increased demand for protective services	Negative	Negligible	Regional	Short-term	Not Significant

5.10.9 Monitoring and Follow-up

Monitoring and follow-up programs are not specifically identified for socio-economics; rather, monitoring for environmental pathways (i.e., for air quality, water quality and groundwater quality) will be implemented to verify effects predictions. This monitoring will be on-going during the construction, operations and closure phases and the need for and duration of monitoring will be reviewed based annual review of monitoring data. This monitoring will be integrated into the CNL Environmental Monitoring Program.

Recognizing people's interest in understanding and participating in decisions that affect them, CNL will proactively seek, engage and support meaningful discussion on issues and opportunities related to the NSDF Project as part of the Public Information Program (PIP, CNL 2020b), which can be found on the CNL website (www.CNL.ca). The PIP includes specific communications to stakeholders and public access to information related to routine activities as well as new projects such as the NSDF Project. These measures are meant to mitigate questions and complaints regarding CNL activities, as well as ensure community input is sought, received and action is taken to respond to these inputs.

The PIP also provides a platform for the public to voice their concerns related to NSDF Project activities and for CNL to address and develop resolutions to these concerns; the process includes:

- Corporate Communications receives issues and concerns through the formal feedback submission on the CNL website (https://www.cnl.ca/contact us), emails (communications@cnl.ca), phone calls (1-800-364-6989), and social media platforms (e.g., Facebook and Twitter);
- All NSDF project-related issues and concerns (including complaints about noise disturbances) received are forwarded to the NSDF Project for resolution;

- The NSDF Project address and resolve concerns about the Project on a case-by-case basis and resolution may include further mitigation of NSDF site activities;
- Throughout this process, CNL will maintain two-way dialogue between the stakeholder and the NSDF team until the issue is resolved; and
- All inquiries are tracked and resolution or responses are recorded once completed.

CNL will continually evaluate both the process and the outcome of the on-going engagement and communication activities to address and manage issues as they arise. The level and nature of engagement with the communities will depend on feedback received.

As part of the Environmental Assessment Monitoring and Follow-up Program, with respect to the noise assessment, a traffic count study will be completed along Highway 17 and Plant Road as a pre-construction activity. Traffic counts will be obtained along both; Highway 17 and Plant Road to establish an Annual Average Daily Traffic (AADT) count in accordance with accepted practices. The study will consider Highway 17 north and south of Plant Road. Average hourly distribution will be established for Highway 17 and Plant Road. The gathered traffic count data will be used to verify the noise modelling result, and if required, additional mitigation will be implemented.

5.10.10 Conclusions

Valued components refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community or the public (The Agency 2018). Socio-economic VCs were selected based on the potential for the NSDF Project to interact with the features of the socio-economic environment, and consist of:

- labour market;
- economic development;
- government finances;
- housing and accommodations;
- services and infrastructure;
- quality of life; and
- public safety.

Residual effects from activities that occur during the construction phase have been identified as the primary linkage to potentially affect socio-economic VCs. During the construction phase, NSDF Project activities will result in residual effects from direct and indirect employment requirements, contracting and supplier opportunities, increased pressure on commercial accommodations, changes in demand for community services and increased degradation of public transportation roads. A summary of the predicated residual effects for socio-economics, including associated mitigation, are provided in Table 5.10.10-1. Examples of mitigation practices implemented to limit predicted residual effects to socio-economic VCs include:

- continued implementation and maintenance of compliance with all applicable health and safety standards and CNL's existing environmental, safety and security programs;

- continued implementation of CNL's procedure for *Management and Monitoring of Emissions*, which includes operational control monitoring and verification monitoring;
- implementation of the Dust Management Plan developed for the NSDF Project, which includes appropriate management techniques to control dust generated by the NSDF Project; and
- Coordinate transportation of equipment and materials during construction to avoid peak traffic times to the extent possible.

Recognizing people's interest in understanding and participating in decisions that affect them, CNL will proactively seek, engage and support meaningful discussion on issues and opportunities related to the NSDF Project as part of the PIP. CNL will continually evaluate both the process and the outcome of the on-going engagement and communication activities to address and manage issues as they arise.

Table 5.10.10-1 summarizes negative residual project and cumulative effects increased pressure on commercial accommodations, changes in demand for community services and increased degradation of public transportation roads. With the implementation of appropriate mitigation, residual effects of the NSDF Project on socio-economic VCs are predicted to be not significant. The NSDF Project may result in positive benefits to the labour market and economic development through potential contracting or employment opportunities, including potential benefits to commercial accommodation providers.

Table 5.10.10-1: Summary of Predicted Residual Effects for Socio economics Valued Components

Valued Components	Assessment Endpoint	Residual Effects	Project Phase Residual Effect Occurs	Contributing Project Activity	Proposed Mitigation	Significance	
						Application Case	RFD Case
Labor Market	Continuation of employment opportunities and income generation.	Direct and indirect employment requirements may affect employment and income with the local and regional study areas.	Construction	Employment of personnel, procurement of goods and services, and expenditures from the NSDF Project.	Canadian Nuclear Laboratories (CNL) employment opportunities that may arise due to project activities will be posted on the vendor portal on www.cnl.ca website.	Positive residual effect, therefore, significance is not determined.	Positive residual effect, therefore, significance is not determined.
Economic Development	Continuation of business and economic development.	The NSDF Project may provide contracting and supplier opportunities to local and regional businesses.	Construction	Employment of personnel, procurement of goods and services, and expenditures from the NSDF Project.	The NSDF Projects will competitively procure material and services local and regional communities.	Positive Residual Effect, therefore, significance is not determined.	Positive Residual Effect, therefore, significance is not determined.
Housing and Accommodations	Maintenance of commercial accommodation availability.	The NSDF Project could increase pressure on commercial accommodations.	Construction	Employment of personnel, use of services and infrastructure for NSDF Project.	None	Not significant (where negative in direction) Positive Residual Effect; therefore, significance is not determined (where positive in direction)	Not significant (where negative in direction) Positive Residual Effect; therefore, significance is not determined (where positive in direction)

Table 5.10.10-1: Summary of Predicted Residual Effects for Socio economics Valued Components

Valued Components	Assessment Endpoint	Residual Effects	Project Phase Residual Effect Occurs	Contributing Project Activity	Proposed Mitigation	Significance	
						Application Case	RFD Case
Services and Infrastructure	Maintenance of community services and infrastructure availability and access.	Increased road degradation due to increased traffic volume from the transportation of workers, supplies and equipment.	Construction	Employment of personnel, use of services and infrastructure for NSDF Project.	Coordinate transportation of equipment and materials during construction to avoid peak traffic times to the extent possible.	Not significant	Not significant
		Changes in demand for community services (health, education, protective and emergency services) with respect to the capacity of LSA services to meet the demand.	All Project Phases	Employment of personnel, use of services and infrastructure for NSDF Project.	Continued implementation and maintenance of compliance with all applicable health and safety standards and CNL's existing environmental, safety and security programs.	Not significant	Not significant

RFD = Reasonably Foreseeable Developments; LSA = local study area.

6.0 INDIGENOUS INTERESTS

6.1 Introduction

Canadian Nuclear Laboratories (CNL) has prepared this stand-alone section on Indigenous interests with respect to the Near Surface Disposal Facility (NSDF) for the disposal of solid, low-level radioactive waste at Chalk River Laboratories (CRL) – the NSDF Project. This is a new section that was not present in the draft version of the NSDF Environmental Impact Statement (EIS) and is intended to consolidate and summarize the major areas of assessment relevant to Indigenous peoples into one single section.

This section of the EIS is divided into seven major subsections, each of which are described below:

- **Section 6.1 – Introduction:** This section outlines the structure of Section 6 and generally describes how CNL is working with Indigenous peoples to include their interests in the NSDF Project environmental assessment.
- **Section 6.2 – Indigenous Engagement:** This section describes Indigenous engagement by community or organization, summarizes key interests/concerns of Indigenous community or organization, how CNL is addressing the interest/concern, how CNL has verified with the applicable Indigenous community or organization that the issue/concern is resolved, and identification of next steps. This section is an updated version of the former Section 4.3.2 "Aboriginal Engagement" of the draft EIS. This section documents all the engagement with Indigenous peoples on the NSDF Project that has occurred. CNL is committed to facilitating opportunities for Indigenous peoples to continue to be involved in the NSDF Environmental Assessment Process and onward. CNL is working with engaged communities to develop a mutual path forward in verifying feedback and addressing issues.
- **Section 6.3 – Valued Components:** This section describes Indigenous-specific Valued Components (VCs). It also describes how comments from Indigenous peoples on VCs are addressed in the VC selection.
- **Section 6.4 – Traditional Land and Resource Use:** This section describes the assessment process for traditional land and resource use and more specifically the scope of the assessment, valued components, assessment boundaries, existing conditions, and potential project interactions and mitigation for traditional land and resource use. This section incorporates information on known traditional land and resource use that has come from existing studies, studies specific to the NSDF and Nuclear Power Demonstration (NPD) projects, and through engagement with regards to Indigenous interests.
- **Section 6.5 – Indigenous Health and Indigenous Receptor:** This section describes the Self-Sufficient Indigenous Group receptor selected as part the NSDF Post-Closure Safety Assessment (Arcadis and Quintessa 2020b) to assess potential future effects of the NSDF Project on Indigenous peoples' future interactions with the environment around the proposed facility.
- **Section 6.6 – CNL's Long-Term Relationship with Indigenous Peoples:** This section describes CNL's long-term approach to working with Indigenous peoples.

This section is supported by CNL's Indigenous Engagement Report (IER), which was recently updated in 2020 (CNL 2020). The IER was prepared in accordance with CNSC's *REGDOC-3.2.2 Indigenous Engagement* (CNSC 2019). The IER outlines CNL's approach to Indigenous engagement to support the environmental assessment process for the planned NSDF Project. The IER is in many respects a more detailed version of this Section 6 and remains a living document that will continue to be updated.

In accordance with *REGDOC-3.2.2*, the scope of the IER includes:

- identification of Indigenous peoples (identified through consultation with the CNSC);
- Indigenous engagement activities that have taken place up to the date of writing and a proposed schedule for interim reporting on these activities to the CNSC; and
- the plan on how CNL has and will continue to engage with Indigenous peoples.

CNL also enhanced the scope of the IER by adding the following:

- a section demonstrating compliance with regulatory requirements;
- an enhanced summary of each identified Indigenous community or organization to demonstrates CNL's understanding of the historical, legal, socio-economic, traditional use and other characteristics, including documenting (where available) their interests in the Ottawa Valley and in the vicinity of the Project;
- a section providing a discussion and summary of the engagement results;
- a section on Valued Components pertaining to Indigenous peoples;
- a summary of the assessment of the impact of the NSDF Project on traditional land and resource use;
- a summary of the assessment of the impact of the project on Indigenous socio-economic interests;
- a section on Indigenous health and the development of an Indigenous receptor; and
- a section describing CNL's approach to long-term relationships with Indigenous peoples.

With these enhancements, CNL has a more comprehensive document with respect to Indigenous peoples and provides most of the information in a single report.

After the filing of the EIS, CNL will continue to engage with Indigenous peoples both about the NSDF Project and also more broadly about the CRL site and other projects. CNL is working towards developing long-term relationships with Indigenous peoples that have traditional territories and modern-day interests near its operations. CNL recognizes that such relationships may take a long time to form but believes this is consistent with the Government of Canada's approach to reconciliation. CNL is working closely with Atomic Energy of Canada Limited (AECL) on Indigenous peoples that reside more within AECL's responsibility. Engagement with regard to Indigenous interests has demonstrated that Indigenous peoples are also interested in fostering such long-term relationships. As such, CNL, AECL and the Indigenous peoples see their relationships as evolving and beyond the scope of a single regulatory project such as the NSDF Project.

Discussions regarding long-term relationships and on specific aspects of projects such as the NSDF Project will be on-going up until and after the CNSC Commission Hearing on the NSDF Project. Because of the on-going nature of these discussions and relationships, CNL intends to provide a revised IER as part of the Commission Member Document package for the CNSC Commission Hearing on the NSDF Project. The revised IER will document the on-going engagement, discussions and negotiations with Indigenous peoples that are relevant both corporately and specific to the NSDF Project.

6.2 Indigenous Engagement

This section summarizes CNL's Indigenous engagement objectives, the methods adopted to meet these objectives, the Indigenous communities and organizations that CNL has identified, engagement activities that have been undertaken as of June 2020, feedback received as of June 2020, and future engagement activities.

6.2.1 Objectives

As part of its corporate, environmental and social responsibility, CNL recognizes and encourages the on-going engagement of Indigenous communities through the course of its environmental assessment process for the NSDF Project. Through its engagement activities, CNL seeks to inform communities while building awareness and understanding of NSDF Project activities. CNL communicates with community members on the potential effects of NSDF Project activities on the environment and on Indigenous and/or treaty rights including rights to trap, hunt, fish, gather or conduct cultural ceremonies.

Regulatory requirements related to these activities are summarized in Section 2 of the IER (CNL 2020). The *Canadian Environmental Assessment Act, 2012* (CEAA 2012) provides a clear description of the environmental effects on Indigenous peoples that are to be taken into account. The CNSC *REGDOC-3.2.2* (CNSC 2019) provides more detailed information and sets out the "requirements and guidance for licensees" with respect to engagement. It also provides procedural direction for licensees:

> *Licensees shall conduct a review to consider whether the activity described in their licence application requesting authorization from the Commission:*
>
> - *could result in impacts to the environment; and*
> - *could adversely impact an Indigenous group's potential or established Indigenous and/or treaty rights, such as the ability to hunt, trap, fish, gather or conduct ceremonies" (CNSC 2019).*

As the CNSC *REGDOC-3.2.2* provides specific requirements and guidance on consideration of rights and activities (i.e., hunt, trap, fish, gather or conduct ceremonies) results of CNL's review are specifically addressed in the IER and this EIS. Section 6 of the IER describes traditional land and resource use, based on existing and available information.

Additional CNSC requirements that are to be addressed or considered with respect to Indigenous peoples are found in Appendix A.3.8 of the CNSC *REGDOC-2.9.1 Environmental Protection: Environmental Principles, Assessments and Protection Measures* (CNSC 2017) and the CNSC's *Generic Guidelines for the Preparation of an Environmental Impact Statement* (Generic EIS Guidelines; CNSC 2016a). These requirements are summarized in Table 2-1 of the IER. Key requirements identified in Table 2-1 generally relate to identifying community perspectives and/or information associated with:

- VCs identified for the NSDF Project;
- spatial and temporal boundaries used in this EIS;
- potential positive or negative effects of the NSDF Project on the natural environment, community socio-economic conditions/elements, community health and diet, traditional and current land and resource use (e.g., hunting, trapping, fishing and gathering), and physical and/or cultural heritage features;
- the mitigation suggested in the EIS with respect to potential effects;

- Indigenous treaties and litigation associated with the CRL site;
- traditional Indigenous knowledge associated with the CRL site; and
- the NSDF Project Indigenous engagement process.

On March 8, 2017, the CNSC released a Record of Decision addressing expectations on the scope of factors to be assessed in the environmental assessments of three CNL designated projects under CEAA 2012. Included in these three was the NSDF Project. Pursuant to Section 19 of CEAA 2012, the CNSC determined the project scope for the environmental assessment must include the factors mandated in paragraphs 19(1) (a) to (h) of CEAA 2012, with no additional factors. The Record of Decision also set out that the environmental assessment must consider the CNSC's Generic EIS Guidelines (CNSC 2016a) with respect to information and requirements for identifying VCs and spatial and temporal boundaries, and engaging Indigenous peoples and the public on these key points. See Appendix A of the IER for a copy of the Record of Decision.

CNL's Indigenous engagement objectives include:

1) initiating and maintaining two-way communication channels between CNL and Indigenous communities to determine the best methods for communicating Project information and to provide opportunities for Indigenous peoples to provide input on Project considerations including: design, the EIS process, and assessment of impacts;
2) developing meaningful, user-friendly information and communication products geared for the public and Indigenous communities, and providing accessible and current information on Project activities;
3) demonstrating CNL's long-term commitment and approach to safe and responsible management of AECL's radioactive waste and decommissioning liabilities;
4) informing and educating Indigenous communities about nuclear decommissioning, environmental remediation and radioactive waste management;
5) using engagement to further the development of long-term relationships with Indigenous communities; and
6) meeting all regulatory-based communication and engagement requirements.

To meet these objectives, CNL has developed specific strategies to increase the effectiveness of the engagement program so that Indigenous engagement requirements for the NSDF Project are met. These strategies include:

- presenting information in a format that is easily understood through a variety of communications channels using targeted key messaging;
- engaging technical experts to communicate information in various formats;
- accomplishing all required activities in a timely manner; and
- providing various means for Indigenous communities to access information.

6.2.2 Identified Indigenous Communities

A proposed list of Indigenous communities with a potential interest in the NSDF Project was identified by CNL and included in the IER. Identification of communities was based on consultation with the CNSC and through the use of publicly available sources of information including:

- Indigenous community and organization websites;
- the Aboriginal and Treaty Rights Information System (Government of Canada and INAC 2016); and
- Crown-Indigenous Relations and Northern Affairs Canada First Nation community profiles.

The proposed list was based on the identified potential or established Indigenous or treaty rights of Indigenous communities in the vicinity of the Project and is provided in Table 6.2.2-1 along with a brief rationale for inclusion. The inclusion of specific communities considers the nature of the established and/or claimed rights and potential effects on those rights caused by the proposed Project based on a preliminary assessment of existing and available information. As such, the working list is subject to change based on information and dialogue with the identified Indigenous communities and organizations.

Table 6.2.2-1: Identified Indigenous Communities and Organizations

Indigenous Communities (by representative organization) and/or Organizations Location	Identification Rationale
▪ Algonquins of Ontario, comprising 10 Algonquin communities: ▪ Antoine Algonquin First Nation ▪ Algonquins of Pikwakanagan First Nation ▪ Algonquin Nation Kijicho Manito Madaouskarini ▪ Bonnechere Algonquin First Nation ▪ Algonquins of Greater Golden Lake First Nation ▪ Mattawa-North Bay Algonquin First Nation ▪ Ottawa Algonquin First Nation ▪ Shabot Obaadjiwan First Nation (Shabot Lake) ▪ Snimikobi (Ardoch) (Beaver Creek) Algonquin First Nation ▪ Whitney and Area Algonquins	▪ The CRL site is located within the vicinity of known traditional territory ▪ Accepted for negotiations with Self-Government ▪ Framework Agreement (Signed) ▪ Established CNL relationship (member of CNL's Environmental Stewardship Council [ESC](a))
Algonquins of Pikwakanagan First Nation (included as part of the AOO but also separately identified)	▪ Historic relationship with AECL and CNL ▪ Closest First Nation to the CRL site ▪ The CRL site is located within the vicinity of known traditional territory ▪ Accepted for negotiations with Self-Government ▪ Framework Agreement (Signed) ▪ Established CNL relationship (member of CNL's ESC(a))
Algonquin Anishinabeg Nation Tribal Council (AANTC) (two of its member communities): ▪ Kebaowek First Nation (formerly known as Eagle Village First Nation) ▪ Kitigan Zibi Anishinabeg First Nation	▪ The CRL site is located within the vicinity of known traditional territory ▪ Assertion of rights

Table 6.2.2-1: Identified Indigenous Communities and Organizations

Indigenous Communities (by representative organization) and/or Organizations Location	Identification Rationale
Métis Nation of Ontario (MNO) (community councils representing the Project location): - MNO North Bay - MNO Mattawa Métis - MNO Sudbury via the Mattawa/Lake Nipissing Traditional Territory Consultation Committee	- Assertion of rights in the vicinity of NSDF Project - Established CNL relationship (member of ESC)[(a)] - Historic Métis community identified at Mattawa
Williams Treaties First Nations, composed of seven First Nations: - Alderville First Nation (Mississaugas) - Beausoleil First Nation (Chippewas) - Chippewas of Georgina Island First Nation - Chippewas of Rama First Nation - Curve Lake First Nation (Mississaugas) - Hiawatha First Nation (Mississaugas) - Mississaugas of Scugog Island First Nation	- Historical treaty, CRL site is located within lands covered by one of the Williams Treaties
Anishinabek Nation (formerly known as Union of Ontario Indians), which advocates for 40 member First Nations, 7 of which are included and noted above (i.e., Alderville First Nation, Beausoleil First Nation, Chippewas of Georgina Island First Nation, Chippewas of Rama First Nation, Curve Lake First Nation, Mississaugas of Scugog Island First Nation and Algonquins of Pikwakanagan First Nation).	- Umbrella organization that has members with potentially affected rights
Algonquin Nation Secretariat (ANS), which represent three First Nation communities in Quebec: Timiskaming First Nation, the Algonquins of Barriere Lake, and Wolf Lake First Nation	- Umbrella organization that has members with potentially affected rights

a) Note that CNL has established an Environmental Stewardship Council (ESC) for the CRL site. The function of the council is to provide opportunity for face-to-face meetings and to build an enhanced working relationship through effective two-way dialogue with a representative membership of community opinions. Of the communities represented by the Algonquins of Ontario, only the Algonquins of Pikwakanagan hold a seat on the ESC. The Métis Nation of Ontario also holds a seat on the ESC.

The IER provides background information on these communities and/or representative organizations with a potential interest in the NSDF Project and includes, where possible, reference to individual community's elected council, geographic location, population, and associations or memberships. The IER TSD will be revised as these communities and organizations provide additional information as the NSDF Project progresses. The information summarized in this EIS reflects a summary information available to CNL as of the end of June 2020. As of the end of June 2020, CNL has undertaken verification process (as outlined in Section 6.2.4) with the identified Indigenous communities groups or have made on-going attempts to engage. CNL utilized all available information from June 2016 to June 2020 to conduct this verification and be in a position to finalize the EIS and submit to the Responsible Authority for the next steps in the EA process. Although the opportunity still exists for the Indigenous communities and organizations to continue involvement, the on-going updates will be incorporated in to the IER as the living document.

As noted in the Record of Decision referenced in Section 6.2.1, funding was offered by the CNSC to assist Indigenous peoples to participate in the NSDF Project, review of the licence application, and the processes for the CNSC Commission Hearing on the NSDF Project. Following consideration of applications (to date) by Indigenous peoples for funding, participant funding was allocated to the Algonquins of Ontario (AOO), Métis Nation of Ontario (MNO) and the Algonquin Anishinabeg Nation Tribal Council (AANTC). Further information on the participant funding process is provided in the CNSC Participant Funding Program, which is available on the CNSC's Project webpage (CNSC 2016b).

CNL has considered and provided capacity funding to specific Indigenous communities to further their ability to participate in the environmental assessment process.

6.2.3 Engagement Methods

Section 6.2.4 describes the engagement that CNL has undertaken with the identified Indigenous communities and organizations (as outlined in Section 6.2.2): Algonquins of Ontario (AOO); Algonquins of Pikwakanagan First Nation (AOPFN); Métis Nation of Ontario (MNO); Algonquin Anishinabeg Tribal Council (AANTC); Kitigan Zibi Anishinabeg First Nation; Keboawek First Nation, Williams Treaties First Nations (WTFN); Anishinabek Nation; and, Mohawks of the Bay of Quinte First Nation. It should be noted that the Mohawks of the Bay of Quinte are not identified on CNL's engagement list (Table 6.2.2-1) but have provided correspondence on the NSDF Project.

Various engagement methods were designed to communicate information to and solicit input from identified Indigenous communities and organizations, while fulfilling CNL's corporate and regulatory objectives. The methods CNL has utilized to date, or plans to undertake, are highly diverse and vary based on expressed community need and desired methods. This includes general information activities to focused community meetings and workshops to long-term relationship building activities. In Section 6.2.4, these activities are described for each community but, in general, the methods have included those summarized in Table 6.2.3-1. Project-specific examples are included however, as noted above, long-term relationship building engagements and funding were also a key activity. CNL recognizes a mutual desire to establish long term relationship agreements to help facilitate many aspects both related and unrelated to projects such as NSDF. While although CNL may have various projects over time, it is important to both the communities and CNL that these relationships endure, grow and respond to future activities.

Table 6.2.3-1: Project-specific Engagement Methods

Engagement Method	Example Activities

Project Specific Agreements and Long-Term Relationship Meetings and Negotiations	▪ Project-specific Agreements (i.e., separate Memoranda of Understanding (MOUs) entered into with the AOO and the MNO):
	  ▪ Provision of funding to assist in resource capacity development; and
	  ▪ Capacity assistance and building, as appropriate, such as basic costs to support meetings such as hall rental or production of print materials, in-kind access to the technical expertise of CNL staff, reimbursement for some expenses to participate in engagement activities such as site visits, tours.
	▪ Broader long-term relationship agreements with CNL

Table 6.2.3-1: Project-specific Engagement Methods

Engagement Method	Example Activities
Technical Assistance and Contribution Agreements	▪ Provision of funding to assist in technical review ▪ Peer review studies and engagements with Indigenous organization consultants and staff ▪ Work plan development to formalize engagement processes with communities and/or organization representatives
Project Specific Meetings and Workshops	▪ Meetings/workshops with Indigenous community and/or organization representatives to discuss the Project and potential effects ▪ Community meetings/open houses ▪ Presentations to Indigenous communities and/or organization representatives upon request ▪ Targeted community initiatives ▪ Workshop attendance and cultural awareness training ▪ Technical meetings, upon request, to provide interested communities and/or organization representatives an opportunity to discuss more detailed technical information concerning the NSDF Project
Specific Communications Activities	▪ Letters to Indigenous communities and/or organization representatives (accompanied by follow-up calls) ▪ Email correspondence and/or phone calls with Indigenous communities and/or organization representatives ▪ Distributing the IER to Indigenous communities and/or organization representatives ▪ Distributing copies of maps, technical studies or reports upon request ▪ Webinars and online meetings with Indigenous communities and organizations
General Communications Activities	▪ NSDF Project notifications and newspaper advertisements ▪ ESC meetings (for ESC member communities) ▪ Public information sessions, including display materials and handouts ▪ Media notifications/releases ▪ Webpage content ▪ Site visits and participation in National Indigenous Day ▪ Participation and presentation at Indigenous Youth Summit ▪ NSDF Project site visits and benchmarking tours

6.2.4 Engagement

6.2.4.1 Introduction

Formal notification of the NSDF Project in the form of a letter was sent to all identified Indigenous peoples communities and organizations on July 15, 2016. The letter provided information about the NSDF Project and provided mechanisms for comments and/or questions. Follow-up outreach (i.e., phone contact) was conducted with recipients to confirm receipt of the NSDF Project information and to ascertain the best means for on-going contact.

Engagement activities have varied and are at the discretion of the various communities and subject to community availability. Table 6.2.4-1 provides a summary of engagement activities that have continued through to June 30, 2020 in preparation of the EIS. As the NSDF Project and environmental assessment process progresses, the IER will be updated and maintained as a living document going forward with any additional engagement activities undertaken and progress made on engagement issues.

There is cross-over in several instances in engagement activities between the NSDF Project and CNL's NPD Closure Project given the proximity and relative timelines of each project. As such, engagement that addresses both projects are also noted here as it would be difficult to extract specific discussions regarding the NPD Closure Project from the summary. Examples of correspondence and meeting materials are provided in the appendices of the IER and all records of meeting presentations are kept and can be provided upon request.

The list of Indigenous communities and organizations included in Table 6.2.2-1 are described in this section of the EIS and in more detail in Chapter 3 of the IER. These sections also describe the rationale for the inclusion of the various communities. Figure 6.2.4.1 below shows the home location (Reserve or office) of these various communities in relation to the NSDF site.

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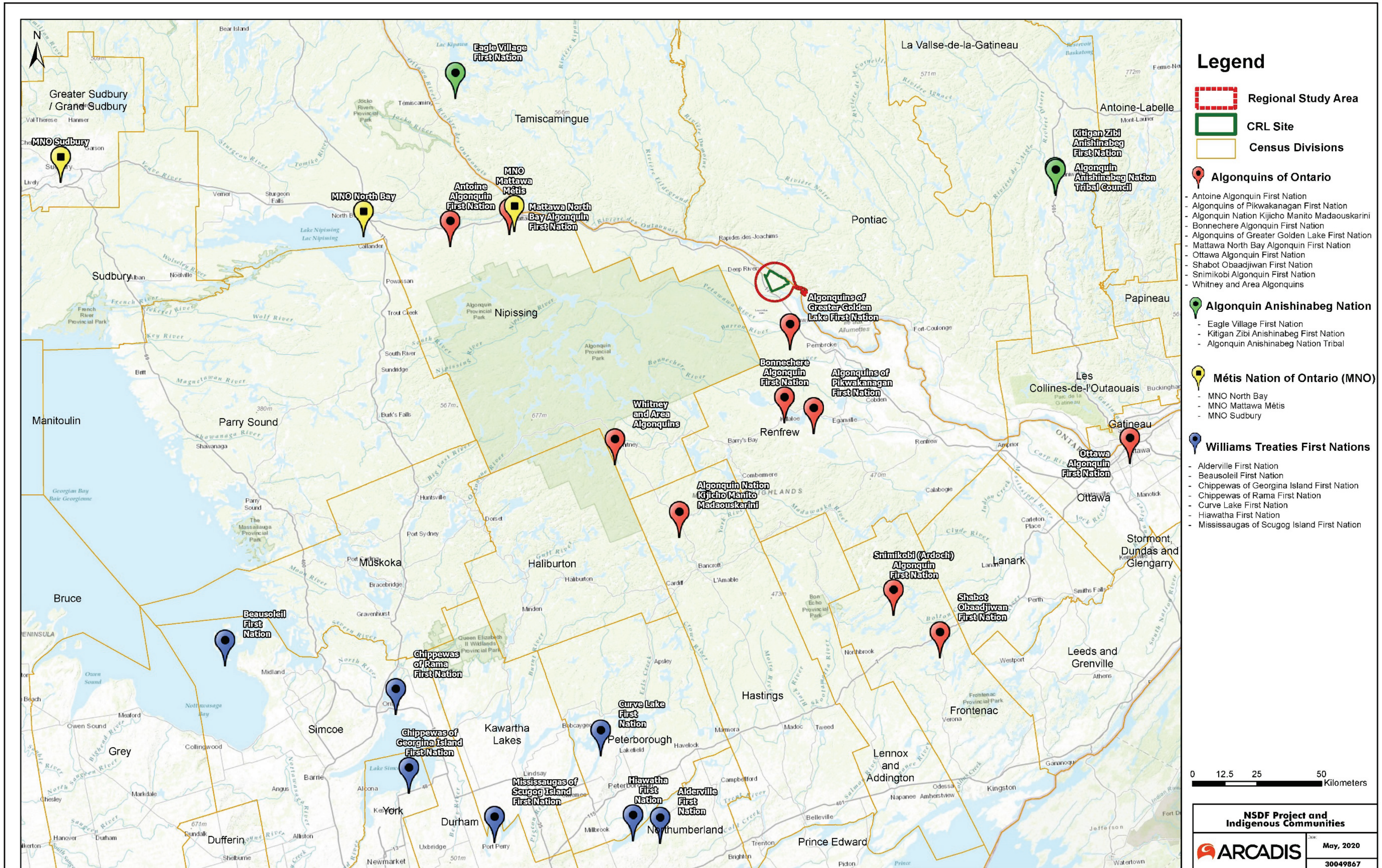

Reference: ESRI ArcGIS Online Base Layer Statistics Canada Census, and EIS for the NSDF Project Description

Figure 6.2.4-1: Indigenous Communities in Relation to the NSDF Site

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Table 6.2.4-1 below quantitatively describes and summarizes the various Indigenous engagement activities undertaken for the NSDF Project. The table is intended to demonstrate two key points:

- CNL has utilized a wide assortment of engagement tools on the consultation spectrum ranging from basic communications to two-way formal and informal dialogues to detailed studies, funding and investigation and finally to the consideration of long-term relationship agreements. The consultation activities in the columns reflect the increasing degree of engagement.
- CNL has reached out to all the Indigenous communities and organizations on the list below in the manner as demonstrated and has indicated that it is willing to engage with any Indigenous community or organization that responds back. At the same time, CNL has “deeply” engaged with those Indigenous communities and organizations that live and practice traditional activities in closest proximity to the NSDF site.

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Table 6.2.4-1: NSDF Identified Indigenous Communities and Organizations Engagement and Involvement

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via mail or registered mail	Phone & email correspondence	General email (i.e., invites to webinars etc.)	Comments submitted via EA process (2016 Project Description, 2017 Draft EIS)	Meetings, Information sessions & tours	CNSC Participant Funding issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or other studies	Reviewing the 2019 revised draft EIS[1]	Long-Term Relationship Agreements (in discussions)
Algonquins of Ontario (AOO)	5	13	12	Yes	20	2019	MOU	In progress	Yes	Yes
Algonquins of Pikwakanagan First Nation (part of the AOO)	8	22	12	—	5	2019	In progress	In progress	Yes	Yes
Algonquin Anishinabeg Nation Tribal Council (AANTC)	5	21	12	Yes	3	2017 & 2019	In progress	—	Yes	—
Kebaowek First Nation (formerly known as Eagle Village First Nation)	5	4	12	—	2	—	—	—	—	—
Kitigan Zibi Anishinabeg First Nation	4	11	12	Yes	3	—	—	—	—	—
Métis Nation of Ontario (MNO)	9	12	12	Yes	11	2017 & 2019	MOU	TKLUS	Yes	Yes
Williams Treaties First Nations (WTFN) Process Coordinator	1	8	12	—	—	—	—	—	—	—
Alderville First Nation	4	17	12	—	1	—	—	—	—	—
Beausoleil First Nation	4	17	12	—	—	—	—	—	—	—
Chippewas of Georgina Island First Nation	4	19	12	—	—	—	—	—	—	—
Chippewas of Rama First Nation	4	17	12	—	1	—	—	—	—	—
Curve Lake First Nation	4	19	12	Yes	2	—	—	—	—	—
Hiawatha First Nation	4	18	12	Yes	2	—	—	—	—	—
Mississaugas of Scugog Island First Nation	4	17	12	—	—	—	—	—	—	—
Anishinabek Nation (Formerly known as Union of Ontario Indians)	4	5	12	Yes	—	—	—	—	—	—
Algonquin Nation Secretariat	4	6	12	—	—	—	—	—	—	—
Not on Engagement/Consultation List										
Mohawks of Bay of Quinte (MBQ)	1	4	1	Yes	—	—	—	—	—	—

[1] All Indigenous communities and organizations listed in Table 6.2.4-1 were provided the 2019 revised Draft EIS. This column identifies those that CNL has received confirmation from that a review of this draft is being conducted.

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Table 6.2.4-1 generally demonstrates that more and deeper engagement has occurred with Indigenous communities and organizations that are generally located closer to the NSDF site, have populations living closer to the NSDF site, and likely have larger numbers of individuals practicing traditional activities near the NSDF site.

Outlined in the remainder of Section 6.2.4 is a summary of engagement that CNL has undertaken with each Indigenous community and organization that CNL has identified. Section 6.2.4 is a summary of the engagement and the reader is encouraged to review the IER for more detail on engagement with each Indigenous community and organization. Chapter 3 of the IER describes each community in detail and Chapter 4 of the IER describes the engagement in detail.

In Chapter 4 of the IER are detailed five-column tables labelled as "Tables of Interests and Concerns of Each Indigenous Community/Organization" (Tables of Interests). These tables were developed for the final revision of the EIS in co-operation with the CNSC and are intended to describe in more detail the substance and stage of engagement with each Indigenous community and organization on the various issues. These Tables of Interests in the IER identify the specific comments that have been formally submitted as part of the engagement process or identify that the concerns and comments have been raised orally or in direct submissions to CNL.

Engagement with individual Indigenous communities and organizations are not all at the same stage. Some Indigenous communities and organizations became engaged early on with NSDF, often on highly specific topics while other communities have only more recently shown a renewed interest in the NSDF Project. As well, some communities may have engaged early on in some issues but only more recently on other concerns or issues. As such, CNL has had significant discourse and formal exchange of comments and responses to some communities on some issues with results having been incorporated into the EIS while with other communities the engagement is not as advanced. The Tables of Interests have been organized and presented to describe the stage of engagement with each community and organization on each issue.

The Tables of Interests are further summarized in this section. With each Indigenous community and organization, CNL has briefly described the Indigenous community or organization and then described the engagement according to the following headings.

- **Engagement.** This sub-section summarizes the engagement CNL has had with the Indigenous community or organization. This is described further in Chapter 4 of the IER.
- **Feedback.** This sub-section describes the specific topics of issue, concern and interest each Indigenous community or organization has identified formally in writing and/or verbally to CNL. Each bullet point represents a general theme identified by each Indigenous community or organization. Within each bullet CNL has generally described the issue as raised and also discussed in summary form its response to the issue and discussions on the topic. This feedback section directly corresponds to Columns 2 (Key Interests and Concerns) and 3 (How CNL is Addressing the Feedback/Concern) in the "Tables of Interests and Concerns of Each Indigenous Community/Organization" that appears in the IER.
- **Verification.** This sub-section is a summary of column four (Verification) from the Tables of Interests. The purpose of the verification section is to describe as accurately as possible the status (as of June 30, 2020) of each issue with each community.
  - Where Indigenous communities or organizations submitted comments on the 2017 Draft EIS, CNL has formally responded to those comments and sent the response back in writing to the respective Indigenous community or organization and/or directly made changes to the EIS to address the concern.

In some cases, the issue raised has been resolved. However, there are also other issues where there may be a difference in opinion and/or the Indigenous community or organization may have not confirmed that the response by CNL is deemed acceptable.

- CNL would note that it has only recently received some submissions or questions from specific Indigenous communities and organizations and CNL is also aware that a couple Indigenous communities and organizations are still formulating more specific questions and issues. This is all considered acceptable to CNL but CNL has attempted to describe the status of this engagement process in as much detail as possible.
- Below, CNL has described in general the status of this verification process but more detail is provided in the five column tables in Chapter 4 of the EIS.

- **Next Steps.** This sub-section describes where CNL is as of end of June 2020 with each Indigenous community or organization and how it plans to address outstanding issues of concern and interest. CNL is under no illusion that all issues can be quickly or easily resolved as some issues go beyond the scope of the NSDF Project or there remain a difference of opinion on certain issues. That being said, CNL is attempting to listen, respond to and, if possible, address all issues raised. “Next Steps” is the last column in the Tables of Interest.

CNL has also developed a system to generally describe where each Indigenous community/organization is in the engagement and verification process/steps. The verification process is similar to the above points but is described below.

- **Process Step #1 –** Receive Formal Comments on the Project Description or Draft EIS from Indigenous community or organization.
- **Process Step #2 –** Share revised Draft EIS and offer to meet and discuss how comments were incorporated:
  - 2 (a) If offer accepted, draft responses to comments on 2017 Draft EIS prior to the meeting (e-mail and/or registered letter); and
  - 2 (b) If no response, share draft responses to comments on 2017 Draft EIS and offer again to meet and discuss (e-mail, registered mail, follow-up by phone).
- **Process Step #3 –** Acknowledgement and possibly feedback from Indigenous community or organization. CNL incorporates any feedback received by revising responses.
- **Process Step #4 –** Share revised draft responses to comments for confirmation by Indigenous community or organization.
- **Process Step #5 –** Finalize EIS.

Where each Indigenous community or organization is in the above process is described below within each Verification sub-heading.

6.2.4.2 Algonquins of Ontario (AOO)

The Algonquins of Ontario (AOO) is an organized collective of Algonquin communities assembled to enable a unified approach to reaching a settlement over a comprehensive land claim including an area of over 3.6 million hectares (ha) within the Ottawa River and Mattawa River watersheds in eastern Ontario (AOO, 2020b). The area that is the subject of the Algonquin Land Claim in Ontario includes the National Capital Region, all of Renfrew County and most of Algonquin Park. The AOO is comprised of ten Algonquin communities located within the Ottawa Valley: Antoine Algonquin First Nation; Algonquins of Pikwakanagan First Nation; Algonquin Nation Kijicho-Manito Madaouskarini; Bonnechere Algonquin First Nation; Algonquins of Greater Golden Lake First Nation; Mattawa/North Bay Algonquin First Nation; Ottawa Algonquin First Nation; Shabot Obaadjiwan First Nation; Snimikobi (Ardoch) (Beaver Creek) Algonquin First Nation; and, Whitney Area Algonquins. Sixteen Algonquin Negotiation Representatives (ANRs), serving three-year terms represent these communities. The ANRs are comprised of the Algonquins of Pikwakanagan First Nation Chief and Council (six Councillors) along with one representative from each of the other Algonquin communities listed above. The CRL property is located within unceded Algonquin Territory. The Algonquins of Ontario have asserted existing Aboriginal rights and title throughout the Settlement Area, including the CRL site. This land claim is currently under negotiation by the Algonquins of Ontario and the Governments of Canada and Ontario.

A fuller description of the AOO can be found in Chapter 3 of the IER.

In 2018, the AOO, AECL and CNL signed a tri-partite Memorandum of Understanding (MOU) to guide dialogue between the parties on matters of mutual interest. More specifically the MOU was intended to be a vehicle to work towards the development of a Long-Term Relationship Agreement amongst the parties. The MOU identified the need for both a Technical Group to deal with the NPD project and a Long-Term Relationship Group that would advance a Long-Term Relationship Agreement amongst the parties. The MOU broadly identified potential topic areas for the Long-Term Relationship Agreement. Over 2019 and 2020, the AOO, AECL and CNL developed a Terms of Reference and work plan for the Long-Term Relationship Agreement. The Long-Term Relationship Agreement is intended to cover such topics as: AOO involvement in environmental and cultural monitoring and stewardship; employment/training; contracting; communications; consultation; etc. The Long-Term Relationship Agreement is intended to cover the interests of all three parties with respect to both the CRL and NPD sites. The Long-Term Relationship Agreement discussions are relevant to NSDF as it is expected that certain themes such as future involvement in monitoring, or employment or contracting would also be relevant to NSDF.

While the AOO decided to initially focus its interests on the Long-Term Relationship Agreement and the NPD project, more recently CNL has learned that the AOO will be reviewing the NSDF Project. While that review could not be incorporated into this version of the EIS, CNL does plan to discuss the AOO comments and its responses in subsequent iterations of the IER.

6.2.4.2.1 Engagement

Table 6.2.4-2 below shows all the engagement activities that have occurred with AOO on the NSDF Project and/or Long-Term Relationship Agreement.

Table 6.2.4-2: Algonquins of Ontario (AOO) Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Algonquins of Ontario	5	13	12	Yes	20	2019	MOU	In progress	Yes	Yes

* The complete table is located in Section 6.2.4.1.

CNL first reached out to representatives with the Algonquins of Ontario (AOO) in 2016 June, after receiving a copy of the AOO's comments on the Project Description for the NSDF Project, with an invitation to meet and discuss the project. Engagement activities with the AOO commenced in August 2016 after receipt of the CNL NSDF Project introductory letter sent in July 2016.

In 2016, CNL hosted AOO Consultation Office and Technical staff for an information session at the CRL site as well a tour of the two proposed NSDF Project location sites. Late 2016 included discussions on archaeological liaison participation at the proposed NSDF site as well as sharing documents of interest to the AOO, which included biodiversity reports, archaeological information and topographical maps of the CRL site.

In early 2017, CNL shared the NSDF Project draft EIS and encouraged the AOO to participate in the public and Indigenous comment period followed by a meeting with the AOO Consultation staff and the Algonquin Negotiation Representatives (ANR) to discuss future engagements on the NSDF Project. CNL also hosted the ANRs to the CRL site for a tour which included the proposed NSDF site. The AOO did not submit comments on the NSDF 2017 draft EIS through the environmental assessment process. In June 2017, an information session for AOO community members was held in Pembroke, ON, which included a project overview as well as an opportunity for one-on-one discussions with NSDF Project technical staff. Over 8 000 AOO community members were sent the invitation by mail and approximately 15 were in attendance. In late 2017, CNL shared the NSDF Aboriginal Engagement Report and requested community input and feedback for incorporation into the EIS and project planning. CNL did not receive any feedback from the AOO on this report.

CNL and the AOO started discussions on developing a Memorandum of Understanding (MOU) in early 2018, which included multiple meetings and email correspondence resulting in a signed MOU in July 2018. The MOU set the platform for AOO, AECL and CNL to enter into discussions on a Long-Term Relationship Agreement. Long-term relationship agreement meetings continue with signing estimated in fall 2020. Separately, CNL along with the CNSC, provided supplemental funding to the AOO to support an Algonquin Knowledge and Land Use Study (AKLUS) which commenced in 2019. CNL provided a NSDF Project overview presentation in June 2019 at the Algonquin Knowledge and Land Use Study Workshop in Deep River, ON. As of 2020 June, this study has not been completed. However, it is CNL's intention to revise the Traditional Land and Resource Use section in the IER with results once received.

Upon request, the NSDF Project provided an update to the AOO's Planning and Environmental Working Group in December 2019 which included Indigenous peoples key issues and the introduction of the new Indigenous Interests section in the upcoming revised draft EIS. In late 2019, CNL shared the revised draft EIS and the latest revision of the IER with the AOO and encouraged community input for the final revision.

In May 2020, CNL followed up with the AOO to inquire on interest level of sharing comments on the 2019 revised Draft EIS and input for the IER and the AOO indicated that comments would be sent to CNL. As of end of June 2020, these comments have not been received by CNL.

Throughout the NSDF Project, CNL has evolved project engagements to meet Indigenous and stakeholder feedback. This included the development of a regular routine of Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates. The AOO received invitations to all engagement activities and have been in attendance at select events.

6.2.4.2.2 Feedback

As indicated above, until recently the AOO has not engaged in detail on the proposed NSDF Project and instead have focused their efforts on the Long-Term Relationship Agreement and the NPD Project. The AOO did provide feedback on the original Project Description in 2016 but did not provide formal comment on the 2017 EIS (CNL undertook open houses for all AOO members in 2017 and 2019). CNL has recently learned (early May 2020) that the AOO has decided to review the NSDF Project in more detail and has requested a review of the 2019 revised Draft EIS.

Chapter 4 in the IER provides a Table of Interests outlining AOO interests and concerns and CNL responses.

The topics in the Table of Interests are briefly summarized below:

- **Acknowledgement that CRL is in the Algonquin Settlement Area**. This has been included in Section 6.2.4.2.
- **Inclusion of AOO in the Engagement Process**. CNL and AOO have implemented an MOU and are in discussions regarding a Long-Term Relationship Agreement.
- **Protection of the Ottawa River, Flora and Fauna**: CNL has updated the EIS to include information from technical supporting documents, and continues to discuss this with AOO.
- **Long-Term Relationship Agreement**. As previously indicated, the AOO, AECL and CNL have undertaken various steps towards a Long-Term Relationship Agreement that will cover both the CRL and NPD sites. The parties continue to move forward with developing and ultimately implementing the LTRA.
- **Environmental and Cultural Heritage Stewardship and Monitoring**. AOO archaeological liaisons participated in work at the NSDF site and CNL has provided AOO with the NSDF Archaeology reports. The AOO and CNL are in discussions of how to more greatly involve the AOO in environmental and cultural heritage monitoring and stewardship activities. This would be relevant for any project and regular monitoring activities undertaken.
- **Consultation, Engagement and Communications**. The AOO, AECL and CNL are in discussions on future and regular consultation, engagement and communication.
- **Employment, Training, Contracting and Other Economic Interests**. The AOO, AECL and CNL are in discussions on enhancing AOO involvement in employment, training, contracting and other economic interests. These can include the NSDF Project but would also include other projects and regular activities.
- **Traditional Knowledge and Land Use**. Both CNSC and CNL have provided financial capacity to the AOO in undertaking an Algonquin Knowledge and Land Use Study. The study was done for both the NSDF and NPD projects. The study has not yet been completed but CNL understands that it will be completed prior to the NSDF Project Commission Hearing. If available CNL will incorporate results of the study in the traditional use existing environment and effects sections in the IER.

6.2.4.2.3 Verification

CNL incorporated comments from the original Project Description into the revised EIS. No further comments have been received from the AOO on this topic. For over two years, AECL, AOO and CNL have been engaged in Long-Term Relationship Agreement discussions and negotiations and all parties are anticipating this to be completed in fall 2020. CNL is aware that the AOO is preparing formal comments on the 2019 revised draft EIS and plans to submit these in late 2020 June. As of June 30, 2020 these have not yet been received by CNL. New comments raised by the AOO will require disposition and verification. CNL is of the opinion that it is at Process Step 5 of the CNL Verification Process with the AOO given the AOO comments on the 2016 Project Description have been incorporated and no formal comments on the 2017 Draft EIS were submitted.

6.2.4.2.4 Next Steps

CNL will continue to engage with the AOO and AECL on completing a Long-Term Relationship Agreement. As well, CNL will continue to address any concerns the AOO might have with the NSDF Project. CNL will also incorporate results from the Algonquin Knowledge and Land Use Study in the NSDF Project in a revised section on the traditional land and resource use that will be in the final IER issued in advance of the Commission Hearing.

6.2.4.3 Algonquins of Pikwakanagan First Nation (AOPFN)

The Pikwakanagan First Nation is located in the Ottawa Valley the southeast shore of Golden Lake where it flows in to the Bonnechere River, in Renfrew County, Ontario. Pikwakanagan has a total registered population of slightly under 3,000 with the majority living off-reserve. The Reserve was established through a Crown patent in 1873 following several petitions from the community who were known at the time as Golden Lake.
The Pikwakanagan First Nation have linguistic traditions in the Algonquin language. The First Nation is governed by an elected council comprised of a Chief and six councillors. The First Nation is a signatory of the AOO Agreement-in-Principle (2016) as well as the earlier issued Algonquins of Ontario (1983) Comprehensive Land Claim. A fuller description of the AOPFN can be found in Chapter 3 of the IER.

CNL and AECL have a long history of engaging with the AOPFN of whom are part of the AOO. A representative of AOPFN has been a member of CNL's Environmental Stewardship Council (ESC) since October 2006, when the ESC was first established. As the AOPFN are part of the AOO they have participated in all the engagement activities as documented in the AOO section above including the development of the LTRA. For brevity, that section is not repeated here. Recently, the AOPFN has undertaken some of their own separate engagement (apart from AOO) on matters specific to the NSDF Project.

6.2.4.3.1 Engagement

Table 6.2.4-3 below shows all the engagement activities that have occurred with AOPFN on the NSDF Project.

Table 6.2.4-3: Algonquins of Pikwakanagan First Nation (AOPFN) Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Algonquins of Pikwakanagan First Nation (part of the AOO)	8	22	12	—	5	2019	In progress	In progress	Yes	Yes

* The complete table is located in Section 6.2.4.1.

The Algonquins of Pikwakanagan First Nation (AOPFN) were introduced to the proposed project prior to the formal submission of the Project Description for the NSDF. In December 2015, CNL hosted the AOPFN to the CRL site which included a tour and a presentation where the proposed NSDF Project was introduced within the context of a larger vision of the contractor company under the new Government-Owned Contractor-Operated (Go-Co) model.

In July 2016, CNL sent the AOPFN a letter to formally introduce the proposed NSDF Project which included a request for community input on any potential adverse impacts from project activities followed by a secondary letter in November 2016 which inquired about AOPFN asserted rights and traditional activities. The AOPFN sent a letter to CNL in January 2017 acknowledging receipt of letters and advised of negotiations with the federal and provincial government on the settlement of their land claim and the interest in meeting later in 2017. CNL followed-up on the AOPFN meeting request from the 2017 January letter and were informed in June 2017 that the AOPFN did not want to meet at this time and that ANRs were involved through the AOO engagement activities.

In early 2017, CNL also shared the draft EIS and encouraged the AOPFN to participate in the public and Indigenous environmental assessment comment period and in June 2017 the AOPFN ANRs participated in a meeting with the AOO Consultation staff and the ANRs to discuss future engagements on the NSDF Project. CNL also hosted the ANRs to the CRL site for a tour which included the proposed NSDF site (several AOPFN ANRs joined this event). The AOPFN did not submit comments on the NSDF 2017 Draft EIS through the environmental assessment process. In late 2017, CNL shared the NSDF Aboriginal Engagement Report and requested community input and feedback for incorporation into the EIS and project planning. CNL did not receive any feedback from the AOPFN on this report.

Throughout 2018 and 2019, AOPFN ANRs continued participation through AOO engagement activities. During this time, CNL also evolved project engagements to meet Indigenous and stakeholder feedback. This included the development of a regular routine of Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates. The AOPFN received invitations to all engagement activities and have not attended any events to date. In late 2019, CNL shared the 2019 revised Draft EIS and the latest revision of the IER with the AOPFN and encouraged community input for the final revision.

In March 2020, CNL received a letter from the AOPFN inviting the NSDF Project to provide a project overview/update at a community meeting in 2020 April. This meeting was postponed one week later due to the COVID-19 pandemic and will be re-scheduled. After receiving the 2020 March letter, discussions commenced between AOPFN and CNL on the AOPFN’s intent to review the 2019 revised Draft EIS and interest in AOPFN specific engagement (in addition to AOO engagement). During these discussions, it was determined that a letter sent from AOPFN to the CNL President and CEO in December 2017 was never received. This letter was resent via email to Environmental Remediation (ERM) Stakeholder Relations in April 2020. The 2017 letter indicated interest in NSDF Project activities as well as CNL procurement and corporate activities. CNL will draft and issue a letter on the subject of AOPFN CNL interests.

In May 2020, CNL sent a letter to the AOPFN following up on recent AOO communications (which involved AOPFN) and made inquiries for AOPFN specific information. A response from the AOPFN Chief was received immediately indicating interest in AOPFN specific engagement and a LTRA with CNL corporate. The Chief also acknowledged upcoming engagement activities with respect to the NSDF Project. In late 2020 May, CNL received comments from the AOPFN on the NSDF 2019 revised Draft EIS. After receipt of the comments, CNL initiated discussions with the AOPFN on establishing a NSDF Project specific contribution agreement to ensure support of

AOPFN's participation in the environmental assessment process. Contribution agreement meetings started in early 2020 June with an estimated signing in mid-late 2020 July. The contribution agreement will include funding for studies as well as for meetings/discussions on the comments received on the 2019 revised Draft EIS as well as engagement leading up to the CNSC Commission Hearing on the NSDF Project.

6.2.4.3.2 Feedback

Until May of 2020 CNL understood that AOPFN feedback was being provided through the AOO. Therefore, all the general feedback provided by the AOO is considered to be valid for AOO. In late May 2020, AOPFN provided a separate submission on their interests and concerns to CNL, CNSC and AECL, based on their review of the 2019 revised Draft EIS.

Chapter 4 in the IER provides a Table of Interests for AOPFN interests and concerns. The topics in the Table of Interests are briefly summarized below:

- Historical Impacts;
- Issues pertaining to Crown Engagement, Management Structure at CNL and a Long-Term Relationship;
- Alternative Means Assessment;
- Traditional Land and Resource Use and Cultural Impacts;
- Project Description and Study Areas;
- Environmental Monitoring;
- End Closure State;
- Waste Inventory;
- Crown Oversight;
- Biological Concerns;
- Environmental Assessment Methodology and Process Issues;
- Impacts on Rights;
- Socio-Economic; and
- Health.

6.2.4.3.3 Verification

In May 2020, CNL received comments on the 2019 revised Draft EIS from the AOPFN. New comments raised by the AOPFN will require disposition and verification. CNL will disposition the comments raised by AOPFN, and incorporate where possible into the final EIS. Continued engagement and verification with AOPFN will be documented in the IER going forward.

6.2.4.3.4 Next Steps

CNL initiated discussions with the AOPFN on establishing a NSDF Project-specific contribution agreement to ensure support of AOPFN's participation in the environmental assessment process. Contribution agreement meetings started in early June 2020 with an estimated signing in mid-late July 2020. The contribution agreement will include meetings/discussions on the comments received on the 2019 revised Draft EIS as well as engagement leading up to the CNSC Commission Hearing on the NSDF Project.

6.2.4.4 Métis Nation of Ontario (MNO)

The Métis Nation of Ontario (MNO) was formed in 1993 to represent communities and individuals recognized by the Métis Nation within Ontario and works to represent the rights, interests and collective aspirations of Métis people and communities throughout the province. The MNO identifies a registry of over 20,000 Métis citizens (MNO, 2020d). Members of the MNO Mattawa/Lake Nipissing Métis Traditional Territory Consultation Committee and MNO Lands, Resources and Consultation Branch have participated in CNL's Indigenous Engagement Program for the Project. A fuller description of the MNO can be found in Chapter 3 of the IER.

The MNO and CNL have signed a MOU along with a Reciprocal Funding Agreement for the NSDF and NPD projects that has allowed the MNO enhanced participation in the NSDF Project. The MOU is with the MNO and more specifically the Mattawa/Lake Nipissing Traditional Territory Consultation Committee which includes the Sudbury Métis Council, the North Bay Métis Council and the Mattawa Métis Council which represent the regional rights-bearing Métis community. A representative of the MNO has been a member of CNL's ESC since March 2012.

The summarized objectives of the MOU include: to establish, in relation to the Projects, a mutually beneficial, cooperative, productive and on-going working relationship; provide a process for CNL to engage with the local and regional Métis communities, address any potential effects and discuss necessary mitigation measures; enhance the ability of the MNO to participate in the environmental assessment processes for the NSDF Project. The MOU also indicates the intention of both parties to pursue a longer-term relationship between CNL and the MNO.

CNL therefore provided funding to the MNO to assist them in enhanced engagement, specific funding for technical studies, VC workshop, and funds to allow staff to co-ordinate activities and work with CNL. The MNO have focused their technical reviews on three specific topics: Métis rights and interests, archaeology and protection of water. The MNO also carried out a comprehensive traditional knowledge and land study funded by the CNSC.

6.2.4.4.1 Engagement

Table 6.2.4-4 below shows all the engagement activities that have occurred with MNO on the NSDF Project.

Table 6.2.4-4: Métis Nation of Ontario (MNO) Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Métis Nation of Ontario (MNO)	9	12	12	Yes	11	2017 & 2019	MOU	TKLUS	Yes	Yes

* The complete table is located in Section 6.2.4.1.

CNL first reached out directly to the MNO in June 2016 to hold a teleconference with MNO representatives to introduce the proposed NSDF Project and enable preliminary discussion. This meeting was followed up by a letter in July 2016. This letter included a request for community input on any potential adverse impacts from project activities.

Later in July 2016, a meeting between the MNO Mattawa/Lake Nipissing Traditional Territory Consultation Committee and CNL was held to share an overview with a wider group of MNO representatives. After these initial contacts, there was some follow-up, including a letter sent from CNL to the MNO in December 2016, which made inquiries about MNO asserted rights and traditional activities. CNL did not receive a response from the MNO.

In early 2017 CNL shared the draft EIS and encouraged the MNO to participate in the public and Indigenous environmental assessment comment period. Following this, the MNO sent a letter to CNL in July 2017 sharing information to CNL on Métis rights, the need for consultation, and confirmation that the MNO Mattawa/ Lake Nipissing Traditional Territory Consultation Committee. CNL responded to this letter with a letter in August 2017 posing interest in developing a plan or agreement for engagement between CNL and the MNO. The MNO provided comments on the draft EIS through the formal environmental assessment process. In the fall of 2017 there was numerous correspondence between CNL and the MNO and a meeting was held in Sudbury in September. This meeting was hosted by the MNO and CNL shared information on environmental monitoring, environmental assessments, a project overview, and the environmental assessment process. In late 2017, CNL shared the NSDF Aboriginal Engagement Report and requested community input and feedback for incorporation into the EIS and project planning.

