CANADIAN NUCLEAR LABORATORIES

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Environmental Impact Statement In Situ Decommissioning of WR-1 at the Whiteshell Laboratories Site

Pinawa, Manitoba

Revision 1



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Submitted to:
Canadian Nuclear Laboratories
Whiteshell Laboratories
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1.0 INTRODUCTION

The Whiteshell Laboratories (WL) site at Pinawa, Manitoba was established in the 1960s by Atomic Energy of Canada Limited (AECL) to conduct nuclear research to demonstrate the organic-cooled reactor concept using heavy water (D_2O) as the moderator. The reactor design also provided a facility for engineering tests and scientific studies on alternative fuels, fuel channels and reactor coolants. The Whiteshell Laboratories site (WL site) carried out significant research programs including the operation of the organic cooled Whiteshell Reactor 1 (WR-1), the Nuclear Fuel Waste Management Program, the SLOWPOKE demonstration reactor, and reactor safety analysis.

The WL site is located in southeastern Manitoba (Figure 1.0-1) and was operated for approximately 40 years under an operating licence issued by the Atomic Energy Control Board. In May 2000, the *Nuclear Safety and Control Act* (*NSCA*) came into force creating the Canadian Nuclear Safety Commission (CNSC). Since then, the WL site has been operated first under an operating licence and then under a decommissioning licence (since March 2002) issued by CNSC. WR-1 is housed within the WR-1 Complex (i.e., Building 100, which includes the WR-1 Building and the east and service wings), which is located entirely with the WL site (Figure 1.0-2). WR-1 has a nominal thermal output of 60 megawatts (MW), approximately equivalent to 20 MW electric. Currently, WR-1 is under a monitoring and surveillance program. The reactor operated from 1965 to 1985, when it was permanently shut down. A first phase of decommissioning occurred in the early 1990s where the reactor was completely de-fuelled, and all coolant and moderator was drained and collected. Equipment was decommissioned and removed from the main reactor hall floor and one floor below-grade and placed in interim storage on site. The removal of fuel, liquids and equipment substantially reduced radioactivity. Activated materials and residual corrosion and fission products have been undergoing decay for 32 years.

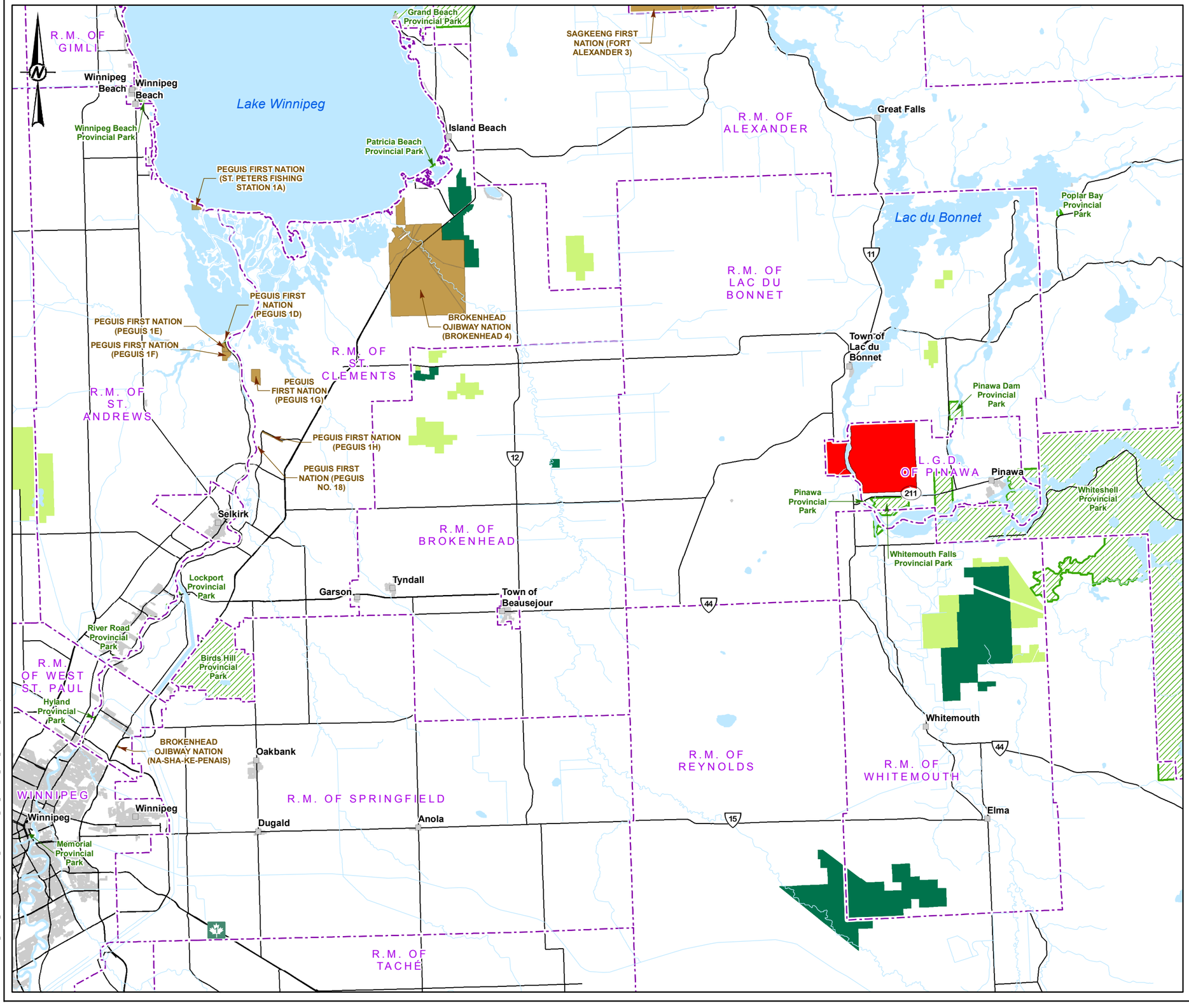
In 1998, the Government of Canada made a decision to decommission the WL site. A Comprehensive Study Report (AECL 2001) under the *Canadian Environmental Assessment Act (CEAA, 1992)* was completed for the decommissioning project. The CNSC and Department of Fisheries and Oceans were the Responsible Authorities. The environmental assessment decision to approve the decommissioning project was announced by the Minister of the Environment in March 2002 and a decommissioning licence was issued.

Canadian Nuclear Laboratories (CNL) is a private-sector company that is contractually responsible for the management, operation and decommissioning of nuclear sites, facilities and assets owned by AECL, a federal Crown corporation. CNL is performing the decommissioning of the Whiteshell Laboratories (WL) nuclear research facility with the outcome of complete site closure by 2024. CNL is licensed to perform this work under a CNSC decommissioning licence. Enabled by the CSR and the site decommissioning licence, CNL is authorized to decommission WR-1 by means of dismantling and demolition.