The next meeting between the MNO and CNL was held in March 2018 and focused on the development of a Memorandum of Understanding (MOU) to create a framework for relationship building between CNL and the MNO. This MOU set the platform for MNO, AECL and CNL to enter into discussions on a Long-Term Relationship Agreement (LRTA). Long-term relationship agreement meetings continue with signing estimated in fall 2020. Another aspect of particular importance relating to the MOU was the provision of capacity to undertake a Traditional Knowledge and Land Use Study (TKLUS). This was jointly funded by CNL, through the MOU, and the CNSC through Public Participant Funding. Information sharing occurred in follow-up to the March 2018 meeting. Further correspondence between the MNO and CNL occurred in 2018 culminating in a meeting and site visit in June 2018 and the signing of the MOU in December 2018.

In February 2019, the MNO shared the TKLUS, which gave insight into the traditional land and resource use of the MNO citizens in the region. This TKLUS has helped inform the recent revisions to the EIS. Following the receipt of the TKLUS, in April 2019, the MNO and CNL met to review the draft dispositions to the MNO comments on the draft EIS. The MNO and CNL met again in North Bay for a two-part meeting in late 2019. The first part involved discussions with the MNO Mattawa/Lake Nipissing Traditional Territory Consultation Committee Councillors. In the evening, a community information session for MNO citizens was held. This information session included a presentation by project representatives and the opportunity for questioning. In November 2019, the MNO sent a formal letter detailing the MNO response to CNL's draft dispositions of the MNO comments on the draft EIS. This included verification on whether the MNO accepted CNL's dispositions or whether they required further information. In late 2019, CNL shared the 2019 revised Draft EIS and the latest revision of the IER with the MNO.

Early in 2020, CNL hosted the MNO at the Port Hope and Port Granby sites for a benchmarking trip to view near surface waste facilities there. Then, in February 2020, the MNO sent CNL a letter providing positive feedback on the 2019 revised Draft EIS, as well as detailed comments that required response from the NSDF Project team.

Meetings aimed at developing an LRTA between CNL and the MNO continued virtually in the spring of 2020.

Throughout the NSDF Project, CNL has evolved project engagements to meet Indigenous and stakeholder feedback. This included the development of a regular routine of Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates. The MNO received invitations to all engagement activities and have been in attendance at select events.

6.2.4.4.2 Feedback

The MNO and CNL have had extensive engagement on the NSDF Project. Through a variety of engagement forums including technical reviews and workshops the MNO has raised a number of issues, concerns and questions that were initially focused on the 2017 draft EIS.

Chapter 4 in the IER provides a Table of Interests for MNO interests and concerns and CNL responses and also identifies and links the issues and concerns with formally submitted comments made through the environmental assessment process.

The topics in the Table of Interests are briefly summarized below:

- **Engagement.** Early in the engagement process the MNO expressed concern about lack of capacity to be involved in the project. This concern was addressed through the signing of the MOU and Reciprocal Funding Arrangement.
- **Long-Term Relationship Building.** Both the MNO and CNL have indicated an interest in developing a longer-term relationship.
- **Métis Rights and Interests and Traditional Uses.** The MNO requested capacity assistance to more deeply understand potential impact of the project on Métis Rights and Interests including traditional uses. CNL has assisted with capacity funding and has had significant engagement with the MNO on better understanding MNO's rights and interests. The MNO remains concerned that perceptions about the CRL site that lead to avoidance strategies by its citizens can represent an impact on their traditional use and therefore harvesting rights. CNL will keep working with MNO citizens on understanding there are no risks to adjacent traditional uses. CNL recognizes this is an important issue for MNO and will continue to work them and their harvesters in the future.
- **Valued Components.** The MNO expressed concern about incorporation of its interests into VCs for the NSDF Project. CNL provided funding for an MNO VC workshop and consulted with the MNO on how their particular VC interests were considered and incorporated into the VCs for the NSDF Project.
- **EIS Section Specific Concerns.** Very early on in the NSDF Project, the MNO raised concerns that MNO interests were not described more fulsomely throughout the draft EIS. CNL has enhanced the discussion of MNO interests in a number of sections. CNL did not update sections of the EIS such as sections on general location and construction materials as the purpose of those sections was not to discuss Métis or other Indigenous interests.
- **EIS General Concerns.** The MNO generated a large number of comments based on the review of the first draft of the EIS. CNL has responded to all these comments as part of the comment process, in direct responses to the MNO and in meetings and workshops. CNL is of the opinion most of them are addressed. However, CNL will continue to work with MNO on any outstanding concerns and interests.

- **Archaeology/Cultural Sites.** The MNO expressed some initial concern about the archaeological work, Métis cultural interests and the Point Au Baptême site. CNL provided capacity assistance to allow the MNO to undertake a peer review of the archaeological work. CNL also took MNO staff and councillors on a visit to the archaeological works at the NSDF site. CNL has also explained that the Point Au Baptême site will not be impacted by the proposed NSDF Project and that CNL does not restrict access to the site. CNL is of the opinion that it has addressed all of the MNO's concerns.
- **Indigenous Health.** Initially, the MNO in their review raised some concerns about the human health assessment and more specifically about whether consumption of country foods were comparable to Métis levels. Specific responses have been made to each of the formally submitted comments and CNL has indicated that it will include the MNO in future lifestyle surveys.
- **Future Involvement in Monitoring and Protection at NSDF.** The MNO has expressed interest in better understanding the environmental program and monitoring at the CRL site and participating in any future monitoring. CNL has indicated that it is willing to involve all Indigenous communities in its monitoring programs and would be pleased to discuss the issue further.
- **Environmental Effects, Mitigation and Monitoring.** With the first draft of the EIS, the MNO expressed some concerns with the environmental effects description and proposed mitigation and monitoring. Over a number of sessions and in response to direct comments, CNL has worked with the MNO to address concerns with the description of environmental effects and proposed mitigation and monitoring measures. CNL is of the opinion that is has addressed all of the MNO's comments and questions but it has asked MNO to raise any outstanding concerns.

6.2.4.4.3 Verification

The MNO and CNL have been deeply engaged since the signing of an MOU in 2018. The MNO and CNL have had extensive communications on their submissions and the 2019 revised EIS incorporated MNO input and findings from their TKLUS and VC workshop. MNO's consultants have reviewed CNL's materials and responses. The MNO provided an acceptance letter in 2020 of CNL's responses. CNL does not want to imply that the MNO is fully accepting of all of CNL's responses but that it is has reviewed and acknowledged them. Further details on this verification is in the MNO Table of Interests that can be found in Chapter 4 of the IER.

The MNO and CNL have had preliminary discussions on a long-term relationship agreement.

CNL is of the opinion that it is at Process Step 5 of the CNL Verification Process with the MNO.

6.2.4.4.4 Next Steps

CNL will continue engagement with the MNO with the objective of addressing or resolving any outstanding issues or concerns with the NSDF Project. As explained in the verification section above, CNL is of the opinion it has addressed all of the MNO's comments and concerns but will work with MNO on ensuring that.

MNO and CNL have started preliminary discussions about entering into a longer-term co-operation or relationship agreement.

6.2.4.5 Algonquin Anishinabeg Nation Tribal Council (AANTC)

The Algonquin Anishinabeg Nation (AAN), also referred to as the Algonquins of Western Quebec, or Algonquin Anishinabeg Nation Tribal Council (AANTC) was voluntarily established in 1992. Its purpose was to provide representation in land claim development and negotiation for member nations. Traditional territories claimed include the Ottawa River valley. At its inception, it comprised five member nations: Kebaowek First Nation (formerly known as Eagle Villiage) First Nation, Lac Simon First Nation, Abitibiwinni First Nation, Kitigan Zibi Anishinabeg First Nation, and Long Point First Nation (Winneway). Later two other communities joined the AANTC. A fuller description of the AANTC can be found in Chapter 3 of the IER.

6.2.4.5.1 Engagement

Table 6.2.4-5 below shows all the engagement activities that have occurred with the AANTC on the NSDF Project.

Table 6.2.4-5: Algonquin Anishinabeg Nation Tribal Council (AANTC) Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the 2019 Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Algonquin Anishinabeg Nation Tribal Council (AANTC)	5	21	12	Yes	3	2017 & 2019	In progress	—	Yes	—

* The complete table is located in Section 6.2.4.1.

In July 2016, CNL sent the AATNC a letter to introduce the proposed NSDF Project which included a request for community input on any potential adverse impacts from project activities followed by a secondary letter in November 2016, which inquired about AANTC asserted rights and traditional activities. CNL did not receive a response from the AANTC.

In early 2017 CNL shared the NSDF Project draft EIS and encouraged the AANTC to participate in the public and Indigenous environmental assessment comment period and in response the AATNC and CNL met in April 2017 to discuss the NSDF Project and gain feedback from AANTC leadership. The AANTC provided comments on the draft EIS through the formal environmental assessment process. In late 2017, CNL shared the NSDF Aboriginal Engagement Report and requested community input and feedback for incorporation into the EIS and project planning. CNL did not receive any feedback from the AANTC on this report.

Throughout 2018 and 2019, CNL evolved project engagements to meet Indigenous and stakeholder feedback. This included the development of a regular routine of Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates. The AANTC received invitations to all engagement activities and attended one event in April 2019. At that time, a tentative meeting date of May 2019 between CNL and the AANTC was discussed. In preparation for the meeting CNL sent the draft dispositions to the formal EIS comments submitted by the AATNC to review prior to meeting. The AANTC did not commit to a meeting date. In late 2019, CNL shared the 2019 revised Draft EIS and the latest revision of the IER with the AANTC and encouraged community input for the final revision.

In early 2020, CNL followed-up once again to determine a suitable meeting time to discuss the AATNC comments on the 2017 draft EIS. The AANTC inquired about NSDF Project timelines as well as the environmental assessment deadlines, which CNL provided. In April 2020, CNL provided updated draft dispositions to AANTC comments based on the 2019 revised Draft EIS and reiterated the importance of meeting to discuss comments and responses. In May 2020, CNL sent a letter to the AANTC following up on the dispositions that were sent, links to the 2019 revised Draft EIS as well as inquiries for specific AANTC information. Following the letter, the AANTC indicated they would be reviewing the revised draft EIS and requested a hard copy of the 2019 revised Draft EIS and a number of technical support documents to support the review.

In May of 2020, the AANTC and Kebaowek First Nation submitted a joint letter to the Government of Canada outlining issues and concerns that included the NSDF Project. While many of these concerns are related to the Government of Canada, CNL is interested in meaningful engagement with the AANTC and Kebaowek First Nation on the NSDF Project

CNL initiated discussions with the AANTC in late May to establish a NSDF Project specific contribution agreement to ensure support of the AATNC's participation in the environmental assessment process. Contribution agreement meetings started in early 2020 June. The contribution agreement will include meetings/discussions on the comments received on the 2017 draft EIS as well as engagement leading up to the CNSC Commission Hearing on the NSDF Project. On June 30, 2020, CNL received follow-up comments to the previous comments on the 2019 revised Draft EIS from the AANTC.

6.2.4.5.2 Feedback

Chapter 4 in the IER provides a Table of Interests for AANTC interests and concerns and CNL responses and also identifies and links the issues and concerns with formally submitted comments made through the environmental assessment process.

The topics in the Table of Interests are briefly summarized below:

- **Alternative Means.** The AANTC identified concerns with the Alternative Means assessment and formalized these into an IR. CNL has responded on two occasions to these issues and questions.
- **Facility Design – Site Location.** The AANTC identified a concern with the location of the NSDF in close proximity to the Ottawa River and potential impacts on the Ottawa River. The concern about the proximity of the proposed project to the Ottawa River and its importance to AANTC member communities has been reiterated by the AANTC in meetings and communications. CNL has followed up with the AANTC on two occasions responding to issues and questions raised by the AANTC in their comments on the 2017 draft EIS and on later inquiries regarding project timelines and environmental assessment deadlines.
- **Facility Design – Engineered Containment Mound**. The AANTC submitted a formal IR on concerns associated with the engineered containment mound. CNL has responded on two occasions to this issue.
- **EIS – French.** The AANTC requested that the EIS be in English and French. Draft dispositions to AANTC comments were provided to AANTC in French. The 2019 revised Draft EIS was also provided in French.
- **Valued Components.** Concern expressed that the VCs lacked consideration of potential adverse impacts of the NDSF Project relative to Indigenous peoples' interests, concerns, conceptions, etc. CNL has responded on two occasions to this issue indicating how the VCs incorporated a diversity of interests.
- **Environmental Effects – Aquatic Environment**. AANTC felt that the EIS was incomplete and expressed concern about the gaps in the draft document concerning aquatic biota. CNL has responded on two occasions to this issue indicating the completion of the aquatic assessment and further work undertaken.
- **Cumulative Effects.** The AANTC did not think cumulative effects had been considered. CNL responded that cumulative effects had been considered and provided an explanation. CNL has responded on two occasions to this issue.
- **Assessment of the Effects on the Environment (General).** The AANTC expressed general concerns about the assessment of the effects on the environment. CNL responded to this comment in detail and has responded on two different occasions.
- **Remediation of Contaminated Areas at CNL.** The AANTC expressed the importance of remediating contaminated areas at CRL. CNL has responded that the remediation of areas is occurring and that the NSDF Project is part of the broader remediation and re-development of the site.
- **Procurement.** The AANTC indicated an interest at one point about procurement or contracting opportunities. CNL has provided information and is willing to follow-up further with the AANTC at their request.
- **Technical Support to Review the EIS.** CNL and AANTC have begun discussions on a contribution agreement to support the AANTC's technical review of the 2019 revised draft EIS.

- **Future Involvement in Monitoring.** Input from the public and Indigenous peoples will be sought on the Environmental Assessment Follow Up Monitoring Plan.

6.2.4.5.3 Verification

In May 2020, the AANTC's consultant acknowledged reviewing the revised draft EIS to ensure AANTC concerns were incorporated (printed 2019 revised Draft EIS and numerous supporting documents were sent via registered mail in May 2020).

A letter with comments on CNL's responses to AANTC comments on the 2017 draft EIS and further comments on the 2019 revised Draft EIS was received by CNL from AATNC in June 2020. AANTC requested the Surface Water Quality Assessment TSD be provided to their consultant for further review. Many positive improvements were noted regarding protection of water resources, with some further clarifications requested.

CNL is of the opinion that it is at Process Step 3 of the CNL Verification Process with the AANTC.

6.2.4.5.4 Next Steps

CNL continued engagement efforts to meet with the AANTC to discuss their comments and CNL responses on the draft EIS after multiple meetings were cancelled due to availability of the AANTC.

CNL met with the AANTC and Kebaowek First Nation (AANTC member) on June 17, 2020 to discuss a NSDF Project-specific contribution agreement to ensure support of the AATNC's participation in the environmental assessment process. The contribution agreement will include meetings/discussions on the comments received on the 2017 draft EIS, as well as engagement leading up to the CNSC Commission Hearing on the NSDF Project. Contribution agreement meetings started in June 2020 with an estimated signing in mid to late July 2020.

On June 30, 2020, CNL received comments on the 2019 revised Draft EIS from the AANTC. CNL has provided requested documents to the AANTC consultant and will respond to comments for further clarification in the AANTC letter.

6.2.4.6 Kitigan Zibi Anishinabeg First Nation

The Kitigan Zibi Anishinabeg First Nation (also known also as the River Desert Band or Maniwaki) is one of the nine currently federally recognized Algonquin communities in Quebec. The community resides on reserve lands which were founded in 1851. The main Reserve is situated to the south-west of the borders of Maniwaki in the Outaouais region of Quebec, on the west bank of the Gatineau River. Kitigan Zibi Anishinabeg First Nation has a total registered population of 3,500. A fuller description of the Kitigan Zibi Anishinabeg First Nation can be found in Chapter 3 of the IER.

6.2.4.6.1 Engagement

Table 6.2.4-6 below shows all the engagement activities that have occurred with the Kitigan Zibi Anishinabeg First Nation on the NSDF Project.

Table 6.2.4-6: Kitigan Zibi Anishinabeg First Nation Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the 2019 Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Kitigan Zibi Anishinabeg First Nation	4	11	12	Yes	3	—	—	—	—	—

* The complete table is located in Section 6.2.4.1.

In July 2016, CNL sent Kitigan Zibi Anishinabeg First Nation a letter to introduce the proposed NSDF Project, which included a request for community input on any potential adverse impacts from project activities followed by a secondary letter in November 2016 which inquired about Kitigan Zibi Anishinabeg First Nation asserted rights and traditional activities. While Kitigan Zibi Anishinabeg First Nation provided comments on the Project Description for the NSDF Project through the formal environmental assessment process, CNL did not receive a response from the First Nation on the 2016 CNL letters.

In early 2017, CNL shared the draft EIS and encouraged Kitigan Zibi Anishinabeg First Nation to participate in the public and Indigenous environmental assessment comment period and in response the AATNC (which included Kitigan Zibi Anishinabeg First Nation) and CNL met in 2017 April to discuss the NSDF Project and gain feedback from AANTC leadership. In May 2017, CNL met with Kitigan Zibi Anishinabeg First Nation Council in Maniwaki, Quebec to discuss the NSDF Project and the comments submitted on the NSDF Project Description. Following this meeting, CNL hosted Kitigan Zibi Anishinabeg First Nation environmental staff for a CRL site visit in July 2017, which included a tour of the proposed NSDF site and an opportunity to provide feedback on the project, which included feedback on species at risk. Kitigan Zibi Anishinabeg First Nation provided comments on the draft EIS through the formal environmental assessment process. In late 2017, CNL shared the NSDF Aboriginal Engagement Report and requested community input and feedback for incorporation into the EIS and project planning. CNL did not receive any feedback from Kitigan Zibi Anishinabeg First Nation on this report.

Throughout 2018 and 2019, CNL evolved project engagements to meet Indigenous and stakeholder feedback. This included the development of a regular routine of Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates. Kitigan Zibi Anishinabeg First Nation received invitations to all engagement activities and have not attended any events to date. In late 2019, CNL shared the 2019 revised Draft EIS and the latest revision of the IER with Kitigan Zibi Anishinabeg First Nation and encouraged community input for the final revision as well as the opportunity to meet one-on-one to discuss their comments submitted on the 2017 draft EIS.

In May 2020, CNL sent a letter to Kitigan Zibi Anishinabeg First Nation which included draft dispositions to their comments on the 2017 draft EIS, links to the 2019 revised Draft EIS as well as inquiries for Kitigan Zibi Anishinabeg First Nation specific information. CNL initiated discussions with the AANTC in late May to establish a NSDF Project specific contribution agreement to ensure support of the AATNC’s participation in the environmental assessment process. The initial contribution agreement meeting with the AATNC was in June 2020 and the AANTC informed CNL that Kitigan Zibi Anishinabeg First Nation would be involved in contribution agreement discussions but they were not in attendance at this meeting.

6.2.4.6.2 Feedback

Chapter 4 in the IER provides a Table of Interests for Kitigan Zibi Anishinabeg First Nation interests and concerns and CNL responses. The table also identifies and links the issues and concerns with formally submitted comments made through the environmental assessment process.

The topics in the Table of Interests are briefly summarized below:

- **General Interest.** Kitigan Zibi Anishinabeg First Nation representatives had some general questions about the NSDF Project that CNL responded to.
- **Biological Concerns – Turtles and specifically Blanding's Turtles**. Kitigan Zibi Anishinabeg First Nation representatives had specific concerns about Blanding's Turtles and their protection. This was expressed at the meeting in Manawaki and was a significant portion of the on-site visit. CNL shared information on how the NSDF Project was mitigating the effects of the project on the turtles. Discussion was also held on CNL research and the radio-collaring of the turtles. CNL is of the opinion that the site visit to CRL and the NSDF site along with the information CNL provided on its work on research and mitigation on Blanding's turtles helped to address this concern.
- **Contract/Employment Opportunities.** A Kitigan Zibi Anishinabeg First Nation representative expressed some interest in contracting opportunities. CNL has discussed contracting opportunities and provided an introduction to CNL procurement staff.

6.2.4.6.3 Verification

In May 2020, CNL sent a letter to Kitigan Zibi Anishinabeg First Nation which included draft dispositions to their comments on the 2017 draft EIS. CNL has not yet received a response to this letter.

CNL is of the opinion that it is at Process Step 2b of the CNL Verification Process with Kitigan Zibi Anishinabeg First Nation.

6.2.4.6.4 Next Steps

CNL acknowledges that Kitigan Zibi Anishinabeg First Nation may have more comments on the project going forward and CNL will continue engagement with Kitigan Zibi Anishinabeg First Nation to provide notifications of project activities. As previously identified, Kitigan Zibi Anishinabeg First Nation is a member of the AANTC and the AANTC indicated that Kitigan Zibi Anishinabeg First Nation will be involved in the AANTC contribution agreement meetings.

6.2.4.7 Kebaowek First Nation

Kebaowek First Nation is one of the nine currently federally recognized Algonquin communities in Quebec. The reserve is situated on the shore of Lake Kipawa to the northeast of Témiscaming, Quebec. Based on discussions in June 2020, a Kebaowek representative has indicated that their community has traditional territory as far south as the Mattawa area.

6.2.4.7.1 Engagement

Table 6.2.4-7 below shows all the engagement activities that have occurred with Kebaowek First Nation on the NSDF Project.

Table 6.2.4-7: Kebaowek First Nation Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the 2019 Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Kebaowek First Nation (formerly known as Eagle Village First Nation)	5	4	12	—	2	—	—	—	—	—

* The complete table is located in Section 6.2.4.1.

In July 2016, CNL sent Kebaowek First Nation a letter to introduce the proposed NSDF Project, which included a request for community input on any potential adverse impacts from project activities followed by a secondary letter in November 2016 which inquired about Kebaowek First Nation asserted rights and traditional activities. CNL did not receive a response from the Kebaowek First Nation.

In early 2017, CNL shared the draft EIS and encouraged Kebaowek First Nation to participate in the public and Indigenous environmental assessment comment period and in response the AATNC (which included Kebaowek First Nation) and CNL met in April 2017 to discuss the NSDF Project and gain feedback from AANTC leadership. Kebaowek First Nation did not submit comments on the NSDF 2017 draft EIS through the environmental assessment process. In late 2017, CNL shared the NSDF Aboriginal Engagement Report and requested community input and feedback for incorporation into the EIS and project planning. CNL did not receive any feedback from Kebaowek First Nation on this report.

Throughout 2018 and 2019, CNL evolved project engagements to meet Indigenous and stakeholder feedback. This included the development of a regular routine of Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates. Kebaowek First Nation received invitations to all engagement activities and have not attended any events to date. In late 2019, CNL shared the 2019 revised Draft EIS and the latest revision of the IER with Kebaowek First Nation and encouraged community input for the final revision.

In May 2020, CNL sent a letter following up on the 2019 revised Draft EIS, the IER as well as inquiries for Kebaowek First Nation specific information. CNL initiated discussions with the AANTC in late May to establish an NSDF Project specific contribution agreement to ensure support of the AATNC's participation in the environmental assessment process. The initial contribution agreement meeting with the AATNC was in 2020 June and Kebaowek First Nation were in attendance. The AANTC informed CNL that Kebaowek First Nation would be involved in contribution agreement discussions and Kebaowek First Nation indicated their specific interest in the NSDF Project.

In May of 2020, Kebaowek First Nation and the AANTC submitted a letter to the Government of Canada outlining issues and concerns that included the NSDF Project. While many of these concerns are related to the Government of Canada, CNL is interested in meaningful engagement with the AANTC and Kebaowek First Nation on the NSDF Project.

6.2.4.7.2 Feedback

Kebaowek First Nation has not submitted any written comments on the NSDF Project Description or the EIS. However, based on the 2020 letter submitted by Kebaowek First Nation to the Government of Canada, the following issues and concerns were identified:

- **Environmental Assessment Process.** Concern was raised regarding the continued use of CEAA 2012 for the NSDF Project. CNL has received a letter from the CNSC indicating that the NSDF Project will continue under CEAA 2012.
- **Consultation and Engagement.** Opportunity for meaningful Indigenous participation. CNL will continue to follow-up with the Kebaowek First Nation on engagement opportunities and about any outstanding interests and concerns.

6.2.4.7.3 Verification

Kebaowek First Nation has not submitted any written comments on the NSDF Project Description or EIS. CNL will continue to follow-up with the Kebaowek First Nation about any outstanding interests and concerns. CNL and Kebaowek FN have begun discussions on a contribution agreement to support engagement in the NSDF Project.

6.2.4.7.4 Next Steps

As previously identified, Kebaowek First Nation is a member of the AANTC and the AANTC indicated that Kebaowek First Nation will be involved in the AANTC contribution agreement meetings. CNL will continue engagement with Kebaowek First Nation and provide notifications of project activities.

6.2.4.8 Williams Treaties First Nations (WTFN)

The Williams Treaties First Nations (WTFN) are the Chippewas of Beausoleil, Georgina Island and Rama, and the Mississaugas of Alderville, Curve Lake, Hiawatha and Scugog Island. These seven First Nations are signatories to various 18th and 19th century treaties that covered lands in different parts of south central Ontario. In 1923, the Chippewas and Mississaugas signed the Williams Treaties, which included one large tract of land between Lake Huron and the Ottawa River bounded on the north by the Mattawa River-Lake Nipissing and French Line and on the south by earlier concluded treaties. A fuller description of the WTFN communities can be found in Chapter 3 of the IER.

6.2.4.8.1 WTFN Process Coordinator Engagement

Table 6.2.4-8 below shows all the engagement activities that have occurred with the WTFN Process Coordinator on the NSDF Project. CNL originally contacted the WTFN Process Co-ordinator because a couple of the Williams Treaty First Nation communities requested it do so. In 2020 CNL was made aware that this position did not co-ordinate any engagements on behalf of these communities and CNL discontinued contacting this individual.

Table 6.2.4-8: Williams Treaties First Nations (WTFN) Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the 2019 Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Williams Treaties First Nations (WTFN) Process Coordinator	1	8	12	—	—	—	—	—	—	—

* The complete table is located in Section 6.2.4.1.

Based on an email from the Chippewas of Rama First Nation advising CNL that the 2016 November CNL letter was sent to the WTFN Process Coordinator for review, CNL sent email correspondence in late 2016 – early 2017 to the Process Coordinator to inquire about whether the WTFN (collectively) were interested in engaging with CNL on the NSDF Project. CNL did not receive a response.

In March 2017, CNL shared the draft EIS and encouraged WTFN communities to participate in the public and Indigenous environmental assessment comment period. Hiawatha First Nations provided comments on the 2017 draft EIS through the environmental assessment process. In late 2017, CNL shared the NSDF Aboriginal Engagement Report and requested community input and feedback for incorporation into the EIS and project planning. CNL did not receive feedback from any WTFN communities on this report.

Throughout 2018 and 2019, CNL evolved project engagements to meet Indigenous and stakeholder feedback. This included the development of a regular routine of Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates. The WTFN Process Coordinator received invitations to all engagement activities and has not attended any events to date. In late 2019, CNL shared the 2019 revised Draft EIS and the latest revision of the IER with WTFN communities and encouraged community input for the final revision.

In February 2020, CNL once again reached out to the WTFN Process Coordinator to inquire about whether the WTFN as a whole were interested in engaging with CNL on the NSDF Project. CNL did not receive a response. As of March 2020, CNL was informed that all engagement activities should be done through each community consultation coordinator/liaison, which is described in further detail below.

6.2.4.8.1.1 Next Steps

CNL is of the opinion that it has addressed all of the WTFN communities concerns and comments to date, however more engagement is planned with these communities and CNL will continue to work with WTFN communities (collectively) or on an individual community basis. CNL will also continue to provide notifications of project activities to WTFN communities until otherwise instructed.

6.2.4.8.2 Alderville First Nation Engagement

Table 6.2.4-9 below shows all the engagement activities that have occurred with Alderville First Nation on the NSDF Project.

Table 6.2.4-9: Alderville First Nation Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the 2019 Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Alderville First Nation	4	17	12	—	1	—	—	—	—	—

* The complete table is located in Section 6.2.4.1.

In July 2016, CNL sent Alderville First Nation a letter to introduce the proposed NSDF Project which included a request for community input on any potential adverse impacts from project activities followed by a secondary letter in November 2016 which inquired about Alderville First Nation asserted rights and traditional activities. CNL did not receive a response from Alderville First Nation.

In early 2017 CNL shared the draft EIS and encouraged Alderville First Nation to participate in the public and Indigenous environmental assessment comment period. Alderville First Nation did not provide comments on the draft EIS through the environmental assessment process. In late 2017, CNL shared the NSDF Aboriginal Engagement Report and requested community input and feedback for incorporation into the EIS and project planning. CNL did not receive any feedback from Alderville First Nation on this report.

Throughout 2018 and 2019, CNL evolved project engagements to meet Indigenous and stakeholder feedback. This included the development of a regular routine of Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates. Alderville First Nation received invitations to all engagement activities and have not attended any events to date. In late 2019, CNL shared the 2019 revised Draft EIS and the latest revision of the IER with Alderville First Nation and encouraged community input for the final revision.

In March 2020, CNL followed up with Alderville First Nation on the 2019 December notification of the 2019 revised Draft EIS. This email follow-up included the Alderville First Nation consultation representative as indicated by the CNSC. In April 2020, CNL sent an invitation to WTFN communities to an interactive webinar to provide an overview of the NSDF Project as well as an opportunity for questions. Alderville First Nation participated in the April 29, 2020 webinar. Actions from the webinar resulted in the distribution of the NSDF – Responsible Water Management video and NSDF Stage 4 Archaeological Assessment online links to all WTFN consultation representatives, as well as a request for a future webinar on the NSDF baseliner system and responsible water management. In May 2020, CNL sent a follow-up letter to the Alderville First Nation regarding the 2019 revised Draft EIS, IER input as well as inquiries for Alderville First Nation specific information. A follow-up email was sent on May 26, 2020 and to date CNL has not received a response. The webinar on the NSDF baseliner system and responsible water management was held on June 30, 2020, Alderville First Nation did not participate.

6.2.4.8.2.1 Feedback

Alderville First Nation has not submitted any written comments on the NSDF Project Description or the EIS. However, based on verbal comments during the April 2020 webinar with WTFN, the following issues and concerns were identified:

- General interest was expressed on how the environment and biological species can be protected. CNL provided an overview of the NSDF Project and measures to protect the environment as part of a presentation to the WTFN communities.

6.2.4.8.2.2 Verification

As there has yet to be any formal comments submitted, there is no verification required.

6.2.4.8.2.3 Next Steps

CNL acknowledges that Alderville First Nation may have comments on the project going forward and CNL will continue engagement with Alderville First Nation and provide notifications of project activities until otherwise instructed.

6.2.4.8.3 Beausoleil First Nation Engagement

Table 6.2.4-10 below shows all the engagement touchpoints and activities that have occurred with Beausoleil First Nation on the NSDF Project.

Table 6.2.4-10: Beausoleil First Nation Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the 2019 Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Beausoleil First Nation	4	17	12	—	—	—	—	—	—	—

* The complete table is located in Section 6.2.4.1.

In July 2016, CNL sent Beausoleil First Nation a letter to introduce the proposed NSDF Project which included a request for community input on any potential adverse impacts from project activities followed by a secondary letter in November 2016, which inquired about Beausoleil First Nation asserted rights and traditional activities. CNL did not receive a response from Beausoleil First Nation.

In early 2017 CNL shared the draft EIS and encouraged Beausoleil First Nation to participate in the public and Indigenous environmental assessment comment period. Beausoleil First Nation did not provide comments on the draft EIS through the environmental assessment process. In late 2017, CNL shared the NSDF Aboriginal Engagement Report and requested community input and feedback for incorporation into the EIS and project planning. CNL did not receive any feedback from Beausoleil First Nation on this report.

Throughout 2018 and 2019, CNL evolved project engagements to meet Indigenous and stakeholder feedback. This included the development of a regular routine of Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates. Beausoleil First Nation received invitations to all engagement activities and have not attended any events to date. In late 2019, CNL shared the 2019 revised Draft EIS and the latest revision of the IER with Beausoleil First Nation and encouraged community input for the final revision.

In March 2020, CNL followed up with Beausoleil First Nation on the December 2019 notification of the 2019 revised Draft EIS. This email follow-up included the Beausoleil First Nation consultation representative as indicated by the CNSC. In April 2020, CNL sent an invitation to WTFN communities to an interactive webinar to provide an overview of the NSDF Project as well as an opportunity for questions. Beausoleil First Nation declined participation in the April 29, 2020 webinar – CNL sent a copy of the presentation and an invitation to meet one-on-one. Actions from the webinar resulted in the distribution of the NSDF – Responsible Water Management video and NSDF Stage 4 Archaeological Assessment online links to all WTFN consultation representatives, as well a request for a future webinar on the NSDF baseliner system and responsible water management. In May 2020, CNL sent a follow-up letter to the Beausoleil First Nation regarding the 2019 revised Draft EIS, IER input as well as inquiries for Beausoleil First Nation specific information. A follow-up email was sent on May 26, 2020 and to date CNL has not received a response. The webinar on the NSDF baseliner system and responsible water management was held on June 30, 2020 and Beausoleil First Nation declined participation.

6.2.4.8.3.1 Feedback

Beausoleil First Nation has not submitted any written comments on the NSDF Project Description or EIS.

6.2.4.8.3.2 Verification

As there has yet to be any formal comments submitted, there is no verification required.

6.2.4.8.3.3 Next Steps

CNL acknowledges that Beausoleil First Nation may have comments on the project going forward and CNL will continue engagement with Beausoleil First Nation and provide notifications of project activities until otherwise instructed.

6.2.4.8.4 Chippewas of Georgina Island First Nation Engagement

Table 6.2.4-11 below shows all the engagement touchpoints and activities that have occurred with Chippewas of Georgina Island on the NSDF Project.

Table 6.2.4-11: Chippewas of Georgina Island First Nation Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the 2019 Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Chippewas of Georgina Island First Nation	4	19	12	—	—	—	—	—	—	—

* The complete table is located in Section 6.2.4.1.

In July 2016, CNL sent Georgina Island First Nation a letter to introduce the proposed NSDF Project, which included a request for community input on any potential adverse impacts from project activities followed by a secondary letter in November 2016 which inquired about Georgina Island First Nation asserted rights and traditional activities. CNL did not receive a response from Georgina Island First Nation.

In early 2017 CNL shared the draft EIS and encouraged Georgina Island First Nation to participate in the public and Indigenous environmental assessment comment period. Georgina Island First Nation did not provide comments on the draft EIS through the environmental assessment process. In late 2017, CNL shared the NSDF Aboriginal Engagement Report and requested community input and feedback for incorporation into the EIS and project planning. CNL did not receive any feedback from Georgina Island First Nation on this report.

Throughout 2018 and 2019, CNL evolved project engagements to meet Indigenous and stakeholder feedback. This included the development of a regular routine of Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates. Georgina Island First Nation received invitations to all engagement activities and have not attended any events to date. In late 2019, CNL shared the 2019 revised Draft EIS and the latest revision of the IER with Georgina Island First Nation and encouraged community input for the final revision.

In March 2020, CNL followed up with Georgina Island First Nation on the December 2019 notification of the 2019 revised Draft EIS. This email follow-up included the Georgina Island First Nation consultation representative as indicated by the CNSC. In April 2020, CNL sent an invitation to WTFN communities to an interactive webinar to provide an overview of the NSDF Project as well as an opportunity for questions. Georgina Island did not participate in the April 29, 2020 webinar – CNL sent a copy of the presentation and an invitation to meet one-on-one. Actions from the webinar resulted in the distribution of the NSDF – Responsible Water Management video and NSDF Stage 4 Archaeological Assessment online links to all WTFN consultation representatives, as well as a request for a future webinar on the NSDF baseliner system and responsible water management. In May 2020, CNL sent a follow-up letter to the Georgina Island First Nation regarding the 2019 revised Draft EIS, IER input as well as inquiries for Georgina Island First Nation specific information. A follow-up email was sent on May 26, 2020 and to date CNL has not received a response. The webinar on the NSDF baseliner system and responsible water management was held on June 30, 2020. Georgina Island First Nation did not participate.

6.2.4.8.4.1 Feedback

Georgina Island First Nation has not submitted any written comments on the NSDF Project Description or EIS.

6.2.4.8.4.2 Verification

As there has yet to be any formal comments submitted, there is no verification required.

6.2.4.8.4.3 Next Steps

CNL acknowledges that Georgina Island First Nation may have comments on the project going forward and CNL will continue engagement with Georgina Island First Nation and provide notifications of project activities until otherwise instructed.

6.2.4.8.5 Chippewas of Rama First Nation Engagement

Table 6.2.4-12 below shows all the engagement touchpoints and activities that have occurred with Chippewas of Rama First Nation on the NSDF Project.

Table 6.2.4-12: Chippewas of Rama First Nation Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the 2019 Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Chippewas of Rama First Nation	4	17	12	—	1	—	—	—	—	—

* The complete table is located in Section 6.2.4.1.

In July 2016, CNL sent Chippewas of Rama First Nation a letter to introduce the proposed NSDF Project which included a request for community input on any potential adverse impacts from project activities followed by a secondary letter in November 2016 which inquired about Chippewas of Rama First Nation asserted rights and traditional activities. CNL did not receive a response from Chippewas of Rama First Nation.

In early 2017 CNL shared the draft EIS and encouraged Chippewas of Rama First Nation to participate in the public and Indigenous environmental assessment comment period. Chippewas of Rama First Nation did not provide comments on the draft EIS through the environmental assessment process. In late 2017, CNL shared the NSDF Aboriginal Engagement Report and requested community input and feedback for incorporation into the EIS and project planning. CNL did not receive any feedback from Chippewas of Rama First Nation on this report.

Throughout 2018 and 2019, CNL evolved project engagements to meet Indigenous and stakeholder feedback. This included the development of a regular routine of Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates. Chippewas of Rama First Nation received invitations to all engagement activities and have not attended any events to date. In late 2019, CNL shared the 2019 revised Draft EIS and the latest revision of the IER with the Chippewas of Rama First Nation and encouraged community input for the final revision.

In March 2020, CNL followed up with Chippewas of Rama First Nation on the December 2019 notification of the 2019 revised Draft EIS. This email follow-up included the Chippewas of Rama First Nation consultation representative as indicated by the CNSC. Chippewas of Rama First Nation acknowledged receipt of email and indicated follow-up would be done on the December 2019 content and they would let CNL know if they had any comments. No comments were received. In April 2020, CNL sent an invitation to WTFN communities to an interactive webinar to provide an overview of the NSDF Project as well as an opportunity for questions. Chippewas of Rama did not participate in the April 29, 2020 webinar – CNL sent a copy of the presentation and an invitation to meet one-on-one. Actions from the webinar resulted in the distribution of the NSDF – Responsible Water Management video and NSDF Stage 4 Archaeological Assessment online links to all WTFN consultation representatives, as well as a request for a future webinar on the NSDF baseliner system and responsible water management. In May 2020, CNL sent a follow-up letter to the Chippewas of Rama First Nation regarding the 2019 revised Draft EIS, IER input as well as inquiries for Chippewas of Rama First Nation specific information. A follow-up email was sent on May 26, 2020 and to date CNL has not received a response. Chippewas of Rama First Nation participated in the June 30, 2020 webinar on the NSDF baseliner system and responsible water management.

6.2.4.8.5.1 Feedback

Chippewas of Rama First Nation has not submitted any written comments on the NSDF Project Description or EIS.

6.2.4.8.5.2 Verification

As there has yet to be any formal comments submitted, there is no verification required.

6.2.4.8.5.3 Next Steps

CNL acknowledges that Chippewas of Rama First Nation may have comments on the project going forward and CNL will continue engagement with the Chippewas of Rama First Nation and provide notifications of project activities until otherwise instructed.

6.2.4.8.6 Curve Lake First Nation Engagement

Table 6.2.4-13 below shows all the engagement touchpoints and activities that have occurred with Curve Lake First Nation on the NSDF Project.

Table 6.2.4-13: Curve Lake First Nation Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the 2019 Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Curve Lake First Nation	4	19	12	Yes	2	—	—	—	—	—

* The complete table is located in Section 6.2.4.1.

In July 2016, CNL sent Curve Lake First Nation a letter to introduce the proposed NSDF Project which included a request for community input on any potential adverse impacts from project activities. Curve Lake First Nation acknowledged the letter and discussed the opportunity of liaisons from Curve Lake participating in the archeological field work based on their comments submitted on the Project Description for the NSDF through the formal EA process. CNL indicated field work was in Stage 3 – Curve Lake did not provide liaisons. A secondary letter was sent in November 2016, which inquired about Curve Lake First Nation asserted rights and traditional activities. While CNL did not receive a formal response to the November 2016 letter, Curve Lake First Nation requested a copy of the NSDF Project archeological assessment report. The report was sent in December 2016 and Curve Lake First Nation acknowledged receipt of report and indicated that they had no comments.

In early 2017, CNL shared the draft EIS and encouraged Curve Lake First Nation to participate in the public and Indigenous environmental assessment comment period. In late 2017, CNL shared the NSDF Aboriginal Engagement Report and requested community input and feedback for incorporation into the EIS and project planning. CNL did not receive any feedback from Curve Lake First Nation on this report.

Throughout 2018 and 2019, CNL evolved project engagements to meet Indigenous and stakeholder feedback. This included the development of a regular routine of Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates. Curve Lake First Nation received invitations to all engagement activities and have not attended any events to date. In late 2019, CNL shared the 2019 revised Draft EIS and the latest revision of the IER with Curve Lake First Nation and encouraged community input for the final revision.

In January 2020, CNL followed up with Curve Lake First Nation on the December 2019 notification of the 2019 revised Draft EIS and the opportunity to meet. In March 2020, CNL followed up with Curve Lake First Nation on the December 2019 notification of the 2019 revised Draft EIS and this email follow-up included the Curve Lake First Nation consultation representative as indicated by the CNSC. In April 2020, CNL sent an invitation to WTFN communities to an interactive webinar to provide an overview of the NSDF Project as well as an opportunity for questions. Curve Lake First Nation participated in the April 29, 2020 webinar. Actions from the webinar resulted in the distribution of the NSDF – Responsible Water Management video and NSDF Stage 4 Archaeological Assessment online links to all WTFN consultation representatives, as well as a request for a future webinar on the NSDF baseliner system and responsible water management. Also due to changes in consultation representatives, the 2016 email correspondence related to the previously sent NSDF Project archeological assessment report to Curve Lake was also included. In May 2020, CNL sent a follow-up letter to Curve Lake First Nation regarding the 2019 revised Draft EIS, IER input, as well as inquiries for Curve Lake First Nation-specific information. A follow-up email was sent on May 26, 2020 and to date CNL has not received a response. CNL also followed up in 2020 June on Curve Lake’s review of the NSDF Stage 4 Archaeological Assessment, no response has been received to date and CNL will continue to follow-up. Curve Lake First Nation participated in the June 30, 2020 webinar on the NSDF baseliner system and responsible water management.

6.2.4.8.6.1 Feedback

Chapter 5 in the IER provides a Table of Interests for Curve Lake First Nation interests and concerns and CNL responses and also identifies and links the issues and concerns with formally submitted comments made through the environmental assessment process.

The topics in the Table of Interests are briefly summarized below:

- **Archaeological Assessment.** Based on a formal review and comment of the 2016 Project Description. Curve Lake First Nation requested the archaeological assessment. CNL provided the archaeological assessment report. No additional comments were submitted. In May 2020, Curve Lake again requested the archaeological assessment. CNL once again provided the archaeological assessment report. No further comments were received.
- **Environmental Protection.** In 2020, a Curve Lake First Nation representative verbally inquired as to how the Ottawa River could be environmentally protected being so close to CRL and NSDF. CNL provided an overview of the NSDF Project and measures to protect the environment, including the Ottawa River in June 2020.

6.2.4.8.6.2 Verification

CNL is of the opinion that it is at Process Step 5 of the CNL Verification Process with Curve Lake First Nation given the Curve Lake First Nation comments on the 2016 Project Description have been incorporated and no formal comments on the 2017 Draft EIS were submitted.

6.2.4.8.6.3 Next Steps

CNL acknowledges that the Curve Lake First Nation may have more comments on the project going forward and CNL will continue engagement with Curve Lake First Nation to provide notifications of project activities.

6.2.4.8.7 Hiawatha First Nation Engagement

Table 6.2.4-14 below shows all the engagement touchpoints and activities that have occurred with Hiawatha First Nation on the NSDF Project.

Table 6.2.4-14: Hiawatha First Nation Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the 2019 Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Hiawatha First Nation	4	18	12	Yes	2	—	—	—	—	—

* The complete table is located in Section 6.2.4.1.

In July 2016, CNL sent Hiawatha First Nation a letter to introduce the proposed NSDF Project which included a request for community input on any potential adverse impacts from project activities followed by a secondary letter in November 2016 which inquired about Hiawatha First Nation asserted rights and traditional activities. CNL did not receive a response from Hiawatha First Nation.

In early 2017 CNL shared the draft EIS and encouraged Hiawatha First Nation to participate in the public and Indigenous environmental assessment comment period. Hiawatha First Nation provided comments on the draft EIS through the environmental assessment process. In late 2017, CNL shared the NSDF Aboriginal Engagement Report and requested community input and feedback for incorporation into the EIS and project planning. CNL did not receive any feedback from Hiawatha First Nation on this report.

Throughout 2018 and 2019, CNL evolved project engagements to meet Indigenous and stakeholder feedback. This included the development of a regular routine of Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates. Hiawatha First Nation received invitations to all engagement activities and have not attended any events to date. In late 2019, CNL shared the 2019 revised Draft EIS and the latest revision of the IER with Hiawatha First Nation and encouraged community input for the final revision as well as the opportunity to meet one-on-one to discuss their comments submitted on the 2017 draft EIS.

In January 2020, CNL followed up with Hiawatha First Nation on the 2019 December notification of the 2019 revised Draft EIS and the opportunity to meet. In March 2020, CNL followed up with Hiawatha First Nation on the December 2019 notification of the 2019 revised Draft EIS and this email follow-up included the Hiawatha First Nation consultation representative as indicated by the CNSC. This email was acknowledged and a recommendation was made by Hiawatha consultation representative to hold WTFN webinar to update the communities collectively. In April 2020, CNL sent an invitation to WTFN communities to an interactive webinar to provide an overview of the NSDF Project as well as an opportunity for questions. Hiawatha First Nation participated in the April 29, 2020 webinar. Actions from the webinar resulted in the distribution of the NSDF – Responsible Water Management video and NSDF Stage 4 Archaeological Assessment online links to all WTFN consultation representatives, as well as a request for a future webinar on the NSDF baseliner system and responsible water management. In May 2020, CNL sent a letter to Hiawatha First Nation which included draft dispositions to their comments on the 2017 draft EIS (with another invitation to meet), links to the 2019 revised Draft EIS, as well as inquiries for Hiawatha First Nation specific information. A follow-up email was sent on May 26, 2020 and while CNL has not received a written response, a verbal acknowledgment of CNL’s response to Hiawatha First Nation’s comments on the 2017 draft EIS were addressed during the April 29, 2020 webinar. CNL will continue to engage with Hiawatha First Nation to ensure their comments have addressed. Hiawatha First Nation participated in the June 30, 2020 webinar on the NSDF baseliner system and responsible water management.

6.2.4.8.7.1 Feedback

Chapter 5 in the IER provides a Table of Interests for Hiawatha First Nation interests and concerns and CNL responses and also identifies and links the issues and concerns with formally submitted comments made through the environmental assessment process.

The topics in the Table of Interests are briefly summarized below:

- **Environmental Protection.** Based on a formal review and comment of the 2017 draft EIS, the Hiawatha First Nation was concerned and looking for reassurance that wildlife, habitat, and water tributaries will be adequately protected from contamination for seven generations. CNL provided a verbal response to this comment as part of a presentation to four of the WTFN communities in April 2020 and a written summary was also provided.

6.2.4.8.7.2 Verification

In 2020 May, CNL received verbal acknowledgement during an NSDF Project update webinar that their concerns had been addressed.

CNL is of the opinion that it is at Process Step 5 of the CNL Verification Process with Hiawatha First Nation.

6.2.4.8.7.3 Next Steps

CNL acknowledges that the Hiawatha First Nation may have more comments on the project going forward and CNL will continue engagement with Hiawatha First Nation to provide notifications of project activities.

6.2.4.8.8 Mississaugas of Scugog Island First Nation Engagement

Table 6.2.4-15 below shows all the engagement touchpoints and activities that have occurred with Mississaugas of Scugog Island First Nation on the NSDF Project.

Table 6.2.4-15: Mississaugas of Scugog Island First Nation Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the 2019 Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Mississaugas of Scugog Island First Nation	4	17	12	—	—	—	—	—	—	—

* The complete table is located in Section 6.2.4.1.

In July 2016, CNL sent Mississaugas of Scugog Island First Nation a letter to introduce the proposed NSDF Project, which included a request for community input on any potential adverse impacts from project activities followed by a secondary letter in November 2016, which inquired about Mississaugas of Scugog Island First Nation asserted rights and traditional activities. CNL did not receive a response from Mississaugas of Scugog Island First Nation.

In early 2017, CNL shared the draft EIS and encouraged Mississaugas of Scugog Island First Nation to participate in the public and Indigenous environmental assessment comment period. Mississaugas of Scugog Island First Nation did not provide comments on the draft EIS through the environmental assessment process. In late 2017, CNL shared the NSDF Aboriginal Engagement Report and requested community input and feedback for incorporation into the EIS and project planning. CNL did not receive any feedback from Mississaugas of Scugog Island First Nation on this report.

Throughout 2018 and 2019, CNL evolved project engagements to meet Indigenous and stakeholder feedback. This included the development of a regular routine of Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates. Mississaugas of Scugog Island First Nation received invitations to all engagement activities and have not attended any events to date. In late 2019, CNL shared the 2019 revised Draft EIS and the latest revision of the IER with Mississaugas of Scugog Island First Nation and encouraged community input for the final revision.

In March 2020, CNL followed up with Mississaugas of Scugog Island First Nation on the December 2019 notification of the 2019 revised Draft EIS. This email follow-up included the Georgina Island First Nation consultation representative as indicated by the CNSC. In April 2020, CNL sent an invitation to WTFN communities to an interactive webinar to provide an overview of the NSDF Project as well as an opportunity for questions. Mississaugas of Scugog Island did not participate in the April 29, 2020 webinar – CNL sent a copy of the presentation and an invitation to meet one-on-one. Actions from the webinar resulted in the distribution of the NSDF – Responsible Water Management video and NSDF Stage 4 Archaeological Assessment online links to all WTFN consultation representatives, as well as a request for a future webinar on the NSDF baseliner system and responsible water management. In May 2020, CNL sent a follow-up letter to the Mississaugas of Scugog Island First Nation regarding the 2019 revised Draft EIS, IER input as well as inquiries for Mississaugas of Scugog Island First Nation-specific information. A follow-up email was sent on May 26, 2020 and to date CNL has not received a response. The webinar on the NSDF baseliner system and responsible water management was held on June 30, 2020. Mississaugas of Scugog Island First Nation did not participate.

6.2.4.8.8.1 Feedback

Mississaugas of Scugog Island First Nation has not submitted any written comments on the NSDF Project description or EIS.

6.2.4.8.8.2 Verification

As there has yet to be any formal comments submitted, there is no verification required.

6.2.4.8.8.3 Next Steps

CNL acknowledges that Mississaugas of Scugog Island First Nation may have comments on the project going forward and CNL will continue engagement with Mississaugas of Scugog Island First Nation and provide notifications of project activities until otherwise instructed.

6.2.4.8.9 Anishinabek Nation Engagement

Table 6.2.4-16 below shows all the engagement touchpoints and activities that have occurred with Anishinabek Nation (formerly known as Union of Ontario Indians) on the NSDF Project.

Table 6.2.4-16: Anishinabek Nation Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the 2019 Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Anishinabek Nation (Formerly known as Union of Ontario Indians)	4	5	12	Yes	—	—	—	—	—	—

* The complete table is located in Section 6.2.4.1.

In July 2016, CNL sent Anishinabek First Nation a letter to introduce the proposed NSDF Project, which included a request for community input on any potential adverse impacts from project activities followed by a secondary letter in November 2016, which inquired about Anishinabek First Nation asserted rights and traditional activities. CNL did not receive a response from the Anishinabek First Nation.

In early 2017, CNL shared the draft EIS and encouraged Anishinabek First Nation to participate in the public and Indigenous environmental assessment comment period. Anishinabek First Nation provided comments on the draft EIS through the formal environmental assessment process. In late 2017, CNL shared the NSDF Aboriginal Engagement Report and requested community input and feedback for incorporation into the EIS and project planning. CNL did not receive any feedback from Anishinabek First Nation on this report.

Throughout 2018 and 2019, CNL evolved project engagements to meet Indigenous and stakeholder feedback. This included the development of a regular routine of Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates. Anishinabek First Nation received invitations to all engagement activities and have not attended any events to date. In late 2019, CNL shared the 2019 revised Draft EIS and the latest revision of the IER with Anishinabek First Nation and encouraged community input for the final revision as well as the opportunity to meet one-on-one to discuss their comments submitted on the 2017 draft EIS.

In January 2020, CNL followed up with Anishinabek Nation on the December 2019 notification of the 2019 revised Draft EIS and the opportunity to meet but did not receive a response. In May 2020, CNL sent a letter to Anishinabek Nation, which included draft dispositions to their comments on the 2017 draft EIS (with another invitation to meet), links to the 2019 revised Draft EIS as well as inquiries for Anishinabek Nation specific information. A follow-up email was sent on May 26, 2020 and to date CNL has not received a response from Anishinabek Nation but will continue to follow-up.

6.2.4.8.9.1 Feedback

CNL received environmental protection comments from Anishinabek Nation on the draft EIS and CNL has provided responses which included an invitation to meet to further discuss the Anishinabek Nation's issues and concerns. Topics included:

- **Site Location –** proximity to the Ottawa River and transport and storage of radioactive waste on First Nations ancestral lands.
- **Seismic events –** Seismic activity, extreme weather events and climate change that occur in the region are not favourable for a nuclear waste storage facility.

6.2.4.8.9.2 Verification

CNL is of the opinion that it is at Process Step 2(b) of the CNL Verification Process with the Anishinabek Nation as CNL awaits either acknowledgement or a response.

6.2.4.8.9.3 Next Steps

To date CNL has been unable to arrange a meeting with the Anishinabek Nation to discuss their comments on the draft EIS but will continue engagement efforts. CNL will continue to provide notifications of project activities.

6.2.4.8.10 Algonquin Nation Secretariat Engagement

Table 6.2.4-17 below shows all the engagement touchpoints and activities that have occurred with Algonquin Nation Secretariat on the NSDF Project.

Table 6.2.4-17: Algonquin Nation Secretariat Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the 2019 Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Algonquin Nation Secretariat	4	6	12	—	—	—	—	—	—	—

* The complete table is located in Section 6.2.4.1.

In July 2016, CNL sent the Algonquin Nation Secretariat a letter to introduce the proposed NSDF Project, which included a request for community input on any potential adverse impacts from project activities followed by a secondary letter in November 2016, which inquired about Algonquin Nation Secretariat asserted rights and traditional activities. CNL did not receive a response from the Algonquin Nation Secretariat.

In early 2017, CNL shared the draft EIS and encouraged the Algonquin Nation Secretariat to participate in the public and Indigenous environmental assessment comment period. The Algonquin Nation Secretariat did not provide comments on the draft EIS through the environmental assessment process. In late 2017, CNL shared the NSDF Aboriginal Engagement Report and requested community input and feedback for incorporation into the EIS and project planning. CNL did not receive any feedback from the Algonquin Nation Secretariat on this report.

Throughout 2018 and 2019, CNL evolved project engagements to meet Indigenous and stakeholder feedback. This included the development of a regular routine of Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates. The Algonquin Nation Secretariat received invitations to all engagement activities and have not attended any events to date. In late 2019, CNL shared the 2019 revised Draft EIS and the latest revision of the IER with the Algonquin Nation Secretariat and encouraged community input for the final revision.

In May 2020, CNL sent a follow-up letter to the Algonquin Nation Secretariat regarding the 2019 revised Draft EIS, IER input, as well as inquiries for Algonquin Nation Secretariat specific information. A follow-up email was sent on May 26, 2020 and the Algonquin Nation Secretariat notified CNL of a new contact name for the Algonquin Nation Secretariat Director. CNL resent the May 2020 letter to the new contact and to date CNL has not received a response from Algonquin Nation Secretariat.

6.2.4.8.10.1 Feedback

Algonquin Nation Secretariat has not submitted any written comments on the NSDF Project Description or EIS.

6.2.4.8.10.2 Verification

As there has yet to be any formal comments submitted, there is no verification required.

6.2.4.8.10.3 Next Steps

CNL will continue to provide notifications of project activities until otherwise instructed.

6.2.4.9 Mohawks of Bay of Quinte

Table 6.2.4-18 below shows all the engagement touchpoints and activities that have occurred with the Mohawks of Bay of Quinte on the NSDF Project.

Table 6.2.4-18: Mohawks of Bay of Quinte (MBQ) Engagement Activities

NSDF Identified Indigenous Communities and Organizations	Letters from/to CNL via Mail or Registered Mail	Phone & Email Correspondence	General Email (i.e., invites to webinars, etc.)	Comments Submitted via EA Process (Project Description, EIS)	Meetings, Information Sessions & Tours	CNSC Participant Funding Issued	MOUs & Contribution Agreements (CNL funding)	TLKUS or Other Studies	Reviewing the 2019 Revised Draft EIS	Long-Term Relationship Agreements (in discussions)
Not on Engagement/Consultation List										
Mohawks of Bay of Quinte (MBQ)	1	4	1	Yes	—	—	—	—	—	—

* The complete table is located in Section 6.2.4.1.

A proposed list of Indigenous communities with a potential interest in the project was identified by CNL and the CNSC based on the identified potential or established Indigenous or treaty rights of Indigenous communities in the vicinity of the project (inclusion of specific communities considers the nature of the established and/or claimed rights and potential impacts on those rights caused by the proposed project based on a preliminary assessment of existing and available information). While the Mohawks of Bay Quinte (MBQ) are not listed as one of CNL's identified communities to engage, the MBQ did provide comments on the 2017 draft EIS through the formal environmental assessment process.

In January 2020, CNL shared the 2019 revised draft EIS and the latest revision of the IER with the MBQ and encouraged community input for the final revision as well as the opportunity to meet one-on-one to discuss their comments submitted on the 2017 draft EIS. In early May 2020, CNL sent a follow-up letter to the MBQ regarding the 2019 revised Draft EIS, the IER as well as inquiries for MBQ specific information. The MBQ responded to the May 2020 letter and indicated an interest in meeting with CNL and the CNSC for an NSDF Project overview/update. In late May 2020, CNL followed up on the request to meet and were informed by MBQ that the next steps on the NSDF Project engagement were currently with the Tyendinaga Mohawk Council. Once a decision has been made, MBQ will reach back to CNL.

The MBQ have been added to the email distribution for Indigenous and stakeholder engagement events, such as the bi-monthly Breakfast Briefings and quarterly webinar updates.