CNL is proposing a revised approach to the WR-1 decommissioning that includes partial dismantling and demolition, along with passive, permanent disposal of the below-grade portions of the facility (the Project). The disposal approach is referred to as In Situ Decommissioning (ISD). ISD is a proven nuclear decommissioning approach that increases worker safety, provides protection of the environment and the public, reduces interim storage and multiple handling, enables permanent nuclear liability reduction and utilizes less resources. All other decommissioning activities as outlined in the Comprehensive Study Report remain the same and are not the subject of this Environmental Impact Statement (EIS).

CNL is proposing the execution of this designated Project on land that is held in the name of AECL. As such, CNL is the proponent for the Project.

In Situ Decommissioning is a departure from the end-states defined in the Comprehensive Study Report. As a result, the Project qualifies as a designated project under Section 37(b) of the *Regulations Designating Physical Activities* of the *Canadian Environmental Assessment Act, 2012* as a project related to "the long term management or disposal of irradiated fuel or nuclear waste". A key element of the regulatory approvals process is the completion of an environmental assessment under the *Canadian Environmental Assessment Act, 2012*, the results of which are documented in this EIS. The environmental assessment is an iterative project planning process, intended to affirm that proposed activities will not cause significant adverse environmental effects (human and non-human biota). The assessment is completed to demonstrate that proposed activities can be safely completed in compliance with the prescribed protective limits, including radiological doses to workers and members of the public and the releases of contaminants to the surrounding environment. The environmental assessment considers the closure phase (which includes decommissioning and reclamation) and long-term performance during the post-closure phase (which includes Institutional Control and post-Institutional Control).



LEGEND

- WHITESHELL LABORATORIES SITE

BASE FEATURES

- CITY/TOWN
- MAJOR ROAD
- WATERCOURSE
- WATERBODY
- MUNICIPAL BOUNDARY
- FIRST NATION RESERVE

PROTECTED AREAS

- PROVINCIAL PARK
- ECOLOGICAL RESERVE
- WILDLIFE MANAGEMENT AREA

0 10 20

1:350,000 KILOMETRES

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
GENERAL LOCATION OF THE WHITESHELL LABORATORIES SITE

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE
REVIEWED	CS
APPROVED	AB

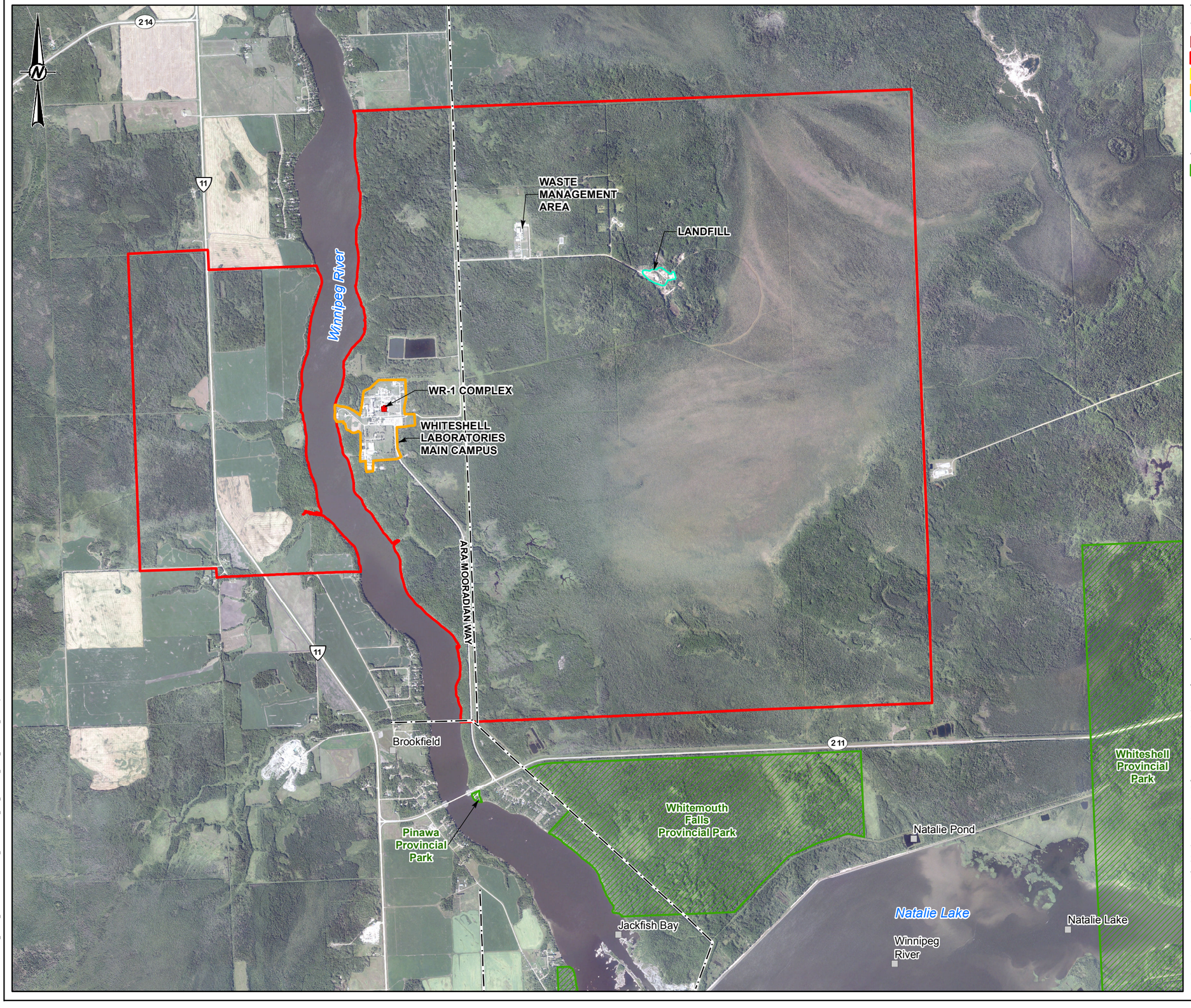
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UNRESTRICTED / ILLIMITÉE



LEGEND

WHITESHELL LABORATORIES

- WR-1 COMPLEX
- WHITESHELL LABORATORIES SITE
- WASTE MANAGEMENT AREA
- WHITESHELL LABORATORIES MAIN CAMPUS
- LANDFILL

BASE FEATURES

- CITY/TOWN
- TRANSMISSION LINE
- PROVINCIAL PARK

0 1,000 2,000

1:40,000 METRES

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE

WHITESHELL LABORATORIES SITE

CONSULTANT

Golder Associates

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PREPARED	CGE
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PROJECT NO.	CONTROL	REV.	FIGURE
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1.1 Project Context

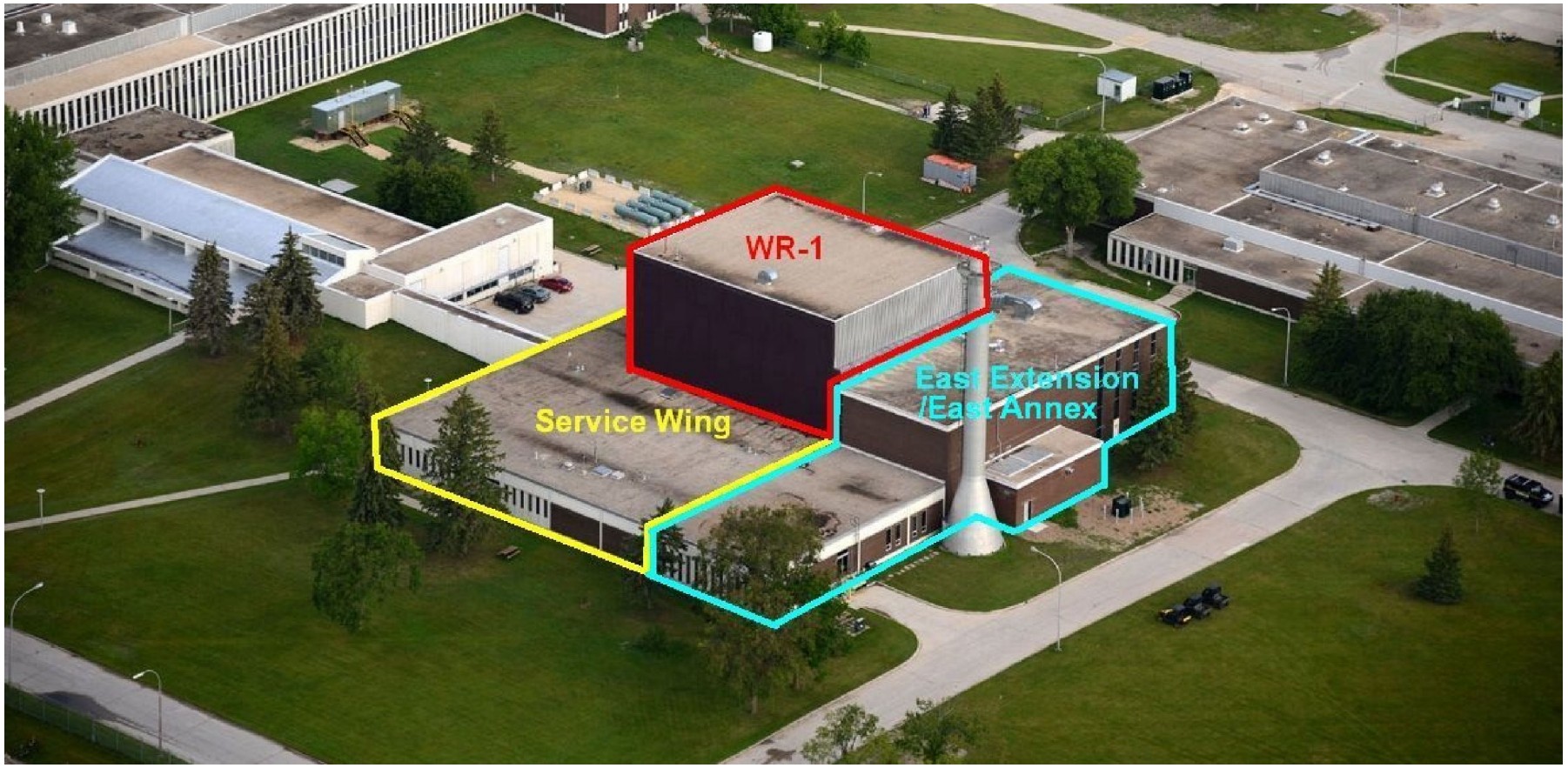
The WR-1 Complex (Figure 1.1-1) includes the WR-1 Building, as well as the east annex and service wings, which contain office space and supporting facilities. The WR-1 Building is seven stories tall, with two stories above-grade and five below-grade (Figure 1.1-2). The most significant contributor to the remaining radioactive source term is the reactor core (calandria and fuel channels) which accounts for 99% of the source term. It is important to note that due to its small size, even when it was operating, WR-1 contained significantly less radioactive material than large power reactors.

The decommissioning approach for the WL site as described in the Comprehensive Study Report was to remove all facilities entirely from the WL site with the exception of low level waste trenches in the Waste Management Area, which may be managed through on-site in situ disposal (AECL 2001). The approved decommissioning approach for the WR-1 Building involved the complete removal and remediation of the building (Licence No. NRTEDL-W5-8.04/2018). Prior to demolition of the WR-1 Complex, all activated and contaminated components would have been removed, packaged and dispositioned at off-site facilities (AECL 2001). The facility structure would be decontaminated and then demolished to achieve unrestricted release criteria. The dismantling and remediation activities previously approved for WR-1 Complex included:

- removal of reactor vault components;
- removal of process piping and equipment;
- transfer of radioactive waste to off-site facilities;
- decontamination of the building structure;
- demolition of the above-grade building structure; and
- remediation of the site to a ‘natural state’.

AECL's mandate is to manage its radioactive waste and decommissioning liabilities in a safe and environmentally responsible manner. AECL has asked CNL to perform the work, and in keeping with international best practices (IAEA 2004, 2006), the decommissioning timeframe has been accelerated with the goal of completing decommissioning of the WL site by 2024. Over the past 10 years, multiple buildings and facilities at the WL site have been decommissioned and the land remediated. In an effort to continue to safely reduce AECL's nuclear legacy liabilities and reduce the need for interim storage of radioactive waste, CNL began to investigate other options that would allow the WR-1 Building to be decommissioned safely. The new proposed approach for WR-1 is In Situ Decommissioning (ISD) which allows CNL to decommission the facility in a safer, compliant manner that reduces interim storage and provides protection of the public and the environment.