6.2.4.9.1 Feedback

CNL received environmental protection comments from MBQ on the draft EIS and CNL has provided responses. The MBQ acknowledged the CNL response and would like to meet to discuss the NSDF Project further. Topics included:

- **Alternative means to carry out the project –** proximity of the facility in proximity of the Ottawa River.
- **Site location –** opposition to transport and storage of radioactive waste on First Nations ancestral lands.
- **General Environmental Protection.**

6.2.4.9.2 Verification

CNL is of the opinion that it is at Process Step 3 of the CNL Verification Process with the MBQ.

6.2.4.9.3 Next Steps

In late May 2020, CNL followed up on the request to meet and were informed by MBQ that the next steps on the NSDF Project engagement was currently with the Tyendinaga Mohawk Council. Once a decision has been made, MBQ will reach back to CNL. CNL will continue to provide project notifications to the MBQ.

6.2.5 Continued Engagement Activities

Engagement activities with Indigenous communities regarding the NSDF Project continue as appropriate, necessary and requested as environmental assessment and Project planning activities progress. The nature of additional engagement activities will be consistent with CNL's Indigenous engagement objectives identified in Section 6.2.1. CNL will endeavour to evaluate and integrate information provided by these communities in the Project planning and design.

CNL has identified additional engagement activities that are planned to take place as the NSDF Project progresses. In general, these additional activities may include:

- sharing the revised IERs with identified communities;
- notifying identified communities of draft EIS submission;
- on-going meetings and/or community information sessions to provide NSDF Project updates, solicit feedback on the NSDF Project and traditional land use activities, and discuss environmental activities and findings;
- on-going engagement with identified communities;
- technical meeting facilitation, upon request, to provide interested parties with more in-depth information and opportunities to question subject matter experts on the project;
- opportunities for NSDF Project site visits, as requested;
- participating in various targeted community initiatives, when appropriate, such as educational events, fairs, science fairs and career days;
- on-going Project notifications (e.g., letters, email correspondence, newspaper advertisements);
- updates to NSDF Project website content as environmental assessment and planning for the Project continues, including posting the final EIS and supporting technical studies;
- on-going tracking and recording of comments, questions, issues and other feedback provided by Indigenous communities and organizations, providing responses and incorporating feedback, as appropriate;
- identification of Indigenous community needs for capacity assistance to effectively participate in the project through a collaborative work plan;
- informally sharing draft responses to their formal comments on the draft EIS to facilitate discussions with respect to the context of their concerns and ensure the Project provides an acceptable and appropriate response; and
- notifying identified communities of final EIS submission.

Indigenous community specific engagement activities will be determined through discussions and identification of community interests. CNL will continue to engage with Indigenous communities (i.e., Chief and Council, representative bodies, community members) to address community information requirements and input.
This activity will address a variety of topics such as VCs, potential environmental effects of the NSDF Project and mitigation identified. On-going engagement will also outline and schedule the documentation that will be shared with Indigenous communities and organizations for their review and comment (e.g., draft EIS, licence application, biodiversity and archaeology studies).

6.2.6 Conclusion

Methods employed to date have helped to establish productive Project discussions aimed at informing and educating Indigenous communities, thereby enabling valuable feedback into the project. The NSDF Project will continue engagement efforts to support growth in awareness and understanding of the project.

CNL has proactively addressed key issues raised by interested Indigenous peoples, using open and transparent communication to share information in regard to traditional land use, biodiversity and archaeology.

CNL continues to be committed to on-going and meaningful Indigenous engagement and will continue to inform and engage communities to improve understanding of the NSDF Project and environmental protection measures put in place by the Project.

6.3 Valued Components

VCs refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, scientists, government agencies, Indigenous communities and organizations, or the public (The Agency 2018). Discussion of VCs in Section 6 focuses on VCs related to Indigenous traditional land and resource use (Section 6.4.2).

Indigenous people have also expressed a great deal of interest in other VCs, particularly those related to the natural environment. VCs were identified based on the potential for the NSDF Project to interact with features or activities of value to Indigenous communities or organizations, as per CNL's IER (CNL 2020).

6.3.1 Methods

6.3.1.1 Indigenous Engagement

The NSDF Project occurs within the general area of the AOO Land Claim (Figure 6.3.1-1), where negotiations with the Crown have occurred since 1991. It also overlaps the Mattawa/Lake Nipissing Traditional Harvesting Territory for the MNO. Discussions with Williams Treaty First Nation communities and AANTC member's communities have also indicated that traditional harvest occurs in the general area surrounding the Chalk River Laboratories site.

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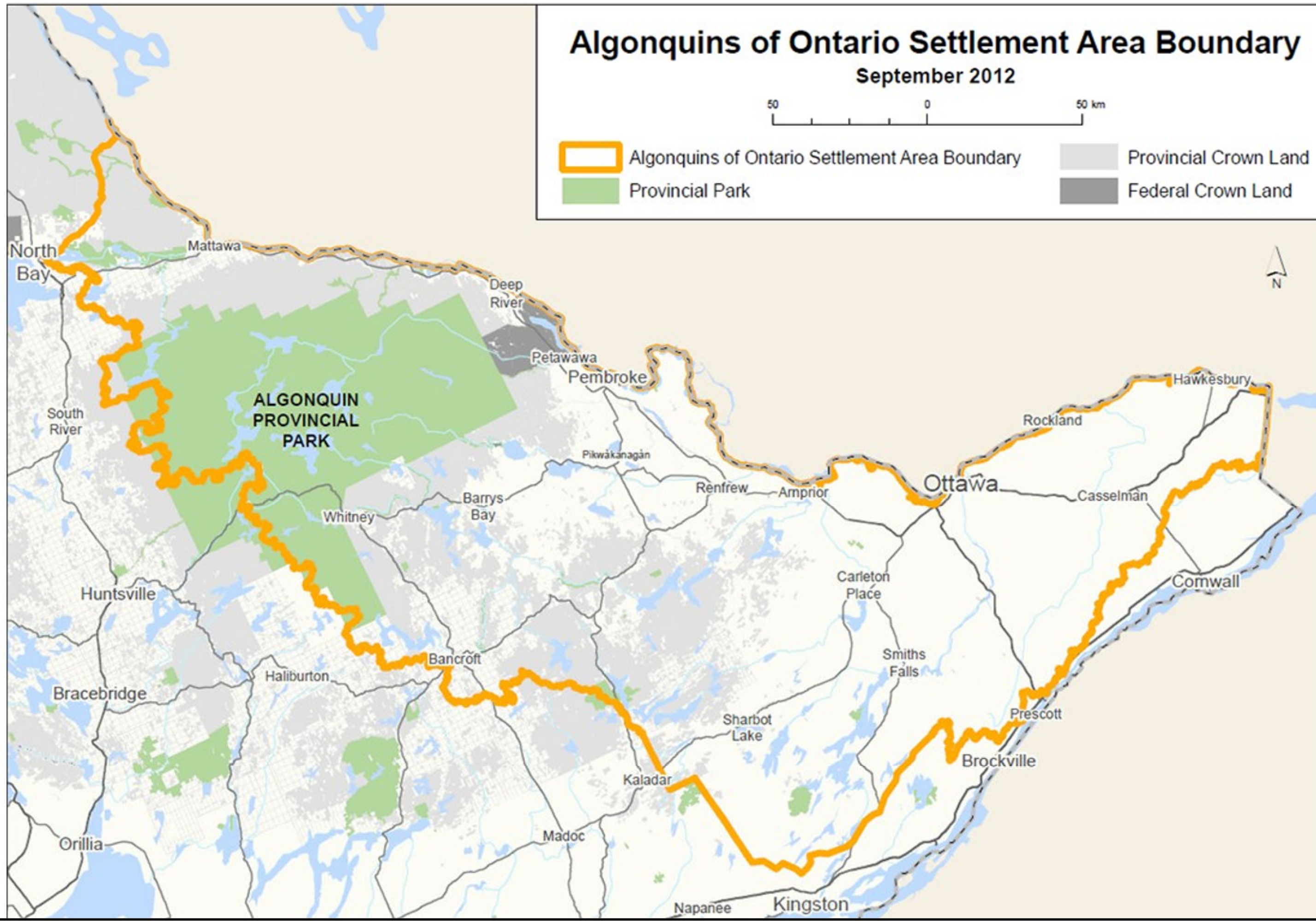

LEGEND

REFERENCE(S)

CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	PR
PREPARED	PR
REVIEWED	CS
APPROVED	AB

TITLE
MAP OF THE ALGONQUINS OF ONTARIO LAND CLAIM

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0023	FINAL 2	**6.3.1-1**

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Indigenous communities or organizations practice or have likely practiced some traditional activities within the Regional Study Area (RSA – Section 6.4.3.1) of the NSDF Project. Through CNL's engagement process, Indigenous communities and organizations have conducted TKLUS to support the NSDF Project EIS and have identified VCs of particular interest to them. Through this engagement process, Indigenous interests have been incorporated into the selection of final VCs for the NSDF Project.

6.3.1.2 Selection of Valued Components by Canadian Nuclear Laboratories

A VC can be a pathway, habitat, a species or a traditional resource (Table 6.3.1-1). The type of VC definitions and associated colour-codes in Table 6.3.1-1 are used to categorize the specific VCs identified for the Project in Table 6.3.2-1.

Table 6.3.1-1: Colour Coded Table for Valued Components Comparison

Type of VC	Definition
Pathway	VCs selected to capture any potential changes in the natural environment on which other VCs depend.
Habitat	Habitat and ecosystems protection to ensure conservation to a broad range of species that depend on the habitat.
Species at Risk, Surrogate species or Indicator species	▪ A Species at Risk or Regionally Rare Species are either species protected under a regulatory regime or species that have been identified as a priority for conservation. ▪ Surrogate species are species or group of species that represent a large pool of species that have something in common, either feeding habitat, same habitat characteristics or behaviour. ▪ Indicator species are species or group of species selected that are expected to respond to a specific disturbance in a similar fashion as the species it represents. Its response to a specific disturbance is predictable and easily measurable.
Traditional Resources	Traditional activities and resources used by Indigenous peoples.

VC = Valued Component.

Selection of VCs for this project was accomplished using a coarse and fine filter approach, which considers rarity, sensitivity, uniqueness, habitat and feeding guild (i.e., species that have similar diets) in the development of a list of VCs potentially on site. The coarse filter approach ensures that a diversity of ecosystem functions is maintained over space and time, which enables an assessment of the effects on broad biodiversity. Whereas, the fine filter approach ensures that the ecological requirements of a particular species or value is considered in the assessment. Combined, the selected coarse and fine filter VCs provide a holistic approach to assessment of the potential effects of the NSDF Project on the environment. Thus, following this process, the selected VCs reflect Indigenous interests raised during the consultation and engagement process.

6.3.2 Results

The VCs selected for the NSDF Project (Table 5.1.2-1) reflect a wide range of environmental effects and Indigenous interests. Table 6.3.2-1 summarizes how the VCs were selected by CNL for the NSDF Project and assessed through Sections 5.2 to 5.10, reflect Indigenous interests. For example, the MNO through their TKLUS study and the AOO identified moose, deer and bear as VCs due to traditional harvesting of these specific biota, while CNL has selected hunting as a VC to protect Indigenous traditional resource use. Turkey, grouse and partridge were also identified as potential VCs and CNL selected the Ruffed grouse (*Bonasa umbellus*) as it is an indicator species that can sufficiently represent the health of populations of other game birds.

A number of species of plants have been noted as important resources for gathering, from which CNL selected all traditionally gathered species as a VC. Cranberries were highlighted as a particularly important resource, so CNL selected reed as it is an indicator species and a measure of habitat quality for cranberries.

Kitigan Zibi First Nation has indicated the importance of the Blanding's Turtle, which was included as a terrestrial VC as it is a SARA-listed species (Section 5.6.2 of EIS). The AOO have indicated the importance of bald eagle given its of cultural significance to the AOO and it was included as a VC (Section 5.7 of EIS).

Finally, CNL selected hydrology, surface water quality, fish habitat, fishing and fish species as VCs as these reflect water quality of the Ottawa River as well as lakes and streams on the CRL site, along with the health of many species of interest to all Indigenous communities that provided feedback on the NSDF Project. Surface water quality is an intermediate component that can capture any potential changes in the natural environment on which other VCs depend, however. Air quality and geology are other intermediate components that can assess Indigenous concerns for air and soil quality.

Table 6.3.2-1: Comparison of Indigenous Suggested Valued Components and Canadian Nuclear Laboratories Selected Valued Components

Fish, Reptiles and Amphibians	NSDF VCs	Indigenous Communities that Expressed Concern about the VC
▪ All species	▪ Hydrology ▪ Surface water quality	▪ All communities
	▪ Fish habitat	▪ All communities
	▪ Fishing	▪ All communities
	▪ Fish species	▪ All communities
▪ Bass ▪ Trout ▪ Walleye ▪ Pickerel ▪ Muskellunge ▪ Whitefish ▪ Sturgeon ▪ Eel	▪ Northern Pike ▪ Black Bullhead	▪ MNO ▪ AOO
▪ Bait fish	▪ Bluntnose minnow	▪ MNO
▪ Bullfrog	▪ Green frog	▪ MNO
▪ Blanding's turtle	▪ Blanding's turtle	▪ Kitigan Zibi First Nation

Table 6.3.2-1: Comparison of Indigenous Suggested Valued Components and Canadian Nuclear Laboratories Selected Valued Components

Mammals	NSDF VCs	Indigenous Communities that Expressed Concern about the VC
All species	Vegetation communities	MNO
Moose and Deer	Moose and White-tailed deer	MNO
Bear	Black bear	MNO
Moose, Deer, Elk and Bear	Hunting	MNO AOO
Lynx, Fox and Wolf	Eastern wolf	MNO AOO
Beaver[2] Marten Mink[2] Otter[2] Rabbit/hare Muskrat[2]	Small mammals (Meadow Vole, Short-tailed Shrew) and Large Mammals (Moose)	MNO AOO
	Fish species	All communities
	Reed	MNO AOO
	Hydrology Surface water quality	All communities
	Trapping	MNO AOO
Birds	**NSDF VCs**	**Indigenous Communities that Expressed Concern about the VC**
All species	Hydrology Surface water quality	MNO
	Vegetation communities	MNO
	Hunting	MNO AOO
Migratory birds	Migratory birds	MNO
Partridge	Ruffed grouse	MNO AOO
Geese Ducks	Great Blue Heron Mallard	MNO AOO
Bald eagle	Bald eagle	AOO

[2] These species are semi-aquatic mammals. Terrestrial exposure pathways are addressed through the meadow vole (herbivore) and short-tailed shrew (omnivore). Exposure pathways to the aquatic environment, including semi-aquatic mammals, are addressed through the hydrology and surface water pathways, reed (aquatic plants for food) and the fish species included in the assessment.

Table 6.3.2-1: Comparison of Indigenous Suggested Valued Components and Canadian Nuclear Laboratories Selected Valued Components

Vegetation		NSDF VCs	Indigenous Communities that Expressed Concern about the VC
All Species		Gathering	MNO AOO
Raspberry Blueberries Service berries Chokeberry Oak	Firewood Ground hemlock Pinecones	Hydrology Surface water quality	MNO AOO
		Vegetation communities	MNO AOO
		Red maple	MNO AOO
Cranberries		Reed	MNO AOO
		Reed	MNO AOO
Environmental		**NSDF VCs**	**Indigenous Communities that Expressed Concern about the VC**
Water Quality		Surface water quality Groundwater quality	All communities
Air Quality		Air Quality	MNO
Soil Quality		Geology	MNO
Environmental systems		All pathways	MNO

Pathway | Habitat | Indicator/Surrogate Species | Traditional

VC = Valued Component

6.4 Traditional Land and Resource Use

This section of the EIS for the NSDF Project seeks to understand and characterize the potential residual effects of the NSDF Project and previous, existing and reasonably foreseeable developments on traditional land and resource use by Indigenous communities.

The assessment of effects on land and resources identifies linkages between the NSDF Project activities and current environment to determine the residual effects of the NSDF Project on traditional land and resource use. Residual effects (i.e., those effects remaining after the implementation of all mitigation) are placed in the context of the cumulative effects of previous, existing and future projects.

6.4.1 Scope of the Assessment

This section focuses on traditional land and resource use. The traditional land and resource use assessment follows the overall environmental assessment approach and methods described in Section 5.1. The assessment was completed following the key steps listed below:

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries and assessment cases** for the traditional land and resource use assessment (refer to Sections 6.4.2 Valued Components and Section 6.4.3 Assessment Boundaries). The VCs and measurement indicators used to assess Project-related changes to the land and resource use environment are described, along with the spatial and temporal boundaries at which the assessment occurred and the assessment cases considered.
- **Step 2 – Describe the existing conditions** (refer to Section 6.4.4 Description of the Environment). Existing conditions in the local and regional areas are described, including the combined effects of previous and existing developments (Base Case). The existing environment represents the historical and current environmental pressures that have shaped the observed patterns in the traditional land and resource use environment. The existing conditions provide a reference to which the effects of the NSDF Project can be compared.
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 6.4.5 Project Interactions and Mitigation). Project components and/or activities with the potential to affect traditional land and resource use are identified and mitigation developed to limit or avoid negative effects, or to maximize benefits is presented. A pathways analysis is then used to focus further assessment on key interactions between the project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. Where effects are adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated.
- **Step 4 – Present the methods and results of the residual effects analysis**. This step was not required as no primary pathways were identified in the traditional land and resource use assessment.
- **Step 5 – Describe the level of certainty and management of uncertainty**. This step was not required as no primary pathways were identified in the traditional land and resource use assessment.
- **Step 6 – Classify and determine the significance of the predicted residual effects**. This step was not required as no residual adverse effects were identified in the traditional land and resource use assessment.

- **Step 7 – Identifying monitoring and follow-up** required to confirm effects predictions and address uncertainty (refer to Section 6.4.6 Monitoring and Follow-up).
- **Step 8 – Present a consolidated summary of conclusions and outcomes of the assessment** of residual effects on land and resource use (refer to Section 6.4.7 Conclusions).

Information and areas of interest raised by Indigenous peoples and regulators during engagement that influenced the scope of the traditional land and resource use assessment are summarized in Table 6.4.1-1. A full record of engagement activities is available in Section 6.2. Other general areas of interests and questions raised during the engagement that pertain to the land and resource use assessment (if any) are documented in CNL's Indigenous Engagement Report (CNL 2020).

Table 6.4.1-1: Summary of Areas of Interest Raised during Engagement Activities that Influenced the Scope of the Traditional Land and Resource Use Assessment

Area of Interest	How the Area of Interest Was Considered or Included in the Land and Resource Use Assessment
Indigenous interest expressed in relation to potential effects on fish and fish harvesting due to concerns of potential contamination or radioactive seepage into Perch Creek, the Ottawa River and other waterbodies from the NSDF Project.	The spatial boundaries of the traditional land and resource use assessment were selected to include consideration of potential effects on water quality and include the aquatics study areas. CNL continues to monitor the aquatic environment extensively, specifically Perch Creek. The NSDF Project has used recent modelling to understand the potential for effects within the Perch Creek basin and the expanded RSA. Existing traditional land use with regard to fishing is described in Section 6.4.4.1.2.3. Potential effects on these VCs are assessed in Section 6.4.5.
Interest in changes in possible land uses caused by accidents and malfunctions, including high levels of precipitation, seismic activity, fault line and system failure, as well as the transportation of radioactive waste through traditional territories.	■ The EIS identifies a number of planned good practices in the form of mitigation to avoid accidents and malfunctions and proactively address potential effects. The design of the facility addresses plausible operational events and natural disasters. Every precaution will be taken to ensure the protection of workers, the public and the environment. ■ Potential effects of accidents and malfunctions are addressed in Section 7.0 of the EIS.
Interest in potential effects on Indigenous cultural heritage resources in the RSA. A request to review any future archaeological assessments has formally been made.	■ An archaeological assessment, including field surveys, was completed for the SSA and surrounding area. Findings of this assessment were used to inform the NSDF Project design team, and the NSDF Project site was subsequently modified so that archaeological sites identified during the field surveys would not be affected. Archeology is addressed in Section 5.9.4.2 and Section 5.9.5.1.2. ■ CNL is committed to engaging and seeking input from Indigenous peoples whose traditional territory, Indigenous and treaty rights have the potential to be affected by the NSDF Project. Traditional hunting, trapping, fishing and gathering activities, as well as cultural resources and ceremonies, are addressed in Section 6.4.4.1 and 6.4.5.
Interest in potential effects to continued Indigenous traditional land and resource use.	The NSDF Project occurs within a general area of traditional land and resource use for Indigenous peoples. Traditional land and resource use are addressed in Section 6.4.4.1 and 6.4.5.
Concerns regarding unidentified Indigenous burial sites and excavation.	If any human remains are identified during construction, CNL will immediately notify Indigenous communities or organizations, as well as the police or coroner and the Registrar of Cemeteries, Ministry of Small Business and Consumer Services. Archeology is addressed in Section 5.9.4.2 and 5.9.5.2.

EIS = Environmental Impact Statement; RSA = Regional Study Area; SSA = Site Study Area; VC = valued component; AOO = Algonquins of Ontario.

The information in Table 6.4.1-1 was used to frame the scope of the assessment and identify VCs (Section 6.4.2). This assessment considers changes in wildlife harvesting and angling and other resource uses identified during the collection of baseline information at the local and regional scales. CNL has and will continue to meet with Indigenous peoples to receive input on the NSDF Project. The objectives of these meetings are to understand the priorities and interests of recreational and traditional users and to review potential mitigation to reduce or eliminate the effects of the NSDF Project. It should be noted that the AOO has received funding for a large Algonquin Knowledge and Land Use from CNSC and CNL and work has commenced but that work is unlikely to be completed until well into 2020.

6.4.2 Valued Components

VCs refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community or the public (The Agency 2018). Land and resource use VCs were selected based on the potential for the NSDF Project to interact with these features or activities of the land and resource use environment.

In addition, VCs for traditional land and resource use were selected based on consideration of a number of factors, including the following:

- knowledge of traditional land and resource use practices that interact with the environment;
- Indigenous and/or treaty rights;
- community engagement; and
- consideration of other environmental assessments.

The VCs selected for assessing potential effects on land and resource use conditions are presented in Table 6.4.2-1.

Table 6.4.2-1: Valued Components for the Land and Resource Use Assessment

Valued Component	Rationale for Selection
Traditional land and resource use by Indigenous peoples	▪ Trapping, hunting, fishing and gathering where traditional and are modern-day land and resource use activities are practised by Indigenous peoples in the Ottawa Valley. These activities provide important links to cultural continuity and traditional way of life. These activities are protected under Section 35 of the Constitution Act, which identifies that existing Aboriginal and treaty rights of the Indigenous peoples of Canada are recognized and affirmed. For Métis people, the rights were affirmed in the courts in 2003 (R. v. Powley) confirming that Métis can assert Aboriginal rights under Section 35 of the Constitution Act. ▪ Indigenous peoples place a high degree of value on specific sites of cultural, historical, spiritual, social or ecological significance. These sites may have broader cultural significance related to the practice of formal or informal ceremonies at or near these sites.

To focus the assessment, the VCs noted in Table 6.4.2-1 are further subdivided into categories, and assessment endpoints and measurement indicators were identified for each category. Assessment endpoints are qualitative expressions used to assess the significance of residual effects on VCs and represent the key properties of the VC that should be protected for future generations. Measurement indicators represent properties of the environment and VCs that, when changed, could result in or contribute to an effect on a VC. Measurement indicators can be used to monitor the success of mitigation and management programs. The assessment endpoints and measurement indicators identified for the land and resource use VCs are presented in Table 6.4.2-2.

Table 6.4.2-2: Assessment Endpoints and Measurement Indicators for the Land and Resource Use Assessment

Valued Component	Sub-component	Assessment Endpoints	Measurement Indicators
Traditional land and resource use by Indigenous peoples	Trapping	Continued traditional land and resource use opportunities	▪ Changes in access to lands for trapping opportunities ▪ Changes in quality and quantity of trapping opportunities
	Hunting	Continued traditional land and resource use opportunities	▪ Changes in access to lands for hunting opportunities ▪ Changes in quality and quantity of hunting opportunities
	Fishing	Continued traditional land and resource use opportunities	▪ Changes in access to lands for fishing opportunities ▪ Changes in quality and quantity of fishing opportunities
	Gathering	Continued traditional land and resource use opportunities	▪ Changes in access to lands for gathering opportunities ▪ Changes in quality and quantity of gathering opportunities
	Cultural resources and ceremonies	Continued access to cultural resources for ceremonial purposes	▪ Changes in access to lands for cultural ceremonial purposes ▪ Changes in quality and quantity of ceremonial opportunities

6.4.3 Assessment Boundaries

6.4.3.1 Spatial Boundaries

The spatial boundaries selected for the traditional land and resource use assessment were chosen because they permit a description of existing conditions in sufficient detail to enable potential Project-VC interactions and effects to be identified, understood and assessed, including the contribution of the NSDF Project to cumulative effects. The spatial boundaries selected for the traditional land and resource use assessment are the same as those identified for the land and resource use assessment and are presented on Figure 6.4.3-1 and are described below:

- **Site Study Area (SSA):** The SSA is the NSDF Project footprint (i.e., where project activities would be undertaken, including the project's proposed facilities, buildings and infrastructure). The SSA covers an area of approximately 37 ha (Figure 6.4.3-1). The SSA falls within the CRL site boundary.
- **Local Study Area (LSA):** The LSA is selected in consideration of the NSDF Project footprint and the spatial extent of potential direct effects of the Project on the VCs. The traditional land and resource use LSA corresponds with the combined area of the terrestrial and aquatics LSAs used for the assessment of the groundwater and surface water environment, aquatic biodiversity and terrestrial biodiversity, and covers approximately 226 ha (Figure 6.4.3-1). The aquatics, terrestrial and biophysical LSAs are defined in Sections 5.2 through 5.6. The LSA is defined to capture both direct and indirect effects on the terrestrial and aquatic environments as a result of the NSDF Project (e.g., changes in groundwater and surface water quality, habitat loss and changes in abundance, distribution and disturbances to wildlife and fish) as these effects have the potential to result in subsequent effects on land and resource use. The LSA falls within the CRL site boundary. No traditional land use activities currently occur within the CRL site boundary.
- **Regional Study Area (RSA):** The RSA is defined as the area within which the potential effects of the NSDF Project may interact with the effects of other existing or reasonably foreseeable projects. The traditional land and resource use RSA is the combined area of the air quality, terrestrial and aquatics RSAs, which have been used for the assessment of the air quality, groundwater, surface water, aquatic and terrestrial environments (Figure 6.4.3-1). The RSA is defined to capture effects on the terrestrial and aquatic environments as a result of the NSDF Project (e.g., habitat loss, sensory disturbance for wildlife and changes to habitat from air quality and surface water quality, changes in groundwater and surface water quality, habitat loss and changes in abundance, distribution and disturbances to wildlife and fish), as these effects have the potential to result in subsequent effects on land and resource use. Therefore, the RSA for traditional land and resource use is a combination of the air quality and aquatic environment RSAs as this is the largest extent of potential cumulative effects on land and resource use. The air quality RSA is defined as an approximately 7.4 km circular radius surrounding the LSA, and the aquatic RSA extends roughly 8 km downstream in the Ottawa River to Harrington Bay. While there are no traditional land use activities occurring within the CRL site boundary, there may be some trapping occurring at Garrison Petawawa and in the RSA. The Ottawa River where it overlaps with the RSA boundaries would also be used for some traditional land and resource uses.

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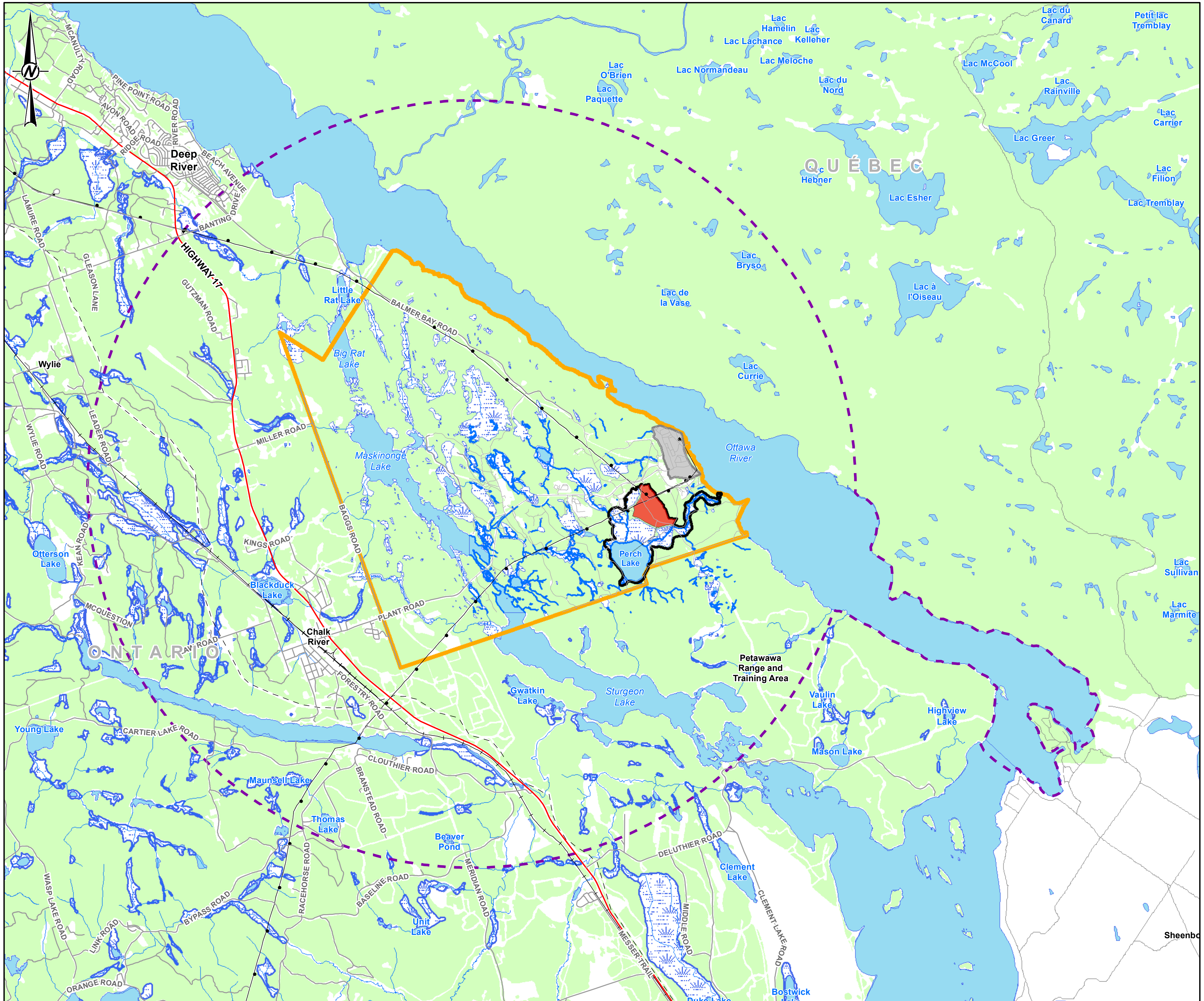

LEGEND

- HIGHWAY
- ROAD
- RAILWAY
- TRANSMISSION LINE
- NATURAL GAS PIPELINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- SITE STUDY AREA (NSDF PROJECT SITE)
- CRL MAIN CAMPUS
- CRL SITE
- LOCAL STUDY AREA
- REGIONAL STUDY AREA

2.5 0 2.5

1:75,000 KILOMETRES

REFERENCE(S)

1. BASEMAP:SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. HIGHWAYS AND FIRST NATION RESERVES MNRF 2016
4 PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
SPATIAL BOUNDARIES SELECTED FOR THE TRADITIONAL LAND AND RESOURCE USE ASSESSMENT

CONSULTANT

GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0023	FINAL 2	6.4.3-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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6.4.3.2 Temporal Boundaries

Temporal boundaries (i.e., project phases) establish the timeframe during which NSDF Project effects are assessed. The temporal boundary represents the timeframe during which project activities are actively occurring, and considers the duration of predicted residual effects. The duration of an effect is defined as the amount of time between the start and end of a project activity or stressor (which is related to the project phases) plus the time required for the residual effect to be reversed. In the case of social land use changes, residual effects may be irreversible due to the nature of changes in human activity. The following phases were identified for the NSDF Project.

- **Construction phase**: This phase includes site preparation and all activities associated with the construction of the NSDF, up until the operations phase commences with the delivery of waste. This phase includes activities such as installing the necessary supporting and/or ancillary facilities and infrastructure to facilitate NSDF operation, inactive commissioning and systems testing, and transportation of construction materials. Construction activities are expected take place from 2021 to 2023.
- **Operations phase**: This phase includes all activities associated with waste placement, water management, Wastewater Treatment Plant (WWTP) operations, vehicle movements into and from the SSA and maintenance activities. Operations activities are expected to last approximately 50 years (i.e., 2024 to 2070).
- **Closure phase:** This phase includes activities necessary to complete the installation of the final cover and implementation of long-term monitoring. Closure activities are expected to start in approximately 2070 and continue through to 2100, after which the NSDF Project will transfer into the post-closure phase.
- **Post-closure phase:** This phase has two discrete periods: institutional control and post-institutional control. The institutional control period includes implementation of controls throughout 2100 to 2400 (i.e., 300 years). During institutional control, environmental monitoring will continue to demonstrate compliance with the environmental assessment predictions. Post-institutional control occurs after year 2400 and continues indefinitely.

The temporal boundaries for the land and resource use assessment consider all NSDF Project phases, from construction through post-closure.

6.4.3.3 Assessment Cases

The assessment cases considered in the traditional land and resource use assessment are the Base Case and Application Case (the Reasonably Foreseeable Development Case has not been considered for the reasons outlined below):

- **Base Case:** This scenario represents existing conditions and characterizes effects from previous and existing developments and activities. The Base Case reflects the effects of existing land and resource uses in the area, such as hunting, fishing, trapping, forestry, agriculture, mining and recreational use. Current effects from the existing CRL facilities and operations are considered part of the Base Case.
- **Application Case:** This scenario represents the effects of the Base Case combined with the predicted effects from the NSDF Project. The Application Case considers effects from the NSDF Project during construction through to post-closure.

- **The Reasonably Foreseeable Development (RFD) Case:** This scenario represents the effects of residual adverse effects of the Application case combined with other reasonably foreseeable projects in the traditional land and resource use RSA. Reasonably foreseeable developments within the RSA includes limited planned construction at Garrison Petawawa, and on the CRL site, new and upgraded research and development facilities, construction and operation of a Small Modular Reactor, new support infrastructure, on-going decommissioning and environmental remediation activities. There are currently no traditional land and resource use activities such as hunting, fishing, gathering and cultural ceremonies occurring in either the SSA or LSA as the CRL site is a restricted public access area. The NSDF Project is not predicted to have any terrestrial effects beyond the CRL site, and results of the aquatic environment assessment identify that measurable residual effects on aquatic biodiversity VCs are not predicted as a result of the NSDF Project. Because RFDs will not have any spatial overlap with potential effects of the Project and/or are not likely to affect traditional land and resource use, an RFD Case is not presented as part of this assessment.

6.4.4 Description of the Environment

This section describes the setting and characterization for traditional land and resource use by Indigenous peoples, as relevant for the assessment of the NSDF Project. It describes the existing conditions (i.e., Base Case) against which potential changes from the NSDF Project are compared and evaluated.

6.4.3.4 Traditional Land and Resource Use by Indigenous Peoples

6.4.3.4.1 Methods

Indigenous interests expressed to CNL during engagement with these communities have been considered in the following assessment. In 2016 CNL sent letters to the identified Indigenous communities and organizations requesting information on traditional land and resource use in the area surrounding the CRL site. CNL send letters again in May 2020 asking relevant questions again to verify assumptions CNL made in lieu of having responses or direct input from the various Indigenous communities and organizations.

Information on traditional land use activities by Indigenous peoples has been drawn from: existing studies and reports; Indigenous organization websites; the MNO Traditional Knowledge and Land Use Study; formal and informal consultation activities; and general knowledge of the region More specifically information on traditional land and resource use and how it was gathered for each Indigenous organization and community is documented below.

Algonquins of Ontario (AOO) and Algonquins of Pikwakanagan First Nation (AOPFN)

The AOO, of which AOPFN is a member, is in the process of completing their Algonquin Knowledge and Land Use Study. Information on their traditional use is documented in supporting documents associated with resource management plans for the Ottawa Valley and surrounding region. Specifically, this information has been documented in Supporting Documentation to Forest Management Plans for the Ottawa Valley Forest, Nipissing Forest, Algonquin Park Forest, Mazinaw-Lanark Forest and Bancroft-Minden Forest. These five forests cover a wide area of central-eastern Ontario roughly equivalent to the AOO Settlement Area.

The Supporting Documentation to those Forest Management Plans includes documents such as the Aboriginal Background Information Reports which describes use of natural resources and protection of identified Aboriginal Values. That information is intended to describe traditional uses and protection of natural resources on Ontario crown land over this wide region but does not include private or federal crown land. Those Reports have been referenced in the EIS. Those Reports describe traditional uses undertaken by all AOO communities including the AOPFN. The CRL site is located within the general area of the Ottawa Valley Forest but that Forest Management

Plan has no jurisdiction over the CRL site nor describes uses on it. These forest management plans do describe in general terms, traditional use occurring on crown lands near the CRL site.

Traditional use from other Indigenous communities and organizations beyond the AOO and AOPFN are not mentioned in those Forest Management Plans because the Ontario Ministry of Natural Resources and Forests did not extend its duty to consult for those forest management plans to those other communities.

Traditional use by AOO members will be enhanced by the large proposed Algonquin Knowledge and Land Use Study. As previously indicated CNL intends to document traditional land and resource use in the revised IER that will be prepared prior to the CNSC Commission Hearing on the NSDF Project as part of the Commission Member filing.

Métis Nation of Ontario (MNO)

The MNO have completed a traditional knowledge and land use study that documents use of lands and waters near the CRL site. Some other information on traditional land and resource use in this area of Ontario was obtained from the MNO website. Forest management plans for the area around the CRL site do not describe MNO use.

Williams Treaties First Nation (WTFN) Communities

While CNL is unable to find any documents such as forest management plans to describe Williams Treaties First Nation community uses near the CRL site, some WTFN members indicated verbally during an engagement in the spring of 2020 that they may have members living and/or harvesting near the CRL site. CNL has requested any information describing these communities' traditional uses near the CRL site. CNL has assumed there is some harvesting activities by Williams Treaties communities in the Ottawa River Valley but specifics are unknown.

Algonquin Anishinabeg Nation Tribal Council (AANTC) Communities

CNL has requested any information describing these communities' traditional uses near the CRL site. While no information describing recent traditional use by AANTC community members has been found or identified CNL is of the opinion that likely there is some use occurring on the Ottawa River or on the Quebec side of the Ottawa River by some individuals from these communities.

6.4.3.4.2 Results

As indicated above, there is a large amount of information documenting traditional use by the AOO and AOPFN in areas near the CRL site. There is also information describing MNO use. While there is very limited information describing traditional use by WTFN and AANTC communities some traditional use likely occurs by some community members historically and into the present.

The NSDF Project occurs within the general area of the AOO Land Claim, where negotiations with the Crown have occurred since 1991 (see Figure 4 in Appendix 5.9-1).

As part of a submission to the CNSC for a 10-year renewal of the Nuclear Research and Test Establishment Operating Licence for the CRL (Commission Member Document 18-H2.51), the AOO identified that it asserts unextinguished and constitutionally protected Aboriginal rights and title to a traditional territory in Eastern Ontario (referred to as the "Settlement Area") and is currently in negotiations towards a modern-day treaty with the governments of Ontario and Canada. The NSDF Project occurs within the Settlement Area. The Settlement Area includes 36,000 km^2 within the watersheds of the Kichisippi (Ottawa River) and the Mattawa River. This area is the traditional territory of the AOO, composed of 10 Algonquin communities—the Algonquins of Pikwakanagan

First Nation, Antoine, Kijicho Manito Madaouskarini (Bancroft), Bonnechere, Greater Golden Lake, Mattawa/ North Bay, Ottawa, Shabot Obaadjiwan (Sharbot Lake), Snimikobi (Ardoch) and Whitney and Area—and it is recognized that AOO citizens continue to practise traditional land use activities throughout this region. Algonquin traditional use has occurred for a very long period of time. In the *Aboriginal Background Information Report* to the Forest Management Plan for the Ottawa Valley Forest 2011 to 2021, it was indicated that:

> *Since the 1700s the Algonquins were known to spend the majority of the year occupying the different parts of the Ottawa Valley, hunting, fishing, trapping and gathering among other things. These activities necessitated use of timber and other resources.* (Ottawa Valley Forest 2011a)

The AOO website describes the importance of traditional harvest:

> *The harvesting of flora and fauna for food and trade has been integral to the Algonquin way of life since time immemorial. These practices embody an inherent respect for the environment and a fundamental commitment to the sustainable management of resources, which has been passed from generation to generation.*
>
> *The rights of Indigenous peoples in Canada to engage in traditional activities, including the harvesting of wildlife, fish, migratory birds and plants, is recognized by the Constitution Act, 1982 and upheld by the Supreme Court of Canada. As stewards of our ancestral lands, the AOO recognize the importance of exercising this right in a responsible manner.* (AOO 2016)

The AOO has further re-iterated the importance of traditional harvest in its Agreement-in-Principle with the Governments of Ontario and Canada. In Chapter 8, it is indicated that:

> *The Final Agreement will provide that Beneficiaries have the right to Harvest Fish, Wildlife, Migratory Birds and Plants for Domestic Purposes throughout the year within the Settlement Area as further described in this Chapter*. (AOO, Government of Ontario, Government of Canada 2016)

As indicated in the quotation above, the intent of such harvest is for subsistence/community use purposes and not for commercial purposes (AOO 2016). It is likely that Indigenous peoples and possibly the ancestors of the modern-day Algonquins living in the Ottawa Valley undertook traditional activities, such as hunting, which would have likely included lands that are currently under federal government control. Archaeological investigations for the NSDF Project have discovered artifacts from CaGi-40, an Early Archaic Period site (i.e., 6,000 to 10,000 years before present; Swayze and Cameron 2016).

The NSDF Project also occurs within the Mattawa/Lake Nipissing Traditional Harvesting Territory for the MNO Mattawa Métis Council, North Bay Métis Council and Sudbury Métis Council (MNO 2017, no date), which is part of MNO Region 5. The MNO has indicated that the CRL site occurs on the border of Region 5 and Region 6. Use of the area around the CRL site by other Indigenous peoples is not certain.

The MNO recently completed a TKLUS (KnowHistory 2019) that was undertaken specifically for the NSDF and NPD projects through funding supplied by the CNSC. The study area used in the TKLUS included a 50 km radius from the NPD and NSDF projects but documented use beyond that radius. While the study only involved 11 participants it did document significant use within its study area. Because the study only involved 11 participants, though, the results should not be taken as the only land uses by MNO citizens in the region.

While best efforts were taken to ensure that the TKLUS was representative of Métis land use, it should be remembered that the study area included a small number of participants and was restricted both due to capacity and by a backlog in the citizenship review process at the MNO registry. Additionally, some Métis Citizens practice avoidance behaviour and do not harvest in the area surrounding the proposed NSDF project due to concerns about plant and animal contamination.

Engagements with the WTFN and AANTC communities have verbally indicated traditional use also occurs near the CRL site. CNL continues to engage these communities on more exact formal indications of traditional use.

6.4.3.4.2.1 Trapping

Trapping in Ontario occurs on licensed traplines administered by the Ministry of Natural Resources and Forestry, as described in Section 5.9.4.1.3.4. There are approximately 50 licensed trapline areas in the Ottawa Valley Forest, which is slightly over 800,000 ha (Ottawa Valley Forest 2011a). The trapping of fur-bearing animals is a traditional and modern-day land and resource use activity practised by Indigenous peoples in the Ottawa Valley.

Trapping is one resource-based activity that has both a traditional and commercial aspect to it. Most Indigenous trappers trap for personal and cultural reasons as well as for the financial benefit of selling the furs. Trapping can produce some income to offset a trapper's costs and time.

The right to trap fur-bearing animals is outlined in Section 8.3.24 of the AOO Agreement-in-Principle (AOO, Government of Ontario, Government of Canada 2016). The inclusion of such a section indicates the importance of trapping as a cultural activity to the AOO. Targeted species include (but are not limited to) beaver (*Castor canadensis*), fisher (*Martes pennant*) and marten (*Martes Americana*) (Ottawa Valley Forest 2011b). The AOO has received funding from CNSC for a large TKLUS in the Ottawa Valley that will encompass traditional uses near the NPD and NSDF Project sites.

In the MNO TKLUS it was identified that trapping has been a foundational element of Métis way of life and land use since the genesis of the Métis. Of the 11 participants in the MNO TKLUS, 7 reported participation in trapping although none had trapped within the 50 km study area.

The SSA, LSA and RSA all overlap the PE002 trapline area. Trapline areas PE025 and PE024 also overlap the western section of the RSA. While trapping is prohibited in the LSA and most areas of the RSA due to restricted public access within the CRL site boundary (see Figure 5.9.4-1)[3], results of consultation and engagement have identified that there may be some limited trapping activities at the southern portion of the RSA, beyond the CRL site boundary, on the Garrison Petawawa property. Engagement with all Indigenous communities to the end of June 2020 has not resulted in the identification of any Indigenous trappers operating within the RSA.

6.4.3.4.2.2 Hunting

Hunting is a popular activity in the Ottawa Valley Forest (Ottawa Valley Forest 2011a), and hunting continues to be practised by Indigenous peoples in the Ottawa Valley (the Ottawa Valley Forest is the provincial Crown land that surrounds the CRL site). Hunting today includes moose (*Alces alces*), elk (*Cervus canadensis*), white-tailed deer *(Odocoileus virginianus),* small game and waterfowl.

The AOO prepares an annual Algonquin Harvest Management Plan specifically to address the hunting of larger game including moose, elk and deer (AOO 2016). The harvesting of wildlife is outlined in Section 8.3 of the

[3] It is noted that CNL contracts a trapper for managing nuisance beavers on the CRL site.

AOO Agreement-in-Principle (AOO, Government of Ontario, Government of Canada 2016). The inclusion of such a section indicates the importance of hunting as a cultural activity to the AOO. As already indicated, the AOO has received funding from the CNSC for a large Algonquin Knowledge and Land Use Study in the Ottawa Valley that will encompass traditional uses near the CRL site. As described in Section 5.9.4.1.3.3, the RSA overlaps wildlife management unit (WMU) 48. Targets for moose have been identified for Algonquin harvest in WMU 48 (AOO 2016). While there is no elk harvest in this WMU, it is expected that there is likely harvest of deer, small game and waterfowl in this management unit.

Seven of the eleven participants in the MNO TKLUS have hunted within the 50 km study area, although the mapping demonstrates that most of the use is in the Deux-Rivières area, close to 40 km west of the CRL site (see Figure 3, KnowHistory 2019). The harvest included both large and small game including moose, partridge, grouse, rabbit, deer, duck and goose (KnowHistory 2019). It should be noted that while the TKLUS study did not appear to document any use within 10 km of the CRL site, there could be MNO citizens that hunt closer to the CRL site.

The LSA is restricted to the CRL site, where recreational hunting is prohibited. Therefore, there is no traditional hunting occurring in the SSA or LSA.

While no Indigenous community or organizations has indicated that it is harvesting specifically within the RSA, it is likely that there has been traditional hunting in the RSA. It is possible that there is waterfowl hunting along the Ottawa River shoreline of the CRL site and Garrison Petawawa property. Hunting for waterfowl in Ontario commonly occurs along waterways, and there are no restrictions preventing an individual from hunting along the Ottawa River. Therefore, it seems reasonable that Indigenous peoples from any and all of the Indigenous organizations and communities may hunt waterfowl along the Ottawa River. On the Ontario side of the Ottawa River, most of the RSA is occupied by the CRL site, Garrison Petawawa and private land, with only a few isolated parcels of Crown land. Therefore, it is likely that traditional hunting on the Ontario side of the RSA is quite limited, which the MNO TKLUS demonstrates (there was no identified hunting in the RSA). However, it is possible that hunting still occurs on Crown or private land (hunting on private land is subject to landowner permission) but that specific locations are not known or not revealed to their communities or organizations. On the Quebec side of the Ottawa River, the area is fairly remote (i.e., limited road infrastructure and not easy to get access to) but could be used for traditional hunting. Both the MNO and the AOO have agreements on hunting with the Ontario Ministry of Natural Resources which suggest the majority of their hunting occurs on the Ontario side of the Ottawa River.

6.4.3.4.2.3 Fishing

Fishing is a traditional and modern-day land and resource activity practised by Indigenous peoples in the Ottawa Valley. The Ottawa River was and is still used for sport and subsistence fishing. Fish species traditionally targeted would have likely included the same type of sport and subsistence fish that occur today such as Walleye (*Sander vitreus)*, Smallmouth Bass (*Micropterus dolomieu)* and Northern Pike (*Esox lucius)* (SENES 2010). Historically, Lake Sturgeon (*Acipenser fulvescens*), Suckers (*Catostomidae* spp.) and American Eel (*Anguilla rostrate*) would have also likely been harvested.

The harvesting of fish is outlined in Section 8.2 of the AOO Agreement-in-Principle (AOO, Government of Ontario, Government of Canada 2016). The inclusion of such a section indicates the importance of fishing as a cultural activity to the AOO. As already indicated, the AOO has received funding from CNSC for a large Algonquin Knowledge and Land Use Study in the Ottawa Valley that will encompass traditional uses near the NPD and NSDF Project sites.

Eight of the eleven participants in the MNO TKLUS have fished in the 50 km study area identified in the KnowHistory (2019) study. This included fishing on the Ottawa River north of Rolphton. There was also other MNO fishing in the study in waterbodies to the west of Ottawa River towards Algonquin Park. Fish species harvested in the MNO study included Walleye, trout, bass, Northern Pike and sturgeon. It was also noted that 3 of the 11 participants participated in a commercial sturgeon fishery as children. It is unclear based on the mapping on Figure 5 of the Know History study where that fishing occurred, but again there is no fishing reported within 10 km of the CRL site. It should be noted that there is no longer a commercial sturgeon fishery on the Ottawa River.

The LSA and SSA fall within federal lands with restricted access, and fishing within the CRL site is prohibited. Therefore, traditional fishing is not occurring in these areas and has likely not since prior to control of the CRL site by the federal government.

While Indigenous peoples in the Ottawa Valley likely fish in many lakes and rivers throughout the valley, it is likely that they also fish in the Ottawa River as there are a diversity of fish species and many access points to the river. Therefore, it is likely that individuals from all the Indigenous communities and organizations fish on the Ottawa River and occasionally within the vicinity of the RSA.

Indigenous people maintain some commercial fish licenses for inland waters in Ontario. However, there is currently no commercial fishery on the Ottawa River. Historically, there likely was a commercial sturgeon fishery on the Ottawa River and members of the MNO in their TKLUS indicated that they had historically participated in a commercial fishery.

Indigenous individuals may also own and operate resource-based tourism establishments such as sport fishing or other water based tourism industries hunting or eco-tourism Such commercial activities would not be rights based but could be operated by Indigenous peoples. CNL is unaware of any such enterprises operating in the study areas but it is possible.

6.4.3.4.2.4 Gathering

Gathering is a traditional and modern-day land and resource use activity practised by Indigenous peoples in the Ottawa Valley. The gathering of plants, berries and mushrooms would have been conducted for subsistence, medicines, crafts and other purposes. Gathering activities can also have a commercial component to them. The most common example of this is blueberry picking. Other gathering activities that might have a commercial component to them such as gathering other plant materials for food or craft use.

The AOO has indicated the importance of traditional harvest in its Agreement-in-Principle with the Governments of Ontario and Canada. In Chapter 8, it is indicated that: “The Final Agreement will provide that Beneficiaries have the right to Harvest Fish, Wildlife, Migratory Birds and Plants for Domestic Purposes throughout the year within the Settlement Area as further described in this Chapter.” (AOO, Government of Ontario, Government of Canada 2016). This would include all Crown lands within the Settlement Area.

As already indicated, the AOO has received funding from CNSC for a large Algonquin Knowledge and Land Use Study in the Ottawa Valley that will encompass traditional uses near the NPD and NSDF Project sites.
The harvesting of plants is outlined in Section 8.5 of the AOO Agreement-in-Principle (AOO, Government of Ontario, Government of Canada 2016). The inclusion of such a section indicates the importance of gathering as a cultural activity to the AOO. While the AOO has yet to complete the study, one would expect that gathering

activities are extensive and would involve the collection of plant material for food consumption (e.g., berries, fruits, mushrooms, fiddleheads, maple sap), medicinal purposes, teamaking and craft and canoe building.

The MNO TKLUS (KnowHistory 2019) documented that the collection of plants, berries, wood and other natural materials is a practice associated with both historical and modern-day Métis communities. Four of the eleven participants in the MNO TKLUS documented collecting and gathering activities within the 50 km study area. The study noted that gathering can be the main reason for a trip or be a secondary reason. The MNO harvesting in this 50 km study area is generally located closer to Deux-Rivières, but there is harvesting closer to the CRL site as it appears harvesting has occurred along and near the Highway 17 corridor. Some of the plant material that was and is gathered includes berries and fruit (raspberries, blueberries, choke cherries); maple syrup; fiddleheads; medicinal plants; tea plants; and materials for crafts and canoe making. Some gathering activities require a wide diversity of plant species for medicinal purposes, tea making and canoe building.

Gathering is an activity that provides important links to cultural continuity and traditional way of life. The SSA and the LSA are located within the CRL site and gathering in this area would be prohibited by CNL. Gathering could occur within the RSA. It is possible there may be some gathering along the shoreline of the Ottawa River, adjacent to the CRL site. Indigenous peoples may collect plants and other materials on Crown lands and public waterways without restrictions. There also could be some gathering activities on Crown or private land within the RSA. While no Indigenous organization has indicated that gathering occurs within the RSA, it is likely that this activity is or has been undertaken by Ontario based Indigenous individuals.

6.4.3.4.2.5 Cultural Resources and Ceremonies

Indigenous peoples place a high degree of value on specific sites of cultural, historical, spiritual, social or ecological significance. These sites may have broader cultural significance related to the practice of formal or informal ceremonies at or near these sites. Both the AOO and MNO have informally communicated the importance of the Ottawa River to their communities, and without question Algonquin communities on the Quebec side of the river have a similar perspective.

In the MNO TKLUS, interviewees have expressed an important spiritual and cultural connection to the Ottawa River corridor.

> *Interviewees reported feeling a spiritual and cultural connection to the Ottawa River corridor. They attributed this feeling to their family being present in this area for generations and the historic connection between the Ottawa River and the fur trade. Many participants shared stories about their ancestors which have been passed down from the 19th century. The historic travel routes, burial grounds, religious sites, and gathering places associated with these stories strengthen links to their Métis heritage.* (KnowHistory 2019)

There is one known site of significance on the CRL site, the Pointe au Baptême site. According to historical records, this sandy spit was where the Voyageurs baptized new members and where local Algonquin camped frequently in the early 20th century. According to a local informant, there is a cemetery at the base of the peninsula. Archaeological site CaGi-7 was revisited in 2007 to record historical Wallace Cottage features and to mark the suspected cemetery with an ornamental fence. Pre-contact stone artifacts have been reported over the years from eroded parts of the site as well (Swayze and Cameron 2016).

Pointe au Baptême has a high management priority rating due to its historical association and the reported human burials (Kinickinick Heritage Consulting and Cameron Heritage Consulting Inc 2018). It is of interest to the Algonquin and Métis communities and has a view of Oiseau Rock across the Ottawa River, which is a sacred pictograph site. Pointe au Baptême has been previously disturbed by an access road turn around (Swayze and Cameron 2016).

Given this information on the Pointe au Baptême site, it is assumed the site is of cultural significance to Indigenous peoples and there may or may not be formal or informal cultural activities associated with it. The Pointe au Baptême site is not within the footprint of the NSDF Project, but is within the RSA on the CRL site.

6.4.4 Project Interactions and Mitigation

6.4.4.1 Methods

This section describes the process by which interactions between NSDF Project components and activities and traditional land and resource use were identified and evaluated. Potential effects pathways are identified and mitigation developed to eliminate and/or reduce effects is presented. A pathways analysis is then used to focus the assessment on key interactions between the NSDF Project and the environment by evaluating the different effects pathways to determine if, after incorporation of mitigation, there is still potential for residual effects. Where effects will be adequately mitigated and are not forwarded for further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are articulated. Primary pathways that may lead to residual effects after incorporation of mitigation are further characterized in subsequent subsections of the assessment. As such, the "Project Interactions and Mitigations" section helps to focus the remainder of the assessment on those interactions (effects pathways) likely to result in residual adverse effects.

The first part of the analysis was to identify the potential effects pathways for all phases of the NSDF Project. The next step in the analysis was the development of environmental design features and mitigation that could be incorporated into the NSDF Project to eliminate and/or reduce effects to traditional land and resource use. Environmental design features included Project design elements, environmental best practices and management policies and procedures. Environmental design features and mitigation were developed through an iterative process between the Project's engineering and environmental teams, combined with input from Project-specific or regional engagement with other interested parties. The environmental design features and/or mitigation activities were selected considering their effectiveness for implementation and maintenance and their appropriateness within the context of the identified effects pathways.

After incorporation of mitigation, potential pathways were evaluated into the following categories using scientific and traditional knowledge, logic, experience with similar developments and the effectiveness of environmental design features and mitigation:

- **No linkage:** The pathway is removed by environmental design features or mitigation such that the NSDF Project would not be expected to result in a measurable environmental change relative to Base Case values and therefore would have no residual effects on traditional land and resource use.
- **Secondary pathway:** The pathway could result in a measurable minor change, but would have a negligible residual effect on traditional land and resource use relative to Base Case values and is not expected to contribute cumulatively to other Project effects or to the effects of other previous, existing or reasonably foreseeable developments to cause a significant effect.

- **Primary pathway:** The pathway is likely to result in an environmental change relative to the Base Case that could contribute to residual effects on traditional land and resource use.

Environmental design features and measures that could be incorporated into the NSDF Project to eliminate and/or reduce adverse effects were considered. Potential pathways that were completely removed due to implementation of environmental design or mitigation were not assessed further. Pathways that were assessed to be secondary and demonstrated to have a negligible residual effect to traditional land and resource use through quantitative and qualitative evaluation of the pathway were also not advanced for further assessment. If identified, primary pathways were carried forward for more detailed quantitative and qualitative effects analysis to characterize the residual effects of the NSDF Project.

6.4.4.2 Results

Pathways through which all phases of the NSDF Project may interact with and result in changes to measurement indicators for traditional land and resource use are provided in Table 6.4.4-1. Environmental design features and management policies implemented to reduce potential effects are also described.