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NOTE(S)

REFERENCE(S)

1. OBTAINED FROM CANADIAN NUCLEAR LABORATORIES, 2017

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PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

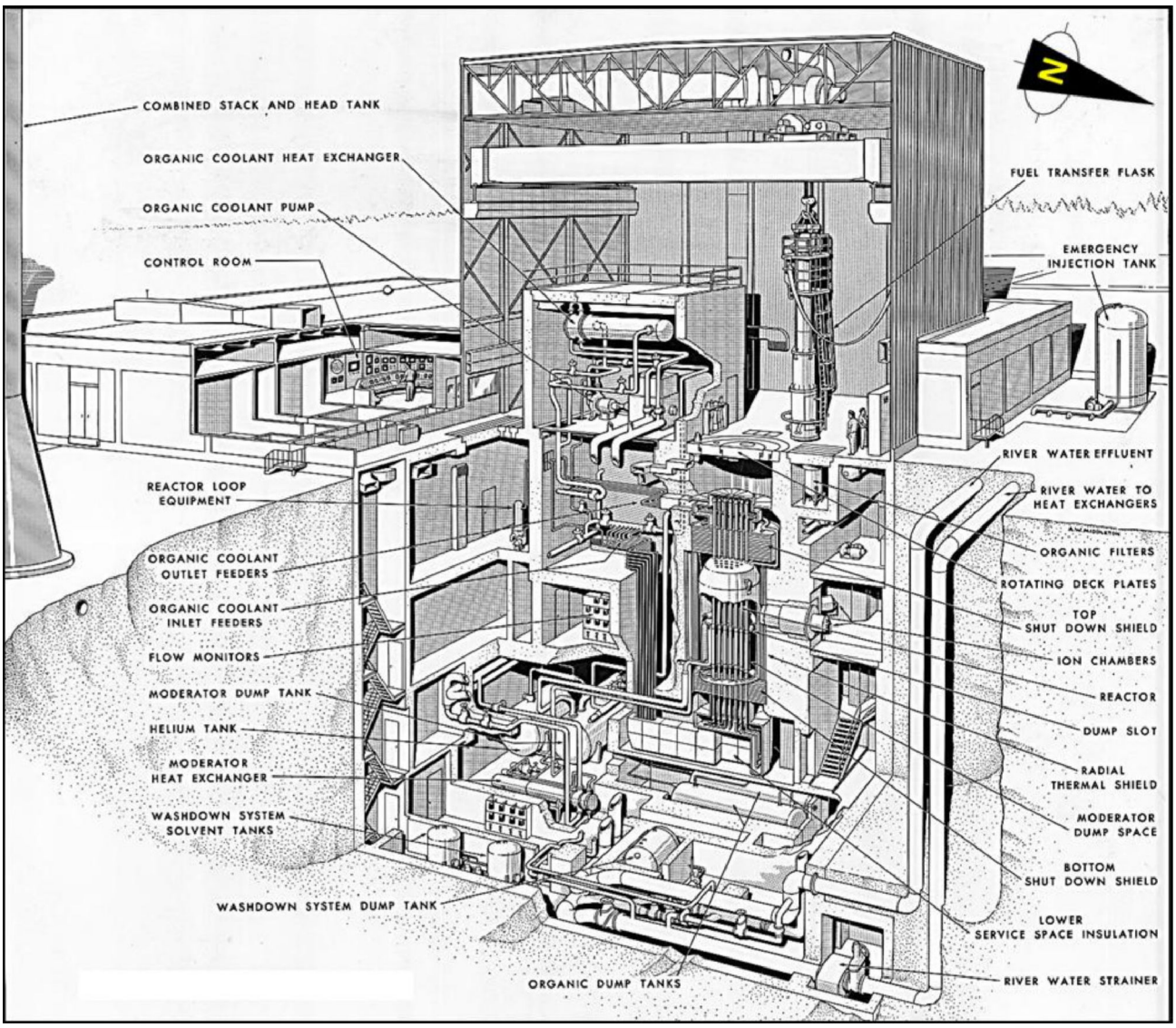
CONSULTANT
Golder Associates

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PREPARED	PR
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APPROVED	-

TITLE
WR-1 COMPLEX

PROJECT NO.	CONTROL	REV.	FIGURE
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REFERENCE(S)

1. OBTAINED FROM CANADIAN NUCLEAR LABORATORIES, WHITESHELL LABORATORIES DETAILED DECOMMISSIONING PLAN: VOLUME 6 -WHITESHELL REACTOR #1: BUILDING 100, FIGURE 2-5 WR-1 REACTOR AT WHITESHELL, 2016

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
WR-1 BUILDING

CONSULTANT
Golder Associates

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PROJECT NO.	CONTROL	REV.	FIGURE
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1.2 Project Overview

CNL is proposing an ISD approach to the decommissioning of the WR-1 Building. WR-1 is located within the WR-1 Complex (Figure 1.1-1). The below-grade reactor systems, components and structures, and associated radiological and non-radiological hazards will be permanently disposed in situ. The above-grade structures will be demolished and removed using traditional demolition methods. During decommissioning, consideration will be given to place some equipment from the heat transport system that is currently located on the ground-level reactor floor to a below-grade position for incorporation in the disposal system. An engineered cover will then be constructed over the below-grade structure to resist intrusion and divert precipitation and surficial runoff. In Situ Decommissioning is a permanent, passive decommissioning end state. The In Situ Decommissioning disposal system utilizes multiple barriers to contain the waste, providing time for the radioactive materials to decay to safe levels.

The Project activities assessed in this EIS are limited to ISD of the WR-1 Building. Other decommissioning activities for the WL site, documented in the Comprehensive Study Report, are assumed to be unmodified. Removal of the east annex and service wings of the Building 100 Complex were assessed as part of the Comprehensive Study Report and are covered under the CNL's existing decommissioning licence for the WL site (Licence No. NRTEDL-W5-8.04/2018). Activities required to prepare for ISD, such as isolation of the WR-1 Complex and targeted remediation of hazardous materials, are also covered under CNL's existing decommissioning licence for the WL site.

The decommissioning activities for the WR-1 Building proposed as part of the Project and assessed in this EIS include:

- preparing for ISD;
- establishing temporary and supporting infrastructure;
- grouting of below-grade structures and systems;
- removing above-grade structures and systems (excluding the east and service wings);
- installing an engineered cover over the grouted below-grade structures and systems;
- final site restoration;
- preparation for Institutional Control; and
- Institutional Control (includes both passive and active controls).

WR-1 is well suited for this decommissioning approach because the small reactor core contains the vast majority of remaining activity and it can be isolated below-grade in a permanent, safe way that provides protection of the environment and people. On the contrary, total dismantling of the below-grade reactor systems exposes workers to many radiological and standard industrial hazards that are avoided through the ISD approach. Some examples include:

- the reactor core contains high radiation dose rates that pose a significant hazard to workers during dismantling activities;
- the reactor facility and systems contain large quantities of asbestos that would have to be abated;

- there is limited access to the subsurface systems making hoisting and rigging operations for material retrieval to the surface very complex, resulting in significant industrial hazards; and
- work in confined spaces, at heights and in extremely congested areas all pose significant risks during total dismantlement of WR-1.

CNL plans to start decommissioning activities related to the WR-1 Building in 2019. The Project site will be turned over to Institutional Control in 2024, which is assumed to last for 300 years, with active controls (e.g., ground water monitoring and site inspection) only required for the first 100 years. This timeframe is consistent with that required for other near surface disposal projects (ranging from 100 to 300 years), including similar projects under CNSC jurisdiction (e.g., Ontario Power Generations's Deep Geological Repository project). The planned schedule for the proposed decommissioning activities are provided in Table 1.2-1.

Table 1.2-1: WR-1 Decommissioning Project Phases and Schedule

Phase	Activity	Duration
Closure	Preparation for In Situ Decommissioning	2019 to 2021
	Grouting of Below-grade Systems and Structures	2021
	Removal of Above-grade Structures	2021 to 2022
	Installation of Engineered Cover	2022 to 2023
	Final Site Restoration	2023
	Preparation for Institutional Control	2024
Post-closure	Institutional Control (Active)	2024 to 2124
	Institutional Control (Passive)	2024 to 2324
	Post-Institutional Control (Passive)	Beyond 2324

1.3 Project Location

The WL site is located in southeastern Manitoba, approximately 100 kilometres (km) northeast of Winnipeg and on the shore of the Winnipeg River (Figure 1.0-1). The WL site contains several nuclear facilities, including WR-1, the Waste Management Area, and other nuclear and non-nuclear facilities and laboratories. The WL site has a total area of 4,375 hectares (ha) and is within the boundaries of the Local Government District of Pinawa (Figure 1.0-1). The Winnipeg River forms the western boundary of the WL site. The Project is located entirely within the WL site (Figure 1.0-2). The approximate geographic coordinates of the Project are 50°10′ 46″N and 96°03′ 35″W.

Nearby communities include the Village of Lac Du Bonnet (9 km north of the WL site), the Local Government District of Pinawa (10 km east of the WL site), and Seven Sisters Falls (located 3.5 km from the WL site). The Village of Lac Du Bonnet has a population of approximately 1,300 residents and Pinawa has a population of approximately 1,400. The closest permanent residents to the Project reside to the west of the Winnipeg River along Highway 11, approximately 2 km from the WL site.

Three First Nations communities are in proximity to the WL site. The Ojibway community of Sagkeeng First Nation (also known as Fort Alexander, Manitoba) is located on the shore of the Winnipeg River at Lake Winnipeg approximately 50 km northwest of the WL site. The Little Black River First Nation is located approximately 60 km northwest of the WL site, in proximity to Sagkeeng First Nation. The Brokenhead Ojibway Nation (also known as

Scanterbury, Manitoba) is located along the shore of the Brokenhead River approximately 50 km west of the WL site. In addition, Hollow Water First Nation, Shoal Lake 40, and Wabaseemoong Independent Nations have also been engaged with as part of the Aboriginal engagement process for the Project. Manitoba Metis Federation as the official democratic and self-governing political representative for the Metis Nation's Manitoba Metis Community, have also been engaged.

The Winnipeg River is the dominant drainage feature in the area. At the WL site, the river is approximately 0.3 km wide, 7 m deep and flows in a northerly direction. Surface water run-off at the WL site drains into the Winnipeg River. The regional surficial geology comprises widespread deposits of till and glacio-fluvial and glaciolacustrine materials. In the immediate vicinity of WL site there are approximately 10 to 20 m of surficial overburden soils overlying Precambrian bedrock. Hydrogeological characterization at the WL Main Campus has shown overburden thickness in the area is up to 15 m thick. 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 up to 0.25 m of surface organics. The foundation of the WR-1 Building extends into the bedrock. Groundwater flow at WR-1 is towards the Winnipeg River.

Terrestrial habitat at the WL site is diverse over short distances. Large tracts of wetland cover the easterly portions of the WL site, with black spruce common. Further to the west are poorly drained clay plains, forested land including species such as ash and poplar and abandoned farm fields vegetated with grasses and shrubs. Land closer to the Winnipeg River include gullies and ravines where beaver dams are common.

Aside from the operations and activities undertaken by CNL, other land uses of the WL site are prohibited due to restricted public access. No hunting or fishing is permitted on the WL site and the site is not used for traditional purposes by Aboriginal people. Land use in the region includes forestry, recreation and tourism, hunting, trapping and fishing and agriculture (AECL 2001). Forestry is a strong industry in the regional area, although little, if any, forestry has occurred in the local area. The WL site is located 7 km northwest of the Whiteshell Provincial Park and 49 km southwest of the Nopiming Provincial Park, both of which are prime outdoor recreation areas in eastern Manitoba. Home and cottage development along the west side of the Winnipeg River indicates that waterways, scenery, trails and wildlife of the region are attracting vacationers and weekend campers. Sport fishing is very popular in the Winnipeg River. Agricultural operations in the region include cereal production, hay, flax, canola and alfalfa crops and dairy and livestock production.

1.4 Proponent

AECL, a federal Crown corporation, is responsible for its radioactive waste liabilities, including the WL site. AECL has contracted CNL to manage and operate its sites on its behalf, including completing the decommissioning of the WL site. As such, CNL is the proponent for the Project.

1.4.1 Corporate History

AECL is a federal Crown corporation, with a core mandate to enable nuclear science and technology and manage Canada's radioactive waste and decommissioning responsibilities. It fulfils this mandate through a long-term contractual arrangement with CNL 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. AECL and the GoCo process bring in world class nuclear decommissioning expertise.