Table 6.4.4-1: Pathways Analysis for the Traditional Land and Resource Use Valued Components

Project Activity	Valued Component	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Construction, operations, closure, post-closure (institutional control)	Traditional land and resource use by Indigenous peoples – trapping	There could be changes in access to trapping activities or quality and quantity of trapping activities.	▪ Access to the LSA and CRL site is restricted; therefore, there are no trapping activities undertaken within the LSA or within the CRL site outside of the LSA. ▪ There is potential trapping identified in the southern portion of the RSA in the Garrison Petawawa property and two trapline areas in the western portion of the RSA. To date, these have not been identified as traplines belonging to Indigenous peoples. ▪ While terrestrial effects are limited to the CRL site, which is restricted access, CNL will work to consult with the trappers to understand any concerns should they be raised. ▪ The RSA has been expanded to include a reach of the Ottawa River extending 8 km downstream of CRL where trapping of aquatic species may take place. Results of the aquatic environment assessment (Section 5.5) identify that measurable residual effects on aquatic biodiversity VCs are not predicted as a result of the NSDF Project. Therefore, trapping of aquatic species will not be affected by the NSDF Project.	Secondary

Table 6.4.4-1: Pathways Analysis for the Traditional Land and Resource Use Valued Components

Project Activity	Valued Component	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment

Construction, operations, closure, post-closure (institutional control)	Traditional land and resource use by Indigenous peoples – hunting	There could be changes in access to hunting activities or in the quality and quantity of hunting activity.	▪ Terrestrial effects are limited to the CRL site boundary, which encompasses the LSA and is restricted access; therefore, no hunting activities of terrestrial species will be affected by the NSDF Project.
			▪ Terrestrial wildlife will be excluded from the SSA by a six foot high chain link perimeter fence that will remain through post closure.
			▪ Ecological health will be protected through implementation of mitigation including:
			  ▪ CNL's procedure for Management and Monitoring of Emissions, which includes operational control monitoring and verification monitoring
			  ▪ Basing the strategy for wastewater treatment on optimizing public and environmental protection by defining an approach to wastewater treatment that uses the best available technology that is economically achievable and capable of meeting regulatory requirements.
				No Linkage

	Traditional land and resource use by Indigenous peoples – fishing	There could be changes in access to fishing activities or in the quality and quantity of fishing activities.	▪ The RSA overlaps a small portion of the Ottawa River, where fishing activities may take place. Results of the aquatic environment assessment (Section 5.5) identify that measurable residual effects on aquatic biodiversity VCs are not predicted as a result of the NSDF Project. Therefore, neither fishing nor the consumption of fish resources will be affected by the NSDF Project.	No Linkage
	Traditional land and resource use by Indigenous peoples – gathering	There could be changes in access to gathering activities or in quality and quantity of gathering activities.	▪ Terrestrial effects are limited to the CRL site which encompasses the LSA and is restricted access. Therefore, no gathering activities will be affected by the NSDF Project.	No Linkage

Table 6.4.4-1: Pathways Analysis for the Traditional Land and Resource Use Valued Components

Project Activity	Valued Component	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Post-closure (post-institutional control)	Traditional land and resource use (all types) by Indigenous peoples	There could be changes in access to hunting, fishing, trapping activities or to cultural resources for ceremonial purposes. There could be changes in the quality and quantity of hunting, trapping or fishing activity.	▪ Environmental monitoring will be completed as required during the institutional control period for the NSDF Project to confirm that the final cover is functioning as intended.	Secondary
Construction, operations, closure, post-closure	Traditional land and resource use by Indigenous peoples – cultural resources and ceremonies	There could be changes in access to cultural resources for ceremonial purposes.	▪ CNL will continue to permit access to one existing site of cultural significance (i.e., Pointe au Baptême); therefore, there are no changes in access to cultural resources that will be affected by the NSDF Project.	No Linkage

LSA = Local Study Area; RSA = Regional Study Area; VC = valued component.

6.4.4.2.1 No Linkage Pathways

The following pathway was assessed as having no measurable environmental change and hence, no linkage to residual effects on traditional land and resource use VCs during construction, operations and post-closure phase.

- **Changes in access to or the quality and quantity of traditional land and resource use activities – hunting, fishing (including commercial and tourism based), gathering and cultural ceremonies (except trapping)**

There are no traditional land and resource use activities occurring in either the SSA or LSA as this is a restricted public access area. Traditional land and resource use activities likely did occur prior to federal control of the CRL site. Effects to wildlife and vegetation by the NSDF Project are limited to the CRL site where access is restricted; therefore, no hunting or gathering activities will be affected by the NSDF Project. The RSA extends 8 km downstream of the CRL site where fishing may take place. There are no known commercial fishing licences in the Ottawa River. The results of the aquatic environment assessment (Section 5.5) identify that measurable residual effects on aquatic biodiversity VCs are not predicted as a result of the NSDF Project. Therefore, fishing will not be affected by the NSDF Project. The aquatic and terrestrial environment assessments also consider conclusions of the ecological health assessment (Section 5.7). The ecological health assessment found no significant residual effects to terrestrial or aquatic species through potential radiological dose and exposure to non-radiological indicator compounds through operations, closure and post-closure of the NSDF. Results of the radiological dose assessment for the operations and closure phase and post-closure phase indicates that doses to ecological health VCs are below their respective benchmark values. The predicted non-radiological concentrations in surface water during operations were less than the selected guidelines for most non-radiological parameters, although some predicted concentrations were greater than their guidelines for some scenarios. However, with the exception of selenium, predicted concentrations did not exceed local ambient concentrations in surface waterbodies. Selenium concentrations were less than the US EPA guidelines for protection of aquatic life and therefore are predicted to not result in adverse effects on aquatic life. Traditional access to the Pointe au Baptême site along the Ottawa River will continue to occur and will not be restricted due to the NSDF Project. As described in Section 5.9.5.2.1, there are no effects anticipated to archaeological resources as most mitigation for archaeological resources are applied and completed in advance of ground disturbance activities. Further, based on the archaeological assessments completed to date, potential archaeological sites within the SSA have been fully excavated and documented to the extent required under the Standards and Guidelines (OMTC 2011). No cultural heritage value or interest remains and the locations have been fully documented and the information is preserved for future study; therefore, no further archaeological work was recommended for the NSDF Project. Should previously undocumented archaeological resources be discovered, CNL will suspend construction immediately and will engage a licensed consultant to carry out archaeological fieldwork, in compliance with Sec. 48 (1) of the *Ontario Heritage Act*. If any human remains are identified during construction, CNL will immediately notify the police or coroner and the Registrar of Cemeteries, Ministry of Small Business and Consumer Services, and Indigenous communities or organizations.

The Comprehensive Preliminary Decommissioning Plan (CPDP) for the CRL site recognizes that the CRL site will be maintained under institutional control for at least 300 years. Where the continued land use designation of the LSA during post-closure is as a monitored site with restricted access, the presence of the NSDF will continue to be aligned, with no pathway to affect other land uses within the SSA.

Overall, there are no anticipated residual effects on continued traditional land and resource opportunities related to hunting, fishing, gathering and cultural ceremonies. No further assessment or characterization of residual effects is undertaken for this VC. However, to address Indigenous peoples concerns with regard to perceived risks on the safety and quality of lands and waters currently utilized for traditional land and resource use activities, considerations for monitoring and follow-up programs are provided in Section 6.4.6.

6.4.4.2.2 Secondary Pathways

Two secondary pathways were identified as having a linkage to the traditional land and resource use by Indigenous peoples – trapping VC during construction, operations and post-closure phase. These secondary pathways have been identified for changes in access to or quality and quantity of trapping opportunities for land and resource users, including Indigenous peoples.

- **Changes in access to traditional land and resource use – trapping**
- **Changes in the quality and quantity of traditional land and resource use – trapping**

The results of research identified that there may be a very limited amount of trapping occurring on Garrison Petawawa property; however there is no evidence to date that these traplines are held by individuals from Indigenous communities. It is possible that a portion of the RSA extends into the Garrison Petawawa property, and trapline PE002 is located on the Garrison Petawawa property (see Figure 5.9.4-1). Also, two trapline areas (PE025 and PE024) are located in the western portion of the RSA. However, the NSDF Project is not predicted to have terrestrial effects beyond the CRL site, and results of the aquatic environment assessment (Section 5.5) identify that measurable residual effects on aquatic biodiversity VCs are not predicted as a result of the NSDF Project. Further, there is a substantial amount of Crown and private land available for trapping outside the CRL site but in the vicinity of the Project.

CNL will work with Garrison Petawawa to consult with trappers about their use of the Garrison Petawawa property for trapping activities. CNL will also consult with trappers in the western portion of the RSA to understand any concerns; however, given the distance from the NSDF Project and that terrestrial effects are limited to the CRL site, no effects to trapping in these areas are anticipated.

No further assessment or characterization of residual effects is undertaken for this VC.

- **Changes in access to in the quality and quantity of traditional land and resource use – hunting, trapping, fishing, or gathering**

As previously noted, there are no traditional land and resource use activities occurring presently in either the SSA or LSA as this is a restricted access area. Traditional land and resource use activities likely did occur within the LSA prior to federal control of the CRL site. Restricted access at the Project site will be maintained until the end of institutional control, after which access within this area may be re-established. This represents a potential beneficial change to access for any hunting, trapping, fishing or gathering resources that may occur at that time and become accessible. However, given the limited areas of the LSA (226 ha) or SSA (37 ha) that may become accessible, this is anticipated to represent a negligible change to the total area within which traditional use is practiced. Access to fishing areas on the Ottawa River or traditional access to the Pointe au Baptême site along the Ottawa River will not be restricted due to the NSDF Project during any project phase.

Quality and quantity of hunting, trapping and fishing consider the health and well-being of people undertaking the activity, as well as ecological health. The effect of radiological and non-radiological releases on terrestrial and aquatic biota during the post-closure phase is assessed in the *Post-Closure Safety Assessment* (Arcadis and Quintessa 2020b) and the Ecological Risk Assessment (Arcadis 2020a), summarized in the assessment of effects of ambient radioactivity and ecological health in Section 5.7. No potential residual effects were identified for ambient radioactivity and ecological health during the post-closure phase. As well, the *Post-Closure Safety Assessment* (Arcadis and Quintessa 2020b) models potential effects of radiological and non-radiological releases on human health, using varying scenarios. Section 5.8 reports these findings as part of the assessment of effects to human health. One of the scenarios, detailed further in Section 6.6, included a Self-Sufficient Indigenous Group receptor, selected to assess potential future effects of the NSDF Project assuming this group obtains all of their food through hunting, and gathering in the area, has increased consumption of fish and wild game and gathers local mushrooms and berries. Modelling (Arcadis and Quintessa 2020b) has demonstrated the results for Self-Sufficient Indigenous Group receptor are below the acceptance criteria, and the modelled radiological dose is 13 times lower than the regulatory dose limit of 1 mSv/y. The highest exposure concentrations for chemical contaminants to human receptors, including the self-sufficient Indigenous receptor group is below the relevant guidelines (Arcadis and Quintessa 2020b).

As no residual effects were identified to the health of terrestrial or aquatic biota, or to the self-sufficient Indigenous receptor group, no change to the quality of hunting, trapping or fishing activities during the post-closure phase is anticipated.

6.4.4.2.3 Primary Pathways

No pathways were identified as having a primary linkage to land and resource use VCs. Therefore, the assessment has concluded that no residual effects on traditional land and resource use are anticipated as a result of the NSDF Project. As such, a residual effects analysis and assessment of significance is not required for traditional land and resource use VCs.

6.4.5 Monitoring and Follow-up

Monitoring and follow-up programs are not specifically identified for traditional land and resource use; rather, monitoring for environmental pathways noted above (e.g., for air quality, surface water quality , groundwater quality and terrestrial biota) will be implemented to verify effects predictions for land and resource use, and to promote land user comfort around the safety of the LSA, RSA and surrounding areas for traditional land and resource use (i.e., to reduce perceptions of adverse NSDF Project effects on traditional land and resource use that are not anticipated to occur). The MNO, through their TKLUS, have indicated that they think their citizens have negative perceptions associated with harvesting near the CRL site which results in not using an area (KnowHistory 2019). CNL's Public Information Program and enhanced engagement with Indigenous peoples is meant to address these negative perceptions by providing educational opportunities and sufficient factual information. CNL will continue to work with Indigenous communities and organizations to address any of these negative perceptions.

Monitoring to verify effects predictions will be on-going during operations, closure and post-closure (institutional control) phases, and the need for and duration of monitoring will be reviewed based on an annual review of monitoring data. This monitoring will be integrated into the CNL Environmental Monitoring Program.

As part of CNL's Public Information Program CNL will continue to engage with Indigenous communities, and share the results of the monitoring and follow-up programs recommended for air quality, surface water quality and groundwater quality data through an accessible format (e.g., NSDF Project website), a recognized best practice used by projects with high levels of perceived risk that may have the potential to alter or reduce land and resource use activity without primary or secondary pathways.

CNL has been carrying out discussions with some Indigenous communities on greater involvement by them in the follow-up monitoring programs. The form and level of this involvement has been discussed in only a preliminary fashion, but CNL is committed to greater Indigenous involvement in these programs.

Follow-up programs for archaeological resources are anticipated to be minimal as most mitigation for archaeological resources is applied and completed in advance of ground disturbance activities. Monitoring will be used to identify unanticipated archaeological resources and apply adaptive management through the implementation of the CNL Archaeological Master Plan and Cultural Resource Management Program (AECOM 2018). Should previously undocumented archaeological resources be discovered, CNL will suspend construction immediately and will engage a licensed consultant to carry out archaeological fieldwork, in compliance with Section 48(1) of the *Ontario Heritage Act* (AECOM 2018).

6.4.6 Conclusions

VCs refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, scientists, government agencies, Indigenous peoples, or the public (The Agency 2018). Traditional land and resource use VCs were selected based on the potential for the NSDF Project to interact with the features of the land and resource use environment. In addition, VCs for traditional land and resource use were selected based on a consideration of knowledge of traditional land and resource use practices that interact with the environment, Indigenous and/or treaty rights and community engagement.

The NSDF Project SSA and LSA are located entirely within the CRL site boundary, on federal lands. Therefore, aside from the operations and activities undertaken by CNL, other land uses of the CRL site are prohibited due to restricted public access. The lands of the RSA also extend into Garrison Petawawa, other federal lands with restricted public access. As such, there are limited land and resource use tenures, other registered interests, or outdoor tourism and recreational areas occurring within the RSA that have the potential to be disturbed by the NSDF Project. Land users have been identified as potentially trapping in the southern and western portions of the RSA, which overlaps the land and resource use RSA. However, the NSDF Project is not predicted to have any terrestrial effects beyond the CRL site, and results of the aquatic environment assessment identify that measurable residual effects on aquatic biodiversity VCs are not predicted as a result of the NSDF Project. Therefore, no effects on terrestrial or aquatic species defined as traditional land and resource use VCs are expected. Traditional access to the Pointe au Baptême site along the Ottawa River will continue to occur and not be restricted because of the NSDF Project. There are no effects anticipated to archaeological resources as most mitigation for archaeological resources is applied and completed in advance of ground disturbance activities. The Cultural Resource Management portion of the Environmental Protection Program will be used to identify unanticipated archaeological resources and implement adaptive management. Consequently, the NSDF Project is not expected to affect the traditional land and resource VCs.

6.5 Indigenous Health and Indigenous Receptor

Indigenous peoples have expressed a general concern about the potential effect of the NSDF Project on their health. This has partially arisen from the view that they have a greater degree of reliance on foods obtained from traditional land and resource use than the general public.

Traditional land and resource use harvesting patterns to date suggest that there is no harvesting at the CRL site because it is restricted access and limited harvesting near or adjacent to the CRL site as there is little to no Crown land in the immediate area (see Section 6.4). No pathways were identified as having a primary linkage to traditional land and resource use VCs.

The hunter/recreational receptor within the Post-closure Safety Assessment (Arcadis and Quintessa 2020b) generally represents CNL's understanding of how Indigenous peoples may interact with the site based on their current practices. This group is represented by a small number of adults and children making hunting and/or recreational use of the area surrounding the ECM, including Perch Creek and the Ottawa River. This group occasionally drinks water from the creek, and eats deer hunted from the site.

To address potential future safety concerns of Indigenous peoples, as part the NSDF Post-closure Safety Assessment (Arcadis and Quintessa 2020b) a Self-Sufficient Indigenous Group receptor was selected to assess potential future effects of the NSDF Project on such a group. This assessment addresses uncertainty in future lifestyle of Indigenous peoples.

The Self-Sufficient Indigenous Group receptor is defined as:

> *"a group of indigenous peoples, including adults and children, using area surrounding the ECM, including Perch Creek and the Ottawa River, for hunting and gathering. Individuals in this group are assumed to obtain all of their food through hunting, and gathering in the area. It is assumed that this group would have increased consumption of fish and wild game. Furthermore, this group is assumed to gather local mushrooms and berries." (Arcadis and Quintessa 2020b)*

The exposure pathways for the Self-Sufficient Indigenous Group are:

- drinking water from Perch Creek;
- ingestion of fish caught from the Ottawa River;
- groundshine (i.e., radiation from radioactive material on the ground), inhalation of dust and inadvertent consumption of soil from occasional use of the area between the ECM and Perch Creek, and while fishing from the river shore;
- hunting of game, such as deer, moose, duck and grouse, that uses the river and creek for drinking water and grazes the area between the ECM and Perch Creek; and
- foraging of wild honey, berries and mushrooms.

Therefore, the Self-Sufficient Indigenous Group receptor is one in which the group is physically located at the NSDF site and relies completely on local food and water consumption in the future. As such, it represents an extreme or cautious future scenario.

Final modelling (Arcadis and Quintessa 2020b) has demonstrated the results for Self-Sufficient Indigenous Group receptor are below the acceptance criteria. Radiological dose to the Self Sufficient Indigenous Group Receptor is 0.077 mSv/yr and occurs 520 years after closure. This dose is 13 times lower than the public dose limit of 1 mSv/yr.

6.6 Canadian Nuclear Laboratories' Long-term Relationship with Indigenous Peoples

In engagements with Indigenous communities, it is clear that Indigenous peoples do not want to look at the NSDF Project solely in isolation from all other issues and matters pertaining to the AECL properties in the Ottawa Valley. Issues raised by the various Indigenous peoples include issues associated with the historical take-up of the lands, long-term operations and future operations and scenarios. CNL respects and understands these opinions and has approached its Indigenous engagement in such a way as to answer and address some of these broader questions as well as engaging directly on the NSDF Project.

CNL is working towards developing long-term relationships with Indigenous peoples that occupy and have traditional territories and modern-day interests near its operations. CNL recognizes that such relationships may take a long time to form but believes this is consistent with the Government of Canada's approach to reconciliation with Indigenous peoples.

CNL has been working closely with AECL on the approach to and activities with respect to Indigenous peoples. AECL's roles and responsibilities on Indigenous engagement and consultation arise from it being a federal Crown corporation and agent of the Government of Canada. As well, AECL is the appropriate entity that can respond to Indigenous peoples on questions surrounding the original take-up of the lands by the Crown, ownership of the lands and future uses of the land. AECL is committed to engaging with Indigenous peoples in an open and cooperative way to work towards mutual understanding and opportunities for mutual benefit.

CNL has been in discussions with various Indigenous peoples and has signed MOUs with the MNO and AOO on developing longer-term relationships. CNL is able to work with Indigenous peoples on subject matters within the scope of its operations. This includes topics such as employment, contracting, engagement, monitoring and other issues. AECL's involvement is required on topics that relate to the property holdings and also out of the Crown's wider responsibilities with respect to Indigenous peoples.

CNL is working closely with AECL on Indigenous peoples that reside more within AECL's responsibility. Engagement with Indigenous peoples has demonstrated that these communities are also interested in fostering such long-term relationships. As such, CNL, AECL and the Indigenous communities see their relationships as evolving and beyond the scope of a single regulatory project such as the NSDF Project. Mechanisms will be built into any such formal or informal relationship agreement that show how specific NSDF Project issues or commitments are to be addressed. For example, longer-term relationship agreements may discuss the topic of Indigenous participation in environmental monitoring, which may be both CRL site wide and/or NSDF Project specific. As well, CNL has moved forward on employment and contracting opportunities for the CRL site in general which would also include the NSDF Project. CNL and AECL are of the opinion that such a broader approach is more consistent with the Government of Canada's approach to reconciliation and its principles respecting the Government of Canada's relationship with Indigenous peoples.

The discussions on long-term relationships and on specific aspects of projects such as the NSDF Project will be on-going up until and after the Commission Hearing for the NSDF Project. Because of the on-going nature of these discussions and relationships, CNL intends to provide a revised IER as part of the Commission Member Document package for the CNSC Commission Hearing on the NSDF Project. That revised IER would document the on-going engagement, discussions and negotiations with Indigenous peoples that would be relevant both corporately and NSDF Project-specific.

7.0 ACCIDENTS AND MALFUNCTIONS

This section of the Environmental Impact Statement (EIS) for the Canadian Nuclear Laboratories (CNL) Near Surface Disposal Facility (NSDF) for the disposal of solid, low-level radioactive waste at Chalk River Laboratories (CRL) (the 'NSDF Project'), identifies accidents and malfunctions, and their potential health and environmental effects that may occur during pre-closure (i.e., construction, operations and closure phases) of the NSDF Project.

Accidents and malfunctions refer to events or upset conditions that are not part of the normal activity/operation of the NSDF Project as planned. An accident is any unintended event, including operating errors, equipment failures or other mishaps, the consequences or potential consequences of which are significant from the point of view of protection of safety (*REGDOC-3.6 Glossary* [CNSC 2018]). The risk of accidents and malfunctions can be reduced and mitigated through design, administrative controls, adoption of safety measures and emergency response planning.

Accidents and malfunctions that may occur during pre-closure of the NSDF Project were identified, characterized and evaluated in the *NSDF Safety Analysis Report* (CNL 2020). The assessment of potential accidents and malfunctions considered both radiological and non-radiological conventional events. Radiological accidents and malfunctions are events that involve radioactive substances and could result in the release of radioactivity as well as non-radiological substances. Non-radiological conventional accidents and malfunctions are events that involve only non-radiological substances and therefore have no potential for the release of radioactivity. Following pre-closure is the post-closure phase of the NSDF Project, where monitoring and long-term care and maintenance will take place during the institutional control period. The *Post-Closure Safety Assessment* (Arcadis and Quintessa 2020) considered disruptive event scenarios and "what-if" cases, which examine the potential effects of unlikely disruptive events that lead to possible penetration of barriers and abnormal degradation and loss of containment. These post-closure disruptive scenarios are designed to test the robustness of the NSDF Project and are not considered accidents and malfunctions. In the post-institutional control period, there will be no workers or activities on-site, and as such there is no possibility for accidents or malfunctions to occur.

The post-closure phase disruptive event scenarios are summarized in Section 5.7 Ambient Radioactivity and Ecological Health and Section 5.8 Human Health.

7.1 Regulatory Context

The EIS Guidelines (CNSC 2016a) dictate that the information in Appendix A.3.4 of *REGDOC-2.9.1 Environmental Protection: Environmental Principles, Assessments and Protection Measures* (CNSC 2017) be used to assess the potential health and environmental effects from postulated accident and malfunction scenarios.

As per *REGDOC-2.9.1* (CNSC 2017), the applicant should provide an assessment of the potential health and environmental effects that occur from radiological and conventional accidents and malfunctions. The EIS should also include mitigation such as monitoring, contingency, clean-up or remediation work in the surrounding environment that would be required during or immediately following the postulated accident and malfunction scenarios.

The safety analysis in the *NSDF Safety Analysis Report* (CNL 2020) follows the safety objectives as defined in CNSC's *REGDOC-2.4.1 Deterministic Safety Analysis* (CNSC 2014).

7.2 General Approach

A systematic and comprehensive approach was used to identify the major hazards and postulated initiating events associated with the design and operations of the NSDF Project. The accident and malfunction assessment includes:

1) Hazard identification and hazard analysis.

2) Screening of hazards.

3) Assessment of bounding or key accidents and malfunctions.

Further details on the hazard identification, hazard analysis and screening process are provided in the *NSDF Safety Analysis Report* (CNL 2020).

7.2.1 Hazard Identification and Hazard Analysis

Hazard identification and hazard analysis was conducted at several stages during the design of the NSDF Project. A series of workshops were conducted with subject matter experts including engineers, safety analysts, waste operations specialists to systematically identify and categorize major hazards and the postulated initiating events associated with the design, construction and operation of the NSDF Project.

In general, the hazard identification and analysis process consisted of:

- Systematically evaluate hazards and initiating events, and develop accident sequences/scenarios and potential consequences.
- Identify the category of the scenario consequence being radiological, industrial (conventional) or environmental.
- Qualitatively estimate the frequency and the severity for the consequence of the mitigated hazard or initiating event scenario.
- The frequency and severity are combined to determine the risk ranking of the mitigated hazard or initiating event scenario.
- Identify mitigation including administrative and engineered controls for the mitigated hazard or initiating event scenario.

Table 7.2.1-1 is the consolidated list of major hazards and initiating events, and potential scenarios applicable to the NSDF, and this list of hazards was used during the hazard analyses.

Table 7.2.1-1: List of Major Hazards/Postulated Initiating Events and Potential Scenarios Applicable to the Near Surface Disposal Facility

Initiating Event / Hazard	Potential Scenarios and Applicable NSDF System
Containment Failure	1. Liner failure (applicable to ECM). 2. Rupture of waste packages (applicable to ECM, WWTP). 3. Failure of piping or tank (applicable to ECM, WWTP and VDF). 4. Final cover degradation on closed disposal cell (applicable to ECM). 5. Leaks from vehicles (applicable to all NSDF systems).
Contamination	1. Contamination on waste packages and bulk waste (applicable to ECM). 2. Contamination (airborne) released during waste placement and compaction (applicable to ECM). 3. Contamination transfer by wildlife (applicable to ECM). 4. Worker contaminated or exposed during facility operations (applicable to ECM, WWTP and VDF). 5. Contamination on transport vehicle (applicable to VDF).
Corrosion	1. Corrosion of waste containers (applicable to ECM). 2. Corrosion of chemical containers (applicable to WWTP).
Crane Failure	1. Crane failure during transfer waste placement (applicable to ECM and WWTP).
Dropped Load	1. Dropped waste package or chemical container due to mechanical failure, malfunction of lifting/hoisting equipment or human error (applicable to ECM and WWTP). 2. Waste package(s) or chemical container(s) fall off of transport vehicle during transport (applicable to ECM).
Explosion (deflagrations and detonations)	1. Burning combustible material in facility (applicable to all NSDF systems). 2. Facility/equipment (applicable to all NSDF systems). 3. Adjacent buildings (applicable to all NSDF systems). 4. Passing vehicle (applicable to all NSDF systems).
External Hazard (Natural)[1]	1. Earthquake (seismic activity) (Applicable to all NSDF systems). 2. Extreme meteorological conditions – temperature, snow, freezing rain, wind, drought, and rain (Applicable to all NSDF systems). 3. Ground subsidence, soil erosion or frost heave (Applicable to all NSDF systems). 4. Flooding – precipitation, dam failure, snow melt, and rise in water table (Applicable to all NSDF systems). 5. Wildland fire (Applicable to all NSDF systems). 6. Tornados and microbursts (with or without projectiles) (Applicable to all NSDF systems). 7. Lightning (Applicable to all NSDF systems). 8. Biological phenomena (e.g., algae, fauna and flora invasion and biological contamination) (Applicable to ECM and WWTP). 9. Intrusion of non-human biota (e.g. animals such as fox, bear, deer, geese, etc.) (Applicable to all NSDF systems).
Damaged Structure	1. Structural collapse (Applicable to all NSDF systems). 2. Collapse or damage of structures during waste placement and compaction (applicable to ECM).
Fire	1. Internally caused fire within ECM 2. Internally caused fire within WWTP. 3. Vehicle fire (applicable to all NSDF systems).
Hazardous Reaction	1. Chemical reaction hazards—applicable to the ECM and WWTP.

Table 7.2.1-1: List of Major Hazards/Postulated Initiating Events and Potential Scenarios Applicable to the Near Surface Disposal Facility

Initiating Event / Hazard	Potential Scenarios and Applicable NSDF System
Loss of Services	1. Loss of facility power due to natural phenomena events and certain external events, (applicable to all NSDF systems). 2. Interruption of electrical power/loss (applicable to all NSDF systems). 3. Loss of facility support systems. 4. Loss of natural gas (applicable to WWTP and associated facilities). 5. Loss of active drain (applicable to WWTP). 6. Loss or malfunction of emergency equipment (applicable to all NSDF systems).
Loss of Shielding	1. Damage to shielded package, leading to worker exposure (applicable to ECM). 2. Loss of shielding, leading to worker exposure (applicable to WWTP).
Loss of Ventilation	1. Failures in ventilation system, including failure or malfunction of high-efficiency particulate air filter, fan and duct (applicable to WWTP and VDF).
Radiation	1. Temporary waste storage area (applicable to ECM). 2. Excessive dose rate encountered (applicable to ECM and WWTP). 3. High doses due to high fields and airborne contamination emanating from waste (applicable to ECM, WWTP and VDF).
Unintended Contents	1. Chemical hazards in waste not adequately treated (applicable to ECM and WWTP). 2. Waste placed in disposal cell is retrieved due to not meeting the WAC (applicable to ECM). 3. Bulk waste is stuck in International Organization for Standardization container being disposed into disposal cell (applicable to ECM). 4. Release of liquid effluent that does not meet effluent discharge targets (applicable to WWTP).
Vehicle Collision	1. Collision of transport vehicles (applicable to all NSDF systems). 2. Transport vehicle falls into disposal cell (applicable to ECM). 3. Vehicle impact with structure (applicable to all NSDF systems). 4. Snow removal equipment impacting structure (applicable to all NSDF systems).
Equipment Failure	1. Loss or malfunction of instrumentation or equipment (Applicable to all NSDF systems). 2. Maintenance or inspection deficiency (applicable to all NSDF systems). 3. Aging of equipment (applicable to all NSDF systems).

ECM = engineered containment mound; WWTP = Wastewater Treatment Plant; VDF = vehicle decontamination facility; WAC = Waste Acceptance Criteria.

1) External hazards (natural) that could result in accidents and malfunctions are not discussed in Section 7 Accidents and Malfunctions and are discussed in Section 10 Effects of the Environment.

7.2.2 Screening of Hazards and Events

The hazards and the events screening involves:

1) Grouping the hazards and events based on the event frequency.

2) Assessing the risk ranking of the mitigated hazards and events. The risk rankings are mitigated risks, taking into account mitigation and administrative controls that potentially lower the frequency and/or the severity of the event. The risk rankings are based on a risk matrix combining qualitative assessments of event frequency and severity, reproduced in Table 7.2.2-1. The risks are described qualitatively in Table 7.2.2-2 and are based on frequency ratings as shown in Table 7.2.2-3 and severity ratings as shown in Table 7.2.2-4.

3) Assessing and selecting the bounding or key accidents and malfunctions based on the mitigated hazards and events with the higher risk ranking and consequence severity.

The hazards and events are grouped based on the frequency of the event (see Table 7.2.2-3):

- Anticipated Operational Occurrences.
- Design Basis Accidents.
- Beyond Design Basis Accidents, including Design Extension Conditions (DECs).

An Anticipated Operational Occurrence is an operational process deviating from normal operations, which is expected to occur once or several times during the operating lifetime of the NSDF Project but which, in view of the appropriate design provisions, does not cause any significant damage to items important to safety nor lead to accident conditions. These include events with frequencies of occurrence greater than or equal to 10^{-2} events per year (i.e., 1 event in 100 years).

Design Basis Accidents are accident conditions against which the NSDF Project is designed according to established design criteria, and for which the release of radioactive materials are kept within authorized limits. These include all events with frequencies of occurrence equal to or greater than 10^{-5} per year (1 event in 10 000 years), but less than 10^{-2} per year (1 event in 100 years). This class of events also includes any events that are used as a design basis for a safety system, regardless of whether the estimated frequencies are less than 10^{-5} per year.

Beyond Design Basis Accidents are accidents falling outside the design envelope of a Nuclear Facility's safety systems (accident conditions more severe than those of a Design Basis Accidents). These include events with frequencies of occurrence less than 10^{-5} per year (less than 1 event in 10,000 years).

Design Extension Conditions are a subset of beyond-design-basis accidents that are considered in the design process of the facility in accordance with best-estimate methodology to keep releases of radioactive material within acceptable limits. Design Extension Conditions could include severe accident conditions. Design Extension Conditions are assessed as a subset of Beyond Design Basis Accidents.

The credible malfunctions and accidents events are Anticipated Operational Occurrences, Design Basis Accidents, and Design Extension Conditions.

Table 7.2.2-1: Risk Matrix

Frequency	S0	S1	S2	S3
Anticipated Operational Occurrences (≥10^{-2}/a)	R0	R1	R2	R3
Design Basis Accidents (≥10^{-5}/a to <10^{-2}/a)	R0	R0	R1	R2
Beyond Design Basis Accidents (10^{-6}/a to <10^{-5}/a)	R0	R0	R0	R1

Table 7.2.2-2: Guidelines for Interpreting Risk Rankings

Risk Ranking	Definition
R0	The risk is negligible; no further action necessary.
R1	The risk is tolerable; further protective measures are not essential but should be considered[1].
R2	The risk is unreasonable; engineered solutions must be put in place to protect against the hazard.
R3	The risk is unreasonable; the proposed process or equipment is inherently unsafe, major modifications to the proposed design are required.

Table 7.2.2-3: Frequency Ratings

Frequency Class	Frequency Range (events/year)	Definition
F0	10^{-6} to <10^{-5}	Selected Beyond Design Basis Accident that is very unlikely to occur over the lifetime of the Facility. An accident less frequent and potentially more severe than a design-basis accident.
F1	≥10^{-5} to <10^{-2}	Design Basis Accident that is unlikely to occur over the lifetime of the facility, but is considered plausible.
F2	≥10^{-2}	An occasional event, Anticipated Operational Occurrence, upset condition, this event is expected to occur over the lifetime of the facility but is not considered a normal operation.

[1] Further measures are typically additional administrative controls and/or simple design changes.

Table 7.2.2-4: Severity Ratings

Severity Rating	Definition
S0	**Industrial Consequences**: Consequences are negligible, minor injury requiring First Aid treatment which does not result in lost time from work [(a)]. **Operational Consequences**: No operational impacts and facility does not require a shutdown (e.g., for clean-up, etc.). **Radiological Consequences**: Effective doses up to 1 mSv (on-site) and/or 0.1 mSv (off-site). **Environmental Consequences**: Negligible release to the environment, effect may be measurable. Impacts to the environment are very small/negligible and localised (on-site)/short duration.
S1	**Industrial Consequences**: Consequences are minor, injury or an occupational disease requiring medical treatment by a medical practitioner[(b)] (other than CNL health centre nurse), a disabling injury resulting in a medical practitioner prescribing work restrictions (and modified work is offered by CNL)[(c)] or time off from work (lost time) of up to 5 days [(d)]. **Operational Consequences**: Minor operational impact and facility may require shut down for up to 1 day. **Radiological Consequences**: Effective doses in the range of 1 to 5 mSv (on-site) and/or 0.1 to 0.5 mSv (off-site). **Environmental Consequences**: Minor release to the environment, effect is measurable. Impacts to the environment are moderately extensive (on-site, may be off-site) and moderate duration.
S2	**Industrial Consequences**: Consequences are moderate, electric shock, toxic atmosphere, or oxygen deficient atmosphere that causes loss of consciousness. The implementation of rescue, revival or other similar emergency procedures. A disabling (non-permanent) injury/disease (to one or more workers) [(e)] resulting in a total lost time >5 days and up to 60 days [(f)]. **Operational Consequences**: Moderate operational impact and facility may require shut down for >1 to 5 days. **Radiological Consequences**: Effective doses in the range of 5 to 50 mSv (on-site) and/or 0.5 to 20 mSv (off-site). **Environmental Consequences**: Moderate release to the environment. Impacts to the environment are extensive (on-site and off-site) and long duration.
S3	**Industrial Consequences**: Consequences are severe, fatality, a disabling injury resulting in loss of a body member or a part thereof, or the complete loss of the usefulness of a body member or a part thereof, permanent impairment of a body function, a disabling (non-permanent) injury (to one or more workers)[(e)] resulting in a total lost time >60 days. **Operational Consequences**: Major operational impact and facility shut down for greater than 5 days. **Radiological Consequences**: Effective doses >50 mSv (on-site) and/or >20 mSv (off-site). **Environmental Consequences**: Major release to the environment. Impacts to the environment are catastrophic.

Note:

(a) Minor cut treated at the CNL health centre (not requiring stitches).

(b) Cut requiring stitches.

(c) Doctor prescribes 'no manual lifting' for employee whose employment requires lifting.

(d) Injury requiring medication to be prescribed which makes it unsafe to attend work.

(e) One person injured or summation of lost time for multiple injured individuals.

(f) Broken bones preventing return to work.

mSv = millisievert.

7.2.3 Assessment of Key Accidents and Malfunctions

The assessment of key accidents and malfunctions includes:

- Identify the hazard.
- Description of the accident or malfunction scenario.
- Identify the potential health and environmental effects.
- Identify mitigation in the NSDF Project design and CNL processes that mitigate the hazard and minimize the potential health and environmental effects.

7.2.3.1 Identification of Valued Components

The bounding or key accidents and malfunctions were evaluated to assess the effects to humans and non-human biota. Human receptors included workers and members of the public (see Section 5.8 Human Health). The list of proposed Valued Components was developed for non-human biota that are found in the vicinity of the NSDF Project site, have potential for exposure, play a key role in the food web, and represent a variety of habits and trophic levels (see Section 5.7). To determine the potential effect of radiological and non-radiological emissions on the environment, a smaller group of indicator species was chosen to represent Valued Components selected for assessment. Tables in Section 7.3 and Section 7.4 identify if there is any pathway linkage to non-human biota, which requires an effects assessment in Section 5.7.

7.3 Radiological Accidents and Malfunctions

This section describes the accidents and malfunctions with radiological consequences during construction, operations and closure. Detailed information on the radiological accidents and malfunctions is available in the *NSDF Safety Analysis Report* (CNL 2020).

7.3.1 Radiological Dose Acceptance Criteria for Accidents

The CNSC has set the regulatory limits for exposure to workers and members of the public (*Radiation Protection Regulations*) to ensure that the probability of occurrence of effects is acceptably low. For normal operations, the radiological doses from radionuclide releases and direct radiation exposure must not exceed 50 millisieverts (mSv) annually for Nuclear Energy Workers and 1 mSv annually for members of the public (at the NSDF Project site boundary) to meet the CNSC regulatory dose limits (SOR/2000-203). In addition, the CRL licensing handbook (CNSC 2019) sets an annual dose constraint of 0.3 mSv for members of the public.

CNL's *Safety Analysis for Decommissioning and Waste Management* (CNL 2019a) and the NSDF Safety Analysis Report (CNL 2020) defines the dose acceptance criteria for accidents, dependent on the frequency of the event, and is provided in Table 7.3.1-1.

For the protection of non-human biota from radiation exposure, the primary concern is the total radiation dose to the organisms resulting in deterministic effects (i.e., threshold below which the effect does not occur). If the estimated dose is less than the no-effects concentration, then the radiological risk is considered acceptable.

Table 7.3.1-1: Dose Acceptance Criteria for Accidents

Frequency	Qualitative Event Description	Off-Site Doses[a] (mSv)	On-Site Doses[b] (mSv)
$\geq 10^{-2}$	Anticipated Operational Occurrences	0.5	5
$\geq 10^{-5}$ to $<10^{-2}$	Design Basis Accidents	20	50
10^{-6} to $<10^{-5}$	Selected Beyond Design Basis Accidents, including Design Extension Conditions	Assessed[c]	Assessed[c]

(a) Off-site doses represent the dose to the public.

(b) On-site personnel, not directly involved in the accident.

(c) When identified, dose assessments should be performed, and if the dose exceed the 20 mSv Design Basis Accidents limit, emergency procedures should be reviewed to determine if new mitigating measures can be identified.

mSv = millisievert.

7.3.2 Construction

Radiological hazards during the site preparation and construction periods are very limited because the NSDF Project site is an area that has never been used by operations at CRL that have involved radioactive (or otherwise contaminated) materials.

7.3.2.1 Assessment of Construction Radiological Accidents and Malfunctions

Table 7.3.2-1 is the assessment of the key potential radiological accident and malfunction that could occur during the construction of the Facility.

Table 7.3.2-1: Assessment of the Key Potential Radiological Accident and Malfunction During Construction

ID	Radiological Hazard	Scenario	Mitigation	Potential Health and Environmental Effects After Mitigation
A1	Radioactive source associated with industrial radiography.	Radiography equipment containing a radioactive source is used for non-destructive testing and human error results in the source being unshielded and potential worker dose.	▪ Proper training of Certified Exposure Device Operators. ▪ Shot Plan for radiography. ▪ Administrative controls, such as restricting access and maintaining a safe distance. ▪ Shielding. ▪ Barriers. ▪ Personal Alarming Dosimeter.	▪ The potential radiological consequence to worker health is minor. There is no linkage pathway to the public or non-human biota as the effect is localized.

7.3.3 Operations and Closure

The radiological accidents and malfunctions during the operations period bound those during the closure period, since the radiological source term in the NSDF Project is greater during the operations period.

7.3.3.1 Assessment of Key Potential Hazards and Accidents during the Operations

Table 7.3.3-1 is the assessment of the key potential radiological accident and malfunction that could occur during the operations of the NSDF Project.

Table 7.3.3-1: Assessment of the Key Potential Radiological Accident and Malfunction During Operations

ID	Radiological Hazard	Scenario	Mitigation	Potential Health and Environmental Effects After Mitigation
B1	Dropped Load – ECM	Dropped load at the ECM during waste package placement or handling could result in potential damage to the waste package and the spread of contamination.	▪ PPE&C. Personal alarming dosimeter. Preventative maintenance of equipment and vehicles. Barriers. Line of fire awareness.	▪ A dropped load results in a localized effect that is readily remediated. The potential health effects to workers is negligible. The dose to the worker is 0.04 mSv (CNL 2020). The primary radionuclides contributing to the worker dose are americium-241, cobalt-60 and plutonium-239 (CNL 2020). ▪ There is no linkage pathway to the public or non-human biota as effects are localized (on-site) with a very short duration.
B2	Internal Fire – ECM	An internal fire resulting in the in the ignition of combustible waste materials, occurs at the Temporary Storage and Waste Receiving and Processing Area (TSWRPA) within the ECM. An internal fire within ECM could be initiated by the wildland fire, lightning, vehicle fire or equipment electrical failure.	▪ CRL Fire Department. ▪ NSDF Fire Water Pump Station. ▪ Vehicle/equipment maintenance. ▪ Portable fire extinguishers on the vehicles.	▪ The waste fire in the TSWRPA results in a localized effect that is readily remediated. The potential health effects are negligible to the on-site receptors and the public, and minor to the NSDF workers. The dose to the NSDF worker is 2.4 mSv (CNL 2020). The dose to the on-site receptor located 1,000 m away is 0.052 mSv (CNL 2020). The doses to the off-site adult and 1-year old child receptors located 3 km away are 0.021 mSv and 0.014 mSv, respectively (CNL 2020). The primary radionuclide contributing to the dose is Cobalt-60 (CNL 2020). ▪ There is a secondary pathway for changes in air quality which can then affect non-human biota. Potential effects are expected to be negligible because they will be short in duration and localized to the NSDF Project site.
B3	Dropped Load - WWTP	Dropped load at the WWTP involving the filter press dewatered residuals bin resulting in the dewater residuals being spilled.	▪ PPE&C. ▪ Personal alarming dosimeter. ▪ Preventative maintenance of equipment and vehicles. Barriers. ▪ Line of fire awareness.	▪ A dropped load results in a localized effect that is readily remediated. The potential health effects to the workers and the public are negligible. The dose to the worker is 0.0074 mSv for a 10-minute exposure, and 0.044 mSv for a 60-minute exposure (CNL 2020). The primary radionuclide contributing to the dose is cobalt-60 (CNL 2020). ▪ There is no linkage pathway to the public or non-human biota as effects are localised (on-site) and for a short duration.

Table 7.3.3-1: Assessment of the Key Potential Radiological Accident and Malfunction During Operations

ID	Radiological Hazard	Scenario	Mitigation	Potential Health and Environmental Effects After Mitigation
B4	Internal Fire - WWTP	An internal fire in the WWTP Residuals Management Area could be initiated due flammable gas release, spontaneous combustion from chemical reaction, vehicle fire or electrical fire resulting in potential dose to the on-site and off-site receptors.	▪ WWTP fire detection system. ▪ CRL Fire Department. ▪ NSDF Fire Water Pump Station. ▪ Vehicle/equipment maintenance. ▪ Portable fire extinguishers on the vehicles.	▪ The fire in the WWTP Residuals Management Area results in a localized effect that is readily remediated. The potential health effects are negligible to the workers and the public. The dose to the on-site receptor located 1,000 m away is 0.00000056 mSv (CNL 2020). The doses to the off-site public adult and 1-year old child receptors located 3 km away are 0.00000024 mSv and 0.00000015 mSv, respectively (CNL 2020). The primary radionuclide contributing to the dose is cobalt-60 (CNL 2020). ▪ There is a secondary pathway for changes in air quality which can then affect non-human biota. Potential effects are expected to be negligible as they will be short in duration and localized to the NSDF Project site.
B5	Contamination - WWTP	WWTP worker could be splashed during the sampling of the process tanks resulting in potential dose to the worker.	▪ PPE&C. ▪ Chemical shower / eye wash stations. ▪ Spill kits.	▪ A worker being splashed in the WWTP results in a localized effect that is readily remediated. The potential health effects to the worker is negligible. The dose to the worker is 0.0003 mSv (CNL 2020). The primary radionuclide contributing to the dose is cobalt-60 (CNL 2020). ▪ There is no linkage pathway to the public or non-human biota as effects are localised (on-site) and would be contained.
B6	Spill/leak of wastewater at WWTP	Mechanical failure of the WWTP tanks, piping and/or valves could result in a spill of wastewater. The event is assumed to affect the membrane filter feed tanks, membrane filter process tanks and associated piping resulting in a spill of 96,000 L with a small amount of water becoming suspended in air following the free-fall spill.	▪ Secondary containment. ▪ Leak detection. ▪ Active drain system. ▪ PPE&C. ▪ Spill kits.	▪ A spill of wastewater in the WWTP results in a localized effect that is readily remediated. The potential health effects to the worker is negligible. The dose to the WWTP worker is 0.000076 mSv (CNL 2020). The primary radionuclides contributing to the dose are cobalt-60 and tritium (CNL 2020). ▪ There is no linkage pathway to the public or non-human biota as effects are localised (on-site) and would be contained.

Table 7.3.3-1: Assessment of the Key Potential Radiological Accident and Malfunction During Operations

ID	Radiological Hazard	Scenario	Mitigation	Potential Health and Environmental Effects After Mitigation
B7	Spill/leak of contaminated IX resin at WWTP	A contaminated IX resin spill may occur during the replacement or transfer of spent resins.	▪ Secondary containment. ▪ Leak detection. ▪ Active drain system. ▪ PPE&C. ▪ Spill kits.	▪ A spill of contaminated IX resin in the WWTP results in a localized effect that is readily remediated. The potential health effects to the worker are negligible. The dose to the worker is 0.0052 mSv for a 10-minute exposure and 0.0031 mSv for a 60-minute exposure (CNL 2020). The primary radionuclide contributing to the dose is cobalt-60 (CNL 2020). ▪ There is no linkage pathway to the public or non-human biota as effects are localised (on-site) and would be contained.

ECM = Engineered Containment Mound; mSv = millisievert; PPE&C = personal protective equipment and clothing; TSWRPA = Temporary Storage and Waste Receiving and Processing Area; WWTP = Wastewater Treatment Plant.

7.3.4 Risk Matrix of Radiological Accidents and Malfunctions

Table 7.3.4-1 presents the risk matrix overlaid with the eight key radiological accidents and malfunctions, according to their severity, frequency and risk ratings. For the radiological accidents and malfunctions, the dose to the workers and the public meet the dose acceptance criteria for accidents, and the risks are acceptable and low with mitigation in place.

Table 7.3.4-1: Risk Matrix of Radiological Accidents and Malfunctions

Frequency	S0	S1	S2	S3
Anticipated Operational Occurrences ($\geq 10^{-2}$/a)	R0 (B1, B3, B5)	R1 (A1, B6)	R2	R3
Design Basis Accidents ($\geq 10^{-5}$/a to $< 10^{-2}$/a)	R0 (B3, B7)	R0 (B2, B4)	R1 (B1[1])	R2
Beyond Design Basis Accidents (10^{-6}/a to $< 10^{-5}$/a)	R0	R0	R0	R1

[1] High dose rate waste package (>2 mSv/hour near contact or >0.1 mSv/hr at 1 m).

7.4 Conventional (Non-radiological) Accidents and Malfunctions

This section describes the accidents and malfunctions with conventional non-radiological consequences during construction, operations and closure. Detailed information on the conventional accidents and malfunctions is available in the *NSDF Safety Analysis Report* (CNL 2020) and the *Conventional Safety Analysis* (AECOM 2018).

7.4.1 Construction

Major construction projects (which includes decommissioning activities) involve the interaction of personnel with hazards such as moving and stationary heavy equipment/machinery, electricity and temporary power lines, working at heights, working in confined spaces, working with potentially unstable structures, etc. In contrast to specific industrial facilities where each activity/position is routine, with little variability, well characterized, and the occupational settings are well defined, construction projects can involve several ad hoc tasks performed by workers as part of the execution of a larger overall activity. Such projects may also use equipment that are generally rotated from one site to another (e.g., cranes). In these situations, conventional non-radiological accidents and malfunctions are governed by the limits of human performance as well as the reliability of the equipment (related to its maintenance).

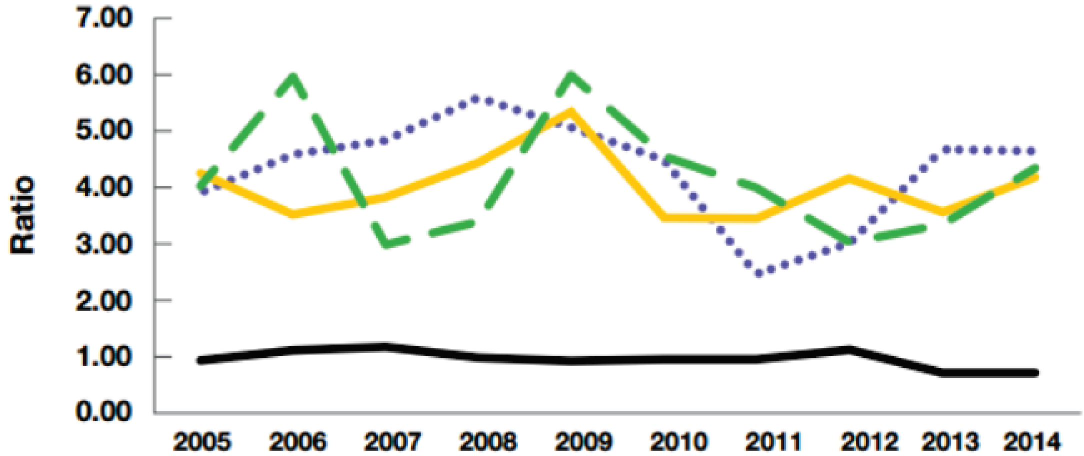
According to the Ontario Ministry of Labour (MOL) report titled *Occupational Health & Safety in Ontario 2014-2015* (MOL 2016), from 2005 to 2014, 28.3% of traumatic fatalities and 28.0% of occupational disease fatalities occurred in the construction sector, while this sector accounted for 7.0% of total employment under provincial jurisdiction (2014). These statistics indicate that higher fatality rates occur in the construction industry compared with other industrial sectors. The MOL (2015) report also noted that for the last 10 years, construction and transportation sectors have been the top two sectors in terms of the fatality rates (depicted in Figure 7.4-1).

The fatality rate in the construction sector has not appeared to change over this time period. This consistency over time suggests that the rates of these accidents and malfunctions in these sectors are being controlled by human performance in typical industry practices, and as such, rates have reached an as-low-as-reasonably-possible state under the existing health and safety regulatory framework. Given the awareness of the roles of human factors in these accidents and malfunctions, provisions including training, procedures, and mitigation have been put in place by CNL to achieve as-low-as-reasonably-possible accidents and malfunctions rates.

It should also be noted that the work-place accident statistics mentioned above are aggregated data collected from a large number of industrial sectors, some of which may not have robust occupational health and safety programs. In contrast, the work carried out for the NSDF Project will be subject to additional oversight, as a result of the safety culture developed in the nuclear industry.

The NSDF construction activities will follow the construction process as defined in CNL's *Construction Program Description Document* (CNL 2017a) and CNL's *Construction Program Requirements Document* (CNL 2019b). The Construction Process establishes the requirements to ensure the successful execution of construction and installation activities (CNL 2019b). An effective Construction Process ensures that activities comply with the design intent, the applicable codes, standards, regulatory requirements, quality standards and applicable environmental and health and safety requirements (CNL 2019b).

A *Construction Safety Hazards Evaluation* is required to be developed during the pre-construction period, to identify and mitigate any known or potential hazards (CNL 2017b). Construction conventional hazards are controlled and managed by the CNL's *Occupational Safety and Health Program* (CNL 2018a).



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Construction Occupational Disease Fatalities (Year of Entitlement)	4.23	3.50	3.80	4.41	5.32	3.44	3.43	4.14	3.54	4.16
Manufacturing Occupational Disease Fatalities (Year of Entitlement)	0.93	1.11	1.17	0.98	0.92	0.95	0.95	1.12	0.71	0.71
Construction Traumatic Fatalities (Year of Death)	4.02	5.96	2.98	3.39	5.09	4.55	3.99	3.02	3.34	4.34
Transportation Traumatic Fatalities (Year of Death)	3.90	4.58	4.83	5.59	5.06	4.48	2.46	3.01	4.67	4.64

Source: Workplace Safety and Insurance Board, By the Numbers, 2014

Notes:
- Fatality rates are calculated based on the number of Workplace Safety and Insurance Board allowed fatalities divided by Workplace Safety and Insurance Board covered employment by industry sectors.
- Fatality rates for top two traumatic fatality and occupational disease fatality sectors shown as a ratio of all-sector fatality rates for occupational disease and traumatic fatalities. For example, in 2014, the traumatic fatality rate in construction was 4.34 times the all-sector rate.

Figure 7.4.1-1: Comparison of Conventional Accident Statistics by Sector (MOL 2016)

7.4.1.1 Assessment of Potential Conventional Accidents and Malfunctions during Construction

The potential conventional non-radiological hazards that exist during site preparation and construction include but not limited to:

- Material movement – lifting and hoisting;
- Drilling and excavation;
- Trenching, sloping and shoring;
- Tree clearing and removal;
- Electrical;
- Traffic (Vehicle and/or pedestrian);
- Welding, cutting and grinding;
- Work at heights;
- Operation of heavy equipment;
- Exhaust from vehicles including heavy equipment;
- Tripping hazards due to un-level surfaces;
- Fuel for equipment;
- Hazardous materials and chemicals;
- Pinch points;
- Environmental including weather, and heat and cold stress;
- Noise;
- Use of power tools;
- Wildlife incursions (e.g., bears);
- Particulate matter and dust generation;
- Leak/spill;
- Vehicle collision;
- Rock blasting, including the hazards:
  - detonator malfunction; and
  - overblasting.
- Fire (internal).

Table 7.4.1-1 is the assessment of the key potential conventional accidents and malfunctions that could occur during the construction of the NSDF Project.

Table 7.4.1-1: Assessment of the Key Potential Conventional Accidents and Malfunctions During Construction

Conventional Hazard	Scenario	Mitigation	Potential Health and Environmental Effects After Mitigation
Leak/spill	Spill of fuel during fueling heavy equipment. Failure of hydraulic oil hose on the heavy equipment.	▪ Heavy equipment fueling utilizes secondary containment ▪ Spill kits ▪ Vehicle maintenance and inspections ▪ Refueling will kept away from surface water features	▪ A leak/spill results in a localized effect that is readily remediated. The potential health effect to the worker are negligible. ▪ There is no linkage pathway to the public as effects are localised (on-site), short in duration and would be contained. ▪ Potential effects to non-human biota related to leaks/spills during the construction of the transfer line to Perch Lake are assessed in Section 5.4.2.5.2.2 (Surface Water Quality) and Section 5.6.5.2.2 (Terrestrial Environment).
Vehicle collision	Construction vehicle collision resulting in potential worker injury and the leak of oil and or fuel from the damaged vehicle.	▪ Speed restriction in the construction area ▪ Seat belts ▪ Vehicle design ▪ Blanding's Turtle Road Mortality Mitigation Plan	▪ The potential health effects are minor, injury or an occupational disease requiring medical treatment by a medical practitioner (other than CNL health centre nurse), a disabling injury resulting in a medical practitioner prescribing work restrictions (and modified work is offered) or time off from work (lost time) of up to 5 days. ▪ Negligible release to the environment due leak of oil or fuel, effect may be measurable. ▪ There is no linkage pathway to the public as effects are localised (on-site), short in duration and would be contained. ▪ Potential effects to Blanding's Turtle and Eastern Milksnake from road mortality are assessed in Section 5.6.7.8 (Blanding's Turtle) and Section 5.6.7.9 (Eastern Milksnake).

Table 7.4.1-1: Assessment of the Key Potential Conventional Accidents and Malfunctions During Construction

Conventional Hazard	Scenario	Mitigation	Potential Health and Environmental Effects After Mitigation
Overblasting	Uncontrolled or unmanaged blasting would result in excess noise and vibration or damage resulting from fly rock extending beyond defined boundaries.	▪ Blasting plan ▪ Barriers ▪ Defined safety limit around the blast area to isolate biota/VCs from the potential effects of flying rock ▪ A 30 m buffer area has been established along all identified wetlands near the ECM and no new construction is permitted within this 30 m buffer zone to protect the wetlands	▪ Noise and vibration effects from an uncontrolled explosion would be short in duration. ▪ The potential environmental effects are negligible. The potential health effects are moderate for workers and negligible for the public.
Fire (internal)	A fire may occur as the result of an accident associated with the activities of the NSDF Project including vehicle and equipment malfunction, and human error resulting in airborne release to the environment.	▪ Fire Department ▪ Fire extinguishers on vehicle ▪ Engine compartment fire suppression system on heavy equipment	▪ The potential health to the on-site worker is negligible. ▪ Negligible release to the environment, effect may be measurable. ▪ There is no linkage pathway to the public or non-human biota as effects are localized (on-site) and are very small/negligible.
Malfunction of detonators used for rock blasting	Malfunction of non-electronic detonator during rock blasting. The detonator malfunction could be the result of: ▪ Manufacture defect. ▪ Pinch or tear in the shock tube during the placement of blasting mats. ▪ Improper tie-in hookup or missed detonator during tie-in hookup. ▪ Damaging the shock tube during the loading operation.	▪ Blasting Plan ▪ Blasting Safety Plan ▪ Blasting system notification and detonator redundancies ▪ Visual inspection of blasting tie-in sequence and shock tube condition prior to placing blasting mats ▪ In the event of a primary detonator malfunction, immediate blasting using the redundant secondary detonator will occur ▪ Barriers for access restrictions ▪ Blasting mats	▪ The potential health effect to the worker is negligible. ▪ The potential environmental effects are negligible and there is no release to the environment. ▪ There is no linkage pathway to the public and non-human biota as effects are localized and are negligible.