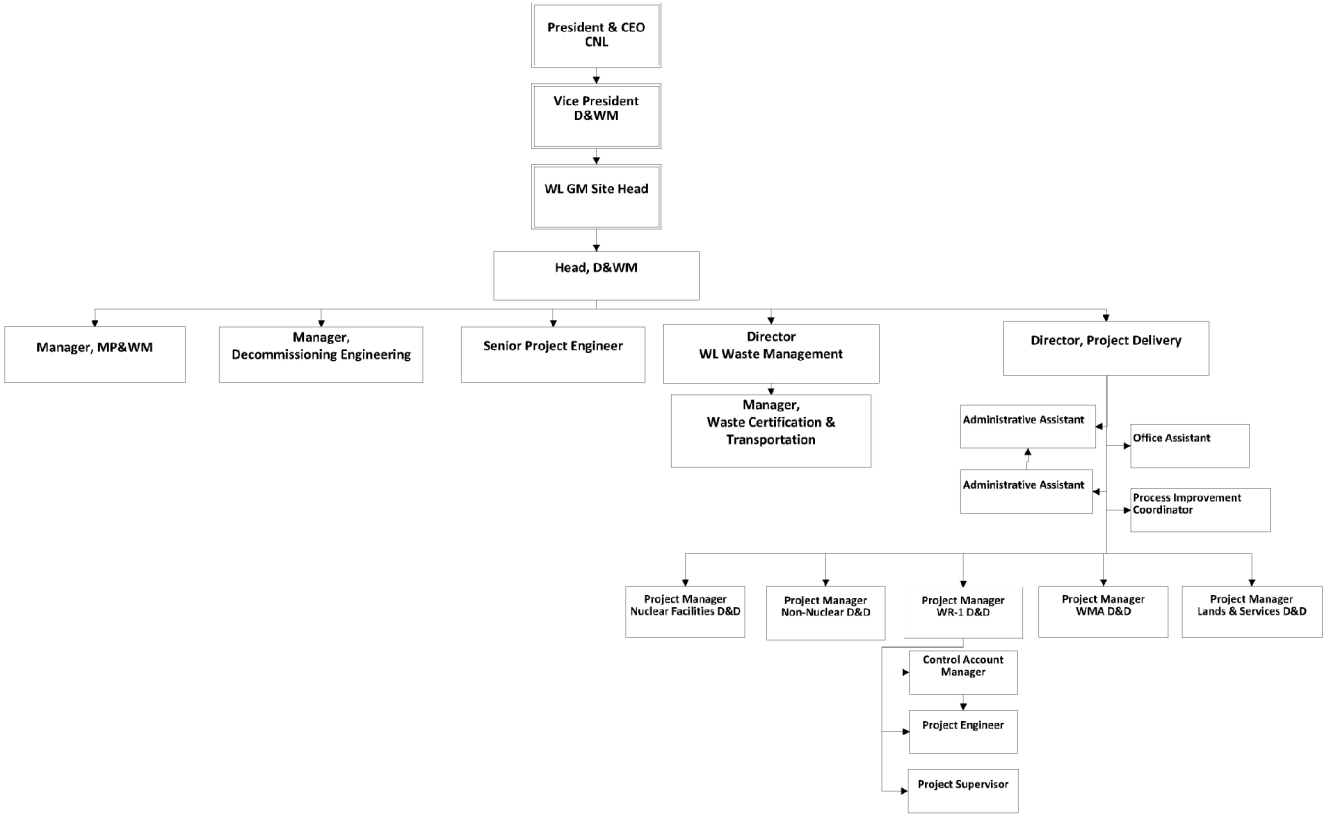
CNL is Canada's leading nuclear science and technology organization and a world leader in developing innovative applications from nuclear technology. Services offered through CNL include research and development, design and engineering to specialized technology, waste management and site decommissioning. 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 their regulators, customers, stakeholders, First Nation and Métis peoples, and the public.

1.4.2 Management Structure

CNL is led by an Executive Team and a Board of Directors. The President and Chief Executive Officer, along with seven Vice Presidents are responsible for different aspects of the business. An organizational chart outlining CNL's internal structure relevant to the Project is provided on Figure 1.4-1. A full listing of CNL's Board of Directors and Executive Team can be found online at www.cnl.ca. The following are key roles related to the execution of the Project.

- CNL President and Chief Executive Officer, who has overall responsibility for CNL's management of legacy waste at the WL site.
- The Vice President Decommissioning and Waste Management, who has overall responsibility for the development of the Project including design, regulatory approvals, and execution. This also includes ensuring the safe conduct of licensed activities associated with the facilities and radioisotope laboratories at the WL site.
- Whiteshell Laboratories Closure Project Site Head is accountable to the Vice President Decommissioning and Waste Management and is responsible for leading and managing the Project and the associated operational activities of the WL site and facilities safely, responsibly, and effectively. The Whiteshell Laboratories Closure Project Site Head is also the holder of the WL site Licence (Licence No. NRTEDL-W5-8.04/2018).
- Head of Whiteshell Laboratories Decommissioning and Waste Management, who has overall responsibility for ensuring decommissioning and waste management activities are planned and performed according to the controls and requirements of the WL Decommissioning Quality Assurance Plan. Implementation and maintenance of the WL Decommissioning Quality Assurance Plan is the responsibility of the WL Site Head.
- Director of Project Delivery, who has overall responsibility for the safe, cost-effective delivery of projects related to the Project, whilst ensuring program, regulatory, and compliance requirements are met. The WL Project Delivery Director is responsible for executing the decommissioning activities at the WL site.

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17 July 2017

NOTE(S)

REFERENCE(S)

1. OBTAINED FROM CANADIAN NUCLEAR LABORATORIES, 2017

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Golder Associates

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PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
ORGANIZATIONAL CHART FOR CANADIAN NUCLEAR LABORATORIES AND MANAGEMENT OF THE PROJECT

PROJECT NO.	CONTROL	REV.	FIGURE
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1.4.3 Key Contact Information

The primary contact for the purposes of the EIS for the Project is:

Mr. Pat Quinn
Director, Corporate Communications
Canadian Nuclear Laboratories
Chalk River Laboratories
Chalk River, Ontario K0J 1J0
Telephone: 613 584 8811 Extension 43417
Fax: 613 584 8272
Email: pat.quinn@cnl.ca

1.5 Environmental Policy

For CNL, business and environmental performance go hand in hand. It is important that CNL leads by example in terms of environmental performance. Activities at the WL site have been ISO 14001 certified since 2010; during this time, there has been a steady evolution of CNL's Environmental Management System. A considerable level of effort and vigilance is required to establish, maintain and improve an Environmental Management System over time. For this reason, CNL has an Environmental Policy (CNL 2017a) that considers the protection of the environment as an integral component of their decision-making in all phases of their business activities, including product development, project planning, project implementation, operations and decommissioning. CNL also focuses their environmental efforts on limiting nuclear legacy obligations for future generations. The Environmental Policy (CNL 2017a) applies to all aspects of CNL's activities and is as outlined below:

- 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 comply with environmental laws, requirements and recognized standards and guidelines applicable to their activities;
- to review the effects 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; and
- to promote public and employee awareness of this policy and their environmental performance.

1.5.1 Health, Safety, Security, Environment and Quality Programs

To demonstrate compliance with the Environment Policy (CNL 2017a) and other regulatory commitments related to health, safety and security, CNL has developed a number of programs outlining corporate expectations regarding the following activities (further detail is provided in Section 3.0 Project Description):

- Occupational Safety and Health Program;
- Radiation Protection Program;
- Environmental Protection Program;
- Waste Management Program;
- Emergency Preparedness Program;
- Human Performance;
- Nuclear Criticality Safety Program;
- Fire Protection Program;
- Security Program;
- Nuclear Materials and Safeguards Management Program;
- Quality Assurance Program; and
- Whiteshell Laboratories Environmental Assessment Follow-up Program.