Table 7.4.1-1: Assessment of the Key Potential Conventional Accidents and Malfunctions During Construction

Conventional Hazard	Scenario	Mitigation	Potential Health and Environmental Effects After Mitigation
Malfunction of detonators used for rock blasting (cont'd)	Malfunction of electronic detonator during rock blasting. The detonator malfunction could be the result of: ▪ Manufacture defect. ▪ Pinch or tear in the leg wire or the trunk line during the placement of blasting mats. ▪ Improper tie-in hookup or missed detonator during tie-in hookup. ▪ Damaging the leg wire during the loading operation.	▪ Blasting Plan ▪ Blasting Safety Plan ▪ Blasting system notification and detonator redundancies ▪ Testing of the electronic detonators and circuit prior to blast initiation ▪ Testing of the electronic detonators and circuit prior to, during and after placing blasting mats ▪ In the event of a primary detonator malfunction, immediate blasting using the redundant secondary detonator will occur ▪ Barriers for access restrictions ▪ Blasting mats	▪ The potential health effect to the worker is negligible. ▪ The potential environmental effects are negligible and there is no release to the environment. ▪ There is no linkage pathway to the public and non-human biota as effects are localized and are negligible.
Particulate Matter and dust generation	Particulate matter and dust is expected to be generated during the following site preparation and construction activities: ▪ Clearing, grading and excavation to support construction. ▪ Rock blasting. ▪ Hauling and loading of excavated materials for construction and transport to spoil or stockpiles areas. Stockpiles are created for imported soil materials including clay, granular materials, and material excavated from the ECM area.	▪ Dust management plan ▪ Water spraying or misting techniques using water trucks	▪ The potential health effect to the worker is negligible. ▪ The potential environmental effects are negligible. ▪ There is no linkage pathway to the public or non-human biota as effects are localized (on-site) and are very small/negligible.

VC = valued component.

7.4.2 Operations and Closure

Conventional non-radiological hazards were evaluated only to the extent of determining their ability to initiate or contribute to accidents with radiological consequences; otherwise such hazards are adequately covered by CNL's *Occupational Safety and Health Program* (CNL 2018a). The conventional non-radiological hazards that exist in the NSDF Project for routine work activities include:

- operation of the filter press in the WWTP;
- handling of large, heavy containers;
- exhaust from vehicles including heavy equipment;
- tripping hazards due to unlevel surfaces;
- pinch points;
- heat and cold stress;
- excavation;
- noise;
- material movement—lifting and hoisting;
- use of power tools;
- operation of heavy equipment;
- fuel for equipment;
- wildlife incursions (e.g., bears);
- confined space;
- working at heights;
- impact/collision;
- chemical exposure;
- hazardous reaction;
- spill or leak; and
- dropped load.

7.4.3 Assessment of Potential Conventional Accidents and Malfunctions during Operations and Closure

Table 7.4.3-1 is the assessment of the key potential conventional accidents and malfunctions that could occur during the operations and closure of the Facility.

Table 7.4.3-1: Assessment of the Key Potential Conventional Accidents and Malfunctions During Operations and Closure

ID	Conventional Hazard	Scenario	Mitigation	Potential Health and Environmental Effects After Mitigation
D1	Impact/collision	Vehicle collision due to human error, resulting in potential worker injury.	▪ Speed restriction in the construction area ▪ Seat belts ▪ Vehicle design ▪ Blanding's Turtle Road Mortality Mitigation Plan	▪ The potential health effects are minor to on-site worker. ▪ Negligible release to the environment, effect may be measurable. ▪ There is no linkage pathway to the public as effects are localised (on-site). ▪ Potential effects to Blanding's Turtle and Eastern Milksnake from road mortality are assessed in Section 5.6.7.8 (Blanding's Turtle) and Section 5.6.7.9 (Eastern Milksnake).
D2	Fall	Worker falls into the contact water or non-contact water pond at the ECM resulting in potential worker injury.	▪ Raised berm ▪ Spotter ▪ Barriers ▪ PPE&C	▪ The potential health effects are minor to on-site worker. ▪ There is no linkage pathway to the public or non-human biota as effects are localised (on-site).
D3	Chemical Spill/Leak	Chemical drum/tote is dropped due to human area in the WWTP chemical storage area resulting in loss of containment, spill and the worker being splashed. Chemical feed tank is overfilled from the chemical totes and or drums.	▪ PPE&C ▪ Secondary containment (chemical room sumps) ▪ Spill kit and chemical neutralizer ▪ Chemical shower / eye wash stations ▪ Spotter ▪ Chemical Feed Tanks have high-level alarms and overflow lines to chemical room sumps	▪ The potential health effects are minor to on-site worker. ▪ There is no linkage pathway to the public or non-human biota as effects are localised (on-site) and would be contained.
D4	Hazardous reaction	Incorrect chemical mixing, wrong chemical addition sequence, or wrong chemical addition resulting in an adverse chemical reaction and potential worker injury and worker exposure to off gassing.	▪ Chemical addition system interlocks ▪ PPE&C ▪ Two separate Chemical Rooms for acidic and caustic chemicals ▪ Secondary containment (chemical room sumps) ▪ Chemical shower / eye wash stations. Hydrogen sulphide monitors with alarms	▪ Hydrogen sulphide gas could be generated by the mixing of incompatible chemicals. The potential health effects are negligible to workers. ▪ There is no linkage pathway to the public or non-human biota as effects are localised (on-site) and would be contained.

Table 7.4.3-1: Assessment of the Key Potential Conventional Accidents and Malfunctions During Operations and Closure

ID	Conventional Hazard	Scenario	Mitigation	Potential Health and Environmental Effects After Mitigation
D5	Dropped load	Dropped load due to human error and or mechanical resulting in potential worker injury.	▪ Spotter ▪ Equipment maintenance and inspection ▪ Barriers ▪ Line of fire (awareness)	▪ The potential health effects are moderate to the workers. ▪ There is no linkage pathway to the public or non-human biota as effects localised (on-site) with a very short duration.

PPE&C = personal protective equipment and clothing; WWTP = Wastewater Treatment Plant.

7.4.4 Risk Matrix of Conventional Accidents and Malfunctions

Table 7.4.4-1 presents the risk matrix overlaid with the five key conventional accidents and malfunctions during the operations, according to their severity, frequency and risk ratings. The risk of the key conventional accidents and malfunctions are acceptable and low with mitigation in place.

Table 7.4.4-1: Risk Matrix of Conventional Accidents and Malfunctions

Frequency	S0	S1	S2	S3
Anticipated Operational Occurrences (≥10^{-2}/a)	R0 (D4)	R1 (D1, D2, D3)	R2	R3
Design Basis Accidents (≥10^{-5}/a to <10^{-2}/a)	R0	R0	R1 (D5)	R2
Beyond Design Basis Accidents (10^{-6}/a to <10^{-5}/a)	R0	R0	R0	R1

7.4.5 Mitigation for Conventional Non-radiological Hazards

The risks of the potential conventional non-radiological hazards are mitigated by the following administrative mitigation and controls:

- use of spotters at a safe distance during material movement, hoisting and heavy equipment operation;
- work/rest cycles based on environmental working conditions;
- work areas controlled with barriers and signage;
- fire protection screening;
- personal protective equipment and clothing, including hard hats, safety footwear, hearing protection, respirators, gloves and safety glasses/face shields/goggles;
- worker training;
- procedural adherence;
- equipment maintenance and inspection—maintenance schedule and monitoring equipment performance; and
- use of spotters and noise makers during wildlife incursions.

The risks of the potential conventional non-radiological hazards are mitigated by the following design mitigation/safeguards and controls:

- interlocks associated with the chemical addition system, chemical precipitation system, polishing system and final pH adjustment;
- separate chemical storage areas for acids and caustics; and
- hydrogen sulphide monitors with alarms.

7.5 Emergency Preparedness

If an accident or malfunction situation occurs, CNL has procedures in place that address requirements for immediate response and post-event clean-up or remediation. Of note, CNL's *Emergency Preparedness Program* (CNL 2018b) (described in Section 3.5.2.5) has been designed for immediate response to emergency situations. The program ensures emergency readiness and emergency management to support programs such as reactor safety/accident management, decommissioning, radiation and environmental protection, fire and occupational health and safety. In terms of post-event clean-up or remediation CNL's *Environmental Protection Program* (CNL 2018c) (see Section 3.5.2.2) includes procedures that address the identification, management and remediation of lands that are contaminated.

Canadian Nuclear Laboratories will establish a project-specific Emergency Preparedness Plan for the NSDF Project, including emergency response procedures. The NSDF Project Emergency Preparedness Plan will establish practices for safe and environmentally sound management of the facility during the construction, operations, closure and post-closure periods.

Emergency response procedures for the NSDF Project will be prepared to address any potential emergencies from accidents including internal fires, minor spill, major spill, natural gas/carbon monoxide leak, loss of power, high radiation, radiological contamination, bomb threat/suspicious package, hold and secure and stay-in. Checklists are also created for evacuation and floor plans and assembly area locations are also defined.

8.0 SUMMARY OF CUMULATIVE EFFECTS

8.1 Introduction and Approach

The *Canadian Environmental Assessment Act, 2012* requires that each environmental assessment of a designated project take into account any cumulative environmental effects that are likely to result from the designated project in combination with the environmental effects of other physical activities that have been or will be carried out (The Agency 2015). The method for assessment of cumulative effects is outlined in Section 5.1 and is consistent with the Canadian Nuclear Safety Commission (CNSC) Generic EIS Guidelines (CNSC 2016) and the Canadian Environmental Assessment Agency's *Technical Guidance for Assessing Cumulative Effects under the Canadian Environmental Assessment Act, 2012* (The Agency 2018). Cumulative effects are assessed using the same approach used for the project-specific effects analysis. The approach follows the same five general steps outlined in the cumulative effects technical guidance document (The Agency 2018):

- **Step 1 –Scoping:**
  - identifying Valued Components (VCs; see Section 5.1.2 Valued Components);
  - determining spatial boundaries (see Section 5.1.3.1 Spatial Boundaries);
  - determining temporal boundaries (see Section 5.1.3.2 Temporal Boundaries); and
  - examining physical activities that have been and will be carried out (see Section 5.1.3.3 Assessment Cases).
- **Step 2 – Analysis** (see Section 5.1.5 Project Interactions and Mitigation and 5.1.6 Residual Effects Analysis).
- **Step 3 – Mitigation** (see Section 5.1.5 Project Interactions and Mitigation and 5.1.6 Residual Effects Analysis).
- **Step 4 – Significance** (see Section 5.1.8 Residual Effects Classification and Determination of Significance).
- **Step 5 – Follow-up** (see Section 5.1.9 Monitoring and Follow-up).

The purpose of the cumulative effects assessment is to evaluate the contribution of effects from the Near Surface Disposal Facility (NSDF) Project (i.e., Application Case) in combination with previous, existing, or reasonably foreseeable developments or activities in the region (i.e., Reasonably Foreseeable Developments [RFD] Case) that may overlap spatially (i.e., the same geographic area) and temporally (i.e., over time). RFDs or activities in the region that have not yet been approved or developments and activities that are currently under application review, or that have officially entered a regulatory application process, are considered reasonably foreseeable. The cumulative effects assessment considers all primary pathways that are likely to result in detectable changes in measurement indicators and subsequent residual effects on VCs after implementation of environmental design features and mitigation.

The VCs requiring an analysis under the RFD Case are determined by understanding whether the residual effects from the NSDF Project and one or more additional developments (or activities) overlap or interact with the temporal or spatial distribution of the VC. For some VCs, there is no potential for cumulative effects to environmental components because there is no overlap of Project effects with the potential effects of other developments. Where potential cumulative effects from the RFD Case are identified for these VCs, these effects were assessed using the same approach used for the Project-specific effects analysis.

For the malfunctions and accidents scenarios described in Section 7.0, all radiological doses meet the acceptance criteria for design basis accidents, for both on-site and off-site workers. The maximum estimated dose during the operations period for an on-site worker is 5 times lower than the regulatory limit of 50 millisieverts per year (mSv/yr) and for the public is almost 50 times lower than the regulatory dose limit of 1 mSv/yr. During post-closure, the maximum estimated dose associated with the most likely future state of the facility is more than 60 times lower than the regulatory dose limit of 1 mSv/yr.

Non-radiological malfunction and accident scenarios were assessed to represent risks classified to be negligible or tolerable, where further protective measures are identified in Section 7.0. As no residual adverse effects are advanced for consideration of significance, no assessment of cumulative effects is identified to be required.

8.2 Reasonably Foreseeable Developments

As described in Section 8.1, the NSDF Project has the potential to interact with previous, existing and reasonably foreseeable developments or activities in the region. Table 8.2-1 provides a summary of the other projects considered in the RFD Case. The potential effects of these projects and activities were then further considered as to whether they were likely to overlap with VCs affected by the NSDF Project.

Table 8.2-1: Reasonably Foreseeable Developments Considered in the Assessment

Type of Project	Location	Examples	Timeframe
Activities related to Canadian Nuclear Laboratories (CNL) Long-Term Strategy (10-Year Integrated Plan)			
New/upgraded research and development facilities	Chalk River Laboratories (CRL)	Advanced Nuclear Material Research Centre Small Modular Reactor	2019 and onward
New support infrastructure	CRL	Office buildings, maintenance facility, logistics facility	2018 to 2026
Infrastructure decommissioning	CRL	Over 100 buildings on CRL site including nuclear laboratories and conventional buildings	2016 to 2026
Environmental remediation	CRL	Remediation of affected lands and non-operating waste management areas (WMAs).	On-going
In situ disposal of Nuclear Power Demonstration (NPD) reactor	Rolphton	The NPD Closure Project (in situ disposal of the NPD waste facility in Rolphton, Ontario)	2021 to 2023
Garrison Petawawa			
Construction of new infrastructure at Garrison Petawawa	Petawawa	Construction of new facility for the Royal Canadian Dragoons (e.g., renovation of three existing buildings, and the replacement of eight obsolete buildings with a single, centralized 9,900 m facility)	2020 to 2021

8.2.1 Ten-year Integrated Plan for Chalk River Laboratories

Over the next decade, Canadian Nuclear Laboratories (CNL) will be transforming its Chalk River Laboratories (CRL) through the revitalization of essential site infrastructure, the decommissioning of aging infrastructure and a significant investment in new, world-class science facilities (CNL 2017a). The *2016–2026 10-Year Integrated Plan* (CNL 2017a) outlines CNL's 10-year science and technology strategic objectives to support the evolving science and technology needs of the Canadian and global nuclear industry by:

- *providing global sustainable energy solutions, including the extension of reactor operating lifetimes, hydrogen energy technologies, and fuel development for the reactor designs of tomorrow;*
- *demonstrating the commercial viability of advanced reactors, including the small and very small modular reactor (SMR);*
- *continuing support of radiochemical therapies, including collaboratively pioneering new alpha therapies; and*
- *protecting Canada's environment by removing and responsibly managing nuclear liabilities.*

CNL's mission also includes a commitment to "enhance national and global nuclear safety and security by developing new technologies to prohibit contraband nuclear material, respond to nuclear incidents, prevent nuclear accidents and strengthen cyber security for nuclear reactors" (CNL 2017a).

Over the next 10 years, CNL will be decommissioning more than 100 buildings and structures to make room for new, renovated and repurposed facilities. The first step in the site revitalization was the creation of the Site Master Plan that meets the goals of the site development and objectives of the Science and Technology Mission outlined in the 10-Year Integrated Plan (CNL 2017a). Through completion of the Site Master Plan, CNL will reduce the site footprint and transform the CRL site to a national nuclear laboratory campus where similar activities are consolidated and co-located to improve efficiency and foster internal and external collaboration, and with sustainable facilities that are reconfigurable to meet changing needs of developing science and technology. Decommissioning redundant facilities and assets also helps to reduce the cost of on-going management.

As presented in Table 8.2-1, these goals will be met through a combination of revitalization activities (i.e., developing new or upgrading existing research and development facilities at CRL, constructing new support infrastructure), decommissioning old infrastructure and conducting environmental remediation.

8.2.1.1 Small Modular Reactor

To meet CNL's long-term strategy goal of demonstrating commercial viability of advanced reactors, including SMRs, an invitation was issued in April 2018 seeking proponents of SMR demonstration projects for construction and operation at a CNL-managed site. In February 2019, CNL announced that the proposal presented by Global First Power had advanced to the third stage of its review process. In July 2019, Global First Power released its Project Description for the Micro Modular Reactor^{TM} (MMR) Project at Chalk River (Global First Power 2019), to provide the CNSC with the required information to make an Environmental Assessment Determination under the *Canadian Environmental Assessment Act, 2012* and establish the requirements for the MMR Project.

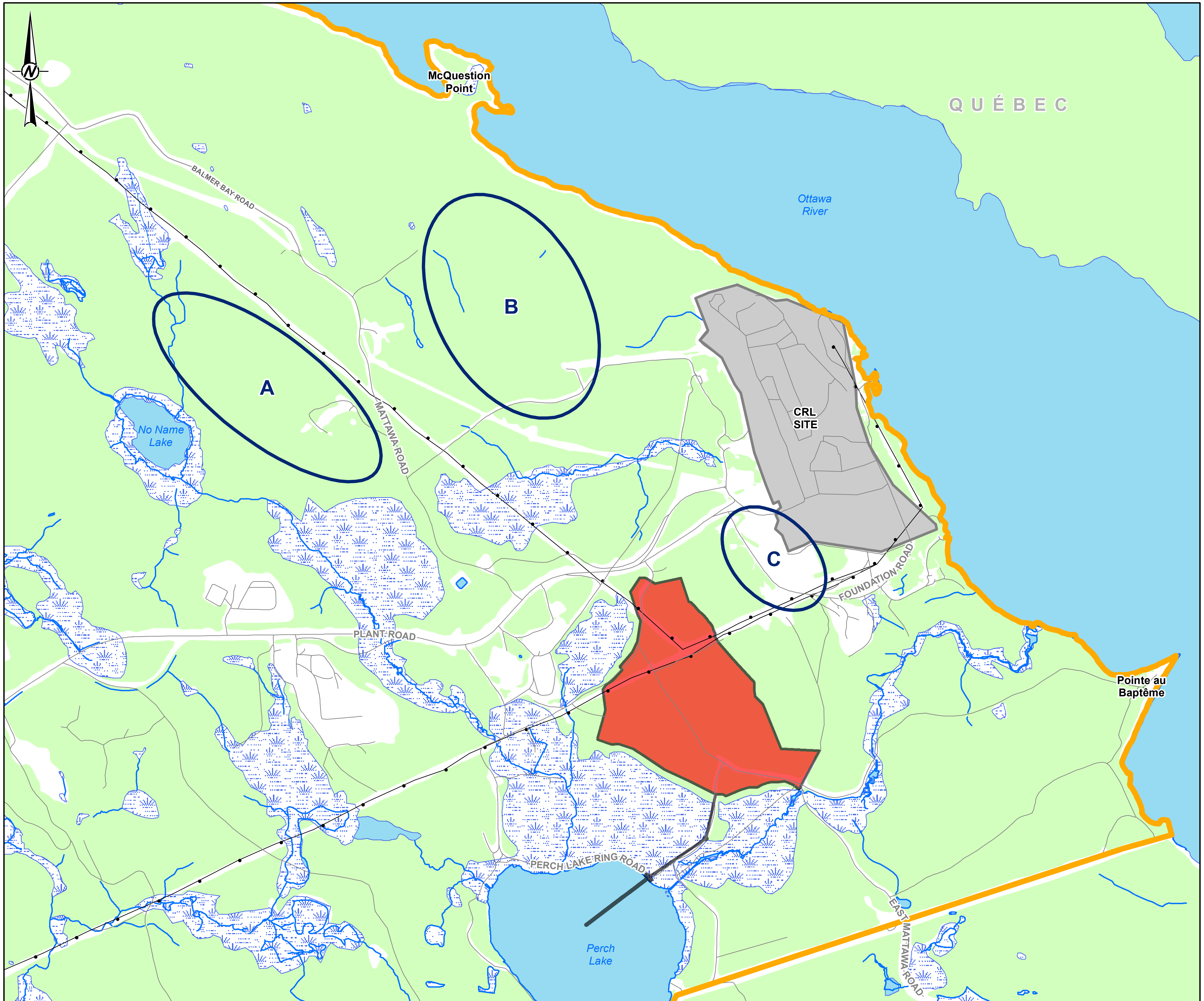
The Project Description explains that:

> *The proposed [MMR] Project will involve the site preparation, construction, operation, and decommissioning of one MMR nuclear reactor and supporting infrastructure on a Project site within the CRL property. The main physical works related to the Project are a Nuclear Plant, which includes an MMR High Temperature Gas-cooled Reactor that will provide approximately 15 MW [thermal] of process heat to a (non-nuclear) Adjacent Plant via molten salt. The process heat will be used in the Adjacent Plant to generate electrical power and/or heat that could be used by CRL, or electrical power to the area grid, over an anticipated life span of 20 years. The Adjacent Plant consists of the equipment and systems that convert the process heat to electrical power or other forms of energy (Global First Power 2019).*

The project has the potential to replace the current heat and power sources at the CRL site. The fenceline of the nuclear plant of the SMR is planned to be approximately 130 m by 100 m and the adjacent plant 180 m by 100 m, with total site dimensions of approximately 180 m by 200 m (Global First Power 2019).

Three candidate sites were identified as feasible by CNL within the CRL site, under consideration for locating the SMR (Figure 8.2.1-1). The closest of these (Site C) is located more than 1 km to the northeast of the NSDF Site Study Area (SSA) near the built-up area of the site, within the Ottawa River direct watershed. The other two candidate sites include some undisturbed vegetated areas (Global First Power 2019) and are located more than 2 km to the north of the SSA, one within the Ottawa River direct watershed (Site B) and the other within the Perch Creek and Perch Lake Watershed (Site A).

Bounding estimated dates indicate site preparation and construction is planned to occur over approximately 2 years between 2021 and 2027 with operation of approximately 20 years between 2023 and 2054. The construction of the SMR may overlap with the construction of the NSDF Project. Following the end of its operational life, decommissioning would occur over approximately two to three years between 2054 and 2058, with abandonment activities occurring over two to three years between 2058 and 2060. For non-radiological components, SMR decommissioning activities are considered to be bounded by the activities of its construction for the purposes of the RFD Case assessment; both SMR construction and decommissioning are scheduled to occur during the operations phase of the NSDF Project. SMR development activities, which will include site characterization and impact assessment activities, are currently underway and anticipated to be completed by 2021, during which a formal project schedule will be finalized.



LEGEND
- HIGHWAY
- ROAD
- RAILWAY
- HYDRO LINE
- RIVER/STREAM
- WATERBODY
- WETLAND
- WOODED AREA
- SITE STUDY AREA (NDSF PROJECT SITE)
- CRL MAIN CAMPUS
- CRL SITE
- POTENTIAL CANDIDATE SITES FOR PROPOSED SMALL MODULAR REACTOR

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1:15,000 KILOMETERS Meters

REFERENCE(S)
1. BASEDATA ONTARIO MNRF 2016, CANVEC 2016, AND CNL 2016
2. PROPERTY BOUNDARY AND NSDF LOCATION PROVIDED BY CNL (MAY 2016 AND MAY 2017)
3. POTENTIAL CANDIDATE SITES FOR PROPOSED SMALL MODULAR REACTOR OBTAINED FROM GLOBAL FIRST POWER. 2019. PROJECT DESCRIPTION FOR THE MICRO MODULAR REACTOR PROJECT AT CHALK RIVER. CRP-LIC-01-001. REVISION 2. JULY 2019.
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY, ENVIRONMENTAL IMPACT STATEMENT
CHALK RIVER, ONTARIO

TITLE
POTENTIAL CANDIDATE SITES FOR PROPOSED SMALL MODULAR REACTOR AT CHALK RIVER LABORATORIES

CONSULTANT
GOLDER

DATE	NOVEMBER 2020
DESIGNED	SO
PREPARED	SO
REVIEWED	CS
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
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8.2.2 Nuclear Power Demonstration Closure Project

The purpose of the Nuclear Power Demonstration (NPD) Closure Project is to safely complete the decommissioning of the NPD Waste Facility, located near the CRL site at Rolphton, Ontario. In situ disposal is the preferred approach proposed by the project to carry out these activities. The Class I nuclear facility is presently in the storage with surveillance phase of decommissioning and has a Decommissioning Waste Facility Licence issued in 2014. The NPD Nuclear Generating Station, consisting of a 20 MW electrical Canada Deuterium Uranium ("CANDU") reactor, was placed in service in 1962 and was operated by Ontario Hydro until 1987. The reactor was heavy water moderated, cooled by pressurized heavy water and fuelled with natural uranium. The main components of NPD Nuclear Generating Station were the reactor, heat transport system, turbine and electrical power generator equipment. Following permanent shutdown of the station, the operating and compliance responsibilities were transferred from Ontario Hydro to Atomic Energy of Canada Limited.

The proposed in situ disposal activities include removing the above-grade structure and placing contaminated materials into the below-grade structure (CNL 2017b). The below-grade structure, reactor vessel and systems and components will be sealed by grouting. The structure will then be capped with concrete and covered with an engineered barrier. In situ disposal will isolate the contaminated systems and components inside the below-grade structure.

The conclusion of the Draft Environmental Impact Statement for the NPD Closure Project (CNL 2017b) identifies that no residual adverse effects are identified as a result of the Project.

8.2.3 Garrison Petawawa

In support of Canada's defense policy, "Strong, Secure, Engaged," a pilot project was announced in January 2019 to deliver new and enhanced facilities for the Royal Canadian Dragoons at 4th Canadian Division Support Base, Garrison Petawawa, located adjacent to the CRL site (Government of Canada 2019). The project includes renovation of three existing buildings and replacement of eight buildings no longer in use with a single, centralized approximately 10,000 m^2 facility with construction planned for 2020 to 2021.

8.3 Summary of Cumulative Effects

8.3.1 Atmospheric Environment

The atmospheric environment assessment (Section 5.2) considered potential cumulative effects as part of the Base Case, Application Case and RFD Case.

Reasonably foreseeable developments in the RSA with potential to overlap with the residual effects of the NSDF Project include revitalization activities (i.e., new/upgrades to research and development facilities, new support infrastructure), on-going decommissioning and environmental remediation activities on the CRL site.
These revitalization and decommissioning activities involve renovation of some current buildings, construction of new buildings, and removal of more than 100 existing buildings on the CRL site over the ten-year period 2016 to 2026. A specific new research and development project announced in 2019 is the planned construction and 20-year operation of a SMR at the CRL site. As well, there may be overlap of the construction period with limited construction at neighbouring Garrison Petawawa.

8.3.1.1 Air Quality

Site revitalization, SMR construction, construction at Garrison Petawawa and on-going decommissioning activities on the CRL site will generate air and dust emissions such as CO, oxides of sulphur (SO_x includes SO_2), oxides of nitrogen (NO_x includes NO_2), particulate matter ($PM_{2.5}$, PM_{10}), and suspended particulate matter (SPM). Air emissions, such as SO_x and NO_x, can result from the use of fossil fuels in generators, vehicles, and machinery. Vehicle exhaust and fugitive dust from unpaved and paved roads is expected to be the largest contributor to particulate matter (SPM, PM_{10}, and $PM_{2.5}$). The waste from the decommissioning of the CRL structures will be placed in the NSDF and the Application Case assessed for the operations phase considers the transport of this waste for disposal in the ECM.

Decommissioning of eight buildings, renovation of three and construction of a new 9,900 m^2 facility for the Royal Dragoons planned within the built-up area at Garrison Petawawa (approximately 10 km south of the SSA) in 2020-2021 are also expected to follow best practice construction techniques. As a result, emissions to air are expected to be short term and limited. Given the distance of these activities from the SSA and limited potential overlap in time of the construction periods, no potential for cumulative effects is identified.

The airborne emissions from new facility construction and decommissioning projects on the CRL site will be assessed as part of the approval process for these projects. Examples of mitigation expected to be implemented by site revitalization, SMR construction and on-going decommissioning activities on the CRL site to limit potential effects to air quality include:

- limiting the construction activities required on-site through the use of modular structures for construction of the SMR (Global First Power 2019);
- staging site revitalization and decommissioning activities over a ten-year period to reduce periods of simultaneous construction at the CRL site;
- implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and verification monitoring;
- implementation of best practice dust management techniques such as water spraying or misting techniques (e.g., water trucks);
- using on-site vehicles and equipment engines that meet Tier 2 emission standards and maintaining them in good working order; and
- limiting idling of vehicles on site.

Site revitalization and decommissioning activities include several small projects staged over a ten-year period where best practices, mitigation and monitoring for management of emissions will to be followed. Accordingly, the incremental additional equipment use and emissions at any one time are expected to be small, distributed across the CRL site and removed from the more intensive activities within the SSA. The conclusions of the NSDF Project assessment in Section 5.2.1.6.2 for the Assessment Case indicate that the predicted concentrations of indicator compounds for air quality are below the relevant guideline/standard during the construction and operations phases, except for 1-hour NO_2. These predictions are based on conservative assumptions around number of heavy-duty vehicles and intensity of use, as well as meteorological conditions. When compared with current CRL site operations and NSDF Project activities, it is anticipated that the small incremental effect to indicator compounds from site revitalization and decommissioning activities in progress at any one time would be negligible to air quality outside of the CRL site. Similarly, the scale and modular construction technique for the SMR limits the length of its construction period, as well as associated equipment use. The locations for placement of the SMR under consideration are removed from the SSA within the CRL site. During operation of the SMR, dry cooling towers may be used to dissipate excess heat from steam condensation in operation of the steam turbine generator. No additional activities or new sources for release of indicator compounds are planned (Global First Power 2019). With effective implementation of mitigation measures and monitoring programs, no cumulative residual effect is identified to air quality.

8.3.1.2 Greenhouse Gas

Consistent with the consideration of the RFD Case for air quality, revitalization activities (i.e., new/upgrades to research and development facilities, new support infrastructure), on-going decommissioning and environmental remediation activities on the CRL site, as well as construction and operations of a SMR at the CRL site will generate GHG emissions that may overlap with residual effects of the Project. As Project contributions within the LSA represent a negligible change to GHG emissions to provincial and national totals, contribution by the limited construction at neighbouring Garrison Petawawa would be anticipated to be similarly negligible and the areas of effect would not be anticipated to overlap.

The airborne emissions from new facility construction and decommissioning projects on the CRL site will be assessed as part of the approval process for these projects. Examples of mitigation to limit effects from GHG emissions applicable to all projects on the CRL site include:

- implementation of CNL's procedure for *Management and Monitoring of Emissions* (CNL 2018), which includes operational control monitoring and verification monitoring;
- on-site vehicles and equipment engines will meet Tier 2 emission standards and be maintained in good working order; and
- limiting idling of vehicles on-site.

Revitalization and decommissioning activities at the CRL site are planned to be staggered over the ten- year period (2016 to 2026), and the required activities to be completed at any one time are anticipated to be less than that required for the larger scale construction of the NSDF Project. Similarly, the equipment requirements for construction and operations of the SMR are expected to be less than that assessed for the NSDF Project. Consistent with the conclusions in Section 5.2.2.6.2 for the Application Case, GHG emissions as a result of RFD Case projects are anticipated to result in a negligible change relative to provincial and national totals. With effective implementation of mitigation measures and monitoring programs, no cumulative residual effect is identified to GHGs.

8.3.2 Geology and Hydrogeology

Measurements of radionuclide concentrations have been performed at specific areas of concern within the CRL site. This included studies of groundwater contamination in areas affected by groundwater plumes from waste management areas at CRL. Radiological contamination in the East Swamp wetland is relevant to the NSDF Project, as this area is immediately west of the SSA. Because this wetland is potentially downgradient of parts of the SSA, characterization of the contamination present is important in defining Base Case conditions. The East Swamp wetland has existing contamination associated with a shallow subsurface plume from the Chemical Pit and a second plume from Reactor Pit 2. Cumulative effects of previous and existing projects on hydrogeology have been considered through assessment of the Base Case and Application Case (see Section 5.3.2.6).

New and upgrades to research and development facilities, construction and operation of the SMR and new support infrastructure are planned within areas of the CRL site removed from the NSDF Project site and generally within existing disturbed areas. Best practices, such as surface water management systems and waste management programs, are expected to be implemented to minimize any potential effects to measurement indicators for geology and hydrogeology, including soil quality, groundwater flow or quality during construction and operation of these facilities. No process intakes of water from or discharges to surface or groundwater are identified in the description of the planned SMR (Global First Power 2019). As such, potential effects from the construction and operation of the SMR or revitalization activities are not expected to spatially overlap with potential effects to geology or hydrogeology from the NSDF Project during normal operations. The end-state plan for the CRL site will be to return lands disturbed by site activities to a condition that is physically stable and safe in keeping with the land use and landscape of the day. Therefore, decommissioning and environmental remediation activities are anticipated to positively affect measurement indicators for geology or hydrogeology such as soil and groundwater quality. As well, no potable water wells are anticipated to be installed within the RSA during the time up to the end of the institutional control period during post-closure.

Because RFDs will either have no spatial overlap, or are likely to positively affect the geology and hydrogeology VCs, an RFD Case is not presented as part of these assessments.

8.3.3 Surface Water Environment

Surface water sampling locations are currently monitored routinely throughout the Perch Creek and Perch Lake watershed. The East Swamp wetland, located in the Perch Creek and Perch Lake watershed, has existing contamination associated with a shallow subsurface plume from the Chemical Pit and a second plume from Reactor Pit 2. Treated effluent from the Wastewater Treatment Plant (WWTP) will be released to an exfiltration gallery to promote the exfiltration of treated water into the local groundwater regime, where small quantities of residual contaminants will migrate towards the East Swamp Stream. Treated effluent will also be discharged directly to Perch Lake via a transfer line. The transfer line to Perch Lake has been designed to manage the full annual volume of treated effluent, if required, which will prevent the potential for overland flow at the exfiltration gallery.

The East Swamp Stream feeds Perch Lake, which is connected to the Ottawa River through Perch Creek. Residual contaminants from the WWTP effluent will be most concentrated with the East Swamp Stream due to further dilution in downstream waterbodies (e.g., Perch Lake, Perch Creek). Because this wetland is potentially downgradient of parts of the SSA, characterization of the contamination present is important in defining Base Case conditions. Cumulative effects of previous and existing projects on surface water have been considered through assessment of the Base Case and Application Case. It is noted that no measurable changes in surface water quality are predicted downstream of the NSDF Project in the Ottawa River.

RFDs within the CRL site (i.e., the RSA) include only the new or upgrades to research and development facilities, construction and operation of the SMR, new support infrastructure, and on-going decommissioning and environmental remediation activities. New support infrastructure and research and development facilities will generally be located within existing disturbed areas on the CRL site (i.e., minimal disturbance to largely undeveloped areas). Disturbance of an approximately 3.5 ha may be required for development of the SMR based on the candidate site selected (Global First Power 2019); therefore, the footprint of the SMR will be approximately 10% of the footprint of the NSDF site.

Applicable erosion and sediment control practices and surface water management systems already in place at the CRL site will be implemented for all new or upgrades to research and development facilities (including the SMR), new support infrastructure, and on-going decommissioning and environmental remediation activities. No process intakes of water from or discharges to surface or groundwater are identified in the description of the planned SMR (Global First Power 2019). It is noted that a small amount of radioactive liquid waste from decontamination activities during the operation of the SMR will be monitored and stored in a holding tank for further processing (Global First Power 2019). A septic field may be used to manage sewage from the SMR site, depending on the candidate site chosen, that would follow required standards and would be located approximately 2 km from the NSDF Project site. Consequently, potential effects from revitalization activities and through development of the SMR are not expected to spatially overlap with potential effects to surface water quality from the NSDF Project. The NSDF Project will enable the remediation of contaminated lands and legacy waste management areas, as well as decommissioning of outdated infrastructure at the CRL site and CNL's other business locations to support future CNL work. The end-state plan for the CRL site will be to return lands disturbed by site activities to a condition that is physically stable and safe in keeping with the land use and landscape of the day. Therefore, decommissioning and environmental remediation activities are anticipated to positively affect hydrology and surface water quality. Because RFDs will either have no spatial overlap (i.e., localized change to surface water quality through surface water or sewage management), no interaction (i.e., change to infiltration on hydrology through site revitalization) or are likely to positively affect the surface water environment VCs (i.e., environmental remediation of hydrology and surface water quality), an RFD Case is not presented as part of the assessment.

Although no measurable residual adverse effects were identified to surface water quality as a result of the NSDF Project, or through consideration of cumulative effects, additional context is provided here with respect to the Ottawa River as a key stakeholder concern.

Construction water will be sourced from the Ottawa River using an existing intake structure to fill temporary storage containers. The intake of water from the Ottawa River for construction purposes (i.e., up to a maximum of 276,000 m^3/yr based on the peak daily usage) is anticipated to have a negligible effect on the overall Ottawa River annual flow rate of 25 billion m^3/yr (as recorded at the Des-Joachims monitoring point) and on the downstream hydrology.

During operations, treated effluent will be sampled and confirmed that it meets effluent discharge targets before release to the environment. A portion of the treated effluent from the WWTP will be released to an exfiltration gallery to promote the exfiltration of treated water into the local groundwater regime; from here, small quantities of residual contaminants will migrate from the East Swamp Wetland to East Swamp Stream. The remaining treated effluent will be released into Perch Lake using a submerged diffuser. It is anticipated that the diffuser placement will result in a ten-fold dilution of any treated effluent discharge to Perch Lake within 100 m of the discharge (Golder 2019a). The East Swamp Stream flows into Main Stream and then Perch Lake, which is connected to the Ottawa River through Perch Creek.

Both aquatic and terrestrial species will be exposed to contaminated surface water and sediment in the East Swamp Stream, Perch Lake, Perch Creek, and possibly the Ottawa River. Doses to non-human biota were calculated based on water concentrations from East Swamp Stream. Although dilution will occur in Perch Lake, Perch Creek and the Ottawa River, the exposure limits within the aquatic environment was conservatively assessed to match that of East Swamp Stream during the period of leachate management system and WWTP operations. Doses to non-human biota were calculated based on the waterborne and airborne emissions from the engineering containment mound and assessed against the most conservative criteria available such as

Environmental Quality Guidelines (CCME 2019) for non-radiological contaminants and No-Effect Concentrations for non-human biota derived for the boreal Canadian Shield forest ecosystem (Arcadis 2019) for radiological contaminants. For most contaminant of potential concern (COPCs), the incremental changes in concentration as a result of the NSDF Project are expected not to be measurable in the Ottawa River. COPCs that increase above background in the Ottawa River included only tritium and gross beta. However, these increases are expected to be within the uncertainty bounds of the surface water quality modelling. Further, results of the radiological dose assessment for the operations phase and post-closure phase also indicates that doses to ecological health VCs are below their respective No Effect Concentrations.

The NSDF Project is confident that there will be no adverse effects to biota during operations phase by ensuring that releases and subsequent environmental concentrations are below the relevant guidelines or are below levels that would result in potential adverse effects on aquatic life. The Ottawa River is expected to adequately rapidly assimilate any discharge from the Perch Creek and Perch Lake Watershed to existing conditions in the river, such that surface water quality and aquatic biodiversity VCs are unlikely to be affected. Given that the effluent discharge meets applicable effluent discharge targets, exposure to humans and biota through this pathway are considered negligible during the operations and closure phase.

Many of the site's existing WMAs, including WMAs A and B and the Liquid Dispersal Area (which includes Reactor Pit 1, Reactor Pit 2 and the Chemical Pit) may also affect the Perch Creek and Perch Lake Watershed. Contaminants are transported by groundwater to nearby wetlands, including East Swamp and via the transfer discharge line directly into Perch Lake, which will be the recipient waterbodies for the NSDF Project wastewater. Contaminants released into the Perch Lake then migrate to Perch Creek from where they reach the Ottawa River, which is the ultimate receptor for all CRL discharges. Estimated doses resulting from historic contamination, due to releases from WMAs and Liquid Dispersal Areas, fall below benchmark values for Perch Lake and Perch Creek.

Residual effects on Ottawa River water quality are determined to be negligible during operations and post-closure phases and may result in a net benefit due to remediation of legacy waste storage areas.

8.3.4 Aquatic Environment

Consistent with Section 8.3.3, RFDs expected within the CRL site (i.e., the RSA) that may interact with the aquatic environment include new or upgrades to research and development facilities, construction and operation of the SMR, new support infrastructure, and on-going decommissioning and environmental remediation activities. Considering the design features and the mitigation for RFD projects described in the preceding sections, potential effects of RFD projects are not identified to spatially overlap with Project effects to surface and groundwater. New support infrastructure and research and development facilities will be located within existing disturbed areas on the CRL site (i.e., no disturbance to largely undeveloped areas). Disturbance of approximately 3.5 ha may be required for development of the SMR depending on the candidate site selected, but no watercourses are identified within any of the three candidate sites (Global First Power 2019). The Project Description document for the SMR notes that the nearest waterbody to Site A is "No Name" lake within the Perch Lake Watershed, and the nearest waterbody to Sites B and C is the Ottawa River within the Ottawa River direct watershed. No process intakes of water from or discharges to surface or groundwater are identified in the description of the planned SMR (Global First Power 2019).

Potential effects from these RFD activities are not expected to spatially overlap with potential effects to the aquatic environment biodiversity from the NSDF Project. No primary pathways, and therefore, no measurable residual adverse effects were identified as a result of the Project to the aquatic environment. The end-state plan for the CRL site will be to return lands disturbed by site activities to a condition that is physically stable and safe in keeping with the land use and landscape of the day. Therefore, decommissioning and environmental remediation activities are anticipated to positively affect fish and fish habitat. Because RFDs will have no spatial overlap in effect or are likely to positively affect the fish and fish habitat, an RFD Case is not presented as part of the assessment.

Although no residual adverse effects were identified to surface water quality or to the aquatic environment as a result of the Project, or through consideration of cumulative effects, additional context in provided above in Section 8.3.3 with respect to the Ottawa River as a key stakeholder concern:

8.3.5 Terrestrial Environment

For the terrestrial environment, the RSA was used as the scale at which cumulative effects to terrestrial biodiversity VCs were assessed (see Section 5.6). Regional disturbance factors (e.g., forestry and climate change) were considered if they were likely to affect vegetation communities or populations of wildlife VCs that overlap with the RSA. The assessment considered the Base Case, which represents existing conditions and characterizes effects from previous and existing developments and activities, as well as the Application Case, which represents the effects of the Base Case combined with the predicted incremental effects from the NSDF Project through all project phases for each VC. The Base Case reflects the effects of existing disturbances in the area, such as forestry, transportation, agricultural, mining, and residential and recreational development.

The VCs selected for the terrestrial environment assessment were vegetation communities, migratory birds, Canada warbler (*Cardellina canadensis*), eastern whip-poor-will (*Antrostomus vociferous*), eastern wood-peewee (*Contopus virens*), golden-winged warbler (*Vermivora chrysoptera*), wood thrush (*Hylocichla mustelina*), bats, Blanding's turtle (*Emydoidea blandingii*), eastern milksnake (*Lampropeltis Triangulum*) and monarch butterfly (*Danaus plexippus*). The assessment endpoint for the terrestrial environment is the maintenance of self-sustaining and ecologically effective vegetation communities or wildlife populations.

Residual effects on terrestrial VCs are primarily associated with vegetation clearing and grubbing and the associated loss or alteration of existing vegetation and topographical features, sensory disturbance from NSDF Project activities during construction and operations, and increased risk of injury or mortality on roads due to equipment and vehicle traffic. The cumulative effects from the NSDF Project and previous and existing activities and developments in the RSA on the population of terrestrial biodiversity VCs that overlap with the RSA are predicted to be not significant for all VCs, with the exception of bats and Blanding's turtle, which are discussed in Sections 8.3.5.1 and 8.3.5.2, respectively.

RFDs expected within the CRL site (i.e., the RSA) that may interact with the terrestrial environment include new or upgrades to research and development facilities, construction and operation of the SMR, new support infrastructure, and on-going decommissioning and environmental remediation activities. New support infrastructure and research and development facilities will generally be located within existing disturbed areas on the CRL site (i.e., no disturbance to largely undeveloped areas) where erosion and sediment control practices and surface water management systems already in place will be implemented. Disturbance of approximately 3.5 ha including potentially undisturbed areas of the CRL site, may be required for development of the SMR based on the candidate site selected (Global First Power 2019). The three candidate sites for locating SMR on the CRL site are located away from the SSA (Figure 8.2.1-1). It is expected that removal of and other potential effects on terrestrial habitat including to species at risk through development of SMR will be reduced through consideration of siting and through mitigation similar to that implemented for the NSDF Project. Potential effects from these revitalization activities, as well as construction and operation of the SMR, are not expected to spatially overlap with potential effects on terrestrial biodiversity from the NSDF Project.

The revitalization of the CRL site is planned to occur over the 10-year period 2016-2026. The workforce numbers and types of work required for site revitalization activities over that period are expected to maintain a similar condition to the site revitalization activities occurring at present on-site, therefore reflected in Base Case characterization such as traffic monitoring. This workforce is anticipated to be approximately equal to that required for the construction of the NSDF Project and the existing roads within the CRL site will continue to be used to access the site. Traffic generated for construction and operations of the SMR will be small compared to that required for NSDF and negligible compared to on-going CRL site operations. Mitigation has been or will be implemented on the CRL Site to limit and offset traffic-related wildlife mortality from previous and existing anthropogenic activities in the RSA.

The end-state plan for the CRL site will be to return lands disturbed by site activities to a condition that is physically stable and safe in keeping with the land use and landscape of the day. Therefore, decommissioning and environmental remediation activities are anticipated to positively affect terrestrial biodiversity. Once existing infrastructure is removed and the CRL site is reclaimed and ceases to be frequented by large numbers of employees, the level of anthropogenic disturbance within the site will be greatly reduced, benefiting the terrestrial environment in the RSA.

RFDs, as currently understood, will either have no spatial overlap or are likely to positively affect terrestrial biodiversity, so no residual adverse cumulative effects are identified. Future, beyond regional disturbance factors (e.g., climate change) were considered qualitatively as part of the Application Case.

8.3.5.1 Bats

Populations of little brown myotis (*Myotis lucifugus*), northern myotis (*Myotis septentrionalis*) and tri-colored bats (*Perimyotis subflavus*) that overlap the terrestrial environment RSA are highly sensitive to changes in survival and reproduction because white nose syndrome has resulted in dramatic declines of these species across the eastern portions of their Canadian range, which includes the RSA. Therefore, the existing level of pressure on these bat species in the Base Case has likely already exceeded their resilience and adaptability limits and they are unlikely to be self-sustaining or ecologically effective. Consequently, the cumulative effects of existing disturbance and especially the introduced white nose syndrome are considered significant in the Base Case (i.e., even before the NSDF Project is included).

The NSDF Project will contribute a small increment to this existing significant adverse cumulative effect. Importantly, because vegetation clearing will be undertaken outside of the maternity roosting season, no mortality of roosting bats is expected as a result of the NSDF Project and effects or the NSDF Project to survival and reproduction are considered neutral. In addition, the remaining availability of potential maternity roosting habitat is not likely a limiting factor in the terrestrial environment RSA. The contribution of the NSDF Project to the existing significant adverse cumulative effect to bats is predicted to be negligible (i.e., no detectable changes to bat populations), and the Project does not contribute to the spread of white nose syndrome, which is the primary driver of the existing significant adverse cumulative effect.

Maternity roost habitat is currently not considered critical habitat under the *Species At Risk Act* and as such, offsetting the removal of potential bat maternity roost trees is not required. However, the use of appropriately designed bat boxes can increase the availability of maternity roosting locations and may aid in the recovery of bats (ECCC 2018). Bat boxes have been installed in suitable locations in the terrestrial environment RSA is recommended to mitigate the incremental contribution of the NSDF Project. Monitoring is being conducted to determine if boxes are being used. As well, a comprehensive Sustainable Forest Management Plan is being developed for the CRL site, with an objective to ensure the long-term retention of trees serving as maternity roosts for bat species.

8.3.5.2 Blanding's Turtle

The SSA would permanently remove 26 ha of critical habitat for Blanding's turtle critical habitat during construction which represents 14.5% of the currently available critical habitat in the LSA. The upland habitat and riparian habitat affected by the NSDF Project has the potential to be used by Blanding's turtle for nesting, thermoregulation and summer inactivity. Females who use the area for nesting may experience a reduction in reproductive success until they find new areas within which to nest. Additionally, females may need to travel greater distances if the availability of new nesting sites is limited and/or use lower quality habitats. The use of lower quality habitats could affect hatchling success rates. In searching for new habitats, individual Blanding's turtles may become exposed to other risks (e.g., roads).

With the implementation of the comprehensive mitigation outlined in the *Blanding's Turtle Road Mortality Mitigation Plan* (Golder 2019b), along with monitoring and adaptive management, CNL's activities in the RSA are predicted to have a net neutral or positive effect on the local Blanding's turtle population during the Base Case. That is, the mitigation that is or will be implemented on the CRL site is considered sufficient to limit and offset mortality from previous and existing anthropogenic activities in the RSA. There is uncertainty regarding the effectiveness of mitigation, but CNL is committed to monitoring and adaptive management, including implementing additional conservation actions should these be necessary, such that CRL operations result in a net neutral or positive effect on the Blanding's turtle population in the RSA.

Potential effects associated with critical habitat loss have been identified according to a precautionary approach. The importance of effects may be overestimated because the occupancy of critical habitat identified in the SSA remains unconfirmed despite considerable survey effort. To mitigate these potential effects, CNL will create new nesting mounds on both sides of Priority 2 culverts after they are replaced. Nest mounds will be monitored weekly during the nesting season and after periods of rain and maintenance of these mounds (e.g., vegetation removal) will also be completed at this time, if females are not present.

The weight of evidence suggests that, with mitigation committed to by CNL, effects from the NSDF Project will not jeopardize the survival of the regional Blanding's turtle population. With sufficient mitigation implemented at CRL, reductions in Blanding's turtle road mortality are possible, even with increased traffic volumes associated with the NSDF Project. Moreover, critical habitat will be assessed annually to ensure no significant loss at CRL and to determine compensation measures initiated at CRL or elsewhere.

8.3.6 Ambient Radioactivity and Ecological Health

Cumulative effects of previous and existing projects on ecological health have been considered through assessment of the Base Case and Application Case (see Section 5.7.6) and no significant adverse effects were identified.

CNL reports the results of the Environmental Monitoring Program for the CRL site each year to the CNSC. The Environmental Monitoring Program data are collected to verify that radiation exposure to ecological receptors as a result of the operations of the CRL site remain as low as reasonably achievable. It is noted that additional future site activities may affect the baseline radioactivity prior to NSDF operations. For example, the National Research Universal reactor was shut down in March 2018, which has reduced airborne emissions at CRL and has lowered environmental concentrations of some radiological contaminants (e.g., tritium). In addition, emissions from the B206 stack and cemented molybdenum waste storage have ceased as the facility has been shut down (production ended in 2016).

Measurements of radionuclide concentrations have been performed at specific areas of concern within the CRL site, and included studies of ambient radiation as well as soil, groundwater and vegetation contamination in areas affected by groundwater plumes from waste management areas at CRL. Radiological contamination in the East Swamp wetland is relevant to the NSDF Project, as this area is immediately west of the SSA. Because this wetland is potentially downgradient of parts of the SSA, characterization of the contamination present is important in defining Base Case conditions. The East Swamp wetland has existing contamination associated with a shallow subsurface plume from the Chemical Pit and a second plume from Reactor Pit 2. The surface contamination distribution in the East Swamp has been characterized on a five-year frequency, with radiation field surveys, surface surveys and vegetation contamination surveys performed in 2002, 2007, and 2012. Additional relevant surveying has been performed to characterize the Chemical Pit plume.

RFDs within the CRL site (i.e., the RSA) include only the new or upgrades to research and development facilities, construction and operation of the SMR, new support infrastructure, and on-going decommissioning and environmental remediation activities. Revitalization projects at the site (i.e., new or upgrades to research and development facilities, new support infrastructure) and decommissioning include several small projects staged over a 10-year period where best practices, mitigation and monitoring for management of emissions will to be followed. No process intakes of water from or discharges to surface or groundwater, or releases to air beyond potential for a limited amount of steam from dry cooling towers, are identified in the description of the planned SMR (Global First Power 2019). During normal operations, the SMR will introduce a very small radiological exposure to the environment near the plant, within the CRL site (Global First Power 2019). The incremental radiological (in proximity to the SMR) and non-radiological emissions from RFD Projects at any one time are expected to be small, distributed across the CRL site and removed from the more intensive activities within the SSA (i.e., the NSDF Project footprint). Potential effects from RFD Projects are not expected to spatially overlap with potential effects to ecological health from the NSDF Project.

The NSDF Project will enable the remediation of contaminated lands and legacy waste management areas, and decommissioning of outdated infrastructure at the CRL site and CNL's other business locations to support future CNL work. The end-state plan for the CRL site will be to return lands disturbed by site activities to a condition that is physically stable and safe in keeping with the land use and landscape of the day. Therefore, decommissioning and environmental remediation activities are anticipated to positively affect ecological health. Because RFDs will have no spatial overlap or are likely to positively affect ecological health, an RFD Case is not presented as part of the assessment.

8.3.7 Human Health

Cumulative effects of previous and existing projects on human health have been considered through assessment of the Base Case and Application Case (see Section 5.8.6) and no residual adverse effects were identified.

CNL reports the results of the Environmental Monitoring Program for the CRL site each year to the Canadian Nuclear Safety Commission. The Environmental Monitoring Program data are collected to verify that radiation doses to members of the public as a result of the operations of the CRL site remain as low as reasonably achievable. The calculated radiation dose to members of the public from CRL operations in 2018 represents the most current baseline radiation dose from CRL prior to the NSDF Project (i.e., Base Case). The 2018 dose assessment of 0.032 millisieverts per year (mSv/yr), showed that radiation dose to the public from CRL operations was below the effective dose limit of 1 mSv/yr for members of the public (CNL 2019).

RFDs within the CRL site (i.e., the RSA) include only the new or upgrades to research and development facilities, construction and operation of the SMR, new support infrastructure, and on-going decommissioning and environmental remediation activities. Revitalization projects at the site (i.e., new or upgrades to research and development facilities, new support infrastructure) and decommissioning include several small projects staged over a 10-year period where best practices, mitigation and monitoring for management of emissions will be followed. No process intakes of water from or discharges to surface or groundwater, or releases to air beyond potential for a limited amount of steam from dry cooling towers, are identified in the description of the planned SMR (Global First Power 2019). During normal operations, the SMR will introduce a very small radiological exposure to workers or members of the public near the plant, within the CRL site (Global First Power 2019). The incremental radiological (in proximity to SMR) and non-radiological emissions from RFD Projects at any one time are expected to be small, distributed across the CRL site and removed from the more intensive activities within the SSA (i.e., the NSDF Project footprint). Potential effects from RFD Projects are not expected to spatially overlap with potential effects to human health from the NSDF Project.

The NSDF Project will enable the remediation of contaminated lands and legacy waste management areas and decommissioning of outdated infrastructure at the CRL site and CNL's other business locations to support future CNL work. The end-state plan for the CRL site will be to return lands disturbed by site activities to a condition that is physically stable and safe in keeping with the land use and landscape of the day. Therefore, decommissioning and environmental remediation activities are anticipated to positively affect human health. Because RFDs will have no spatial overlap or are likely to positively affect human health, an RFD Case is not presented as part of the assessment.

8.3.8 Land and Resource Use

The land and resource use RSA is defined as the area within which the potential effects of the NSDF Project may interact with the effects of other existing or reasonably foreseeable projects. The land use and resource use RSA corresponds with the combined area of the terrestrial and aquatics RSAs and is defined to capture direct and indirect effects on the terrestrial and aquatic environment resulting from the Project (e.g., habitat loss, sensory disturbance for wildlife and changes to habitat from dust deposition) as these effects have the potential to result in subsequent effects on land and resource use. No cumulative effects with RFDs were identified in Sections 8.3.4 and 8.3.5 (aquatic environment, terrestrial environment) that could potentially introduce indirect effects to land and resource use. Similarly, of the RFDs identified (see Section 8.2), none will result in change in broad land use category, use or access to land outside of the CRL site. As such, potential effects from RFDs are not expected to spatially overlap with potential effects to land and resource use from the NSDF Project. Because RFDs will have no spatial overlap, an RFD Case is not presented as part of the assessment.

8.3.9 Socio-economics

The socio-economics assessment (Section 5.10) considered potential cumulative effects as part of the Base Case, Application Case and RFD Case. RFDs in the RSA that are anticipated to overlap with the NSDF Project include new or upgrades to research and development facilities, construction and operation of the SMR, new support infrastructure, and on-going decommissioning and environmental remediation activities on the CRL site and the NPD Closure Project. As well, there may be overlap of the construction phase with limited construction at neighbouring Garrison Petawawa. The effects of the RFD projects were considered for their potential to affect socio-economic VCs (i.e., labour market and economic development, services and infrastructure, and housing and accommodation).

8.3.9.1 Labour Market and Economic Development

CNL is planning new nuclear research facilities and support buildings to revitalize the CRL site. The revitalization of the CRL site is planned to occur over the 10-year period 2016-2026. The workforce required for site revitalization activities at any point is expected to be maintain a similar rate to the workforce on-site supporting those activities at present, captured as part of existing conditions. This workforce is anticipated to be approximately equal to that required for the construction of the NSDF Project. CNL will continue to provide updated information to interested contractors and suppliers on work packages as they develop. Nonetheless, the business prospective of the NSDF Project has motivated prospective contractors to engage local and Indigenous companies. A specific new research and development project announced in 2019 is the proposal by Global First Power to build and operate a small modular reactor at the CRL site. Based on the small scale of the development, labour resources for construction will be small compared to that required for the NSDF Project and negligible compared to on-going CRL site operations.

CNL's proposed NPD Closure Project is expected to be executed over a two-year period from 2021 to 2023. It will employ an average of 40 people (approximately 30 existing CNL employees and 10 external contractors). External contractors that may be sourced from the LSA and RSA communities, with possibly some specialized contractors coming from Ottawa and beyond. The peak workforce is expected to be approximately 340 workers in RFD Case (300 peak workforce for the NSDF Project and approximately 40 person workforce for the NPD Closure Project).

Decommissioning of eight buildings, renovation of three and construction of a new 9,900 m facility for the Royal Dragoons planned within the built-up area at Garrison Petawawa (approximately 10 km south of the SSA) in 2020 to 2021 may require labour resources for construction from within the RSA.

Given the size of the labour force in the LSA and RSA in 2016 of approximately 3,370 and 791,985 respectively, with an unemployment rate of 6.6% for both the LSA and RSA (Statistics Canada 2017a,b,c,d), it is not expected that local labour will be constrained in consideration of the demand for labour from the RFD Case. A positive cumulative effect is identified on employment opportunities and income generation (see Section 5.10.8.2.1 Labour Market and Economic Development).

8.3.9.2 Service and Infrastructure

8.3.9.2.1 Transportation and Traffic

It is anticipated that there will be additional traffic associated with an estimated average of 225 full time equivalent workers commuting to and from the CRL site each day for the NSDF Project. CNL is planning new nuclear research facilities and support buildings to revitalize the CRL site. The revitalization of the CRL site is planned to occur over the 10-year period 2016-2026. The workforce required for site revitalization activities at any point is expected to be maintain a similar rate to the workforce on-site supporting those activities at present, captured as part of traffic monitoring to characterize existing conditions. This workforce is anticipated to be approximately equal to that required for the construction of the NSDF Project. On-going decommissioning and environmental remediation activities on the CRL site will primarily be completed by CNL employees.