1.5.2 Environmental Protection Program

The Environmental Management System (EMS), referred to as the Environmental Protection (EnvP) Program, is part of the overall CNL Management System as a functional support area under Health, Safety, Security, and Environment. The program implements CNL's Environment Policy described in Section 1.5 Environmental Policy and provides compliance with legal and other environmental obligations applicable at CNL operated sites in Canada. The Environmental Policy outlines the strategic environmental objectives for CNL sites, including the WL site. A comprehensive list of the documentation associated with the Environmental Protection Program is provided in CNL's Environmental Protection Program Governing Documentation Index procedure (CNL 2017b). Some of the key requirements of the Environmental Protection Program include:

- identify and evaluate the effects of the environmental aspects associated with CNL's activities;
- identify and provide access to applicable legal and other environmental requirements and obligations;
- monitor and measure to verify environmental performance and compliance;
- manage cultural resources;
- manage land and habitat;
- ensure appropriate level of environmental training and awareness;
- establish and maintain emergency preparedness and response procedures; and
- implement "Green Initiatives" to improve waste management, energy and vehicle usage.

1.6 Regulatory Framework

1.6.1 Federal Review Process

The federal environmental assessment requirements are detailed within the *Canadian Environmental Assessment Act, 2012 (CEAA, 2012*). Under Section 8 of *CEAA, 2012*, a Project Description is required to initiate the screening process through which the Canadian Environmental Assessment Agency (the Agency) will determine if a federal environmental assessment is required for all designated projects. Designated projects are defined under the *Regulations Designating Physical Activities* for *CEAA, 2012*. The Regulations Designating Physical Activities identify the CNSC as the Responsible Authority for projects that are regulated under the *NSCA*. 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 2016 Project Description document (CNL 2016), the CNSC issued a Record of Decision (CNSC 2017a) and determined that the Project requires a federal environmental assessment pursuant to *CEAA, 2012*.

Federal permits, licences and authorizations that may be required for the Project are listed below.

- Petroleum storage tank permit(s) from Environment Canada may be required, depending on the size of fuel tanks installed on the site.
- Waste generator registration will be maintained through the Manitoba Conservation and Water Stewardship, and in compliance with the *Dangerous Goods Handling and Transportation Act.*

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

Under Section 15 of *CEAA 2012*, the CNSC is considered to be the Responsible Authority for the Project. As documented in the Record of Decision (CNSC 2017a), CNSC staff have notified all relevant federal authorities, as well as all relevant provincial authorities in Manitoba with respect to the Project. All federal authorities indicated that they possess specialist knowledge with respect to the Project and expertise that could be drawn upon during the environmental assessment process. In addition, the province of Manitoba expressed interest in receiving regular updates on the environmental assessment for the Project (CNSC 2017a).

1.6.2 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 is completed in a manner consistent with direction in:

- *Canadian Environmental Assessment Act, 2012.* SC 2012, c 19, s 52;
- Operational Policy Statement: Addressing 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);
- Technical Guidance: Assessing Physical and Cultural Heritage or any Structure, Site or Thing that is of Historical, Archeological, Paleontological or Architectural Significance under the *Canadian Environmental Assessment Act, 2012* (the Agency 2015e);
- Draft Technical Guidance: Assessing Cumulative Environmental Effects under the *Canadian Environmental Assessment Act, 2012* (the Agency 2014);
- Generic Guidelines for the Preparation of an Environmental Impact Statement pursuant to the *Canadian Environmental Assessment Act, 2012* (CNSC 2016a);
- REGDOC-2.9.1 Environmental Protection: Environmental Policy, Assessments and Protection Measures (CNSC 2017b);
- REGDOC-3.2.2 Public and Aboriginal Engagement (CNSC 2016b);
- REGDOC-2.4.1 Deterministic Safety Analysis (CNSC 2014);
- CNSC Guidance Document G-320: Assessing the Long-term Stability of Radioactive Waste Management (CNSC 2006);
- CSA N286-12: Management System Requirements for Nuclear Facilities (CSA Group 2012a);
- CSA N288.1 Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities (CSA Group 2014);
- CSA N288.4 Environmental monitoring programs at Class 1 nuclear facilities and uranium mines and mills (CSA Group 2010);
- CSA N288.5 Effluent monitoring programs at Class 1 nuclear facilities and uranium mines and mills (CSA Group. 2011);
- CSA N288.6 Environmental Risk Assessment at Class 1 nuclear facilities and uranium mines and mills. (CSA Group 2012b);
- CSA N288.7 Groundwater Protection Programs at Class 1 nuclear facilities and uranium mines and mills (CSA Group 2015); and
- *Nuclear Safety and Control Act. 2017*. SC 1997, c 9.

Discipline-specific standards, codes and guidelines used in the assessment of effects are identified as appropriate within each discipline section (Sections 6.2 to 6.9).

To demonstrate compliance with the Generic Guidelines for the Preparation of an Environmental Impact Statement pursuant to the *Canadian Environmental Assessment Act, 2012* (CNSC 2016a), REGDOC-2.9.1 Environmental

Protection: Environmental Principles, Assessments and Protection Measures (CNSC 2017b), and facilitate access to information within the EIS document, a concordance table (or cross-referencing table) has been prepared (Appendix 1.0-1) that lists the requirements detailed in the Guidelines and REGDOC-2.9.1 and the location for the corresponding information provided within the EIS.