Traffic generated for construction and operations of the SMR, as well as for limited construction at Garrison Petawawa will be small compared to that required for NSDF and negligible compared to on-going CRL site operations.

The NPD Closure Project is not expected to require regular transportation to and from the CRL site. The NPD Closure Project is projected to increase traffic on local roads including Highway 17 by approximately 70 trips per day delivering materials, personnel and services to the CNL NPD site (approximately 30 trips a day for raw materials and 40 trips per day for personnel travel).

Overall, if there is temporal overlap of the NSDF Project, NPD Closure Project and the CNL site revitalization projects, this could result in an average additional 265 workers (225 for the NSDF Project and 40 for the NPD Closure Project) commuting in the region, with approximately 225 of these additional workers commuting to the CRL site. As well, based on estimates of truck deliveries to the NSDF Project site during the 24-month construction period, approximately 200 shipments per day are anticipated during the nine-month construction season.

In consideration of the increased traffic from the NSDF Project and applicable RFD Projects, and the annual average daily traffic levels in the LSA and RSA, which range from 6,700 to 12,300 vehicles per day, the cumulative effects of traffic from the RFD Case may slightly increase traffic levels during the morning and evening commutes.

The increase in traffic from the transportation of workers, supplies and equipment for the NSDF Project and applicable RFD projects is expected to result in degradation of public transportation infrastructure. The incremental increase in traffic expected from applicable RFD Projects is small, when considered with the NSDF Project during construction. Overall, the cumulative residual effect on transportation and traffic is predicted to be not significant for the RFD Case (see Section 5.10.8.2.3 Services and Infrastructure).

8.3.9.2.2 Emergency and Protective Services

Emergency and protective services at CRL generally rely on CNL's own internal capacity. For medical emergencies, trained CNL personnel will conduct initial evaluation and assistance, and will request external EMS, as required. Chalk River Laboratories' existing emergency and protective services at the CRL site are expected to be sufficient for the NSDF Project, construction and operation of the SMR, and on-going decommissioning and revitalization projects. Existing emergency and protective services around the NPD site are also expected to be sufficient for the NPD Closure Project activities. There may be an increase in demand for emergency and protective services in the LSA and RSA communities, as well as the County of Renfrew, due to the need to support more serious project-related incidents (e.g., incidents requiring hospitalization). However, the predicted residual effect is expected to be limited due to the size of the workforces at any one time for the RFD projects. The cumulative residual effects on emergency and protective services for the RFD Case are determined to be not significant (see Section 5.10.8.2.3 Services and Infrastructure).

8.3.9.3 Housing and Accommodations

Similar to the NSDF Project, it is expected that a portion of the RFD project workforce would come from the LSA and RSA and, therefore, already be residents of the area and not require temporary accommodation. In addition, not all of the RFD projects would occur at the same time. For example, the NPD Closure Project is anticipated to occur over a 2-year period from 2021 to 2023, whereas revitalization and decommissioning activities at the CRL site will occur progressively over the 10-year period 2016 to 2026. The construction of the SMR may overlap with the construction of the NSDF Project; however, based on the small scale of the development, labour resources for construction will be small compared to that required for the NSDF Project. Based on the small scale of the development and short timeline for construction, labour requiring temporary accommodation will be small compared to that required for the NSDF Project. Limited construction at neighboring Garrison Petawawa is planned between 2020 and 2021. When considered with the NSDF Project temporary accommodation requirements, and the availability of hotels, motels and other accommodation in the LSA and RSA, it is not expected that the combined effects of the RFD projects will place considerable constraints on temporary accommodation in LSA and/or RSA communities. Overall, the cumulative residual effect on commercial accommodation availability is predicted to be not significant for the RFD Case (see Section 5.10.8.2.2 Housing and Accommodations).

8.3.10 Indigenous Interests

8.3.10.1 Traditional Land and Resource Use

RFDs in the Regional Study Area (RSA) may overlap with potential effects from the NSDF Project include new or upgrades to research and development facilities, construction and operation of the SMR, new support infrastructure, and on-going decommissioning and environmental remediation activities on the CRL site, as well as, briefly, the construction at Garrison Petawawa.

The traditional land and resource use RSA is defined to capture effects on the terrestrial and aquatic environments as a result of the NSDF Project (e.g., habitat loss, sensory disturbance for wildlife and changes to habitat from air quality and surface water quality, changes in groundwater and surface water quality, habitat loss and changes in abundance, distribution and disturbances to wildlife and fish), as these effects have the potential to result in subsequent effects on land and resource use. The RSA for traditional land and resource use is a combination of the air quality and aquatic environment RSAs as this is the largest extent of potential cumulative effects on land and resource use. There are no traditional land and resource use activities such as hunting, fishing, gathering and cultural ceremonies occurring in either the SSA or LSA as this is a restricted public access area. Traditional land and resource use activities likely did occur prior to federal control of the CRL site. It is possible that traditional land uses continue with parts of the RSA outside of the restricted public access areas such as fishing or waterfowl hunting along the Ottawa River shoreline of the CRL site and Garrison Petawawa property. There is potential trapping identified in the southern portion of the RSA in the Garrison Petawawa property and two trapline areas in the western portion of the RSA. To date, these have not been identified as traplines belonging to Indigenous peoples.

The NSDF Project is not predicted to have any terrestrial effects beyond the CRL site, and results of the aquatic environment assessment identify that measurable residual effects on aquatic biodiversity VCs are not predicted as a result of the NSDF Project. Therefore, no effects on traditional land users are expected. Because no residual effects are identified and therefore RFDs will have no spatial overlap, an RFD Case is not presented as part of the assessment.

8.3.10.2 Socio-economics

RFDs in the Regional Study Area (RSA) may overlap with potential effects from the NSDF Project include new or upgrades to research and development facilities, construction and operation of the SMR, new support infrastructure, and on-going decommissioning and environmental remediation activities on the CRL site, as well as, briefly, the construction at Garrison Petawawa.

No pathways were identified as having a primary linkage to Indigenous socio-economic VCs. Secondary pathways were identified related to employment, contracting and supplier opportunities and potential noise and air quality effects related to construction activities. The NSDF Project may result in small positive effects to local Indigenous peoples through potential contracting or employment opportunities, which may act cumulative with similar small positive effects resulting from the identified RFDs.

8.3.11 Uncertainty in the Assessment

Consideration of cumulative effects is based on understanding at the time of assessment of what developments are reasonably foreseeable and how those developments will be implemented.

It is noted that transport of waste from decommissioning activities for facilities on the main CRL campus are considered through this assessment. The decommissioning activities and haulage of waste from remediation of WMAs on the CRL site located outside of the main campus are anticipated to use existing roadways to NSDF; however, remedial action plans for the large-scale cleanup of the WMAs are not yet developed thus there is uncertainty on the extent of waste that will be received in NSDF and their transport routes. Once Remedial Action Plans are developed for WMAs (or other areas of large land contamination), the waste transport plans would be developed and trigger the appropriate Environmental Reviews at that time.

If NSDF Project follow-up monitoring identifies a residual effect not predicted or anticipated by the EIS, the cumulative effects of the project would be re-evaluated.

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9.0 SUMMARY OF SIGNIFICANCE OF RESIDUAL EFFECTS

The following assessments were completed to evaluate the biophysical and human environment effects of the Near Surface Disposal Facility (NSDF) Project and to satisfy the requirements of the review being undertaken under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012):

- Section 5.2 Atmospheric Environment;
- Section 5.3 Geological and Hydrogeological Environment;
- Section 5.4 Surface Water Environment;
- Section 5.5 Aquatic Environment;
- Section 5.6 Terrestrial Environment;
- Section 5.7 Ambient Radioactivity and Ecological Health;
- Section 5.8 Human Health;
- Section 5.9 Land and Resource Use;
- Section 5.10 Socio-economic Environment; and
- Section 6.0 Indigenous Interests.

The residual effects classification of primary pathways and the associated predicted changes in measurement indicators provide the foundation for determining the significance of incremental and cumulative effects from the NSDF Project and other existing, approved and reasonably foreseeable developments on valued component (VC) assessment endpoints. The overall environmental assessment approach described in Section 5.1 was used for the assessment of residual effects that cannot be avoided or mitigated through the re-design or relocation of the proposed NSDF Project or through proponent commitments. Modifications in the approach (where applicable) are described in detail in the discipline assessments (Sections 5.2 through 6.0).

Table 9-1 summarizes the proposed environmental design features and mitigation, residual effects and significance of effects (where applicable) for the Application Case and the Reasonably Foreseeable Development (RFD) Case (where applicable) for each of the VCs. The classification of residual adverse effects and the determination of significance are completed only for those VCs that have assessment endpoints. The intent of the environmental assessment is to predict if the NSDF Project is likely to cause a significant adverse (i.e., negative) effect on the environment. Although the neutral and positive residual effects associated with the NSDF Project are reported in the relevant discipline assessments, they are not assessed for significance.

No pathways were identified as having a primary linkage to land and resource use VCs, Indigenous traditional land and resource VCs or Indigenous socio-economic VCs, so no assessment of significance was undertaken. The NSDF Project may result in small positive effects to local Indigenous peoples through potential contracting or employment opportunities.

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Table 9-1: Summary of Predicted Residual Effects on Valued Components and Significance – Application Case and Reasonably Foreseeable Developments Case

Discipline	Valued Component	Assessment Endpoint	Residual Effect	Project Phase the Effect Occurs in	Contributing Project Activity	Mitigation	Significance	
							Application Case	RFD Case

Atmospheric Environment	Air Quality	Performance against criteria and thresholds for protection of human health and the environment	▪ Construction activities use vehicles and equipment that combust fuel and emit indicator compounds. These activities involve material handling, vehicles travelling on paved and unpaved roads, and wind erosion of stockpiles that will result in fugitive dust emissions.	Construction	▪ Site preparation
					▪ Construction of the engineered containment mound (ECM)
					▪ Development of surface water management structures
					▪ Construction of the Wastewater Treatment Plant (WWTP) and other support facilities
					▪ On-site road and access development
					▪ Vehicle traffic on-site including soil spoils haulage to a soil storage area
						▪ Implementation of CNL's procedure for Management and Monitoring of Emissions (CNL 2018), which includes operational control monitoring and air verification monitoring.
						▪ The *Dust Management Plan* (AECOM 2018) to be implemented for the NSDF Project will provide information on dust mitigation, including:
						  ▪ Use of water spraying or misting techniques (e.g., water trucks) as the primary dust control method.
						  ▪ Use of fixatives (e.g., chemical suppressant) for dust control.
						  ▪ Covering stockpiles and exposed areas prior to high wind or dry conditions where standard dust suppressants may be inadequate in preventing dust generation caused by wind erosion.
						  ▪ Minimizing the size of the exposed working areas containing contaminated materials to the extent practicable using a phased excavation approach.
						  ▪ Revegetating affected areas or adding mulch to completed cells and excavated areas as soon as practicable.
						  ▪ Dampening soil in dry areas prior to commencing truck/machinery activities in the area.
						  ▪ Reducing activities to avoid unnecessary dust generation;
						  ▪ Using wind fencing around work areas.
						  ▪ Postponing work activities likely to cause dust if sustained wind speeds are predicted to exceed 40 km/hr, unless it can be shown that the work site is sufficiently protected that wind will not generate unacceptable amounts of dust.
						▪ On-site vehicles and equipment engines will meet Tier 2 emission standards and be maintained in good working order.
						▪ Limit idling of vehicles on-site.
						▪ Processed wastewater will not be heated within the WWTP (raising the temperature increases potential release rates).
						▪ There is active ventilation within the WWTP building and all active ventilation exhaust will be filtered through HEPA prior to release.
							Not Significant	Not applicable

			▪ Most activity and material handling occur during the operations phase and pathways include:
			  ▪ vehicles and equipment combust fuel and emit indicator compounds.
			  ▪ material handling, vehicles travelling on paved and unpaved roads and wind erosion of stockpiles emit fugitive dust.
			  ▪ release of emissions from the disposal cell cover and passive vents.
			  ▪ emissions from the decomposition of waste.
			  ▪ the disposal cell cover and the WWTP emit odour.
				Operations	▪ Phased development of ECM disposal cells
					▪ On-site transportation of waste and placement of waste in the ECM
					▪ Progressive closure of disposal cells and installation of final cover
					▪ Operation of the WWTP
							Not Significant	Not applicable

			▪ Air emissions from the decomposition of waste.	Operations and Post-closure	▪ Placement of waste in the ECM	▪ Installation of the interim and final covers will reduce release of emissions from the ECM.	Not Significant	Not applicable

Table 9-1: Summary of Predicted Residual Effects on Valued Components and Significance – Application Case and Reasonably Foreseeable Developments Case

Discipline	Valued Component	Assessment Endpoint	Residual Effect	Project Phase the Effect Occurs in	Contributing Project Activity	Mitigation	Significance	
							Application Case	RFD Case
Atmospheric Environment (continued)	Greenhouse Gases (GHG)	Comparison to provincial and national totals	▪ GHG emissions from the decomposition of waste.	Operations and Post-closure	▪ Placement of waste in the ECM	▪ Installation of the interim and final covers will reduce release of emissions from the ECM.	Not Significant	Not applicable
			▪ Construction activities use vehicles that combust fuel and emit GHGs. These vehicles travel on roads on CRL site and are used for material handling. ▪ Additionally, there are GHG emissions associated with land clearing for the NSDF project. One-time emissions will be presented over the life-time of the NSDF project. ▪ Most activity and material handling occur during Operations. Vehicles and equipment combust fuel and emit GHGs. These activities involve material handling with vehicles travelling on roads. The disposal cell emits GHG emissions from the decomposition of waste. The WWTP will be fuelled by Natural Gas. Additionally, there is a loss of carbon sink as a result of the cleared land for the NSDF Project.	Construction and Operations	**Construction** ▪ Site preparation ▪ Construction of the ECM ▪ Development of surface water management structures ▪ Construction of the WWTP and other support facilities ▪ On-site road and access development ▪ Vehicle traffic on-site including soil spoils haulage to a soil storage area **Operations** ▪ Phased development of disposal cells ▪ On-site transportation of waste and placement of waste in the ECM ▪ Progressive closure of disposal cells and installation of final cover ▪ Operation of the WWTP	▪ Implementation of CNL's procedure for Management and Monitoring of Emissions (CNL 2018a), which includes operational control monitoring and verification monitoring. ▪ On-site vehicles and equipment engines will be maintained in good working order. ▪ Limit idling of vehicles on-site.	Not Significant	Not applicable

Table 9-1: Summary of Predicted Residual Effects on Valued Components and Significance – Application Case and Reasonably Foreseeable Developments Case

Discipline	Valued Component	Assessment Endpoint	Residual Effect	Project Phase the Effect Occurs in	Contributing Project Activity	Mitigation	Significance	
							Application Case	RFD Case
Hydrogeology	Groundwater Quantity	Intermediate component (i.e., it does not have an assessment endpoint)	▪ The construction of the NSDF Project will physically alter groundwater levels and flows.	▪ All phases	▪ Project activities during the construction phase: ▪ Site preparation ▪ Construction of the ECM ▪ Development of surface water management structures ▪ Construction of the WWTP and other support facilities ▪ On-site road and access development	▪ The NSDF Project Footprint has been designed to limit disturbance to the natural environment. ▪ Discharge of treated effluent primarily to the exfiltration gallery area will help to reduce water loss from the hydrogeological system. ▪ Discharge of treated effluent to Perch Lake via transfer line will help reduce high water table conditions in the area of the exfiltration gallery.	Significance is not determined as Valued Component (VC) does not have an assessment endpoint.	Not applicable
		Intermediate component (i.e., it does not have an assessment endpoint)	▪ Adverse changes to groundwater quality from the discharge of treated effluent from the WWTP to the exfiltration gallery.	Operations	▪ Discharge of treated effluent to the exfiltration gallery	▪ The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses the best available technology that is economically achievable, and capable of meeting regulatory requirements. ▪ Effluent discharge targets for wastewater discharges are protective of the environment and human health. ▪ Discharge targets for non-radiological contaminants are sourced from federal and provincial guidelines for protection of aquatic biota. ▪ Discharge targets for radionuclides are the Canadian Drinking Water Guidelines with the exception of tritium for which a site-specific target is developed (Section 3.4.2.5.1). ▪ Treated effluent will be sampled and confirmed that it meets the effluent discharge targets before release to the environment. ▪ When applied, the proposed exfiltration gallery will promote the exfiltration of treated water into the local groundwater regime where further retention of radioactivity by the geosphere is anticipated. ▪ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water and groundwater quality. ▪ Appropriate procedures will be in place to effectively identify spill occurrences in the event treated effluent is released to areas other than directly to the exfiltration gallery and initiate appropriate emergency responses.	Significance is not determined as Valued Component (VC) does not have an assessment endpoint.	Not applicable

Table 9-1: Summary of Predicted Residual Effects on Valued Components and Significance – Application Case and Reasonably Foreseeable Developments Case

Discipline	Valued Component	Assessment Endpoint	Residual Effect	Project Phase the Effect Occurs in	Contributing Project Activity	Mitigation	Significance	
							Application Case	RFD Case
Hydrogeology (continued)	Groundwater Quality	Intermediate component (i.e., it does not have an assessment endpoint)	▪ Leakage of leachate from the ECM during the post-closure phase (i.e., after Year 2400) from liner and final cover degradation as a result of normal evolution can cause changes to groundwater quality.	Closure and Post-closure	▪ Installation of final cover, restoration and grading of Site Study Area (SSA). ▪ On-going long-term performance monitoring, transfer of NSDF Project into Institutional Control. ▪ Liner and final cover degradation as a result of normal evolution.	▪ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound and minimize leachate generation. ▪ The final cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity. ▪ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the final cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. ▪ The ECM final grading and drainage plan also includes collection ditches along the top of the ECM berm road to collect side slope drainage. ▪ The design life for the ECM is 550 years to meet the required time period to allow for radioactive decay of the waste placed in the facility (i.e., until it has decayed to levels that do not present a risk to the public and environment). ▪ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to groundwater quality.	Significance is not determined as VC does not have an assessment endpoint.	Not applicable
Surface Water Environment	Hydrology	Intermediate component (i.e., it does not have an assessment endpoint)	▪ The construction of the NSDF Project will physically alter drainage patterns in the Perch Creek and Perch Lake Watershed and may change downstream discharge, water levels, channel and bank stability, and water levels in adjacent wetlands.	Construction	▪ Site Preparation ▪ Construction of the ECM ▪ Development of surface water management structures ▪ Construction of the WWTP and other support facilities ▪ On-site road and access development ▪ Construction of transfer line and Perch Lake diffuse	▪ The NSDF Project footprint has been designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. ▪ A 30 m buffer will be established along identified wetlands near the SSA; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion. ▪ Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the CRL site will be used during construction around disturbed areas, where appropriate. ▪ During the construction phase, erosion and sediment control measures in place to mitigate the effects of sediment transport include the use of erosion control blankets, as needed, to control erosion on steep slopes, check dams in ditches and swale. ▪ Surface water from all external areas will be conveyed by ditches, swales and culverts to SWMPs to address water quality and water quantity criteria established for the wetland receiving waters and, ultimately, Perch Creek. ▪ Where drainage crosses roadways, culverts are sized to convey the 25-year design event without road overtopping. ▪ The SWMPs are designed to address erosion and sediment control concerns during construction by providing interim sediment control and by providing water quality/quantity controls during operations, closure and post-closure. ▪ Annual maintenance activities will identify any erosion problems. ▪ Inspections will be undertaken and maintenance activities completed, as required, after major storm events and after the annual spring melt to confirm there are no major erosion issues.		

Table 9-1: Summary of Predicted Residual Effects on Valued Components and Significance – Application Case and Reasonably Foreseeable Developments Case

Discipline	Valued Component	Assessment Endpoint	Residual Effect	Project Phase the Effect Occurs in	Contributing Project Activity	Mitigation	Significance	
							Application Case	RFD Case
Surface Water Environment (continued)	Hydrology	Intermediate component (i.e., it does not have an assessment endpoint)	▪ The installation of the ECM will physically alter drainage patterns and may change downstream discharge, water levels in adjacent wetlands, and channel and bank stability.	Closure and Post-closure	▪ Construction of the ECM ▪ Development and operation of surface water management structures ▪ Construction the WWTP and other support facilities ▪ On-site road and access development	▪ The final cover and site grading are designed to promote positive drainage from the NSDF SSA and reduce erosion or abrasion of the final cover. ▪ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound and minimize leachate generation. ▪ The final cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity. ▪ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the final cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. ▪ The ECM final grading and drainage plan includes collection ditches along the top of the ECM berm road to collect side slope drainage. ▪ The SWMPs are designed to address erosion and sediment control concerns by providing water quality/quantity controls during operations, closure and post-closure. ▪ Environmental monitoring will be completed as required during the institutional control period for the NSDF Project to confirm that the final cover is functioning as intended.	Significance is not determined as VC does not have an assessment endpoint.	Not applicable

	Surface Water Quality	Intermediate component (i.e., it does not have an assessment endpoint)	▪ Adverse changes to downstream surface water quality from the discharge of treated effluent from the WWTP to the exfiltration gallery and/or Perch Lake.	Operations and Closure	▪ Discharge of treated effluent
					▪ Surface water management
					▪ Operation of the WWTP
						▪ The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses best demonstrated available technology that is economically achievable and capable of meeting regulatory requirements.
						▪ Effluent discharge targets for wastewater discharges are protective of the environment and human health:
						  ▪ Discharge targets for non-radiological contaminants are sourced from federal and provincial guidelines for protection of aquatic biota.
						  ▪ Discharge targets for radionuclides are the Canadian Drinking Water Guidelines with the exception of tritium for which a site-specific target is developed (Section 3.4.2.5.1).
						▪ Treated effluent will be sampled to confirm it meets treatment targets before release to the environment.
						▪ When applied, the proposed exfiltration gallery will promote the exfiltration of treated water into the local groundwater regime where further retention of radioactivity by the geosphere is anticipated.
						▪ The Perch Lake diffuser design provides additional dilution of treated effluent at the point of release
						▪ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water quality.
						▪ Appropriate procedures will be in place to effectively identify spill occurrences in the event treated effluent is released to areas other than directly to the exfiltration gallery or to Perch Lake and initiate appropriate emergency responses.
							Significance is not determined as VC does not have an assessment endpoint.	Not applicable

Table 9-1: Summary of Predicted Residual Effects on Valued Components and Significance – Application Case and Reasonably Foreseeable Developments Case

Discipline	Valued Component	Assessment Endpoint	Residual Effect	Project Phase the Effect Occurs in	Contributing Project Activity	Mitigation	Significance	
							Application Case	RFD Case
Surface Water Environment (continued)	Surface Water Quality (continued)	Intermediate component (i.e., it does not have an assessment endpoint) (continued)	▪ Leakage of leachate from the ECM during the post-closure phase (i.e., after Year 2400) from liner and final cover degradation as a result of normal evolution can cause changes to downstream surface water quality.	Closure and Post-closure	▪ Installation of final cover, restoration and grading of SSA ▪ On-going long-term performance monitoring, transfer of NSDF Project into institutional control ▪ Liner and final cover degradation as a result of normal evolution	▪ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound and minimize leachate generation. ▪ The final cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity. ▪ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the final cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. ▪ The ECM final grading and drainage plan includes collection ditches along the top of the ECM berm road to collect side slope drainage. ▪ The design life for the ECM is 550 years to meet the required time period to allow for radioactive decay of the waste placed in the facility (i.e., until it has decayed to levels that do not present a risk to the public and environment). ▪ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water and groundwater quality.	Significance is not determined as VC does not have an assessment endpoint.	Not applicable
Terrestrial Environment	Vegetation Communities (including wetlands)	Maintenance of self-sustaining and ecologically effective vegetation communities	▪ Permanent loss of 33 ha of forested communities. ▪ Permanent changes to the distribution of forested habitats; no changes to the distribution of wetlands. ▪ Permanent edge effects may alter adjacent vegetation community richness.	All phases	▪ Vegetation clearing and grubbing	▪ The SSA has been designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. ▪ A 30 m buffer will be established along identified wetlands near the SSA; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion. ▪ A 5 m tree-line buffer is established from all property lines on the NSDF site to limit disturbance to vegetation and large tree roots at the treeline.	Not Significant	Not applicable

Table 9-1: Summary of Predicted Residual Effects on Valued Components and Significance – Application Case and Reasonably Foreseeable Developments Case

Discipline	Valued Component	Assessment Endpoint	Residual Effect	Project Phase the Effect Occurs in	Contributing Project Activity	Mitigation	Significance	
							Application Case	RFD Case
Terrestrial Environment (continued)	Canada Warbler	Maintenance of self-sustaining and ecologically effective populations	▪ Permanent loss of 28 ha of suitable habitat. ▪ Possible long-term avoidance in the Local Study Area (LSA) from sensory disturbance. ▪ Permanent small change in movement in the LSA. ▪ Permanent small reduction in carrying capacity.	All phases	▪ Vegetation clearing and grubbing ▪ Mobilization of equipment ▪ Hauling of materials ▪ Blasting	▪ The SSA has been designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. ▪ A 30 m buffer will be established along identified wetlands near the SSA; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion. ▪ A 5 m tree-line buffer is established from all property lines on the NSDF site to limit disturbance to vegetation and large tree roots at the treeline. ▪ Avoid conducting the activities with highest levels of noise and habitat disturbance during most sensitive life history phase (i.e., breeding and nesting for birds) by conducting vegetation clearing and grubbing before April 8, or after August 31 to avoid effects on nesting birds.	Not Significant	Not applicable
	Eastern Whip-poor-will	Maintenance of self-sustaining and ecologically effective populations	▪ Permanent loss of 2 ha of suitable habitat. ▪ Possible long-term avoidance in the LSA from sensory disturbance. ▪ Permanent small change in movement in the LSA. ▪ Permanent small reduction in carrying capacity.	All phases	▪ Vegetation clearing and grubbing ▪ Mobilization of equipment ▪ Hauling of materials ▪ Blasting		Not Significant	Not applicable
	Eastern Wood-pewee	Maintenance of self-sustaining and ecologically effective populations	▪ Permanent loss of 18 ha of suitable habitat. ▪ Possible long-term avoidance in the LSA from sensory disturbance. ▪ Permanent small change in movement in the LSA. ▪ Permanent small reduction in carrying capacity.	All phases	▪ Vegetation clearing and grubbing ▪ Mobilization of equipment ▪ Hauling of materials ▪ Blasting		Not Significant	Not applicable
	Golden-winged Warbler	Maintenance of self-sustaining and ecologically effective populations	▪ Permanent loss of 27 ha of suitable habitat. ▪ Possible long-term avoidance in the LSA from sensory disturbance. ▪ Permanent small change in movement in the LSA. ▪ Permanent small reduction in carrying capacity.	All phases	▪ Vegetation clearing and grubbing ▪ Mobilization of equipment ▪ Hauling of materials ▪ Blasting		Not Significant	Not applicable
	Wood Thrush	Maintenance of self-sustaining and ecologically effective populations	▪ Permanent loss of 28 ha of suitable habitat. ▪ Possible long-term avoidance in the LSA from sensory disturbance. ▪ Permanent small change in movement in the LSA. ▪ Permanent small reduction in carrying capacity.	All phases	▪ Vegetation clearing and grubbing ▪ Mobilization of equipment ▪ Hauling of materials ▪ Blasting		Not Significant	Not applicable

Table 9-1: Summary of Predicted Residual Effects on Valued Components and Significance – Application Case and Reasonably Foreseeable Developments Case

Discipline	Valued Component	Assessment Endpoint	Residual Effect	Project Phase the Effect Occurs in	Contributing Project Activity	Mitigation	Significance	
							Application Case	RFD Case
Terrestrial Environment (continued)	Bats	Maintenance of self-sustaining and ecologically effective populations	▪ Permanent loss of 28 ha of potential maternity roost habitat. ▪ Potential long-term avoidance of adjacent maternity roosting habitat in the LSA from sensory disturbance. ▪ Permanent negligible change in movement corridors between maternity roosting habitat patches.	All phases	▪ Vegetation clearing and grubbing ▪ Mobilization of equipment ▪ Hauling of materials ▪ Blasting	▪ The SSA has been designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. ▪ A 30 m buffer will be established along identified wetlands near the SSA; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion. ▪ A 5 m tree-line buffer is established from all property lines on the NSDF site to limit disturbance to vegetation and large tree roots at the treeline. ▪ Avoid conducting the activities with highest levels of noise and habitat disturbance during most sensitive life history phase (i.e., maternity roosting for bats) by conducting vegetation clearing and grubbing before April 8, or after August 31 to avoid effects on bat maternity roosts. ▪ Bat boxes are relatively inexpensive and can be highly effective at providing habitat for roosting little brown myotis and possibly northern myotis. Tri colored bats are less likely to use bat boxes, but may use other forms of artificial roosting habitat; these options may be considered. Installation of bat boxes in suitable locations in the RSA is recommended to offset the incremental contribution of the NSDF Project to cumulative effects on SARA listed bats. ▪ In consultation with CNL biologists and in consideration of future losses of anthropogenic structures that may provide roosting habitat, offsetting in the form of 16 bat boxes was recommended. Bat boxes were installed in May 2017. Each two chambered box (Bat Conservation International approved design) was installed back to back on wooden poles in eight different locations around the proposed NSDF location. Occupancy was confirmed in July 2018 and has been increasing since then. This box design is suggested to have capacity for 350–400 individual bats per box, providing roosting habitat for a potential maximum of 6,400 individual bats (with 16 boxes). ▪ Criteria for appropriate siting included accessibility of box locations for installation and future monitoring of utilization/effectiveness, avoidance of areas with radiological contamination in surface water features and appropriate distance to anthropogenic disturbances to avoid sensory effects (i.e., noise). Immature forested areas adjacent to larger uncontaminated waterbodies and wetlands are high priority locations because these forest types do not currently provide high quality roosting habitat and would be most benefited by installation of bat roost boxes to expand the spatial coverage of potential roosting habitat within the RSA. Final site selection will be at the discretion of CNL biologists. ▪ Monitoring is being conducted at least weekly to determine if boxes are being used. Boxes not being used may be moved to an alternate location. ▪ A project in collaboration with Trent University is currently underway, where bats are being trapped and tracked back to the roost site (natural tree or bat box). Guano collection is being performed as well. This work has a duration of two years and will provide CNL with a better understanding of habitat occupancy by the bat species at risk, including bat boxes, and habitat preference. This work will support the objective of addressing knowledge gaps on the three bat species at risk ▪ A comprehensive Sustainable Forest Management Plan will be implemented to ensure the long-term retention of trees serving as maternity roosts for the bat species.	Not Significant	Not applicable

Table 9-1: Summary of Predicted Residual Effects on Valued Components and Significance – Application Case and Reasonably Foreseeable Developments Case

Discipline	Valued Component	Assessment Endpoint	Residual Effect	Project Phase the Effect Occurs in	Contributing Project Activity	Mitigation	Significance	
							Application Case	RFD Case
Terrestrial Environment (continued)	Blanding's Turtle	Maintenance of self-sustaining and ecologically effective populations	▪ Long-term loss of 26 ha of critical habitat with implementation of mitigation to ensure no significant loss of critical habitat. ▪ Permanent change in potential movement corridors between habitat patches. ▪ Long-term increased risk of injury or mortality on roads from increased traffic (but mitigation may be sufficient to prevent this effect). ▪ Permanent increased risk of mortality from changes to movement patterns.	All phases	▪ Vegetation clearing and grubbing ▪ Mobilization of equipment ▪ Hauling of materials ▪ Installation and maintenance of perimeter fencing	▪ The SSA has been designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. ▪ A 30 m buffer will be established along identified wetlands near the SSA; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion. ▪ A 5 m tree-line buffer is established from all property lines on the NSDF site to limit disturbance to vegetation. ▪ Critical Blanding's turtle habitat will be assessed annually to ensure no significant loss at CRL and to determine compensation measures initiated at CRL or elsewhere. ▪ Artificial nest mounds will be constructed on both sides of new and replaced culverts. ▪ New and replaced culverts will be enhanced by planting native vegetation around the culvert entrances, while maintaining a clear line of site through the culvert. ▪ Reptile exclusion fencing will be installed around the perimeter of the SSA prior to initiating activities during the construction phase and prior to the active Blanding's turtle season (i.e., prior to April). ▪ Damaged or ineffective fencing and signage will be repaired. ▪ Road grading and levelling activities will not be completed during the turtle nesting season (May 15 to June 30). ▪ Temporary exclusion fencing will be installed around the NSDF EMR footprint during construction of the NSDF Project. This temporary exclusion fencing will be replaced by permanent fencing by the end of construction of the NSDF Project. ▪ A road mortality survey will be completed for turtles in the species' active seasons of April 15 to September 30. ▪ After replacement, culverts will have appropriate permanent fencing installed for 200 m on either side of the culvert to guide turtles through the tunnel. ▪ Following approval of the NSDF Project, additional permanent exclusion fencing will be installed in reptile hotspots along Plant Road. ▪ Drivers have standard safety training and are provided with environmental awareness training. ▪ Enforce existing CRL site speed limits on access roads. ▪ Post signs warning drivers of high use wildlife areas and reduce speed limits in these areas. ▪ Employees in vehicles encountering wildlife of concern (e.g., Blanding's turtle) on roads are required to communicate the presence of wildlife on the roads to other employees working in the area and to CNL's Environmental Staff. ▪ The existing CNL Employee Education Program will be adapted to the NSDF Project prior to construction. All employees and contractors will be trained on the identification and safe handling of Blanding's turtle to help the turtle across the road. ▪ As per CNL's Management of Land, Habitat and Wildlife procedure (CNL 2018b), dead or wounded animals on roads must be reported to the environmental department. ▪ Blanding's turtle collisions with vehicles will be monitored, which provides feedback for adaptive management.	Not Significant	Not applicable

Table 9-1: Summary of Predicted Residual Effects on Valued Components and Significance – Application Case and Reasonably Foreseeable Developments Case

Discipline	Valued Component	Assessment Endpoint	Residual Effect	Project Phase the Effect Occurs in	Contributing Project Activity	Mitigation	Significance	
							Application Case	RFD Case
Terrestrial Environment (continued)	Eastern Milksnake	Maintenance of self-sustaining and ecologically effective populations	▪ Direct loss of some suitable milksnake habitat. ▪ Potential avoidance of otherwise suitable habitat due to sensory disturbance in the LSA Permanent small change in movement in the LSA. ▪ Permanent small reduction in carrying capacity.	All phases	▪ Vegetation clearing and grubbing ▪ Mobilization of equipment ▪ Hauling of materials ▪ Blasting	▪ A 5 m tree-line buffer is established from all property lines on the NSDF site to limit disturbance to vegetation and large tree roots at the treeline. ▪ Temporary exclusion fencing will be installed around the NSDF EMR footprint during construction of the NSDF Project. This temporary exclusion fencing will be replaced by permanent fencing by the end of construction of the NSDF Project. ▪ Damaged or ineffective fencing and signage will be repaired. ▪ Drivers have standard safety training and are provided with environmental awareness training. ▪ Enforce existing CRL site speed limits on access roads. ▪ Post signs warning drivers of high use wildlife areas and reduce speed limits in these areas. ▪ Employees in vehicles encountering wildlife of concern (e.g., milksnake) on roads are required to communicate the presence of wildlife on the roads to other employees working in the area and to CNL's Environmental Staff. ▪ The existing CNL Employee Education Program will be adapted to the NSDF Project prior to construction. All employees and contractors will be trained on the identification and safe handling of milksnake to help the snake across the road. ▪ As per CNL's Management of Land, Habitat and Wildlife procedure (CNL 2018b), dead or wounded animals on roads must be reported to the environmental department. ▪ Milksnake collisions with vehicles will be monitored, which will provide feedback for adaptive management.	Not Significant	Not applicable
	Monarch Butterfly	Maintenance of self-sustaining and ecologically effective populations	▪ Permanent loss of 5 ha of suitable habitat. ▪ Permanent small change in movement in the LSA. ▪ Permanent small reduction in carrying capacity.	All phases	▪ Vegetation clearing and grubbing	▪ The SSA has been designed to avoid wetlands and limit disturbance to the natural environment to the extent feasible. For example, as the ECM is developed sequentially, undeveloped cells may be prepared and used as stockpile areas to store overburden soils to be used during construction or for daily ECM cover stockpiles. This approach reduces the required area for the laydown and stockpile of materials. ▪ A 30 m buffer will be established along identified wetlands near the SSA; where the buffer can not be maintained, appropriate mitigation will be established to address any risk of erosion. ▪ If vegetation clearing is scheduled in open habitat between late May and October, the habitat will be searched in advance of construction for the presence of milkweed. Removal of milkweed between May and October will be managed in accordance with CNL Environmental Protection Program.	Not Significant	Not applicable

Table 9-1: Summary of Predicted Residual Effects on Valued Components and Significance – Application Case and Reasonably Foreseeable Developments Case

Discipline	Valued Component	Assessment Endpoint	Residual Effect	Project Phase the Effect Occurs in	Contributing Project Activity	Mitigation	Significance	
							Application Case	RFD Case

Ambient Radioactivity and Ecological Health	All Ecological Health VCs	Protection of ecological health	▪ Dust may be created during the handling of bulk materials, and emissions of gases may be released during storage and disposal of radioactive materials, which can affect ecological health.
			▪ Emissions may be released from the WWTP to air during operations, which can affect ecological health.
				Operation and Closure	▪ Phased development of disposal cells in the ECM
					▪ On-site transportation of waste and placement in the ECM
					▪ Progressive closure of disposal cells and installation of final cover
					▪ Operation of the WWTP
						▪ CNL's procedure for Management and Monitoring of Emissions (CNL 2018a), which includes operational control monitoring and verification monitoring will be implemented.
						▪ The buildup of gaseous emission from waste in closed cells is mitigated by gas venting in the final cover.
						▪ The *Dust Management Plan* (AECOM 2018) for the NSDF Project will include:
						  ▪ restricting or suspending activities if unacceptable amounts of dust are generated due to winds or other site conditions;
						  ▪ use of water spraying or misting techniques (e.g., water trucks) as the primary dust control method;
						  ▪ use of fixatives (e.g., chemical suppressant) for dust control, and for use as daily/interim cover;
						  ▪ suspension of excavating, loading, hauling and disposal operations when wind speeds exceed the specified criterion; and
						  ▪ vehicles that have come into contact with contamination will be required to pass through the vehicle decontamination facility
						▪ Processed wastewater will not be heated within the WWTP (raising the temperature increases potential release rates).
						▪ There is active ventilation within the WWTP building, and active ventilation exhaust will be filtered through HEPA prior to release.
						▪ A perimeter fence around the NSDF will be implemented to prevent terrestrial land-based wildlife from gaining access to the ECM. Given the transient nature of exposure to birds and the low expected ambient concentrations, low exposures are expected for birds and as such no specific mitigations have been proposed.
							Not Significant	Not applicable

	All Ecological Health VCs	Protection of ecological health	▪ Discharge of treated effluent from the WWTP to the East Swamp Wetland via the exfiltration gallery and/or directly to Perch Lake can cause changes to groundwater quality in the wetland and downstream surface water quality, which can affect ecological health.	Operation and Closure	▪ Surface water management
					▪ Operation of the WWTP
					▪ Discharge of treated effluent from the WWTP
						▪ The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses the best available technology that is economically achievable and capable of meeting regulatory requirements.
						▪ Effluent discharge targets for wastewater discharges are protective of the environment and human health:
						  ▪ Discharge targets for non-radiological contaminants are sourced from federal and provincial guidelines for protection of aquatic biota.
						  ▪ Discharge targets for radionuclides are the Canadian Drinking Water Guidelines with the exception of tritium for which a site-specific target is developed (Section 3.4.2.5.1).
						▪ Treated effluent will be sampled to confirm that it meets effluent discharge targets before release to the environment.
						▪ When applied, the proposed exfiltration gallery will promote the exfiltration of treated water into the local groundwater regime where further retention of radioactivity by the geosphere is anticipated.
						▪ The Perch Lake diffuser design provides additional dilution of treated effluent at the point of release
						▪ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water quality.
						▪ Appropriate procedures will be in place to effectively identify spill occurrences in the event treated effluent is released to areas other than directly to the exfiltration gallery and initiate appropriate emergency responses.
							Not Significant	Not applicable

Table 9-1: Summary of Predicted Residual Effects on Valued Components and Significance – Application Case and Reasonably Foreseeable Developments Case

Discipline	Valued Component	Assessment Endpoint	Residual Effect	Project Phase the Effect Occurs in	Contributing Project Activity	Mitigation	Significance	
							Application Case	RFD Case
Ambient Radioactivity and Ecological Health (continued)	All Ecological Health VCs (continued)	Protection of ecological health (continued)	▪ Volatiles (e.g., radon, tritium) may be released to air, which can affect ecological health.	Post-closure	▪ On-going long-term performance monitoring, transfer of NSDF Project into the post-institutional control period	▪ A passive landfill gas venting system will be constructed at the same time as installation of the ECM final cover system. ▪ The landfill gas monitoring probes will also be installed around the perimeter of the ECM to detect evidence of potential landfill gas migration away from the ECM. ▪ Radon-emitting wastes will be preferentially placed in the lower levels of the ECM.	Not Significant	Not applicable
			▪ Leachate may be released to soil via overtopping the berm, which can affect ecological health.	Post-closure	▪ On-going long-term performance monitoring, transfer of NSDF Project into the post-institutional control period	▪ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound and minimize leachate generation. ▪ The cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity. ▪ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. ▪ The ECM final grading and drainage plan includes collection ditches along the top of the ECM berm road to collect side slope drainage. ▪ Environmental monitoring will be completed as required throughout the institutional control period for the NSDF Project to confirm that the cover is functioning as intended.	Not Significant	Not applicable
	All Ecological Health VCs (continued)	Protection of ecological health (continued)	▪ Leachate may be released through the base liner to groundwater, which can affect ecological health.	Post-closure	▪ On-going long-term performance monitoring, transfer of NSDF Project into the post-institutional control period	▪ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound and minimize leachate generation. ▪ The cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity. ▪ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. ▪ The ECM final grading and drainage plan includes collection ditches along the top of the ECM berm road to collect side slope drainage. ▪ The design life for the ECM is 550 years to meet the required time period to allow for radioactive decay of the waste placed in the facility (i.e., until it has decayed to levels that do not present a risk to the public and environment). ▪ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to groundwater quality.	Not Significant	Not applicable

Table 9-1: Summary of Predicted Residual Effects on Valued Components and Significance – Application Case and Reasonably Foreseeable Developments Case

Discipline	Valued Component	Assessment Endpoint	Residual Effect	Project Phase the Effect Occurs in	Contributing Project Activity	Mitigation	Significance	
							Application Case	RFD Case

Human Health	▪ Worker
	▪ Public
	▪ Residential
	▪ Seasonal
		Protection of Human Health	▪ Dust may be created during handling of bulk materials and emissions of gases may be released during storage and disposal of radioactive materials, which can affect human health.
			▪ Emissions may be released from the WWTP to air during operations, which can affect human health.
				Operations and Closure	▪ Phased development of disposal cells in the ECM
					▪ On-site transportation of waste and placement in the ECM
					▪ Progressive closure of disposal cells and installation of final cover
					▪ Operation of the WWTP
						▪ All activities will be covered by either CNL's work permits with completed Radiological Safety Assessments, as required, or by approved work procedures.
						▪ CNL's procedure for Management and Monitoring of Emissions (CNL 2018a), which includes operational control monitoring and verification monitoring, will be implemented.
						▪ The buildup of gas emissions from waste in closed cells is mitigated by gas venting in the final cover.
						▪ The *Dust Management Plan* (AECOM 2018) for the NSDF Project will include:
						  ▪ restricting or suspending activities if unacceptable amounts of dust are generated due to winds or other site conditions;
						  ▪ use of water spraying or misting techniques (e.g., water trucks) as the primary dust control method;
						  ▪ use of fixatives (e.g., chemical suppressant) for dust control, and for use as daily/interim cover;
						  ▪ suspension of excavating, loading, hauling and disposal operations when wind speeds exceed the specified criterion; and
						  ▪ vehicles that have come into contact with contamination will be required to pass through the vehicle decontamination facility
						▪ Processed wastewater will not be heated within the WWTP (raising the temperature increases potential release rates).
						▪ There is active ventilation within the WWTP building and active ventilation exhaust will be filtered through HEPA prior to release.
							Not Significant	Not applicable

Table 9-1: Summary of Predicted Residual Effects on Valued Components and Significance – Application Case and Reasonably Foreseeable Developments Case

Discipline	Valued Component	Assessment Endpoint	Residual Effect	Project Phase the Effect Occurs in	Contributing Project Activity	Mitigation	Significance	
							Application Case	RFD Case

Human Health (continued)	▪ Worker
	▪ Public
	▪ Residential
	▪ Seasonal
	(continued)
		Protection of Human Health (continued)	▪ Discharge of treated effluent from the WWTP to ground (via an exfiltration gallery) and to Perch Lake (via a transfer line) may cause changes to surface water quality, which can affect human health.	Operations and Closure	▪ Surface water management
					▪ Operation of the WWTP
					▪ Discharge of treated effluent from the WWTP
						▪ All activities will be covered by either CNL's work permits with completed Radiological Safety Assessments, as required, or by approved work procedures.
						▪ The strategy for wastewater treatment is based on optimizing public and environmental protection by defining an approach to wastewater treatment that uses best available technology that is economically achievable and capable of meeting regulatory requirements.
						▪ Effluent discharge targets for wastewater discharges are protective of the environment and human health.
						  ▪ Discharge targets for non-radiological contaminants are sourced from federal and provincial guidelines for protection of aquatic biota.
						  ▪ Discharge targets for radionuclides are the Canadian Drinking Water Guidelines with the exception of tritium for which a site-specific target is developed (Section 3.4.2.5.1).
						▪ Effluent treatment targets for wastewater discharges are the federal and provincial water quality guidelines for protection of the environment and human health (CNL 2019).
						▪ Treated effluent will be sampled to confirm that it meets effluent discharge targets before release to the environment.
						▪ When applied, the proposed exfiltration gallery will promote the exfiltration of treated water into the local groundwater regime where further retention of radioactivity by the geosphere is anticipated.
						▪ The Perch Lake diffuser design provides additional dilution of treated effluent at the point of release
						▪ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water and groundwater quality.
						▪ Appropriate procedures will be in place to effectively identify spill occurrences in the event treated effluent is released to areas other than directly to the exfiltration gallery and initiate appropriate emergency responses.
							Not Significant	Not applicable

Table 9-1: Summary of Predicted Residual Effects on Valued Components and Significance – Application Case and Reasonably Foreseeable Developments Case

Discipline	Valued Component	Assessment Endpoint	Residual Effect	Project Phase the Effect Occurs in	Contributing Project Activity	Mitigation	Significance	
							Application Case	RFD Case
Human Health (continued)	▪ Worker ▪ Public ▪ Residential ▪ Seasonal (continued)	Protection of Human Health (continued)	▪ Volatiles (e.g., radon, tritium) may be released to air, which can affect human health.	Post-Closure	▪ On-going long-term performance monitoring, transfer of NSDF Project into the post-institutional control period	▪ A passive landfill gas venting system will be constructed at the same time as installation of the ECM final cover system. ▪ The landfill gas monitoring probes will also be installed around the perimeter of the ECM to detect evidence of potential landfill gas migration away from the ECM.	Not Significant	Not applicable
			▪ Leachate may be released to soil via overtopping the berm, which can affect human health.	Post-Closure	▪ On-going long-term performance monitoring, transfer of NSDF Project into the post-institutional control period	▪ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the mound, and minimize leachate generation. ▪ The cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity. ▪ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. ▪ The ECM final grading and drainage plan includes collection ditches along the top of the ECM berm road to collect side slope drainage. ▪ Environmental monitoring will be completed as required during the institutional control period for the NSDF Project to confirm that the cover is functioning as intended.	Not Significant	Not applicable
			▪ Leachate may be released through the baseliner to groundwater, which can affect human health.	Post-Closure	▪ On-going long-term performance monitoring, transfer of NSDF Project into the post-institutional control period	▪ The final cover system will be constructed to promote the shedding of surface water to mitigate infiltration into the ECM and reduce leachate generation. ▪ The cover system design incorporates a series of shallow, trapezoidal, riprap-lined drainage channels that are designed to convey water at low velocity. ▪ The perimeter road ditch will route the runoff around the ECM perimeter to minimize ponding of water into the closed ECM, erosion of the cover and underlying waste materials, destabilization of the ECM structure and damage to access roads. ▪ The ECM final grading and drainage plan includes collection ditches along the top of the ECM berm road to collect side slope drainage. ▪ The design life for the ECM is 550 years to meet the required time period to allow for radioactive decay of the waste placed in the facility (i.e., until it has decayed to levels that do not present a risk to the public and environment). ▪ The Waste Acceptance Criteria developed for the NSDF Project will limit the level of contamination (i.e., only LLW) and types of waste to be disposed in the ECM. This will limit the magnitude of potential changes to surface water and groundwater quality.	Not Significant	Not applicable

Table 9-1: Summary of Predicted Residual Effects on Valued Components and Significance – Application Case and Reasonably Foreseeable Developments Case

Discipline	Valued Component	Assessment Endpoint	Residual Effect	Project Phase the Effect Occurs in	Contributing Project Activity	Mitigation	Significance	
							Application Case	RFD Case
Socio-economic Environment	Labor Market	Continuation of employment opportunities and income generation	▪ Direct and indirect employment requirements may affect employment and income with the local and regional study areas.	Construction	▪ Employment of personnel, procurement of goods and services, and expenditures from the NSDF Project	▪ CNL employment opportunities that may arise due to NSDF Project activities will be posted on the vendor portal on www.cnl.ca website.	Positive Residual Effect; therefore, significance is not determined	Positive Residual Effect; therefore, significance is not determined
	Economic Development	Continuation of business and economic development	▪ The NSDF Project may provide contracting and supplier opportunities to local and regional businesses.	Construction	▪ Employment of personnel, procurement of goods and services, and expenditures from the NSDF Project	▪ The NSDF Project will competitively procure material and services from local and regional communities.	Positive Residual Effect; therefore, significance is not determined	Positive Residual Effect; therefore, significance is not determined
	Housing and Accommodations	Maintenance of commercial accommodation availability	▪ The NSDF Project could increase pressure on commercial accommodations.	Construction	▪ Employment of personnel, use of services and infrastructure for NSDF Project	▪ None	Not significant (where negative in direction) Positive Residual Effect; therefore, significance is not determined (where positive in direction)	Not significant (where negative in direction) Positive Residual Effect; therefore, significance is not determined (where positive in direction)
	Services and Infrastructure	Maintenance of community services and infrastructure availability and access	▪ Increased road degradation due to increased traffic volume from the transportation of workers, supplies and equipment.	Construction	▪ Employment of personnel, use of services and infrastructure for NSDF Project	▪ Coordinate transportation of equipment and materials during construction to avoid peak traffic times to the extent possible.	Not significant	Not significant
			▪ Changes in demand for community services (health, education, protective and emergency services) with respect to the capacity of LSA services to meet the demand.	All phases	▪ Employment of personnel, use of services and infrastructure for NSDF Project	▪ Continued implementation and maintenance of compliance with all applicable health and safety standards and CNL's existing environmental, safety and security programs.	Not significant	Not significant

CNL = Canadian Nuclear Laboratories; VC = Valued Component; ECM = Engineered Containment Mound; LSA = Local Study Area; SSA = Site Study Area; NSDF = Near Surface Disposal Facility; RFD = Reasonably Foreseeable Developments; CRL = Chalk River Laboratories; ha = hectare; m = metre.

10.0 EFFECTS OF THE ENVIRONMENT ON THE PROJECT

This section of the Environmental Impact Statement (EIS) discusses the effects of the environment on the Near Surface Disposal Facility (NSDF) Project, in a manner consistent with Section 19(1)(h) of the *Canadian Environmental Assessment Act, 2012*, which indicates that, among other considerations, the environmental assessment of a designated project must take into account "any change to the designated project that may be caused by the environment". Accordingly, this section focuses on the effects of natural hazards (i.e., extreme weather events, forest fires, seismic events, glaciation and climate change on the NSDF Project. It summarizes the risks associated with each kind of environmental change, along with environmental design features, management practices and other mitigation to reduce the risks. Malfunctions and accident scenarios, which are not caused by natural hazards, are identified in Section 7.0 Malfunctions and Accidents, including the estimated likelihoods and consequences to the environment and public and worker safety.

As discussed in Section 3.0, the NSDF Project incorporates design features to minimize its effect on the environment during facility operation and after facility closure. To ensure the effects on the environment are minimized, the design basis of the NSDF accounts for the expected environmental conditions of the site.

The systematic and comprehensive approach, documented in Section 7.2, was used to identify and categorize the major external hazards (natural) and postulated initiating events associated with the design and operations of the NSDF Project. Table 7.3.2-1 provides the consolidated list of external hazards and initiating events, and potential scenarios applicable to the NSDF Project. Further details on the hazard identification, hazard analysis and screening process are provided in the NSDF *Safety Analysis Report* (CNL 2020).

In the post-closure phase of the NSDF Project, many scenarios and models, including those involving major external events, are developed by examining the features, events and processes (FEPs) that could affect the long-term performance and safety of the NSDF Project. This includes physical FEPs directly or indirectly influencing the release and transport of contaminants (radiological and non-radiological) from the NSDF Project or subsequent radiation exposures to humans, as well as factors such as regulatory requirements or modelling issues that constrain or focus the analysis (IAEA 2004). The FEPs list was developed in a systematic manner following the latest readily available Nuclear Energy Agency (NEA) International FEP list (NEA 2014). Further details on the FEP screening and analysis are provided in the NSDF *Post-Closure Safety Assessment* (PostSA; Arcadis and Quintessa 2020).

10.1 Extreme Weather Events

Weather events can produce extreme conditions affecting the performance of facilities and management systems. These events include extreme temperature fluctuations, thunderstorms, flooding and tornadoes, among others. In this section, potential effects from extreme weather events and the associated mitigation to be implemented are described. Potential effects from shifts in the frequency and/or intensity of extreme weather events due to climate change are discussed in Section 10.4.

10.1.1 Temperature Fluctuations

Temperature fluctuations and the effects of freeze-thaw cycles are considered in the design of the engineered containment mound (ECM) base and final cover system. There are multiple natural and synthetic components of the base and cover lining systems, including a high density polyethylene (HDPE) geomembrane liner, geosynthetic clay liner, compacted clay liner and final granular/soil cover; these lining systems are expected to perform effectively through the ECM's 550-year design life (i.e., 50-year of operations and 500 years of post-closure).

Natural freeze-thaw cycles could damage the linings of the ECM final cover system, leading to water infiltration into the waste. To mitigate this, the NSDF Project has been designed to include a layer of clean fill on the floor of the ECM of sufficient thickness to prevent freezing of the base liner systems prior to waste placement. Placement of similar frost protection fill on the perimeter sideslopes of the ECM is not practical and would be susceptible to erosion given that parts of the slopes will remain exposed for several years prior to buttressing with waste fill. Hence, the sideslope lining system will be subjected to freeze-thaw action. A freeze-thaw assessment (AECOM 2017a) concluded that the sideslope HDPE geomembrane liner component of the sideslope lining system will not be adversely affected by freeze-thaw cycles, whereas the geosynthetic and compacted clay liner components of the sideslope lining system could undergo an increase in hydraulic conductivity prior to placement of the wastes on the sideslopes. However, after placement of the waste, the clay liners will consolidate under the weight of the waste, healing the voids caused by freezing such that the potential increase in hydraulic conductivity would be negligible for the geosynthetic clay liner and up to a factor of 2 for the compacted clay liner. The final cover system will be installed to its full thickness progressively as areas of the ECM reach the final waste contours. The final cover system design has 1.75 m of granular/soil materials above the lining system, which is sufficient to prevent freezing of the final cover system liner components.

Extreme temperature fluctuations could also affect the successful establishment of vegetation used in remediation of the site. For example, the vegetated top of the final cover system has been designed to withstand erosion and gully initiations. The vegetation for the final cover system will be limited to grass species that are drought resistant. Bare or eroded areas will be rolled, regraded, replanted and remulched in the same way as in the original installation to produce a uniformly smooth grassed surface. Treatments will be applied as required to keep grass and soil free of pests and pathogens or disease (AECOM 2017b).

10.1.2 Extreme Rainfall Events, Snowmelts and Flooding

Extreme rainfall and snowmelt events and the potential for flooding are considered in the design of the surface water management systems, berms and the final cover system for the ECM. The NSDF Project design will comply with all relevant federal and provincial regulations, guidelines, acts, standards and codes, including standard industry practice.

The NSDF Project uses different design criteria to size contact and non-contact surface water management systems. The different criteria reflect the different potential for significant environmental effects. For example, the contact water management and the non-contact water management systems are sized for the back-to-back, 24-hour, 100-year storm (the most rigorous criterion), because this is a large volume of potentially contaminated water and would cause the most adverse effects if it was released to the environment. The NSDF water collection and conveyance systems are typically designed to resist erosion, safely convey flows and maintain structural integrity during peak flows generated from various design storms up to a probable maximum precipitation (PMP) storm event. Major non-contact surface water systems (e.g., surface water management ponds and major conveyance systems) are designed for a single 100-year storm plus 25%, reflecting the lower level of environmental risk from high volumes of uncontaminated water. The design of the non-contact water ponds is consistent with the typical standard for surface water management pond design in Ontario and typically applies to all land development projects in the Province. Minor non-contact water systems (e.g., minor ditches and culverts) are designed for a 25-year storm, supplemented by overland flow routes for larger storm events, reflecting the lowest level of environmental risk from low volumes of uncontaminated water.

During the Operations phase, the strategy for wastewater treatment of contact water (Section 3.4.2 Wastewater Treatment) is based on optimizing public and environment protection by defining an approach to wastewater treatment that uses best available technology that is economically achievable, and is capable of meeting or exceeding regulatory requirements. Another important design consideration is the maximum wastewater flow rate that must be received and processed by the Wastewater Treatment Plant (WWTP). The maximum flow rate was determined by evaluating the expected contact water volume that would be produced during two back-to-back 100-year, 24-hour storm events. Under these conditions, it is expected that a maximum of approximately 4,700 m^3 of contact water would be produced, and that this contact water would be removed from the ECM at a maximum rate of approximately 100 m^3/hr. This was selected as a worst-case design condition for determining the required volume of wastewater collection tanks. The contact water ponds are expected to overflow during events larger than a 100-year storm (such as a PMP storm), however all of the water which falls will be contained within the ECM berm during the event so that no contact storm water, that is storm water that has come into contact with waste, will escape into the surrounding environment. In the event that the contact water ponds do overflow, there is possibility that contact water will mix with non-contact water in the ECM. In order to avoid release of any potentially contaminated water outside of the ECM boundary during this scenario, when water levels suggest there is a possibility of overtopping in the contact water pond, the non-contact water pumps would be shut off or flows diverted back into the ECM until all of the contained water can be treated by the WWTP.

The surface water management ponds for non-contact water are designed to address erosion and sediment control concerns during construction. Severe precipitation generates surface water that may result in the release of silt/sediment to the adjacent wetlands. The mitigation in place included silt fencing (heavy and light duty) for sediment control, and the three stormwater management ponds are used as interim sediment control. The surface water management ponds also provide water quality and quantity controls during operations, closure and post-closure. The current surface water management pond footprints reflect the overall storage required to control post-closure flows to predevelopment levels for the 2-year through to 100-year rainfall events at the site (Section 3.4.4.5.1 Surface Water Management Ponds). This volume also contains the storage required for sediment control during construction and water quality control during operations. The current footprints typically assume a maximum 100-year operating water level at a 3 m depth with 1 m of freeboard that includes allowance for climate change effects and rain on snowmelt. Major system (i.e., 100-year) flow routes follow the road system and ditches to the relevant surface water management ponds. The PMP flow generally follows the major system route using the road, related ditches and adjacent lands. The PMP flow will exceed the surface water management ponds' attenuation capacity but is adequately conveyed by inlet and emergency outlet structures adjacent to the surface water management ponds (Section 3.4.4.5.1 Surface Water Management Ponds).

Severe rainstorms or snowmelts could also affect roads and cause damage to natural or engineered slopes (e.g., berms). All roads, including the perimeter road, have ditches that convey not only road drainage but drainage from adjacent lands to the surface water management ponds. These have been designed to convey the 25-year post-development peak design flow (Section 3.4.4.5.2 Drainage Ditches and Swales). Annual inspection and maintenance activities will identify any erosion problems. In addition, an inspection and maintenance review will be completed after major storm events and after the annual spring melt to confirm there are no major erosion issues. Where drainage crosses roads, culverts are sized to convey the 25-year design event without road overtopping. A box storm sewer has been sized to convey the 100-year flow to Surface Water Management Pond 1, and is adjacent to the access road due to constraints imposed by property and road limits that preclude the use of a ditch (Section 3.4.4.5.3 Culverts and Sewers). Annual maintenance activities will identify any erosion or blockage problems. In addition, a maintenance review will be completed after major storm events and after the annual spring melt to confirm there are no major erosion or blockage issues at the culvert and sewer inlet or outlet.

The perimeter berm from the NSDF Project consists of three main geotechnical elements, or layers, each contributing to the soundness and integrity of the berm itself and the whole ECM (Section 3.4.1.5 Berms). The inside face of the berm will be covered with the various liner system layers, while the outer face will be covered with the intrusion barrier rockfill over geomembrane, geotextile cushion and geogrid. The top of the berm is covered with various layers of granular "A" material, HDPE geomembrane and geotextile cushion, with the top layer of granular A material becoming the top-of-berm road. During the post-closure period, disruptive scenarios where the berm becomes damaged are assessed (e.g., Damage to the Berm), and the resulting consequences are within the regulatory dose limit. The full assessment can be found in the PostSA (Arcadis and Quintessa 2020).

Extreme rainfall and snowmelt events could also lead to soil erosion on the ECM final cover system. As part of the closure phase, a final cover system will be installed on the ECM. The final cover system is designed to limit water infiltration, to direct infiltration and surface water runoff away from the ECM waste placement area, and to resist degradation by surface geologic processes and biotic activity (e.g., prevent burrowing of animals) and inadvertent intruder attempts to access or excavate into the waste cell (Section 3.4.1.9.3 Final Cover). A series of drainage control features will be installed in conjunction with placement of the final cover system over the ECM. The finished surface of the ECM is elevated from the surrounding terrain, which limits the quantity of surface water entering the ECM from areas outside the extent of the ECM. The topographical slopes within the ECM footprint are sufficient to promote drainage, and by lining the ECM surface water collection ditches and stilling basins with rip rap and other erosion control measures, sediment transport and erosion will be minimized (Section 3.4.1.9.3 Final Cover). Construction, operation and closure activities of the ECM are designed to provide a stabilized waste array with the purpose of minimizing settlement and water infiltration. The PostSA studies the effect of enhanced erosion on the engineered containment mound in the "Enhanced Erosion Case" scenario. Results of the assessment are within the dose acceptance criteria for Disruptive Events. The full assessment is found in the PostSA (Arcadis and Quintessa 2020). In addition, the low point of the ECM has an elevation of approximately 156 metres above sea level (masl), while the 100-year flood elevation for the portion of the Ottawa River adjacent to the Chalk River Laboratories (CRL) site is 115 masl. When the potential failure of the two upstream dams is considered combined with a 1 in 10,000-year precipitation event and snow melt from 1 in 100-year snow accumulation, the flood elevation is 122 masl for the portion of the Ottawa River adjacent to the CRL site. Therefore, the ECM is above the Ottawa River flood level.

Heavy downpours and runoff could increase the probability of a vehicle accident, as a result of reduced visibility and poor road conditions. These concerns are already addressed by procedures in place at site, including reduced traffic speeds, increased following distance, addressing road conditions (e.g., adding aggregate) as quickly as possible and, if necessary, issuing stop-work orders.

10.1.3 Heavy Snowfall

Severe snowstorms are primarily a concern during the construction and operations phases related to worker safety, performance of facilities and loss of production. The NSDF Project is designed for year-round operation; however, waste placement operation may be constrained during the winter months.

Severe snowstorms could affect vehicle operation at the site because of reduced traction and visibility and could increase the probability of vehicle accidents. Safety procedures are in place to address worker safety, including reduced traffic speeds, increased following-distances, addressing road conditions (e.g., snow removal, sanding) as quickly as possible, and if necessary, issuing work-stop orders.

Weather uncertainties have been accounted for, and risks associated with severe snowstorms and snow loadings to facilities are managed through design criteria for the NSDF Project. For example, requirements for surface water management systems include considerations for climate change, as well as accounting for at least 1 m of snowfall accumulation on the ground in advance of all design storm events. In addition, building structures at the CRL main campus are designed according to the relevant requirements regarding withstanding large accumulations of snow, such as Part 4 of the National Building Code of Canada (NBCC) 2015 (NRCC 2015). Infrastructure and facilities required to support the NSDF Project will be built to meet or exceed this code. Furthermore, the infrastructure and facilities design will comply with all relevant federal and provincial regulations, guidelines, acts, standards and codes, including standard industry practice. Consequences of potential heavy snowfalls, such as a power outage, are also encompassed by CNL's Emergency Preparedness Program.

10.1.4 High Winds

High winds can occur either on a large scale, from extra-tropical storms or low-pressure systems and fronts, or on a small scale, from thunderstorms or the local geography. High winds generally fall into three categories:

- tornadoes;
- extra-tropical storms (hurricanes); and
- thunderstorm winds.

Only tornadoes and thunderstorms are relevant to the NSDF Project site; hurricanes do not affect locations that are more than a few hundred kilometres from the ocean. Tornadoes are recognized as a hazard to the facilities on the CRL site, including the NSDF Project. Tornadoes are intense rotary storms of small diameter and are associated with thunderstorms. The vortex is usually visible as a funnel cloud. The frequency for a tornado strike on the CRL site is estimated to be 0.000054 per year and a return period of 200,000 years (Cheng et al. 2013). The *CRL Site Characteristics* report (CNL 2018a) analyzes the location of the CRL site and concludes that the CRL site is in a geographical area that could reasonably expect a tornado strike once in 100,000 years. The maximum wind speed for a tornado event of this caliber is 220 km/hr. There is concern that climate change will increase the frequency and severity of summer storms, including tornadoes, hailstorms and lightning events (Peterson et al. 2008). These summer storms are encompassed by CNL's Emergency Preparedness Program, including extreme storms such as an EF2 tornado (i.e., wind speeds up to 220 km/hr). The design basis tornado event for the CRL site was reviewed in 2018 after a series of tornados occurred in the Ottawa Valley. The current choice of an upper EF2 tornado for the CRL site remains appropriate (CNL 2018b).

High winds, atmospheric pressure changes and wind-induced projectiles have the potential to cause structural damage and/or failure of infrastructure. The NBCC was updated in 2005 to include provisions so that basic structural resilience under low-end tornadic loads in areas of Canada defined as "tornado prone," and Environment and Climate Change Canada has recently compiled an updated 30-year national tornado database (Cheng et al. 2013). Extreme winds including tornado or microburst events may cause potential minor damage to the building structures which are designed to NBCC. The collection tanks are designed to API-650 (API 2013) and designed to withstand a design basis tornado.

Severe winds or tornadoes are primarily a concern during the Construction and Operations phases related to worker safety, performance of facilities and loss of production, and are already encompassed by CNL's Emergency Preparedness Program. The risks associated with severe winds or tornadoes are managed through design criteria and management practices described above. Facilities are designed according to the appropriate codes, such as the NBCC 2015 (NRCC 2015). Consequences of potential tornadoes, such as a power outage, are encompassed by CNL's Emergency Preparedness Program.

High winds during construction and operations have the potential to cause increased dust generation and airborne emissions. Dust control will be conducted to support waste placement operations in accordance with the Dust Management Plan during loading, transportation, placement and compaction operations (Section 3.4.1.7.1 Waste Placement Procedures). Work areas that have the potential for generating dust will require dust suppression techniques and monitoring. The primary dust control method will include water spraying or misting techniques (e.g., water trucks).

High winds could also cause soil erosion on the ECM final cover system, leading to water infiltration into the waste. In addition to the mitigation described in Section 10.1.2, the final cover system will be vegetated to enhance evapotranspiration and reduce the potential for soil erosion from wind and water. The vegetation will be limited to grass species that are drought resistant. Trees will not be allowed to establish on the final cover system as they may cause considerable damage to the topsoil and soil cover layers, as well as exposing the intrusion barrier if uprooted due to heavy winds (3.4.1.9.3 Final Cover). Bare or eroded areas will be rolled, regraded, replanted and remulched, and treatments will be applied as required to keep grass and soil free of pests and pathogens or disease (AECOM 2017b).

A soil loss/erosion calculation was completed for the proposed ECM final cover system (AECOM 2017b). The Revised Universal Soil Loss Equation for Application in Canada method was used in the calculation (AECOM 2017b). The results show that the average soil loss for the final ECM cover system is estimated at 0.21 tonnes per hectare per year and 1.12 tonnes per hectare per year, for the vegetated top slope and vegetated upper side slope portions of the final cover system (AECOM 2017b). Both of these calculated soil loss amounts are lower than the maximum annual allowable soil loss of 12.36 tonnes per hectare per year.

In addition to the calculations for the operational period, the PostSA assesses the consequences of erosion in both the Normal Evolution Scenario and the disruptive event of “Enhanced Erosion”. The dose consequences from these scenarios are within the dose acceptance criteria (Arcadis and Quintessa 2020).

10.2 Forest Fires

At the NSDF Project site boundary, there is a neighbouring forested area, which represents a potential fire hazard. The potential for a forest fire to affect the NSDF Project is limited through meeting minimum distances between the NSDF Project and the forest edge. At its closet point the top of the ECM perimeter berm is approximately 45 m from the NSDF fence line and the forest edge is 4 m beyond the NSDF fence line. This is in compliance with the National Fire Protection Association 1144, “Standard for Reducing Structure Ignition Hazards from Wildland Fires” (NFPA 2013).

Having an effective response to fires is facilitated through CNL's Emergency Preparedness Program (Section 3.5.2.5 Emergency Preparedness Program) and the Fire Protection Program (Section 3.5.2.9 Fire Protection Program). The risks associated with wildfires will continue to be managed through existing procedures and design criteria. The probability of such an event has been assessed as very low; however, a fire buffer zone (5 m minimum) between forest stands and equipment will be established to further reduce the probability of a neighbouring forest fire affecting operations (Algonquin Forestry Services 2001). In the event of a forest fire, the CRL Fire Department provides firefighting capacity 24 hours a day, 7 days a week, and firefighting procedures are in place and are backed up by CNL's Emergency Preparedness Program.

Design of infrastructure incorporates fire protection as appropriate in accordance with the NBCC 2015 (NRCC 2015). The Fire Protection Program is dedicated to the delivery of a compliant Fire Protection Program that will provide the highest level of fire and life safety to all CNL employees and facilities. The objectives of the Fire Protection Program include preventing fire losses, providing responsible fire protection management, demonstrating compliance with applicable fire protection codes and standards, and providing reliable facilities from a fire protection perspective. The Fire Protection Program provides services including developing fire prevention processes and conducting fire safety inspections. Fire hazard analyses, code compliance reviews and fire protection screenings are also conducted as part of the program. Consequences of a fire, such as a power outage, are encompassed by CNL's Emergency Preparedness Program.

In addition, as part of the *Safety Analysis Report* (CNL 2020), an assessment of the consequences of a fire during the Operations phase at the NSDF Project site, caused by a forest fire, lightning strike or other means, was completed. A scenario was developed to evaluate the effects of 800 m^3 of bulk waste and packaged waste burning in a temporary staging area for 1 hour. The evaluation concludes radiological doses to workers and member of the public are below regulatory limits and meet safety objectives for the NSDF Project.

10.3 Seismic Events

Major seismic events (i.e., earthquakes) are related to movements at tectonic plate boundaries. The CRL site is located in the Ottawa-Bonnechere Graben geologic feature and adjacent to the Western Quebec Seismic Zone. This region of the country has continued to experience minor to moderate seismic activity, and within this zone, several earthquakes were documented. These include the following:

- Timiskaming, Quebec, earthquake of 1935 (6.2 on the Richter Scale and epicentre over 100 km away);
- Cornwall, Ontario, earthquake of 1944 (5.6 on the Richter Scale and epicentre over 200 km away); and
- Val-des-Bois, Quebec, earthquake of 2010 (5.0 on the Richter Scale and epicentre over 137 km away).

Most recently, an earthquake with a magnitude of 3.7 on the Richter Scale occurred on October 15, 2015, approximately 40 km from the NSDF Project site, and an earthquake with a magnitude of 3.5 occurred on May 14, 2016, approximately 10 km from the NSDF Project site, 6 km north of Petawawa, Ontario.

Should a seismic event occur at or near the NSDF Project site, this could lead to a rupture of soil material beneath the ECM and potentially result in a failure of the engineered berms and final cover system, resulting in damage to ECM liners and the leachate collection system. This could result in the exposure of radioactive waste at surface and leachate to flow into the groundwater without treatment.

To support the design of the NSDF Project, a probabilistic seismic hazard assessment was prepared, which outlines the site-specific seismic conditions and discusses applicable seismic design criteria (AECOM 2019). To characterize the seismic hazard, the peak horizontal ground acceleration at the site is determined using seismic information from the seismic hazard maps developed for the NBCC in 2015 (NRCC 2015). The peak ground acceleration at the NSDF Project site is comparable to typical high seismic zones in North America.

The NSDF Project facilities, including the final cover system design and infrastructure, are designed to meet safety factors and earthquake loading requirements, as outlined in the following design guides:

- National Building Code of Canada Seismic Design Parameters (NRCC 2015); and
- AECL's Design for Earthquakes (Seismic Qualifications at CRL) (CNL 2017).

The design of buildings and other conventional structures for the NSDF Project was based on a NBCC (NRCC 2015) design basis earthquake with a 2,475-year frequency of occurrence. However, the seismic design of the ECM was based on a design basis earthquake with a 10,000-year frequency of occurrence as defined by Canadian Standards Association Standard N289.1-18 (CSA Group 2018).

An analysis of liquefaction potential was completed and indicated that the 10,000-year design seismic event scenario may cause liquefaction in the saturated native sand to silty sand soils underlying the ECM resulting in unacceptable vertical and horizontal displacements. Based on this, CNL has added additional mitigation to limit the potential for liquefaction. Overburden soils beneath the ECM containment berm will be excavated down to the top of the bedrock, extending horizontally from beneath the containment berm to a distance at which the slopes of the containment berm intersect the bedrock surface. The removed overburden soils then can be replaced with backfill material in multiple lifts. Each lift can be compacted to the desired density using vibratory roller compactors. The edges of excavation can be sloped back temporarily to provide stability. Dynamic compaction could also be used in select areas of the construction site where the existing grade is relatively flat and in the limited areas where proximity of the existing wetlands would require the use of sheet piling or other temporary excavation support. This excavation and replace method can produce a high-quality ground mass with high density and desired permeability. Since the sand layer components of the ECM will be installed in a controlled manner with a high level of compaction, the sand layer components will be similar to dense sand deposits, which are generally not susceptible to liquefaction.

Based on the conclusions of a seismic analysis completed on the NSDF Project design and with the incorporation of the liquefaction mitigation described above, the ECM is expected to remain functional under the 10,000-year design seismic event scenario (AECOM 2019). During operations through the institutional control phases of the NSDF Project, the consequences of any damage to the engineered berms or the ECM final cover system from a beyond-design earthquake would be mitigated as required. Consequences to the facility, such as a power outage, are encompassed by CNL’s existing Emergency Preparedness Program.

In the post-closure phase the consequence of a significant seismic event is evaluated through a number of disruptive events (e.g., failure of the berm, cap and liner). The dose consequences of these scenarios are within dose acceptance criteria (Arcadis and Quintessa 2020).

10.4 Climate Change

Changes in the global and regional climate could affect the NSDF Project during the approximately 50-year operations phase and into the long-term post-closure phase (i.e., 500 years) and beyond. The Canadian Nuclear Safety Commission requires that effects assessments take into account any potential effects of climate change on a project, including an assessment of whether the project might be sensitive to changes in climate condition during its life span (CNSC 2016). As such, an effects assessment of climate change was completed that follows the guidance provided by the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment. This general guidance document is for practitioners incorporating climate change issues into an environmental assessment (FPTCCCEA 2003).

10.4.1 Global Climate Change Trends

The world’s climate is changing as a result of a combination of natural and anthropogenic factors, and the changes over the twentieth century can largely be attributed to human activities (AMAP 2011; IPCC 2007; NRCan 2011). Human activities affect climate by changing the land surface and altering the composition of the atmosphere. A 100-year warming trend in surface air temperature of 0.85°C was observed over the period from 1880 to 2012 (IPCC 2013). Over the Canadian landmass, the annual average surface air temperature warmed by

1.5°C from 1950 to 2010 (Vincent et al. 2012), and for 2011 and 2012 surface air temperatures were 1.5°C and 1.9°C, respectively, warmer than the reference period from 1961 to 1990 (Bush et al. 2014). Also, Canada has generally become wetter in recent decades, with an increase in annual precipitation of about 16% over the period from 1950 to 2010 (Mekis and Vincent 2011). Even if considerable measures to reduce greenhouse gas emissions are introduced today, it is predicted that climate change will continue to have an environmental effect for centuries. It is recognized that these effects will not occur uniformly across the country, but will vary regionally (NRCan 2004).

Climate change projections are provided by mathematical models based on the physical laws governing the behaviour of the climate. Climate change scenarios, as summarized by the Intergovernmental Panel on Climate Change (IPCC), predict that mean global temperatures are likely to increase by 1.1°C to 5.4°C for the period of 2090 to 2099 as compared to the reference period from 1980 to 1999. The IPCC is generally considered to be the definitive source of information related to past and future climate change, as well as climate science.

It is predicted that the North and the southern and central Prairies of Canada will experience more of a warming than other regions (NRCan 2004). This warming is expected to vary on a seasonal basis, being greater in the winter than the other seasons, and with nights warming more than days. As warm air can hold more moisture, changes in precipitation patterns and shifts in the frequency and intensity of extreme climate events are expected to accompany this warming (NRCan 2004). Mean results for Canada show that even under lowered emission scenarios, summer and winter temperatures by the middle of the century are anticipated to warm by about 1.5°C to 2.5°C and 3°C to 7°C, respectively (NRCan 2014).

10.4.2 Current and Future Climate Change Trends

10.4.2.1 Current Climate Trends

The current climate is based on available long-term daily meteorological observations from a climate station in the vicinity of the NSDF Project. In general, the current climate normals and trends indicate a climate that has likely become warmer and wetter over time. The analysis of climate station data shows that temperatures are increasing, with the exception of spring, and the total seasonal precipitation shows increasing trends except for winter and spring, which show a decreasing trend as shown in the NSDF Project Climate Change Assessment Technical Supporting Document (TSD) (Golder 2019).

An analysis of the Petawawa Hoffman climate station data was completed illustrating:

- Total annual precipitation is increasing; however, the trend was not statistically significant.
- Summer total precipitation is increasing.
- The number of days with more than 20 mm of rainfall is increasing.
- Average annual temperature is increasing.
- Average annual summer temperature is increasing.
- Average annual fall temperature is increasing.
- The number of periods (more than three days) with minimal temperatures below 15°C are decreasing.

10.4.2.2 *Future Climate Conditions*

Future climate projections were derived using general circulation models for two time periods, the Mid Term representing the second half of the operations phase (2041 through 2070) and the Far Term representing the closure phase and beginning of the post-closure phase (2070 through 2100) (Golder 2019). Climate projections were also considered for the Long Term (2100 through 3000) using publicly available literature (Golder 2019).

The model projected means for the Mid Term and Far Term are greater than the observed climate normals for both temperature and precipitation as shown in Tables 10.4.2-1 and 10.4.2-2 and in the NSDF Project Climate Change Assessment TSD (Golder 2019). On a month-to-month basis, the projections indicate a future that is likely warmer and wetter than currently observed. The change in temperature normal between the currently observed and projected monthly periods is more pronounced than the monthly projected changes in precipitation. The projected changes in monthly temperature appear reasonably uniform over the year, while the fall and early winter show the largest change in the mean precipitation.

Table 10.4.2-1: Model Projected Mean and Climate Normal for NSDF Project for the Mid Term – 2041 to 2070

Period	Temperature (°C)			Precipitation (mm)		
	Climate Normal	Projected Mean	Difference	Climate Normal	Projected Mean	Difference
Spring	5.0	6.1	1.1	201.1	208.7	7.5
Summer	19.0	21.0	1.9	251.1	263.7	12.7
Fall	7.5	10.8	3.3	243.9	294.7	50.9
Winter	-9.3	-6.8	2.5	155.9	192.6	36.6
Annual	5.7	7.8	2.2	852.0	924.1	72.0

Table 10.4.2-2: Model Projected Mean and Climate Normal for NSDF Project for the Far Term – 2070 to 2100

Period	Temperature (°C)			Precipitation (mm)		
	Climate Normal	Projected Mean	Difference	Climate Normal	Projected Mean	Difference
Spring	5.0	6.9	1.8	201.1	214.2	13.1
Summer	19.0	21.8	2.8	251.1	265.2	14.1
Fall	7.5	11.6	4.1	243.9	302.6	58.8
Winter	-9.3	-6.0	3.3	155.9	207.0	51.0
Annual	5.7	8.6	3.0	852.0	940.6	88.6

For the Long Term, based on representative concentration pathways described in IPCC's fifth assessment report, global temperatures are predicted to rise between 0.6°C and 7.8°C by the year 3000, as shown in Table 10.4.2-3 and in the NSDF Project Climate Change Assessment TSD (Golder 2019). The majority of the warming will occur before 2300. Changes in precipitation distribution and variability are anticipated to increase after 2100, with an estimated increase in global precipitation of 1% to 3% per degree Celsius of increase in temperature over the period from 2100 to 3000 (IPCC 2013).

Table 10.4.2-3: Projected Climate for the Mid Term, Far Term and Long Term

Period	Temperature (°C)	Precipitation (mm)
	Climate Normal	Climate Normal
Current Climate (1994 to 2015)	5.7	852.0
Mid Term Change (2041 to 2070)	2.2	72.0
Far Term Change (2071 to 2100)	3	88.6
Long Term (2100 to 3000)[a]	0.6 to 7.8[b]	1%/°C to 3%/°C[b]

a) Long Term projections are provided as global values, while Current Climate, Mid Term and Far Term projections represent the NSDF Project site.

b) Projections represent change above those of the reference period of 1986 to 2005.

%/°C= percentage increase in precipitation per degree Celsius.

10.4.3 Climate Change Effects on the NSDF Project

Climate change may result in shifts in the frequency and/or intensity of the extreme weather events and forest fires. As such, the NSDF Project design features and mitigation described in Section 10.1 and 10.2, respectively, also take into consideration the potential effects of climate change. Further, the PostSA (Arcadis and Quintessa 2020) considered potential climate change as part of the Normal Evolution Scenario to inform the evolution of the environment over time. The effects of climate change are typically measured over longer periods, with the potential for climate change effects increasing as the period over which they are measured increases.

Shifts in the frequency and/or intensity of extreme weather events are expected to accompany the general warming of surface air temperatures. Increased evaporation will result in more moisture in the air, and warmer air can hold more moisture; therefore, more intense precipitation events (i.e., rainstorms and snowmelts) are expected. As discussed in Section 10.1, the WWTP is designed to accommodate a maximum flow rate that would be produced during two back-to-back 100-year, 24-hour storm events. This was selected as a worst-case design condition for determining the required volume of wastewater storage. In addition, surface water management design will consider climate changes over 500 years (post-closure design life) and will incorporate the 2-year, 5-year, 10-year, 25-year, 50-year and 100-year (or prevailing regional) precipitation storm events and seasonal precipitation averages. For example, historical peak precipitation has been considered in design of surface water management structures (i.e., surface water management ponds, drainage ditches, culverts). The annual snowfall for Canada has increased by about 4% over the time period of 1950 to 2009 (Mekis and Vincent 2011) and the current climate general circulation models for the NSDF Project indicate that snowfall is increasing. In addition, the conservative freeboard estimate includes the effects of climate change (a 25% increase in rainfall intensity over the next 100 years) and rain on snowmelt. All building design specifications will meet NBCC 2015 code requirements (NRCC 2015).

As described in Section 10.1, the ECM base liner and final cover system have been designed as multilayer systems to withstand effects from extreme weather events, such as freeze-thaw cycles, extreme rainfall and snowmelt, and high winds. These design features also take into account potential effects from climate change.

Climate change has the potential to greatly influence Canada's forests, since even small changes in temperature and precipitation can affect forest growth and survival. A small increase in temperature can result in a longer growing season, increased plant growth and a shift in tree species occurrence and abundance (NRCan 2004). None of these biological changes could directly affect the NSDF Project; however, the probability of forest fires increases with dry conditions, as well as lightning strike probability, and a forest fire could affect the NSDF Project infrastructure and workers' safety.

A Closure Plan has been developed as part of the NSDF Project, which describes the program for completing final closure of the ECM and associated facilities. The intention is for this plan to be an evolutionary document that continues to be refined throughout the life of the NSDF Project. The plan will be reviewed prior to implementation such that changes in environmental conditions (i.e., weather events, forest fires and seismic events); improved technologies; confirmation of predicted effects; and adaptive management can be integrated. An updated and revised Final Closure Plan will be prepared based on actual, verified conditions, either two years prior to the end of the operations phase or when 90% of the total waste volume has been placed in the ECM, whichever comes first (AECOM 2017b).

As an adaptation measure for climate change, the potential effects of a changing climate will be considered as part of the re-evaluation of the plan. During the post-closure phase, monitoring will be incorporated into the Final Closure Plan to help identify any potential future climate change effects beyond what has been considered in the assessment. This would include evaluating long-term monitoring results, documented changes in the local climate and up-to-date climate change predictions. Examples of adaptive management to be integrated into closure and post-closure planning could include mitigation to address:

- changes to temperature and precipitation have affected the vegetation used in the rehabilitation of the site; or
- climate changes (e.g., increased erosion rates) have affected the final cover system design.

10.5 Glaciation

The earth is currently in an interglaciation period, meaning that it is between ice ages. It is estimated that the current period, called the Holocene, began approximately 11,700 years ago (Clark et al. 2016). Records suggest that previous interglaciation periods have lasted anywhere from 10,000 to 20,000 years (Berger et al. 2003). The global warming projected until the year 3000 (0.6°C to 7.8°C over 1,000 years) represents a much higher warming rate than the rate seen at the end of the last glacial period (4°C over an estimated 8,000 years). Coupling of climate change models and glaciation models predicts a relatively long interglacial period; the next significant glacial event is not projected to occur before 60,000 (Berger et al. 2003) to 100,000 years (Peltier 2011) after present.

Typically, glacial cycles are assumed to be approximately 100,000 years, with the glaciation phase lasting approximately 90,000 years and the deglaciation phase lasting approximately 10,000 years (Peltier 2011). Peltier (2011) also notes that if the concentrations of greenhouse gases remain similar to the present, another glacial event is unlikely due to the increased surface warmth. However, projections for atmospheric concentrations 60,000 years after present are not available; therefore, the potential for a glacial event should not be discounted.

Hallet (2011) studied the potential erosion from glacial activity in Kincardine, Ontario. Results of several studies provided a broad range of glacial scouring (erosion resulting from glacial action). The depths ranged from several metres to approximately 300 m at the most over a 1,000,000-year time scale, assuming a 100,000-year glacial cycle. These studies did not include topographic features or other factors that would tend to localize erosion. In addition, studying the past record of erosion near Kincardine showed a more site-specific estimate of 100 m for a 1,000,000-year time scale. No site-specific information was available for the NSDF Project site.

Global warming is projected until the year 3000, up to about 8°C over 1,000 years (Golder 2019). This represents a much higher warming rate than that seen at the end of the last glacial period and corresponds to a higher rate of increase in atmospheric carbon dioxide concentrations than in previous periods. It is therefore expected that there will be a relatively long interglacial period, so the next glaciation cycle is not likely to occur before 100,000 years after present (Peltier 2011). It is predicted that glacier will cover the territory of Ontario, which includes the CRL site, for tens of thousands of years.

The assessment timeframe for the Post-SA (Arcadis and Quintessa 2020) is 10,000 years. The timeframe was determined using the criteria within *REGDOC-2.11.1 Waste Management: Volume III: Assessing the Long-Term Safety of Radioactive Waste Management* (CNSC 2018). The 10,000-year assessment timeframe captures the period of peak radioactivity[1] and dose consequence[2], the design life of the engineered and natural barriers, and takes the 1-in-10,000-year seismic design basis into account. By 10,000 years post-closure, the radioactivity concentration in the ECM is very close to natural background concentrations. Glaciation may occur 100,000 years into the future, far beyond the timeframe that the facility is hazardous.

10.6 Summary of NSDF Project Design Features and Mitigation

Table 10.6-1 summarizes the design features and mitigation implemented to reduce or eliminate potential effects of the environment on the NSDF Project components and activities.

Table 10.6-1: Environmental Factors That Can Affect the NSDF Project and Associated Mitigation

Project Component or Activity	Factors	Mitigation
Infrastructure and Support Facilities	Extreme Events	Extreme events (e.g., storms) may result in a potential interaction with infrastructure and support facilities, but this is accounted for in the design specifications and will be addressed through on-going maintenance. For example, all building layouts will meet NBCC 2015 requirements. The effects of the PMP were considered by identifying flowpaths and possible risk to infrastructure.
Wastewater Treatment Plant	Rain, Extreme Events	Extreme rainfall and snowmelt events and the potential for flooding are considered in the design of the WWTP. The maximum flow rate was determined by evaluating the expected contact water volume that would be produced during two back-to-back 100-year, 24-hour storm events. This was selected as a worst-case design condition for determining the required volume of wastewater collection tanks.

[1] Peak radioactivity: the maximum concentration of a radionuclide in the receiving environment as a result of releases from the Engineered Containment Mound over the assessment timeframe.

[2] Dose consequence: the maximum radiological dose to humans from internal and external exposure to radioactivity over the assessment time frame.

Table 10.6-1: Environmental Factors That Can Affect the NSDF Project and Associated Mitigation

Project Component or Activity	Factors	Mitigation
Drainage Ditches and Culverts	Rain, Extreme Events	Extreme rainfall and snowmelt events and the potential for flooding are considered in the design of the surface water management systems. All roadways, including the perimeter road, have ditches that convey not only roadway drainage but drainage from adjacent lands to the surface water management ponds. These have been designed to convey the 25-year post-development peak design flow, which includes consideration of climate change. For example, historical peak precipitation has been considered in design of drainage ditches and culverts. Where drainage crosses roads, culverts are sized to convey the 25-year design event without road overtopping. Annual maintenance activities will identify any erosion or blockage problems for ditches and culverts. In addition, a maintenance review will be completed after major storm events and after the annual spring melt to confirm there are no major erosion or blockage issues at the culvert and sewer inlet or outlet.
Surface Water Management Ponds	Rain, Extreme Events	Extreme rainfall and snowmelt events and the potential for flooding are considered in the design of the surface water management ponds. The current surface water management pond design considers climate change over 500 years and reflects the overall storage required to control flows for the 2-year through to 100-year rainfall events at the site. This volume also contains the storage required for sediment control during construction and water quality control during operations. The current footprints typically assume a maximum 100-year operating water level at a 3 m depth with 1 m of freeboard that includes allowance for climate change effects and rain on snowmelt. Major system (i.e., 100-year) flow routes follow the road system and ditches to the relevant surface water management ponds. The PMP flow generally follows the major system route using the road, related ditches and adjacent lands. The PMP flow will exceed the surface water management ponds attenuation capacity, but is adequately conveyed by inlet and emergency outlet structures adjacent to the surface water management ponds.
Engineered Containment Mound Berm	Rain, Extreme Events	Severe rainstorms or snowmelts could affect roads and cause failure of natural or engineered slopes (e.g., berms). Designed berms consist of three main geotechnical elements, or layers, each contributing to the soundness and integrity of the berm itself and the whole ECM.

Table 10.6-1: Environmental Factors That Can Affect the NSDF Project and Associated Mitigation

Project Component or Activity	Factors	Mitigation
Engineered Containment Mound and Berm	Seismic	The design of the ECM has considered significant seismic events such to mitigate against damage to the safety features. The NSDF Project facilities, including the final cover system design, are designed to meet safety factors and earthquake loading requirements. To support the design of the NSDF Project, a PSHA was prepared and an analysis of liquefaction potential was conducted; mitigation has been implemented into the design of the ECM to limit the potential for liquefaction. Based on the conclusions of the seismic analysis and with the implementation of the proposed mitigation for liquefaction, the ECM is expected to remain functional under the 10,000-year design seismic event scenario. During operations through the institutional control phases of the NSDF Project, the consequences of any damage to the engineered berms or the ECM final cover system from a beyond design earthquake would be mitigated as required.
Engineered Containment Mound Final Cover System	Extreme Rain and Wind	The final cover system is designed to limit water infiltration, to direct infiltration and surface water runoff away from the ECM waste placement area, and to resist degradation by surface geologic processes and biotic activity (e.g., prevent burrowing of animals) and inadvertent intruder attempts to access or excavate into the waste cells. A series of drainage control features will be installed in conjunction with placement of final cover system over the ECM. The finished surface of the ECM is elevated from the surrounding terrain, which limits the quantity of surface water entering the ECM from areas outside the extent of the ECM. The topographical slopes within the ECM footprint are sufficient to promote drainage, and by lining the ECM surface water collection ditches and stilling basins with rip rap and other erosion control measures, sediment transport and erosion will be minimized. Meteorological records will be reviewed annually to confirm that the final cover system performance is not overloaded in any post-closure year.
Engineered Containment Mound Final Cover System and Liner	Temperature	The NSDF Project has been designed to include a layer of clean fill on the floor of the ECM of sufficient thickness to prevent freezing of the base liner systems prior to waste placement. The HDPE geomembrane liner components of the sideslope lining system will not be adversely affected by freeze-thaw cycles, whereas the geosynthetic and compacted clay liner components of the sideslope lining system could undergo an increase in hydraulic conductivity prior to placement of the wastes on the sideslopes. However, after placement of the waste, the clay liners will consolidate under the weight of the waste, healing the voids caused by freezing. The final cover system will be installed to its full thickness progressively as areas of the ECM reach the final waste contours. The final cover system design has 1.75 m of granular/soil materials above the lining system, which is sufficient to prevent freezing of the final cover system liner components.

Table 10.6-1: Environmental Factors That Can Affect the NSDF Project and Associated Mitigation

Project Component or Activity	Factors	Mitigation
Remediation	Temperature, Precipitation	Grading of the site will be designed taking into consideration the potential for future extreme weather events. Changes to temperature and precipitation may affect the vegetation used in remediation of the site and will be considered in the closure and post-closure planning. For example, the vegetated top of the final cover system will be designed for withstanding erosion and gully initiations. The vegetation for the final cover system will be limited to grass species that are drought-resistant. Treatments will be applied as required to keep grass and soil free of pests and pathogens or disease (AECOM 2017b). Changes to climate can be addressed through adaptive management plans that consider projected changes in climate relevant to the local vegetation.

Note: The factors include consideration of the shifts in frequency and/or intensity of these events due to climate change.

NBCC = National Building Code of Canada; WWTP = Wastewater Treatment Plant; PMP = probable maximum precipitation;

ECM = engineered containment mound; HDPE = high density polyethylene; PSHA = Probabilistic Seismic Hazard Assessment.

11.0 SUMMARY OF MONITORING AND FOLLOW-UP PROGRAMS

Each of the discipline-specific assessments presented in Sections 5.2 through 5.10 and Section 6.0 of the Environmental Impact Statement (EIS) propose conceptual monitoring and follow-up programs to be undertaken by Canadian Nuclear Laboratories (CNL) during the construction, operations, closure and post-closure (institutional control) phases of the Near Surface Disposal Facility (NSDF) Project. These monitoring and follow-up programs will serve to address the uncertainties associated with the effects predictions and the performance of mitigation, verify the effects predictions, identify any unanticipated effects and provide for the implementation of adaptive management to limit these effects.

Table 11.0-1 summarizes the proposed environmental assessment follow-up monitoring programs discussed in Sections 5.2 through 5.10 and Section 6.0. The programs will be carefully integrated with CNL's on-going monitoring and management plans, where appropriate, and will reference CNL Standard Practices and Procedures. Wherever possible, existing programs will be adapted to meet the objectives of monitoring the predictions made by the environmental assessment for the NSDF Project. CNL's existing compliance programs are summarized in Section 3.5.2.

The monitoring and follow-up plan presented in this section is conceptual and provides a preliminary description of the activities and framework for monitoring proposed for the NSDF Project. This plan will be developed into detailed monitoring and follow-up programs as detailed NSDF Project design is finalized, which may influence the nature, frequency and locations of monitoring. In addition, input from regulatory agencies, the public and Indigenous peoples will be considered. These monitoring and follow-up programs will include sufficient information on the type, quantity and quality of information required to reliably verify predicted effects (or absence of them) and confirm the effectiveness of mitigation. These programs will also be prepared consistent with the Canadian Standards Association's Standards N288.4-10 (*Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [CSA Group 2010]), N288.5-11 (*Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [CSA Group 2011]) and N288.7-15 (*Groundwater Protection Programs At Class I Nuclear Facilities and Uranium Mines and Mills* [CSA Group 2015), as applicable.

One key component of the monitoring and follow-up plan will be the implementation of the Waste Acceptance Criteria (WAC) verification for the NSDF Project. The WAC verification ensures that all waste received for disposal is in compliance with the design and safety basis of the facility. The tracking of the waste inventory into the facility allows for the verification of the assumptions used in this EIS (e.g., pathways analysis modelling is based on the licensed inventory proposed to be disposed in the ECM).

CNL's Functional Support Manager for Environmental Protection will be responsible for the delegation of resources to develop, implement and integrate the environmental assessment monitoring and follow-up programs identified in Table 11.0-1. Monitoring and follow-up programs will be carried out throughout all phases of the NSDF Project. The following phases were identified for the NSDF Project:

- **Construction Phase**: includes site preparation and all activities associated with the construction of the NSDF Project. This phase includes activities such as installing the necessary supporting and/or ancillary facilities and infrastructure to facilitate NSDF Project operations, inactive commissioning and systems testing, and transportation of construction materials. Construction activities are expected take place from 2021 to 2023.

- **Operations Phase**: includes all activities associated with waste placement, water management, Wastewater Treatment Plant (WWTP) operations, vehicle movements into and from the NSDF Project site and maintenance activities. Operations activities are expected to last approximately 50 years (i.e., 2024 to 2070). Follow-up monitoring during operations will be incorporated into CNL's routine environmental monitoring programs.
- **Closure Phase:** includes activities necessary to complete the installation of the final cover and implementation of long-term monitoring. Closure activities are expected to start in 2070 and continue through to 2100, after which the NSDF Project will transfer into the post-closure phase.
- **Post-closure Phase:** has two discrete periods: institutional control and post-institutional control. The institutional control period includes implementation of controls throughout 2100 to 2400 (i.e., 300 years). During institutional control, groundwater monitoring and groundwater quality management will continue to demonstrate compliance with the Post-Closure Safety Assessment assumptions (Arcadis and Quintessa 2020). Post-institutional control occurs after year 2400 and continues indefinitely.

11.1 Data Management

The development and implementation of mitigation identified for the NSDF Project and housed in the monitoring and follow-up programs are tracked in relevant management plans, where data management, including collection, storage, standards and responsible roles, are defined. Data collected will meet the required guidelines for collection and quality assurance and control. CNL will store information generated from the environmental assessment monitoring and follow-up program in a robust database for future analysis and reporting. Analysis of results from the monitoring and follow-up program will be reported and submitted to the relevant regulatory agencies as required.

11.2 Adaptive Management

CNL is committed to achieving continual improvement in environmental performance through its management systems. CNL manages environmental related matters through an existing Environmental Protection Program that is registered to ISO 14001. CNL's Chalk River Laboratories have been ISO 14001 certified since 2004 (CNL 2019a). CNL's Environmental Protection Program includes compliance and adaptive management systems to evaluate areas for improvement or trending. The program will continue to be implemented for the NSDF Project during construction and operations and will be updated, as needed, as part of an annual management review process.

The development and implementation of mitigation identified in the NSDF Project environmental assessment monitoring and follow-up programs will be tracked in existing CNL management plans. Adaptive management is a means by which uncertainties in outcomes can be reduced through monitoring. CNL's approach to adaptive management is defined in each plan. As site conditions and monitoring dictate, CNL will adaptively manage site practices and monitoring programs to meet the defined objectives. For some programs, this involves regular evaluation of predictive models; which are clearly defined in each applicable management plan.

If an environmental monitoring and follow-up program identifies that adverse environmental effects are greater than predicted, then CNL will evaluate whether they result in changes to the conclusions in this EIS. If changes are confirmed, then CNL will evaluate the need for revised mitigation actions and management practices to manage effects. CNL's evaluation process for monitoring data include environmental performance criteria that are based on statistical measures and ecological health benchmarks. An exceedance of environmental performance criteria triggers CNL's non-conformance and corrective action process and includes notifying management and further investigation. Where the need for revised mitigations is identified they will be developed and implemented. This evaluation process is documented in Chalk River Laboratories' environmental protection procedures.

Some aspects of the adaptive management which may require revised mitigations can come from public input and feedback related to NSDF activities. As an example, the residual effects of changes in ambient noise due to construction and road traffic may affect the quality of life of local residents (Indigenous and non-Indigenous) near the NSDF site. Through the Public Information Program (PIP, CNL 2020), which provides a platform for two-way dialogue between CNL and its stakeholders, CNL is able to record feedback and concerns from the general public about the NSDF as it progresses through the construction, operations, closure, and post-closure period. While the PIP can provide a short-term complaints response plan, marked changes can be recorded in follow-up monitoring as trends throughout the NSDF phases. Adaptive measures can then be developed and implemented as part of follow-up monitoring to permanently mitigate concerns.

Monitoring during the institutional control period will confirm the performance of the containment system, and if necessary, remedial actions will be taken. Examples of mitigation that would be implemented include:

- If erosion were present, the final cover would be repaired.
- If a localized breach of the final cover were present, the cover would be repaired and the leachate system would be periodically assessed and inspected.
- If there were multiple or and indeterminant number of breach locations in the final cover, another cover / cap system could be installed over the existing cover.
- If the monitoring wells detected abnormal performance results, additional wells could be installed and the monitoring frequency increased.
- Erosion of the berm would be mitigated by maintaining a healthy vegetation cover.

11.3 Engagement and Communication

Recognizing people's interest in understanding and participating in decisions that affect them, CNL will proactively seek, engage and support meaningful discussion with the public and Indigenous peoples on issues and opportunities related to the NSDF Project, including the environmental assessment monitoring and follow-up programs, through CNL's PIP (CNL 2020), which can be found on the CNL website (www.CNL.ca). The PIP includes specific communications to stakeholders and public access to information related to routine activities as well as new projects such as the NSDF Project. These measures are meant to mitigate questions and complaints regarding CNL activities, as well as ensure community input is sought, received and action is taken to respond to these inputs.

The PIP also provides a platform for the public to voice their concerns related to NSDF Project activities and for CNL to address and develop resolutions to these concerns; the process includes:

- Corporate Communications receives issues and concerns through the formal feedback submission on the CNL website (https://www.cnl.ca/contact us), emails (communications@cnl.ca), phone calls (1-800-364-6989), and social media platforms (e.g., Facebook and Twitter).

- All NSDF project-related issues and concerns (including complaints about noise disturbances) received are forwarded to the NSDF Project for resolution.
- The NSDF Project address and resolve concerns about the Project on a case-by-case basis and resolution may include further mitigation of NSDF site activities.
- Throughout this process, CNL will maintain two-way dialogue between the stakeholder and the NSDF team until the issue is resolved.
- All inquiries are tracked and resolution or responses are recorded once completed.

CNL will continually evaluate both the process and the outcome of the on-going engagement and communication activities to address and manage issues as they arise.

Table 11.0-1: Environmental Assessment Monitoring and Follow-up Programs Proposed for the NSDF Project

EIS Section	Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Section 5.2 Atmospheric Environment	Air Quality	Construction activities will result in fugitive dust emissions.	▪ Verify that mitigation is being implemented effectively. ▪ Verify predictions in the assessment are reasonable and conservative. ▪ Verify predictions are within air quality criteria (SPM monitoring).	▪ Application of aggregate to unpaved roads – a record will be kept of the date of each application of aggregate to unpaved roads. ▪ Road misting and fixative application – a record will be maintained of dust suppression applications. ▪ Site inspection – during periods of high dust susceptibility, regular inspections will be carried out to monitor the efficacy of dust mitigation and any potential concerns with regards to fugitive dust, and, if required, implementation of mitigation will be recommended. Environmental conditions will be recorded. ▪ Particulate monitoring –SPM using a high volume sampler.	Through the construction phase.	Dust Management Plan (AECOM 2018a) to be implemented for the NSDF Project.
		Operations activities will result in fugitive dust emissions.	▪ Verify that the mitigation is being incorporated as planned, and are effective. ▪ Verify predictions in the assessment are reasonable and conservative. ▪ Verify predictions are within air quality criteria.	▪ Application of aggregate to unpaved roads – a record will be kept of the date of each application of aggregate to unpaved roads. ▪ Road misting and fixative application – a record will be maintained of dust suppression application. ▪ Site inspection – during periods of high dust susceptibility, regular inspections will be carried out to monitor the efficacy of dust mitigation and any potential concerns with regards to fugitive dust, and if required implementation of mitigation will be recommended. Environmental conditions will be recorded. ▪ Particulate monitoring – SPM using a high volume sampler.	Based on observations and monitoring data during first year of operation, the frequency of monitoring will be determined.	Captured through the implementation of the Dust Management Plan (AECOM 2018a) and CNL's procedure for Management and Monitoring of Emissions (CNL 2018a), which includes operational control monitoring and air verification monitoring.
	Greenhouse gases	GHG emissions from the decomposition of waste during operations and closure.	▪ Verify that the measures for controlling landfill gas generated from waste deposited in the ECM during operations and following final closure are adequate. ▪ Verify that methane emission rates used in the assessment are reasonable and conservative. ▪ Verify that there is no combustion hazard from methane gas generation.	▪ Monitoring for methane will be performed using handheld portable combustible gas meter detectors. ▪ A passive landfill gas venting system will be constructed contemporaneously with installation of the ECM cover system which will provide measured concentrations and emission rates. ▪ The landfill gas monitoring probes will also be installed around the perimeter of the ECM to detect evidence of potential landfill gas migration away from the ECM.	Periodic monitoring during operations and for a specific period of time during closure phase (during which the frequency may be progressively reduced and possibly ultimately eliminated if no evidence of landfill gas migration from the ECM is detected).	Landfill Gas Management Plan (AECOM 2018b) to be implemented for the NSDF Project.
		Construction and operations activities will result in increased GHG emissions.	Verify that GHG emission rates used in the assessment are reasonable, but conservative. Monitoring results will be used for GHG reporting requirements.	Fuel Usage – a record will be kept of the fuel usage related to the NSDF Project.	Annual estimations and GHG reporting as required.	Captured through the implementation of CNL's procedure for Management and Monitoring of Emissions (CNL 2018a), which includes operational control monitoring and verification monitoring.
Section 5.3 Geological and Hydrogeological Environment	Hydrogeology	The NSDF may affect groundwater quality during operations, closure and post-closure (institutional control).	▪ Verify environmental assessment predictions on groundwater from the ECM and WWTP operation. ▪ Verify the effectiveness of mitigation.	▪ Groundwater elevation measurements to determine groundwater flow direction and gradients. ▪ Sampling to confirm groundwater quality to detect potential releases of constituents from the ECM containment area. ▪ Initial sampling frequency will likely be twice per year (Spring and Fall).	Groundwater monitoring will continue through operations, closure and post-closure (institutional control). The number of parameters, locations and frequency may change based on review of monitoring data.	NSDF Project groundwater monitoring will be integrated into the overall CNL Groundwater Monitoring Program, and will be compliant with CSA N288.7-15.

Table 11.0-1: Environmental Assessment Monitoring and Follow-up Programs Proposed for the NSDF Project

EIS Section	Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Section 5.4 Surface Water Environment	Hydrology	The installation of the ECM will physically alter drainage patterns, and may change downstream discharge, water levels in adjacent wetlands and channel and bank stability.	Operational monitoring – Verify the SWMPs are performing as designed.	Monitoring of water levels and sediment build up in the SWMPs.	The water level at the SWMP will be monitored during construction and operations. The need for and duration of monitoring will be revaluated based on an annual review of monitoring data.	Integrated into the NSDF Project Environmental Protection Plan (AECOM 2018c) to be implemented for the NSDF Project.
			Environmental monitoring – Confirm that the ecological function and structure of the wetland system is maintained.	Monitoring of wetland water elevations and surface water flows to verify changes from the presence of the ECM.	Water level and surface water flows monitoring of the wetland system will be initiated pre-construction (baseline) and continue through construction and operations. The need for and duration of monitoring will be evaluated based on an annual review of monitoring data.	Water level and surface water flows monitoring of the wetland system will be integrated into the CNL Environmental Monitoring Program.
	Surface Water Quality	▪ Discharge of treated effluent from the WWTP to the East Swamp Wetland and/or Perch Lake can cause changes to downstream surface water quality. ▪ Leakage of leachate from the ECM during the post-closure phase (i.e., after Year 2400) from liner and final cover degradation as a result of normal evolution can cause changes to downstream surface water quality.	Environmental monitoring – Verify environmental assessment predictions related to surface water quality.	Monitor the quality of surface water surrounding the ECM footprint area to evaluate whether the quality of the water is affected by the ECM or by operation of surface water management pond(s).	Water quality monitoring will continue through operations, closure and post-closure (institutional control). The number of parameters and locations may change based annual review of monitoring data.	Surface water monitoring in the receiving environment is integrated into the CNL Environmental Monitoring Program.
			▪ Operational monitoring – Verify the surface water management ponds are performing as designed. ▪ Demonstrate compliance with effluent discharge targets developed for the NSDF Project.	▪ Each pond weir outlet water quality will be sampled to identify if any contact surface water or leachate contamination of the non contact surface water is entering the surface water management ponds and to confirm total suspended solid concentrations. ▪ WWTP effluent verification monitoring consistent with CSA Standard N288.5-11.	▪ Routine visual inspections and surface water sampling during operations, closure and post-closure (institutional control) as required. ▪ Effluent monitoring will continue throughout operation of the WWTP.	Effluent water quality monitoring will be integrated into the CRL Radioactive Effluent Verification Monitoring Program.

Table 11.0-1: Environmental Assessment Monitoring and Follow-up Programs Proposed for the NSDF Project

EIS Section	Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Section 5.5 Aquatic Environment	▪ Perch Creek and Perch Lake Watershed Fish Habitat (i.e., Fish Habitat) ▪ Perch Creek and Perch Lake Watershed Fish Community (i.e., Fish Community) ▪ Fish Species of Conservation Concern	▪ Measurable residual effects on aquatic biodiversity VCs are not predicted as a result of the NSDF Project. Potential effects are related to: ▪ Physical change to fish habitat and temporary riparian area disturbances from the installation of diffuser and transfer line construction and footprint that may affect fish and fish habitat. ▪ Non-radiological air emissions and dust emissions (including sulphur dioxide, nitrogen oxides and particulate matter) and subsequent deposition may cause a change in surface water quality and fish habitat quality. ▪ Discharge of treated effluent from the WWTP to the exfiltration gallery and Perch Lake may cause changes to groundwater quality and to downstream surface water quality, which can affect fish habitat quality, survival and reproduction. ▪ Leakage of leachate from the ECM during the post-closure phase (i.e., after Year 2100 to 2400) from liner and final cover degradation as a result of normal evolution may cause changes to groundwater quality and downstream surface water quality in wetlands, affecting fish habitat quality, survival and reproduction.	▪ Operational monitoring – Verify the surface water management ponds are performing as designed. ▪ Demonstrate compliance with effluent treatment targets developed for the NSDF Project.	See Surface Water Quality. If the environmental monitoring program for surface water quality identifies that adverse environmental effects are greater than predicted, then CNL will evaluate the need for revised mitigation actions and management practices to manage effects. CNL's evaluation process for monitoring data include environmental performance criteria that are based on statistical measures and ecological health benchmarks. An exceedance of environmental performance criteria triggers CNL's non-conformance and corrective action process and includes notifying management and further investigation. Where the need for revised mitigations is identified they will be developed and implemented. The evaluation process is documented in CNL's Environmental Monitoring Program (CNL 2018b).	See Surface Water Quality.	See Surface Water Quality.

Table 11.0-1: Environmental Assessment Monitoring and Follow-up Programs Proposed for the NSDF Project

EIS Section	Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Section 5.6 Terrestrial Environment	Canada warbler	▪ **Habitat Availability**: Permanent, direct loss of 28 ha of suitable habitat. Long-term reduction in quality of nesting habitat and possible avoidance in the LSA from sensory disturbance. ▪ **Habitat Distribution**: Small, permanent change in local movement. ▪ **Survival and Reproduction**: Small reduction in reproductivity from habitat loss and sensory disturbance.	Verify environmental assessment predictions through collection of data on relative abundance and other key demographic parameters for breeding bird populations that overlap with the RSA.	Data on relative abundance and other key demographic parameters for breeding birds in the RSA will be collected during pre- and post-construction surveys using automated recording units. Collected data will be used to evaluate trends in populations of breeding birds that overlap with the RSA, including Canada warbler, eastern whip-poor-will, eastern wood-pewee, golden-winged warbler and wood thrush. If declining trends are observed for these species in the RSA, then the need for additional mitigation will be evaluated.	Every 5 years	Monitoring will be integrated into CNL's existing Species at Risk Program.
	Eastern whip-poor-will	▪ **Habitat Availability**: Permanent, direct loss of 2 ha of suitable habitat. ▪ **Habitat Distribution**: Small, permanent change in local movement. ▪ **Survival and Reproduction**: Small reduction in reproductivity from habitat loss and sensory disturbance.				
	Eastern wood-pewee	▪ **Habitat Availability**: Permanent, direct loss of 18 ha of suitable habitat. ▪ **Habitat Distribution**: Small, permanent change in local movement. ▪ **Survival and Reproduction**: Small reduction in reproductivity from habitat loss and sensory disturbance.				
	Golden-winged warbler	▪ **Habitat Availability**: Permanent, direct loss of 27 ha of suitable habitat. ▪ **Habitat Distribution**: Small, permanent change in local movement. ▪ **Survival and Reproduction**: Small reduction in reproductivity from habitat loss and sensory disturbance.				
	Wood thrush	▪ **Habitat Availability**: Permanent, direct loss of 28 ha of suitable habitat. ▪ **Habitat Distribution**: Small, permanent change in local movement. ▪ **Survival and Reproduction**: Small reduction in reproductivity from habitat loss and sensory disturbance.				

Table 11.0-1: Environmental Assessment Monitoring and Follow-up Programs Proposed for the NSDF Project

EIS Section	Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Section 5.6 Terrestrial Environment (cont'd)	Bats	▪ **Habitat Availability**: Permanent, direct loss of 28 ha of potential maternity roosting habitat. ▪ **Habitat Distribution**: Gap in potential maternity roosting habitat, but negligible change in local movement patterns. ▪ **Survival and Reproduction**: No residual effects due to the NSDF Project.	Verify effectiveness of bat boxes as maternity roosting habitat offsetting measure, by determining number of individuals and species of bats using boxes for roosting habitat.	▪ Installation of bat boxes in suitable locations in the RSA is recommended to offset the incremental contribution of the NSDF Project to cumulative effects on SARA-listed bats. Monitoring is being conducted at least weekly to determine if bat boxes are being used. Boxes not being used may be moved to an alternate location. ▪ A project in collaboration with Trent University is currently underway, where bats are being trapped and tracked back to the roost site (natural tree or bat box). ▪ Guano collection is being performed as well. This work has a duration of two years and will provide CNL with a better understanding of habitat occupancy by the bat species at risk, including bat boxes, and habitat preference. This work will support the objective of addressing knowledge gaps on the three bat species at risk.	Bat boxes will remain in place throughout the construction and operations phases. Visual monitoring of bat boxes will be conducted weekly every year during the pre-construction phase and will continue through construction and for three years after start of operations.	Monitoring will be integrated into CNL's existing Species at Risk Program.
	Blanding's Turtle	▪ **Habitat Availability**: Direct, permanent loss of 26 ha of critical habitat. ▪ **Habitat Distribution**: Permanent change in local movement. ▪ **Survival and Reproduction**: Reduced reproductive success and mortality of individuals over the lifespan of the NSDF Project.	Confirm effectiveness of mitigation through tracking wildlife mortality and use information for adaptive management.	Wildlife-vehicle collision monitoring will be conducted in the SSA. — Vehicle-caused Blanding's turtle mortality will be reported and data will be compiled in be used to inform adaptive management for the site.	On-going during the construction and operations phases and closure.	Monitoring will be integrated into CNL's existing Species at Risk Program.
			Identify and map critical habitat in the SSA.	As part of the SARA permitting process for the removal of critical habitat, critical habitat will be assessed annually to ensure no significant loss at CRL and to determine compensation measures initiated at CRL or elsewhere. Monitoring will be integrated into CNL's existing Species at Risk Program.	Critical habitat will be assessed annually to ensure no significant loss at CRL and to determine compensation measures initiated at CRL or elsewhere.	Habitat compensation will be implemented as part of the SARA permitting process and consist of the creation of nest mounds for the species.
			Confirm integrity temporary and permanent of exclusion fencing.	Exclusion fencing will be inspected for integrity.	Annually during the construction and operations phases and closure.	Monitoring will be integrated into CNL's existing Species at Risk Program.
			Confirm integrity of culverts in the RSA.	Culverts will be inspected for barriers to turtle movements.	Weekly during the active season for Blanding's turtle (April 15 to October 15).	Monitoring will be integrated into CNL's existing Species at Risk Program.
			Confirm integrity of artificial nest mounds.	Nesting mounds will be inspected for suitability and mounds will be maintained by removing vegetation as needed.	Weekly during the nesting season for Blanding's turtle (May 15 to June 30).	Monitoring will be integrated into CNL's existing Species at Risk Program.

Table 11.0-1: Environmental Assessment Monitoring and Follow-up Programs Proposed for the NSDF Project

EIS Section	Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Section 5.6 Terrestrial Environment (cont'd	Blanding's Turtle (cont'd)		Confirm integrity of nest cages.	Nest cages will be inspected for integrity.	Weekly during the nesting and hatchling emergence season for Blanding's turtle (May 15 to October 15).	Monitoring will be integrated into CNL's existing Species at Risk Program.
			Confirm use of culverts by Blanding's turtles.	Cameras will be installed at culverts and will record photographs on a time-lapse basis. Photographs will be reviewed and data compiled.	Continuously during the active season for Blanding's turtle (April 15 to October 15) every year for the next 5 years.	Monitoring will be integrated into CNL's existing Species at Risk Program.
	Eastern Milksnake	▪ Habitat Availability: Direct, permanent loss of habitat. ▪ Habitat Distribution: Permanent change in local movement. ▪ Survival and Reproduction: increased risk of injury/mortality on roads.	Confirm effectiveness of road mitigation to minimize or eliminate the potential for road mortality in the LSA.	Exclusion fencing will be inspected for integrity.	Annually during the construction and operations phases and closure.	Monitoring will be integrated into CNL's existing Species at Risk Program.
			Confirm effectiveness of road mitigation to minimize or eliminate the potential for road mortality in the LSA	Road mortality surveys to be conducted weekly during pre-construction and operations within the NSDF Project site. During construction, mortality survey to be conducted daily during the species active period (April 15 to September 30).	On-going during construction and operation phases.	Monitoring will be integrated into CNL's existing Species at Risk Program.
	Monarch butterfly	▪ Habitat Availability: Permanent, direct loss of 5 ha of suitable habitat. ▪ Habitat Distribution: Small, permanent change in local movement. ▪ Survival and Reproduction: Small reduction in reproductivity from habitat loss.	N/A(a)	N/A[(a)]	N/A[(a)]	N/A[(a)]
▪ Section 5.7 Ambient Radioactivity and Ecological Health ▪ Section 5.8 Human Health	All VCs	During the operations and closure phases: ▪ Airborne emissions may be released from the ECM from contaminated dust created during handling of bulk materials and emissions of gases may be released during storage and disposal of radioactive materials. ▪ Emissions may be released from the WWTP to air during operations and closure. ▪ Discharge of treated effluent from the WWTP to the East Swamp Wetland and Perch Lake can cause changes to groundwater quality in the wetland and downstream surface water quality, which can affect ecological health. During the post-closure phase (institutional control): ▪ Volatiles (e.g., radon, tritium) may be released to air. ▪ Leachate may be released to soil via overtopping the berm. ▪ Leachate may be released through the base liner to groundwater.	Verify effectiveness of mitigation.	▪ Air quality (i.e., dust) will be monitored at the SSA and air effluent verification monitoring may be required at the WWTP. ▪ Dust samples collected in the high volume air sampler during construction and operations will be screened for radioactivity. ▪ Treated effluent from the WWTP, storm water pond effluent and surrounding surface water quality will be monitored. ▪ Ambient radioactivity will be measured at the SSA. ▪ Groundwater monitoring will be performed surrounding the ECM, to confirm groundwater quality and detect potential releases of constituents from the ECM containment area.	On-going during operations, closure and post-closure (institutional control). The need for and duration of monitoring will be reviewed based on annual review of monitoring data.	▪ Integrated into the existing Effluent Verification Monitoring Program, Groundwater Monitoring Program and Environmental Monitoring Program.

Table 11.0-1: Environmental Assessment Monitoring and Follow-up Programs Proposed for the NSDF Project

EIS Section	Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Section 5.9 Land and Resource Use	▪ Land and Resource Tenures and Other Registered Interests ▪ Outdoor Tourism and Recreation ▪ Archaeological Sites	▪ No residual adverse effects identified. Potential effects are related to: ▪ Change in access to or availability of tenured land use opportunities and other registered interests. ▪ Changes in access to or quality and quantity of outdoor tourism and recreation activities (except trapping). ▪ Ground disturbance from the NSDF Project during construction may cause disturbance or destruction to archaeological sites.	Verify mitigation is effective	Monitoring and follow-up programs are not specifically identified for land and resource use; rather, monitoring for environmental pathways (i.e., for air quality, surface water quality and groundwater quality) will be implemented to verify effects predictions for land and resource use, and to promote land user comfort around the safety of the Land and Resource Use LSA, RSA and surrounding areas for land and resource use, outdoor tourism and recreation, and commercial (i.e., tenured) land use activities (i.e., to reduce perceptions of adverse NSDF Project effects on land and resource use that are not anticipated to occur). Monitoring will be used to identify unanticipated archaeological resources and apply adaptive management through the implementation of the CNL Archaeological Master Plan and Cultural Resource Management Program.	▪ On-going during operations, closure and post-closure (institutional control) phases. ▪ The need for and duration of monitoring will be reviewed based on an annual review of monitoring data.	▪ Integrated into CNL's Environmental Monitoring Program. ▪ Executed as part of CNL's Public Information Program. ▪ CNL's Archaeological Master Plan and Cultural Resource Management Program.
Section 5.10 Socio-economic Environment	▪ Labour Market ▪ Economic Development ▪ Government Finances ▪ Housing and Accommodations ▪ Services and Infrastructure ▪ Quality of Life ▪ Noise Levels ▪ Public Safety	Employment of personnel, procurement of goods and services, and expenditures from the NSDF Project: ▪ Increased pressure on commercial accommodations. ▪ Increased road degradation due to increased traffic volume from the transportation of workers, supplies and equipment. ▪ Increased demand for emergency services. ▪ Increased demand for protective services. Construction and Operations Phase ▪ Increased traffic along local roadways (i.e., Highway 17 and Plant Road).	Verify mitigation is effective	▪ Monitoring and follow-up programs are not specifically identified for socio-economics; rather, monitoring for environmental pathways (i.e., for air quality, surface water quality and groundwater quality) will be implemented to verify effects predictions. ▪ CNL will proactively seek, engage and support meaningful discussion on issues and opportunities related to the NSDF Project as part of the Public Information Program (PIP, CNL 2020), which can be found on the CNL website (www.CNL.ca). CNL, as part of the PIP, will notify residents of NSDF project construction commencement via door-to-door delivery of letters, where stakeholders will have the opportunity to voice their questions or concerns about activities related to the NSDF Project construction commencement. As part of the notification, the letter will include all CNL contact details (e.g., website, telephone, email) to provide clear direction on how to contact CNL if they have questions, concerns or complaints related to the NSDF Project. A web link to a Feedback Form that is currently on the NSDF webpage on www.CNL.ca will also be included in the notification and will outline the above process of when an issue or concern is submitted. CNL will continually evaluate both the process and the outcome of the on-going engagement and communication activities to address and manage issues as they arise. ▪ As part of the Environmental Assessment Monitoring and Follow-up Program, with respect to the noise assessment, a traffic count study will be completed along Highway 17 and Plant Road as a pre-construction activity. Traffic counts will be obtained along both; Highway 17 and Plant Road to establish an Annual Average Daily Traffic (AADT) count in accordance with accepted practices. The study will consider Highway 17 north and south of Plant Road. Average hourly distribution will be established for Highway 17 and Plant Road. The gathered traffic count data will be used to verify the noise modelling result, and if required, additional mitigation will be implemented for the project.	On-going during the construction, operations and closure phases and the need for and duration of monitoring will be reviewed based annual review of monitoring data. The level and nature of engagement with the communities will depend on feedback received.	▪ Integrated into CNL's Environmental Monitoring Program. ▪ Executed as part of CNL's Public Information Program.

Table 11.0-1: Environmental Assessment Monitoring and Follow-up Programs Proposed for the NSDF Project

EIS Section	Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Section 6 Indigenous Interests - Traditional Land and Resource Use	Traditional Land and Resource Use by Indigenous Peoples	No residual adverse effects identified. Potential effects are related to: ▪ Changes in access to or quality and quantity of trapping opportunities. ▪ Changes in access to the quality and quantity of traditional land and resource use – trapping.	Verify mitigation is effective	▪ Monitoring and follow-up programs are not specifically identified for traditional land and resource use; rather, monitoring for environmental pathways (i.e., for air quality, surface water quality, groundwater quality and terrestrial biota) will be implemented to verify effects predictions for traditional land and resource use, and to promote land user comfort around the safety of the Traditional Land and Resource Use LSA, RSA and surrounding areas for traditional land and resource use (i.e., to reduce perceptions of adverse NSDF Project effects on traditional land and resource use that are not anticipated to occur). ▪ As part of CNL's Public Information Program, CNL will continue to engage with Indigenous peoples, and share the results of the air quality, surface water quality, groundwater quality and terrestrial biota monitoring through an accessible format (e.g., NSDF Project website), a recognized best practice used by projects with high levels of perceived risk that may have the potential to alter or reduce land and resource use activity without primary or secondary pathways. ▪ Monitoring will be used to identify unanticipated archaeological resources and apply adaptive management through the implementation of the CNL Archaeological Master Plan and Cultural Resource Management Program.	▪ On-going during operations, closure and post-closure (institutional control) phases. ▪ The need for and duration of monitoring will be reviewed based on an annual review of monitoring data.	▪ Integrated into CNL's Environmental Monitoring Program. ▪ Executed as part of CNL's Public Information Program. ▪ CNL's Archaeological Master Plan and Cultural Resource Management Program.
Section 6 Indigenous Interests - Indigenous Socio-economic Environment	▪ Decision-making ▪ Population and demographics ▪ Economy and employment ▪ Housing and infrastructure ▪ Indigenous resident – use and enjoyment of private property	No residual adverse effects identified. Potential effects are related to: ▪ The NSDF Project could affect air quality through the generation of emissions and fugitive dust. ▪ The NSDF Project could affect ambient noise levels due to construction traffic. ▪ The NSDF Project could affect ambient noise levels due to blasting activities. ▪ The NSDF Project could have a negative effect on visual aesthetics. ▪ Direct and indirect employment requirements may affect employment and income within the local and regional study areas. ▪ The NSDF Project may provide contracting and supplier opportunities to Indigenous local and regional businesses. ▪ Involvement with the NSDF Project may require more time on the part of Indigenous governance bodies.	Verify mitigation is effective	▪ Monitoring and follow-up programs are not specifically identified for Indigenous socio-economics; rather, monitoring for environmental pathways (i.e., for air quality, surface water quality and groundwater quality) will be implemented to verify effects predictions. ▪ CNL will proactively seek, engage and support meaningful discussion on issues and opportunities related to the NSDF Project as part of the PIP (CNL 2019b), which can be found on the CNL website (www.CNL.ca). CNL, as part of the PIP, will notify residents of NSDF project construction commencement via door-to-door delivery of letters, where stakeholders will have the opportunity to voice their questions or concerns about activities related to the NSDF Project construction commencement. As part of the notification, the letter will include all CNL contact details (e.g., website, telephone, email) to provide clear direction on how to contact CNL if they have questions, concerns or complaints related to the NSDF Project. A web link to a Feedback Form that is currently on the NSDF webpage on www.CNL.ca will also be included in the notification and will outline the above process of when an issue or concern is submitted. CNL will continually evaluate both the process and the outcome of the on-going engagement and communication activities to address and manage issues as they arise.	▪ On-going during the construction, operations and closure (institutional control) phases and the need for and duration of monitoring will be reviewed based annual review of monitoring data. ▪ The level and nature of engagement with the Indigenous peoples will depend on feedback received.	▪ Integrated into CNL's Environmental Monitoring Program. ▪ Executed as part of CNL's Public Information Program.

GHG = greenhouse gas; ECM = engineered containment mound; N/A = not applicable.

(a)Monitoring programs are not proposed for monarch butterfly.

12.0 CONCLUSIONS

This Environmental Impact Statement (EIS) describes the NSDF Project and the existing environmental conditions on the Chalk River Laboratories (CRL) site, and assesses the likely effects of the NSDF Project on the environment. The EIS also includes an assessment of likely cumulative effects of the NSDF Project in combination with other previous, existing or reasonably foreseeable developments, as required. It describes the effects for normal conditions and as a result of accidents and malfunctions. The EIS also describes and assesses the likely effects of the environment on the NSDF Project. Throughout the environmental assessment process, Canadian Nuclear Laboratories (CNL) has solicited input from the public and Indigenous peoples and incorporated this feedback into the EIS where appropriate. Examples of this includes changes to the waste inventory (i.e., only low-level waste) and expansion of the EIS study areas to include a larger downstream portion of the Ottawa River. Further, CNL has entered into long-term relationship agreements with Indigenous peoples to work collaboratively to meet the needs of the individual communities as well as CNL’s Project requirements.

The development of a near surface disposal facility for solid, low-level radioactive waste at the CRL site will reduce potential risks associated with Atomic Energy of Canada Limited’s legacy wastes liabilities. The NSDF Project will enable the remediation of historically contaminated lands and legacy waste management areas, as well as decommissioning of outdated infrastructure to facilitate the CRL site revitalization. The current CRL waste management practice is to safely store radioactive waste on-site in individual facilities in accordance with current licence conditions. However, appropriate nuclear waste management includes full life cycle management from generation to disposal. The NSDF Project will accommodate the permanent disposal of current and future low-level radioactive waste at the site. The EIS demonstrates that the NSDF Project can be constructed, operated and closed in a manner that is protective of human health and the environment.

The significance of the likely environmental effects of the NSDF Project has been assessed in Section 5.0 and Section 6.0. A summary of the residual adverse effects, mitigation and significance of residual adverse effects is provided in Section 9.0. The proposed monitoring and follow-up programs to be undertaken during all phases of the NSDF Project (i.e., construction, operations, closure and post-closure) are summarized in Section 11.0.

Residual adverse effects were identified for air quality (including greenhouse gases), hydrogeology, hydrology, surface water quality, terrestrial biodiversity, ecological health, human health and socio-economics (housing and accommodations, and services and infrastructure). Beneficial effects were identified for socio-economics (labour market, economic development, Indigenous). CNL has proactively addressed key issues raised by interested Indigenous peoples, using open and transparent communication to share information in regard to traditional land use, biodiversity and archaeology. Overall, it is CNL's conclusion that with the identified mitigation, the implementation of the NSDF Project is not likely to result in significant residual adverse effects.

All predicted effects for human health are well below regulatory criteria during the life of the NSDF Project, including post-closure. The maximum estimated dose during the operations period for an on-site worker is 5 times lower than the regulatory limit of 50 millisieverts per year (mSv/yr) and for the public is almost 50 times lower than the regulatory dose limit of 1 mSv/yr. During post-closure, the maximum estimated dose associated with the most likely future state of the facility is more than 60 times lower than the regulatory dose limit of 1 mSv/yr. Residual effects on Ottawa River water quality are determined to be negligible during operations and post-closure phases and may result in a net benefit due to remediation of legacy waste storage areas.

Potential effects of the NSDF Project on the environment are limited because the NSDF Project has been designed in consideration of site-specific characteristics and to be suitable for the proposed inventory, the vast majority of which are comprised of impacted soils and demolition debris. The engineered containment mound is designed to contain and isolate the wastes from the environment for 550 years. Since the NSDF only accepts LLW and most of the radioactivity; thus, the hazard, decays in the first 100 years after closure, the design of the NSDF is commensurate with the hazard. The safety of the NSDF during post-closure is provided by means of passive features (e.g., berm, base liner and cover systems) that will end the need for active management, in alignment with Canadian Nuclear Safety Commission requirements and International Atomic Energy Agency guidance.

A conceptual follow-up and monitoring program was developed to verify that mitigation is being implemented effectively and to confirm environmental assessment predictions. The details of this program will be further developed into detailed monitoring and follow-up programs as detailed NSDF Project design is finalized, with input from the public, Indigenous peoples and regulatory agencies. The facility will be a licenced nuclear facility under the *Nuclear Safety and Control Act* with regulatory oversight as long as required.

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13.12 Section 12.0 - Conclusions

None.

14.0 GLOSSARY, ACRONYMS AND UNITS

14.1 Glossary

Table 14.1-1: Glossary of Terms

Term	Definition
Abiotic	Relating to the non-living parts of the environment such as air, rock, soil and water. Some abiotic components are topography, hydrology, drainage, climate, meteorology, and land-use patterns by members of the public.
Acceptance Criteria	Specified bounds on the value of a functional or condition indicator used to assess the ability of a structure, system or component to meet its design and safety requirements.
Accident	Any unintended event, including operating errors, equipment failures or other mishaps, the consequences or potential consequences of which are significant from the point of view of protection or safety. With respect to nuclear criticality safety, the term **accidents or accident sequences** means events or event sequences, including external events, that lead to violation of the subcriticality margin (that is, to exceeding the upper subcritical limit).
Acute	With reference to toxicity, having a sudden onset, lasting a short time (usually within hours or days). With reference to a stimulus, severe enough to rapidly induce a response.
Acute Toxicity	Adverse effects occurring following oral or dermal administration of a single dose of a substance, or multiple doses given within 24 hours, or an inhalation exposure of 4 hours.
Adaptive Management	A planned and systematic process for continuously improving management practices (primarily environmental) by learning from their outcomes. For an environmental assessment, it involves, among other things, the implementation of new or modified mitigation measures over the life of a project to address unanticipated environmental effects.
Adiabatic	Relating to or denoting a process or condition in which heat does not enter or leave the system concerned.
Advection	The transfer of matter by the flow of a fluid.
Aeolian	Relates to or arising from the action of the wind.
Alpha particle	A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. **Note**: An alpha particle is identical to a helium nucleus, which has a mass number of 4 and an electrostatic charge of+2. An alpha particle has low penetrating power and a short range (a few centimetres in air). Alpha particles will generally fail to penetrate the dead layers of cells covering the skin and can be easily stopped by a sheet of paper. However, alpha-emitting isotopes are harmful if ingested.
Alpha radiation	The emission of an alpha particle from the nucleus of an atom.
Ammonia	A colorless, pungent gas used to manufacture a wide variety of nitrogen-containing organic and inorganic chemicals.
Anaerobic Conditions	Anaerobic conditions refer to a lack of free oxygen within a watercourse or waterbody. During anaerobic conditions, there is little to no biologically available oxygen.
Ancillary Infrastructure	Infrastructure necessary to support the transmission of electric power from seller to purchaser given the obligations of control areas and transmitting utilities within those control areas to maintain reliable operations of the interconnected transmission system.
Anion	A negatively charged ion.

Table 14.1-1: Glossary of Terms

Term	Definition
Anisotropic	An object or substance having a physical property that has a different value when measured in different directions.
Anoxic	Deficient in oxygen or having no oxygen.
Anthropogenic	Coming from or having been caused by humans.
Anticipated Operational Occurrences	An operational process deviating from normal operation which is expected to occur at least once during the operating lifetime of a facility but which, in view of appropriate design provisions, does not cause any significant damage to items important to safety nor lead to accident conditions.
Archaeological Resources	Any material remains of past human life or activities which are of archaeological interest.
Areas of Natural and Scientific Interest (ANSI)	An official designation by the provincial Government of Ontario in Canada applied to contiguous geographical regions within the province that have geological or ecological features which are significantly representative provincially, regionally, or locally.
As Low As Reasonably Achievable (ALARA)	An optimization tool in radiation protection used to keep individual, workplace and public dose limits as low as reasonably achievable, social and economic factors being taken into account. ALARA is not a dose limit; it is a practice that aims to keep dose levels as far as possible below regulatory limits.
Assessment Endpoints	Assessment endpoints are qualitative expressions used to assess the significance of residual effects on Valued Components (VCs) and represent the key properties of the VC that should be protected for future generations.
Background Radiation	The dose or dose rate (or an observed measure related to the dose or dose rate) attributable to all sources other than the one specified.
Baseline	A set of measurements (or metrics) representing the starting level of performance for a structure, system or component.
Bathtubbing	A process in which the waste material degrades, producing voids within a disposal trench, followed by subsidence of the overlying soil and the entry of surface water into the trench. In cases where the soil surrounding the trenches is sufficiently impermeable, the trenches fill with water. Overflow of water from this "bathtub" would have the potential to distribute radionuclides across the surrounding ground.
Bear Management Area (BMA)	An area of Crown land licenced annually to a tourist operator for providing bear hunting services to non-resident clients. Some BMAs can completely surround private or patent land. Bear hunting services can occur on these lands provided the licenced tourist operator allocated the BMA has obtained permission of the land owner to provide bear hunting services on the property.
Best Available Technology and Techniques Economically Achievable (BATEA)	Minimum pollution prevention performance standards for which effluent and/or emission concentrations have been demonstrated to be achievable within an industrial sector and are therefore economically achievable across that industrial sector. BATEA takes into account both treatment technologies and techniques used to achieve the desired effluent and/or emission concentrations. The way in which the installation is designed, built, maintained, operated and decommissioned is also considered as part of these technologies and techniques.
Best Estimate	An unbiased estimate obtained by using a mathematical model, calculation method or data to realistically predict behaviour and important parameters.
Becquerels	The International System unit of radioactivity, corresponding to one disintegration per second.

Table 14.1-1: Glossary of Terms

Term	Definition
Beta Particle	A charged particle that is emitted from the nucleus of a radioactive element during radioactive decay of an unstable atom. Large amounts of beta radiation may cause skin burns, and beta emitters are harmful if they enter the body. Beta particles may be stopped by thin sheets of metal or plastic.
Beta Radiation	The emission of a beta particle from the nucleus of an atom.
Beyond-design-basis accident (BDB)	An accident less frequent and potentially more severe than a design-basis accident.
Bioassay	The study of all living organisms to measure the effect of a substance, factor or condition by comparing before-and-after exposure or other data. **Note**: Specific to radiation exposure in humans, bioassay is any procedure used to determine the nature, activity, location or retention of radionuclides in a body by direct (*in vivo*) measurement or by indirect *(in vitro*) analysis of material excreted or otherwise removed from a body. *In vivo* bioassay may be referred to as direct bioassay; *in vitro* bioassay may be referred to as indirect bioassay.
Biophysical	Of or pertaining to a combination of biology and physics.
Bounding Scenario	An accident or disruptive event with consequences larger (i.e., greater releases to the environment) than others considered.
Brownfield	Abandoned, idled or under-used industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination.
CANDU reactor	A Canadian-invented pressurized heavy-water reactor that uses heavy water (deuterium oxide) for moderator and coolant and natural uranium for fuel. "CANDU" is short for CANada Deuterium Uranium. Also called CANDU.
Catchment area	An extent or an area of land where all surface water from rain, melting snow, or ice converges to a single point at a lower elevation, usually the exit of the basin, where the waters join another body of water, such as a river, lake, reservoir, estuary, wetland, sea, or ocean.
Chelating Agents	A substance whose molecules can form several bonds to a single metal ion.
Chronic	Involving stimulus that is lingering or continues for a long time; often signifies periods from several weeks to years, depending on the reproductive life cycle of the species. Can be used to define either the exposure or the response to an exposure (effect). Chronic exposure typically induces a biological response of relatively slow progress and long continuance.
Cloudshine	External exposure to penetrating radiation (i.e., gamma radiation) in a plume.
Contact Water	Water that has come in contact with waste and is considered contaminated.
Contaminated Areas	An area where the condition or state of soil, water, or air caused by a substance release or escape results in an impairment of, or damage to, the environment, human health, safety, or property.
Corporate Social Responsibility	A business approach that contributes to sustainable development by delivering economic, social and environmental benefits for all stakeholders.
Criticality	The creation of a series of nuclear reactions that is self-sustaining. This is the normal operating condition of a nuclear reactor.
Crown Corporation	Any corporation that is established and regulated by a country's state or government.

Table 14.1-1: Glossary of Terms

Term	Definition
CSA Group	A standard-setting body that works with the regulator, industry and stakeholders to produce consensus-based Canadian industry standards that may be used by the regulator or industry. Formerly called Canadian Standards Association.
Daily Cover	Daily cover is applied at the end of each work day over the active disposal area or the placed waste working face, to control the release of fugitive dust from the surface of the waste. The daily cover consists of 0.150 m layer of clean soil or an alternative daily cover material that is pre-approved for use including tarpaulin, fixative (crusting agent), or similar temporary cover system material.
Dangerous goods	Dangerous goods include explosives, gases, flammable liquids, flammable solids, oxidizing substances and organic peroxides, toxic and infectious, radioactive material, corrosives and miscellaneous.
Datum	A fixed starting point of a scale or operation.
Decommissioning	Administrative and technical actions taken to allow the removal of some or all of the regulatory controls from a facility. This does not apply to a repository or to certain nuclear facilities used for mining and milling of radioactive materials, for which closure is used.
Deep Geological Repository	A facility for disposal of radioactive waste located underground (usually several hundred metres or more below the surface) in a geological formation to provide long term isolation of radionuclides from the biosphere.
Deglaciation	Transitions from full glacial conditions to warm interglaciations (within an ice age), characterized by global warming and sea level rise due to change in continental ice volume.
Delineation	The action of describing or portraying something precisely.
Derived Release Limit	As defined in the CSA Group publication CSA N288.1, *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities*: The release rate that would cause an individual of the most highly exposed group to receive and be committed to a dose equal to the regulatory annual dose limit due to release of a given radionuclide to air or surface water during normal operation of a nuclear facility over the period of a calendar year.
Design Basis	The range of conditions and events taken explicitly into account in the design of a nuclear facility, according to established criteria, such that the facility can withstand this range without exceeding authorized limits. **Note**: Design extension conditions are not part of the design basis.
Design-Basis-Accident (DBA)	Accident conditions for which a nuclear facility is designed according to established design criteria and for which damage to the fuel and the release of radioactive material are kept within authorized limits. DBA is a plant state.
Detritus	Waste or debris of any kind.
Dioxin	A colourless toxic liquid used as an organic solvent.
Discharge Criteria	Legislative criteria detailing the amount of radioactive material acceptable within gas or liquid for a planned and controlled release to the environment.
Disposal	The placement of radioactive waste without the intention of retrieval.
Disposal Cell	Individual engineered cell as part of the engineered containment mound. The cells hold disposed radioactive waste.
Drainage Basins	Area draining to a lake, stream, reservoir or other body of water.

Table 14.1-1: Glossary of Terms

Term	Definition
Duty to Consult	In Canada, the duty to consult and accommodate with Indigenous peoples arises when the Crown contemplates actions or decisions that may affect an Indigenous person's Aboriginal or Treaty rights.
Dystrophic	Brown acidic water that is low in oxygen and supports little life, owing to high levels of dissolved humus.
Effective Porosity	Effective porosity is the total porosity less the fraction of the pore space occupied by shale or clay. In very clean sands, total porosity is equal to effective porosity.
Effluent	Liquid waste or sewage discharged into a river, lake or the sea.
Engineered Containment Mound	A physical structure designed to prevent the dispersion of radioactive substances consisting of a primary and secondary composite base liner system and composite final cover system, made up of both natural materials (e.g., compacted clay, granular materials) and synthetic materials (e.g., geosynthetic clay liner, geomembrane, geotextiles).
Environmental Assessment	An assessment of the environmental effects of a project.
Environmental Impact Statement	A detailed technical document prepared by the proponent of a designated project to be assessed pursuant to the *Canadian Environmental Assessment Act, 2012*. The environmental impact statement identifies the potential adverse environmental effects of a designated project including cumulative effects, measures to mitigate those effects, and an evaluation of whether the designated project is likely to cause any significant adverse environmental effects.
Environmental Management System (EMS)	The part of an organization's management system used to develop and implement its environmental policy and manage its environmental aspects. An EMS consists of policies and procedures forming an integrated set of documented activities to provide a framework for effective environmental protection measures.
Environmental Media	Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.
Environmental Risk Assessment (ERA)	A process that identifies, quantifies and characterizes the risk posed by contaminants (nuclear or hazardous substances) and physical stressors in the environment. An ERA is a practice or methodology primarily developed by regulatory agencies to provide scientific input to decision makers. In this way, ERAs commonly serve as a supportive tool providing technical information in a manageable form to a larger environmental assessment.
Eutrophic	A lake or other body of water that is rich in nutrients and supporting a dense plant population, the decomposition of which kills animal life by depriving it of oxygen.
Exfiltration Gallery	A series of underground trenches of clear stones that encourage dispersal of treated effluent into the groundwater, similar to a septic system.
Evapotranspiration	The process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants.
Fissile	Capable of undergoing fission by interaction with slow neutrons.
Fission	The division of a heavy nucleus into two (or, rarely, more) parts with masses of equal order of magnitude; usually accompanied by the emission of neutrons and gamma radiation.
Frac-out	The condition where drilling mud is released through fractured bedrock into the surrounding geology and travels toward the surface.

Table 14.1-1: Glossary of Terms

Term	Definition
Fugitive Dust	Small airborne particulate matter which generally comes from soil. Fugitive dust is suspended in the air by wind action and human activities.
Fulvic Acid	A highly soluble organic phenol found in humus that chelates elemental mineral nutrients.
Furan	A cyclic flammable liquid (chemical compound C4H4O) that is obtained from wood oils of pines or made synthetically and is used especially in organic synthesis.
Gamma Radiation	Penetrating electromagnetic radiation emitted from an atom's nucleus. Also called gamma rays.
Gamma Spectroscopy	The quantitative study of the energy spectra of gamma-ray sources, in the nuclear industry, geochemical investigation, and astrophysics. Most radioactive sources produce gamma rays, which are of various energies and intensities.
Gamma-emitters	Radionuclides that emit gamma ray photons during radioactive decay.
Geiger Tube	It is a gaseous ionization detector and uses the Townsend avalanche phenomenon to produce an easily detectable electronic pulse from as little as a single ionising event due to a radiation particle.
Geomembrane	Is a very low permeability synthetic membrane liner or barrier used with geotechnical engineering related material to control fluid (or gas) migration in a human-made project, structure, or system.
Geomorphology	The science dealing with relief features of the Earth and interpretation of them based on their origins and development.
Glacial Till	Unsorted sediment of glacial origin derived by erosion and entrainment of material by the moving ice of a glacier.
Gneissic Rocks	A highly foliated, coarse-grained metamorphic rock consisting of light-colored layers, usually of quartz and feldspar, alternating with dark-colored layers of other minerals, usually hornblende and biotite.
Gray (Gy)	The International System of Units (SI) unit of measurement used to express absorbed dose. One gray is defined as the absorption of 1 joule of ionizing radiation by 1 kilogram of matter. For gamma and beta radiations, the gray is numerically equal to the Sievert.
Green Algae	Photosynthetic algae that contain chlorophyll and store starch in discrete chloroplasts. They are eukaryotic and most live in fresh water, ranging from unicellular flagellates to more complex multicellular forms.
Greenfield	Parkland, undeveloped open space and agricultural land, usually located near the outskirts of cities and large metropolitan areas.
Greenhouse Gases	A gas in the atmosphere that absorbs and emits radiation within the thermal infrared range. The primary greenhouse gases in the Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone.
Groundshine	Exposure to penetrating radiation from radioactive material that is deposited on the ground.
Ground-truthing	Information provided by direct observation (i.e., empirical evidence) as opposed to information determined by inference.
Groundwater Discharge	The movement of groundwater from the subsurface to the surface. There is natural discharge which occurs into lakes, streams and springs as well as human discharge, which is generally referred to as pumping.

Table 14.1-1: Glossary of Terms

Term	Definition
Groundwater Recharge	A hydrologic process, where water moves downward from surface water to groundwater. Recharge is the primary method through which water enters an aquifer.
Grouted	Radioactive waste materials that have been treated and conditioned into forms that are suitable for their subsequent management, including transportation, storage and disposal. Grout is typically a cementitious mortar or paste that can fill gaps and crevices.
Guild	A group of species that that use the same resources, or that use different resources in similar ways.
Halocarbon Refrigerants	Chemicals in which one or more carbon atoms are linked by covalent bonds with one or more halogen atoms (fluorine, chlorine, bromine or iodine) resulting in the formation of organofluorine, organochlorine, organobromine, and organoiodine compounds.
Hazardous Materials	Materials that are potentially hazardous to human health and/or the environment due to their nature and quantity and that require special handling and storage techniques.
Hibernacula	Plural of hibernaculum. Places of refuge occupied by animals, such as bats, during the winter when the species becomes dormant to avoid times when resources are limited and temperatures are below freezing.
High Level Waste	Used nuclear fuel and other wastes (e.g., reprocessing wastes) that have been declared as radioactive waste that generates significant heat via radioactive decay. Used nuclear fuel is associated with penetrating radiation and contains significant quantities of long-lived radionuclides.
Holocene Period	Denoting the present period (epoch) of geologic time, which began after the Pleistocene approximately 11,700 years before present.
Humic Acid	Humic acids are a principal component of humic substances, which are the major organic constituents of soil (humus), peat and coal.
Hydraulic Conductivity	Symbolically represented as K, is a property of vascular plants, soils and rocks that describes the ease with which a fluid (usually water) can move through pore spaces or fractures.
Hydrofluorocarbons	Organic compounds that contain fluorine and hydrogen atoms, are the most common type of organofluorine compounds. They are commonly used in air conditioning and as refrigerants.
Hypolimnion	The hypolimnion, or under lake, is the dense, bottom layer of water in a thermally-stratified lake. It is the layer that lies below the thermocline. Typically, the hypolimnion is the coldest layer of a lake in summer, and the warmest layer during winter. Being at depth, it is isolated from surface wind-mixing during summer, and usually receives insufficient irradiance (light) for photosynthesis to occur.
Indicator Species	An organism whose presence, absence or abundance reflects a specific environmental condition. Indicator species can signal a change in the biological condition of a particular ecosystem, and thus may be used as a proxy to diagnose the health of an ecosystem.
Indigenous peoples	Includes the First Nations, Inuit and Métis people of Canada.
Induced Employment	Employment opportunities arising from Project employees (direct employment) and employees of business supporting the Project (indirect employment) spending their Project-generated income in the broader economy (e.g., food, clothing, entertainment).
Infrared Radiation	A type of electromagnetic radiation, as are radio waves, ultraviolet radiation, X-rays and microwaves. Infrared light is the part of the electromagnetic spectrum that people encounter most in everyday life, although much of it goes unnoticed. It is invisible to human eyes, but people can feel it as heat.

Table 14.1-1: Glossary of Terms

Term	Definition
In-situ Treatment	A method of managing or treating contaminated soils, sludges and waters “in place” in a manner that does not require the contaminated material to be physically removed or excavated from where it originates.
Interim Cover	The interim cover consists of 0.3 m layer of clean soil or clean sand that is overlain by a sacrificial liner to promote non-contact surface water run-off, and minimize precipitation infiltration into the waste material. The interim cover is applied to: 1) waste disposal areas that will remain inactive for more than 30 days; and 2) waste disposal areas that have reached the design waste fill grade.
Interglaciation	The warm periods between ice age glaciations. Often defined as the periods at which sea levels were close to present sea level.
Intermediate Level Waste	Typically exhibits levels of penetrating radiation sufficient to require shielding during handling and interim storage and contains significant quantities of long lived radionuclides.
Interstratified	A series of rock strata arranged in alternating beds.
Ion Exchange	A usually reversible exchange of one ion with another, either on a solid surface, or within a lattice. A commonly used method for treatment of liquid waste.
Ion-exchange Resins	A resin or polymer that acts as a medium for ion exchange.
Ionizing Radiation	For the purposes of radiation protection, radiation capable of producing ion pairs in biological material(s). **Note**: Ionizing radiation is constantly present in the environment and includes the radiation that comes from both natural and artificial sources, such as cosmic rays, terrestrial sources (radioactive elements in the soil), ambient air (radon), and internal sources (food and drink).
Isopach Map	A map illustrating variations in thickness of a geological unit, layer, or stratum. Isopachs are contour lines of equal thickness.
Kd	A dissociation constant; a specific type of equilibrium constant that measures the propensity of a larger object to separate (dissociate) reversibly into smaller components, as when a complex falls apart into its component molecules, or when a salt splits up into its component ions.
LC50	LC50 is the lethal concentration of a toxin that is required to kill 50% of the population.
Legacy Waste	Wastes inherited from other companies or facilities. With respect to CNL, this refers to the wastes generated from 65 years of past operation that are now in interim storage in the CRL site.
Leachate	A solution that has been in contact with soil or waste and, as a result, may contain some of the soluble or suspended constituents of the material.
Lampricide	A lampricide is any chemical designed to target the larvae of lampreys in river systems before they develop into parasitic adults. One lampricide is used in the headwaters of Lake Champlain and the Great Lakes to control the sea lamprey (*Petromyzon marinus*), an invasive species to these lakes.
Licensed Inventory	The maximum radioactivity of significant radionuclides that the NSDF will accept. Note: Significant radionuclides are the radionuclides that were identified in the NSDF Reference Inventory.
Life History Stages	The various forms in which an organism expresses or manifests itself in its development from the primary stage to its natural death (e.g., juvenile, adult).

Table 14.1-1: Glossary of Terms

Term	Definition
Lithic Scatters	Sites where prehistoric stone artefacts are found exposed, usually on the modern ground surface, having been disturbed from their original context and 'scattered' by natural or agricultural processes.
Littoral Zones	Near shore area where sunlight penetrates all the way to the sediment and allows aquatic plants (macrophytes) to grow.
Longitudinal Dispersivity	Dispersivity is an empirical property of a porous medium that determines the characteristic dispersion of the medium by relating the components of pore velocity to the dispersion coefficient across a longitudinal gradient.
Low Level Waste	Radioactive solid waste that contains material with radionuclide content above established clearance levels and exemption quantities, but that generally has limited amounts of long-lived activity.
Ludlum 44-9 Pancake Geiger-Mueller Detector	The Geiger-Muller pancake-type detector in the Model 44-9, made by Ludlum Measurements Inc., is arguably the most popular radiation detector used throughout the world. This detector is sensitive to alpha, beta, and gamma radiation, is enclosed within a rugged metal enclosure, and is conveniently shaped and sized for checking contamination on people and objects.
Measurement Indicators	Measurement indicators represent properties of the environment and Valued Components (VCs) that, when changed, could result in or contribute to an effect on a VC.
Metamorphism	The change of minerals or geologic texture (distinct arrangement of minerals) in pre-existing rocks (protoliths), without the protolith melting into liquid magma (a solid-state change). The change occurs primarily due to heat, pressure, and the introduction of chemically active fluids.
Metasedimentary	Sediment or sedimentary rock that appears to have been altered by metamorphism.
Mitigation	Measures aimed at eliminating, reducing or controlling the adverse effects of a licensed activity, substance, equipment or facility. Mitigation may include restitution for any damage caused by such effects, such as through replacement, restoration or compensation.
Mixed Waste	Radioactive waste that also contains hazardous substances.
Molybdenum	The chemical element of atomic number 42, a brittle silver-gray metal of the transition series, used in some alloy steels.
Mucocilliary	Relating to, or involving, cilia of the mucous membranes of the respiratory system.
Near Surface Disposal Facility	A facility for disposal of radioactive waste located at or within a few metres from the earth’s surface.
Nitrate	A salt or ester of nitric acid, containing the anion NO_3^- or the group $—NO_3$.
Nitrification/Denitrification	The biological oxidation of ammonia or ammonium to nitrite followed by the oxidation of the nitrite to nitrate. The transformation of ammonia to nitrite is usually the rate limiting step of nitrification. Nitrification is an important step in the nitrogen cycle in soil.
Nitrite	A salt or ester of nitrous acid, containing the anion NO_2^- or the group $—NO_2$.
Noble Gases	Any of the gaseous elements helium, neon, argon, krypton, xenon, and radon, occupying Group 0 (18) of the periodic table. They were long believed to be totally unreactive but compounds of xenon, krypton, and radon are now known.
Non-contact Water	Water that has not been in contact with waste materials.

Table 14.1-1: Glossary of Terms

Term	Definition
Notice of Commencement	A notice or letter that signifies the starting point for a project and the environmental assessment for the project.
Nuclear Facility, Sites	A facility and its associated land, buildings and equipment in which radioactive materials are produced, processed, used, handled, stored or disposed of on such a scale that consideration of safety is required.
Official Plan	Describes the upper, lower or single–tier municipal council's policies on how land in their community should be used.
Overburden	Material overlying the bedrock surface, including rock as well as soil and other unconsolidated (loose) material, such as glacial deposits, sand and sediment.
Pathway	The way in which project components or activities can cause potential effects to valued environmental or socio-economic components of the environment.
Permeameter Test	The permeameter test measures the permeability (also called hydraulic conductivity) of the soil at the bottom of a borehole, above the water table by temporarily saturating the soil at the bottom of the borehole. It measures the “field-saturated hydraulic conductivity”, which is commonly abbreviated as Kfs.
Perfluorocarbons	Organofluorine compounds with the formula CxFy, i.e. they contain only carbon and fluorine.
Pleistocene Period	Denoting the period (epoch) of geologic time prior to the Holocene. The Pleistocene is the geological epoch which lasted from about 2,588,000 to 11,700 years ago, spanning the world's most recent period of repeated glaciations.
Polychlorinated Biphenyls (PCBs)	Any of a class of toxic aromatic compounds, often formed as waste in industrial processes, whose molecules contain two benzene rings in which hydrogen atoms have been replaced by chlorine atoms.
Pool Riffle Sequence	Pool and riffle sequence is deep and shallow portions of an undulating stream bed. Pools are most easily seen in a meandering stream where the outer edge of each meander loop is deep and undercut; riffles form in the shallow water of the short, straight, wide reaches between adjacent loops
Pyrophoric Materials	Materials that are often water-reactive and will ignite when they contact water or humid air. They can be handled safely in atmospheres of argon or (with a few exceptions) nitrogen. Most pyrophoric fires should be extinguished with a Class D fire extinguisher for burning metals.
Qualitative	Relating to, measuring, or measured by the quality of something rather than its quantity.
Quantitative	Relating to, measuring, or measured by the quantity of something rather than its quality.
Radiation	The emission by a nuclear substance, the production using a nuclear substance, or the production at a nuclear facility of, an atomic or subatomic particle or electromagnetic wave with sufficient energy for ionization.
Radiation Field	Represents the energy lost from the source radiator to space.
Radioactive	Emitting or relating to the emission of ionizing radiation or particles. Exhibiting radioactivity. A radioactive material is a substance containing radioactivity above a specified level.

Table 14.1-1: Glossary of Terms

Term	Definition
Radioactive Decay	The spontaneous transformation of one radioisotope into one or more different isotopes (known as decay products or daughter products), accompanied by a decrease in radioactivity (compared to the parent material). This transformation takes place over a defined period of time (known as a half-life), as a result of electron capture; fission; or the emission of alpha particles, beta particles, or photons (gamma radiation or X-rays) from the nucleus of an unstable atom. Each isotope in the sequence (known as a decay chain) decays to the next until it forms a stable, less energetic end product. In addition, radioactive decay may refer to gamma-ray and conversion electron emission, which only reduces the excitation energy of the nucleus.
Radioactive Waste	For the purposes of waste management, any material (liquid, gaseous, or solid) that contains a radioactive nuclear substance, as defined in section 2 of the *Nuclear Safety and Control Act*, and which the owner has declared to be waste. In addition to containing nuclear substances, radioactive waste may also contain non-radioactive hazardous substances, as defined in section 1 of the *General Nuclear Safety and Control Regulations*.
Radioactivity	The spontaneous transformation of an atom's nucleus by expulsion of particles. Radioactivity can be accompanied by electromagnetic radiation. Solids, liquids or gases can be radioactive.
Radiocarbon Dated	Also referred to as carbon dating or carbon-14 dating, is a method for determining the age of an object containing organic material by using the properties of a radioactive isotope of carbon (C-14).
Radiological	Relating to the science of X-rays and other high-energy radiation. Of or pertaining to radiation or radioactivity.
Radionuclide	A nucleus (of an atom) that possesses properties of spontaneous disintegration (radioactivity). Nuclei are distinguished by their mass and atomic number.
Reasonably Foreseeable Developments	Industrial or construction projects and developments that are approved or under approval, and are likely to commence in the reasonably foreseeable future.
Reference Inventory	The radiological inventory of significant radionuclides that was used to inform the design and safety analysis.
Refuse Pit	Artifacts left behind when a settlement or activity area is abandoned.
Relic Shoreline	Shorelines of waterbodies that were present in past glaciation periods.
Remediation	Any measures that may be carried out to reduce the exposure from existing contamination through actions applied to the contamination itself (the source) or to the exposure pathways to humans.
Residual Effects	Environmental effects predicted to remain after the application of mitigation outlined in an environmental assessment. The predicted residual effects are considered for each Project phase.
Reverse Osmosis	Movement of a solvent out of a solution under pressure through a semipermeable membrane into pure solvent or a less concentrated solution at lower pressure. This process can be used to increase the radionuclide concentration in a solution. It can also be used to remove ions, molecules and larger particles from drinking water.
Sacrificial Liner	The sacrificial liner is a linear low-density polyethylene (LLDPE) geomembrane that promotes non-contact surface water runoff and minimizes precipitation infiltration.
Sheet Flow	Water, usually storm runoff, flowing in a thin layer over the ground surface.
Sievert	The International System of Units (SI) unit of equivalent dose and effective dose, equal to 1 joule/kilogram.

Table 14.1-1: Glossary of Terms

Term	Definition
Sorb	To take up and hold by either adsorption or absorption.
Sorption	The interaction of an atom, molecule or particle with the surface of a solid. A general term including absorption (sorption taking place largely within the pores of a solid) and adsorption (surface sorption with a non-porous solid). The processes involved may also be divided into chemisorption (chemical bonding with the substrate) and physisorption (physical attraction, for example by weak electrostatic forces).
Source Term	The amount and isotopic composition of material released (or postulated to be released) from a nuclear facility.
Spatial Boundary	The geographic extent of the study area.
Stage 1 assessment	A desktop assessment to identify areas where potential archaeological resources may exist.
Stage 2 assessment	The Stage 2 component of an Archaeological Assessment begins with test pit surveys completed in areas where archaeological potential was identified during the background study and property inspection (Stage 1). The second phase of Stage 2 involves “infilling” where at each positive test pit, further excavation is completed to determine if further inspection of the area is necessary.
Stage 3 assessment	The Stage 3 component of an Archaeology Assessment is a site-specific assessment and involves controlled surface pick up of material and excavation to determine the location and number of significant test pits.
Stage 4 assessment	Stage 4 in an Archaeological Assessment involves implementing long-term management strategies for those sites recommended for mitigation in Stage 3.
Stochastic effect	A radiation-induced health effect, the probability of occurrence of which is greater for a higher radiation dose and the severity of which (if it occurs) is independent of dose. **Note**: Stochastic effects may be somatic effects or hereditary effects, and generally occur without a threshold level of dose. Examples include cancer and leukemia.
Stratified	Formed or arranged into strata or layers.
Subsurface Water	Water that flows or collects beneath the Earth's surface.
Sulphur Hexafluoride	Organic, colorless, odorless, non-flammable, extremely potent greenhouse gases, which are excellent electrical insulators.
Surface water	Surface water is water collecting on the ground or in a stream, river, lake, wetland, or ocean.
Tailings	The waste material and water mixture left over after a mill removes the valuable rocks. The rock material in tailings is usually the size of sand grains or smaller. **Note**: Tailings that result from uranium milling contain long-lived radionuclides (such as thorium-230 and radium-226) produced from the decay of uranium, as well as trace metals like arsenic and nickel. They also contain chemical residues from the milling process.
Tarpaulin	Heavy-duty waterproof cloth, originally of tarred canvas.
Temporal Boundary	Timeframe during which project activities are actively occurring, including the duration of predicted residual effects.
Thermal Stratification	Refers to a change in the temperature at different depths in the lake, due to the change in the water's density with temperature. Cold water is denser than warm water and the epilimnion (surface layer) generally consists of water that is not as dense as the water in the hypolimnion (deeper layer).

Table 14.1-1: Glossary of Terms

Term	Definition
Thermoluminescent Dosimeters (TLD)	A type of radiation dosimeter. A TLD measures ionizing radiation exposure by measuring the intensity of visible light emitted from a crystal in the detector when the crystal is heated. The intensity of light emitted is dependent upon the radiation exposure.
Total Suspended Solids	Solids in water that can be trapped by a filter. TSS can include a wide variety of material, such as silt, decaying plant and animal matter, industrial wastes, and sewage. High concentrations of suspended solids can cause many problems for stream health and aquatic life.
Tritium	An isotope that occurs both naturally and as a by-product in nuclear reactors. Tritium is a radioactive isotope of hydrogen having two neutrons and one proton in its nucleus; hydrogen, by comparison, has only one proton. Tritium decays by emitting an electron (beta radiation) and has a half-life of 12.33 years.
Valued Component	Environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous peoples, the scientific community or the public.
Volatile Organic Compounds	Organic compounds that easily become vapors or gases.
Waste Acceptance Criteria	Quantitative or qualitative criteria specified by the regulatory body, or specified by an operator and approved by the regulatory body, for radioactive waste to be accepted by the operator of a repository for disposal, or by the operator of a storage facility for storage.
Waste Streams	The total flow of solid waste from homes, businesses, institutions, and manufacturing plants that is recycled, burned, or disposed of in landfills, or segments thereof.
Wastewater	Used water from any combination of domestic, industrial, commercial or agricultural activities, surface runoff or stormwater, and any sewer inflow or sewer infiltration.
White Nose Syndrome	A fungal disease caused by *Pseudogymnoascus destructans* that affects hibernating bats by causing unusual winter behavior like abnormally frequent or abnormally long arousal from hibernation.

14.2 Acronyms

Table 14.2-1: List of Acronyms

Acronym	Definition
AAQC	Ambient Air Quality Criteria
AGCV	Above-Ground Concrete Vault
AECL	Atomic Energy of Canada Limited
AECOM	AECOM Canada Ltd.
ALARA	As Low As Reasonably Achievable
Am-241	Americium-241
AOO	Algonquins of Ontario
AOO	Anticipated Operational Occurrences
APV	Aquatic Protection Value

Table 14.2-1: List of Acronyms

Acronym	Definition
Ar-41	Isotope Argon-41
BBS	Breeding Bird Survey
BDBA	Beyond Design Basis Accident
BMA	Bear Management Area
BP	Before Present
BV	Benchmark Value
C-14	Isotope Carbon 14
C2H3Cl	Vinyl Chloride
C3H4O	Acrolein
CA	Census Agglomeration
CAAQS	Canadian Ambient Air Quality Standards
CANDU	Canada Deuterium Uranium
CCME	Canadian Council of Ministers of the Environment
CEAA 2012	*Canadian Environmental Assessment Act, 2012*
CFB	Canadian Forces Base
CH4	Methane
CNL	Canadian Nuclear Laboratories
CNSC	Canadian Nuclear Safety Commission
CO	Carbon Monoxide
CO2	Carbon Dioxide
CO2e	Carbon Dioxide Equivalent
Co-60	Isotope Cobalt-60
COG	CANDU Owners Group
COPCs	Constituents of Potential Concern
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CRA	Commercial, Recreational, or Aboriginal
CRL	Chalk River Laboratories
CRM	Cultural Resource Management
Cs-137	Isotope Cesium-137
CSA	Canadian Standards Association
DBA	Design Basis Accident
DFO	Fisheries and Oceans Canada
DGR	Deep Geological Repository

Table 14.2-1: List of Acronyms

Acronym	Definition
DO	Dissolved Oxygen
DRL	Derived Release Limit
EA	Environmental Assessment
EC20	Effective Concentration to Induce a 20% Change in Response
ECCC	Environment and Climate Change Canada
ECM	Engineered Containment Mound
EDT	Effluent Discharge Targets
EIS	Environmental Impact Statement
ELC	Ecological Land Classification
EMP	Environmental Management Plan
EMR	East Mattawa Road
EPA	Environmental Protection Agency
EPP	Environmental Protection Plan
EQS	Environmental Quality Standard
ERA	Environmental Risk Assessment
ESC	Environmental Stewardship Council
ESW	East Swamp Weir
ETMF	Exposure and Toxicity Modifying Factor
EVMP	Effluent Verification Monitoring Program
FMU	Forest Management Unit
FMZ	Fisheries Management Zone
FRI	Forest Resource Inventory
GAC	Granular Activated Carbon
GHG	Greenhouse Gas
GHGRP	Greenhouse Gas Reporting Program
GIS	Geographic Information System
Golder	Golder Associates Ltd.
GPR	Ground Penetrating Radar
GWMF	Geologic Waste Management Facility
GWP	Global Warming Potential
H2S	Hydrogen Sulfide
HDPE	High-Density Polyethylene
Hg	Mercury

Table 14.2-1: List of Acronyms

Acronym	Definition
HLW	High-Level Waste
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IER	Indigenous Engagement Report
ILW	Intermediate-Level Waste
IMAC	Interim Maximum Acceptable Concentration
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
Kd	Distribution Coefficient
LC50	Lethal concentration required to kill 50% of the population
LCS	Leachate Collection System
LDA	Liquid Dispersal Area
LFG	Landfill Gas
LDS	Leak Detection System
LiDAR	Light Detection and Ranging
LIO	Land Information Ontario
LLW	Low-Level Radioactive Waste
LSA	Local Study Area
MBCA	*Migratory Birds Convention Act, 1994*
MBR	Membrane Bioreactor
MECP	Ministry of Environment, Conservation and Parks [2018 to current]
MNDM	Ministry of Northern Development and Mines
MNO	Métis Nation of Ontario
MNRF	Ministry of Natural Resources and Forestry
MOE	Ministry of the Environment [1972 to 1993]
MOECC	Ministry of the Environment and Climate Change [2014 to 2018]
MOEE	Ministry of the Environment and Energy [1993 to 1997, 2002]
MP	Member of Parliament
MRC	Municipalité Régionale de Comté
MSC	Main Stream Culvert
N_2O	Nitrous Oxide
NAPS	National Air Pollution Surveillance Network
NBCC	National Building Code of Canada

Table 14.2-1: List of Acronyms

Acronym	Definition
NEA	Nuclear Energy Agency
NEC	No Effect Concentration
NES	Normal Evolution Scenario
NGO	Non-Governmental Organization
NO_2	Nitrogen Dioxide
NOx	Nitrogen Oxides
NPD	Nuclear Power Demonstration
NPRI	National Pollutant Release Inventory
NRU	National Research Universal
NSDF	Near Surface Disposal Facility
NV	No Value
O. Reg.	Government of Ontario Regulation
O_3	Ozone
OBBA	Ontario Breeding Bird Atlas
OECD	Organization for Economic Co-operation and Development
MNR	Ontario Ministry of Natural Resources
MNRF	Ontario Ministry of Natural Resources and Forestry
OPG	Ontario Power Generation
OPSS	Ontario Provincial Standard Specification
OTR98	Ontario Typical Range
OU	Odour Unit
PAB	Pointe au Baptême
Pb	Lead
PCO	Perch Creek Outlet
PCW	Perch Creek Weir
PL	Perch Lake
PL2	Perch Lake Inlet #2
PLO	Perch Lake Outlet
PM_{10}	Particulate matter less than 10 microns in diameter
$PM_{2.5}$	Particulate matter less than 2.5 microns in diameter
PMP	Probable Maximum Precipitation
PostSA	Postclosure Safety Assessment
PSHA	Probabilistic Seismic Hazard Assessment

Table 14.2-1: List of Acronyms

Acronym	Definition
PWQMN	Provincial Water Quality Monitoring Network
PWQO	Provincial Water Quality Objective
RB	Risk Benchmark
REGDOC	Regulatory Document
RFD	Reasonably Foreseeable Developments
Rn-222	Isotope Radon-222
ROW	Right-of-Way
RSA	Regional Study Area
SAR	Safety Analysis Report
SARA	*Species At Risk Act*
SENES	Senes Consultants Limited
SF6	Sulphur Hexafluoride
SI	Screening Indices
SMR	Small Modular Reactor
SO_2	Sulphur Dioxide
SOx	Sulphur Oxides
SPM	Suspended Particulate Matter
SSA	Site Study Area
SSG	Specific Safety Guide
SSW	South Swamp Weir
SWH	Significant Wildlife Habitat
SWMP	Surface Water Management Pond
The Agency	The Canadian Environmental Assessment Agency
TKLUS	Traditional Knowledge and Land Use Study
TLD	Thermoluminescent Dosimeters
TR	Technical Record
TSD	Technical Supporting Document
TSP	Total Suspended Particles
TSS	Total Suspended Soils
TSWRPA	Temporary Storage and Waste Receiving and Processing Area
US EPA	United States of America Environmental Protection Agency
UNFCCC	United Nations Framework Convention on Climate Change
UNSCEAR	United Nations Scientific Committee on the Effects on Atomic Radiation

Table 14.2-1: List of Acronyms

Acronym	Definition
US	United States
US EPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
VC	Valued Component
VDF	Vehicle Decontamination Facility
VOC	Volatile Organic Compounds
WAC	Waste Acceptance Criteria
WHO	World Health Organization
WL	Whiteshell Laboratories
WMA	Waste Management Areas
WMU	Wildlife Management Unit
WNS	White Nose Syndrome
WR-1	Whiteshell Reactor 1
WTC	Waste Treatment Centre
WWTP	Wastewater Treatment Plant

14.3 Units of Measure

Table 14.3-1: List of Units

Unit	Name
%	percent
<	less than
>	greater than
≤	less than or equal to
°	degree
°C	degrees Celsius
$	Canadian dollar unless otherwise noted
µm	micron
µg/g	micrograms per gram
µg/L	micrograms per litre
µg/m	micrograms per metre
µg/m^3	micrograms per cubic metre
µGy	microgray

Table 14.3-1: List of Units

Unit	Name
µGy/day	microgray per day
µGy/hr	microgray per hour
µGy/yr	microgray per year
µm	micrometre
µSv	microSievert
µSv/yr	microSieverts per year
Bq	becquerels
Bq/g	becquerels per gram
Bq/kg	becquerels per kilogram
Bq/L	becquerel per litre
Bq/m^2	becquerels per square metre
Bq/m^3	becquerels per cubic metre
Bq/yr	becquerels per year
BqMeV/year	becquerels-million electron volts per year
cm	centimetre
CO_2e	carbon dioxide equivalent
dB	decibel
g/cm^3	grams per cubic centimetre
g/day	grams per day
g (dw)/day	grams (dry weight) per day
H:V	horizontal distance to vertical rise
ha	hectare (10 000 m^2)
kcal/day	kilocalories per day
kg	kilogram
kg/day	kilogram per day
km	kilometre
km/hr	kilometres per hour
km^2	square kilometre
kV	kilovolt
kW/m^3	kilowatt per cubic metre
L/day	litres per day
L/s	litres per second
M	million

Table 14.3-1: List of Units

Unit	Name
m	metre
m/m	metres per minute
m/s	metre per second
m^2	square metre
m^3	cubic metre
m^3/d	cubic metres per day
m^3/hr	cubic metre per hour
m^3/s	cubic metre per second
m^3/yr	cubic metre per year
masl	metres above sea level
mbgs	metres below ground surface
mg	milligrams
mg N/L	milligrams per litre as nitrogen
mg/L	milligrams per litre
mL	millilitres
mm	millimetre
mm(eq)	millimetres equivalent
mm/yr	millimetres per year
mSv	millisieverts
mSv/hr	millisieverts per hour
mSv/yr	millisieverts per year
MW	megawatt
nSv/hr	nanosieverts per hour
OU/day	odour units per day
OU/m^3	odour units per cubic metre
ppb	parts per billion
Tbq	tera becquerels
yr	year

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