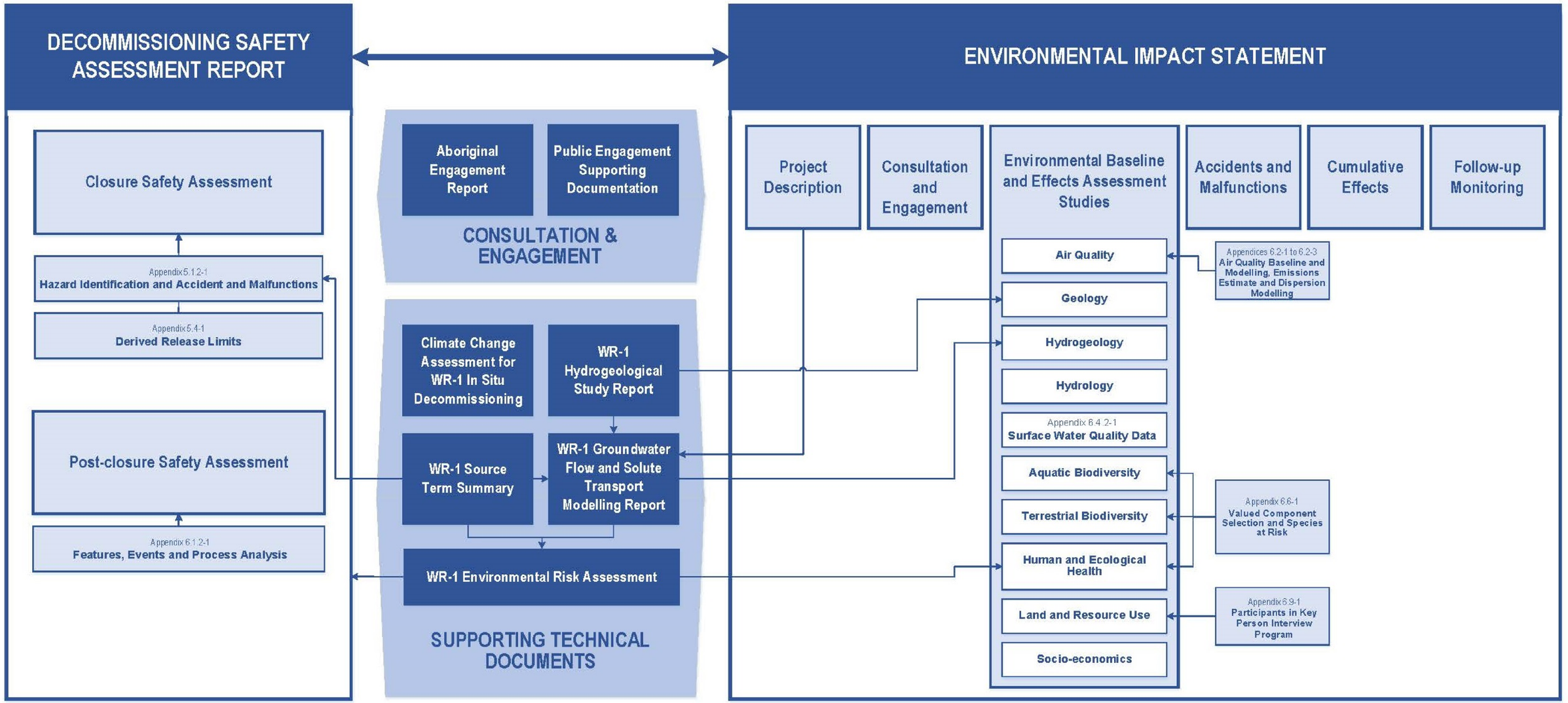
1.7 Structure of the Document

This document represents CNL's EIS for the Project. It has been prepared following the *Generic Guidelines for the Preparation of an Environmental Impact Statement pursuant to the Canadian Environmental Assessment Act, 2012* (CNSC 2016a). This EIS is organized into the sections described below and shown on Figure 1.7-1 (only those documents shown under the "Environmental Impact Statement" heading on Figure 1.7-1 will be submitted as part of the EIS):

- **Executive Summary –** contains a description of all key components of the 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 Project after considering mitigation and the significance of those effects.
- **Section 1.0 Introduction –** includes an overview of the Project, provides an introduction to CNL, outlines the regulatory framework the Project will follow and outlines the organization of the document.
- **Section 2.0 Purpose of the Project and Alternative Means for Carrying out the Project –** identifies the objectives of the Project, the problems or opportunities that the Project is intended to satisfy and presents the rationale for proceeding with the development. This section also considers the effects of alternative means of carrying out the Project, identifies the economically and technically feasible alternatives and includes environmental and social considerations that were evaluated as means of implementing the Project.
- **Section 3.0 Project Description –** provides a description of all phases of the Project in sufficient detail to allow CNL to predict potential adverse environmental, economic, social and health effects and to address concerns from interested parties; timeline for all phases of the Project will be provided, as well as a discussion of components and activities, including infrastructure that will be developed as part of the Project.
- **Section 4.0 Aboriginal Engagement –** summarizes CNL's engagement activities with Aboriginal communities, including documentation of meetings, discussion topics and outcomes and relevant agreements that were developed.
- **Section 5.0 Public Engagement –** summarizes CNL's engagement activities with the public and regulators, including documentation of meetings, discussion topics and outcomes and relevant agreements that were developed.
- **Section 6.0 Environmental Effects –** outlines the environmental assessment approach, selection of valued components (VCs), discipline specific definition of assessment boundaries, describes the Project setting, and presents the results of the environmental assessment and determination of significance of effects on the environmental, economic, social, heritage and health effects of the Project.
  - Section 6.1 Environmental Assessment Approach;
  - Section 6.2 Atmospheric Environment;

- Section 6.3 Geological and Hydrogeological Environment;
- Section 6.4 Surface Water Environment;
- Section 6.5 Aquatic Environment;
- Section 6.6 Terrestrial Environment;
- Section 6.7 Human and Ecological Health;
- Section 6.8 Land and Resource Use; and
- Section 6.9 Socio-economic Environment.

- **Section 7.0 Malfunctions and Accidents –** presents a description of potential credible malfunctions and accidents associated with the Project, the conditions under which they could occur, proposed mitigations and contingency plans.
- **Section 8.0 Summary of Cumulative Effects –** contains a summary of residual cumulative environmental, economic, social and health effects predicted to occur as a result of the Project that cannot be avoided or mitigated through the re-design or relocation of the Project or through commitments made by CNL.
- **Section 9.0 Summary of Significance of Residual Effects –** contains a summary of significance of residual environmental, economic, social and health effects predicted to occur as a result of the Project that cannot be avoided or mitigated through the re-design or relocation of the Project or through commitments made by CNL and will present the conclusion of the evaluation of significance for residual effects predicted to occur to VCs for Project effects and cumulative effects.
- **Section 10.0 Assessment of Effects of the Environment on the Project –** contains the assessment of effects of the environment on the 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 –** presents the reporting structure and timelines for the various management plans, continuing or follow-up monitoring plans and commitments made for the Project.
- **Section 12.0 Conclusions –** includes a summary of the findings of the effects assessments, the significance of the Project and the residual effects predicted to occur because of the Project and other reasonably foreseeable developments and provides an overall conclusion for the EIS.
- **Section 13.0 References –** includes the references cited throughout the EIS.



CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
ENVIRONMENT IMPACT STATEMENT DOCUMENT STRUCTURE

CONSULTANT
Golder Associates

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2.0 PURPOSE OF THE PROJECT AND ALTERNATIVES TO THE PROJECT

2.1 Introduction

The Whiteshell Reactor 1 (WR-1) was permanently shut down in 1985 and decommissioned to a secure state in a reduced site access-controlled area. The first stage of decommissioning of the WR-1 Building included the removal of easily mobilized radioactivity material (e.g., fuel, fluids) and decontamination of the main floor (600 level) and first sublevel (500 level) space. The last irradiated fuel was removed from the storage bays and transferred to dry storage at the Concrete Canister Storage Facility adjacent to the WL Waste Management Area (WMA). Bulk organic coolant was also removed from the reactor cooling circuits and transferred to the WL WMA for incineration. Reactor control systems were isolated and all building services systems are maintained in an operating mode. This initial decommissioning work prepared the WR-1 Building for a deferment period and substantially decreased potential hazards from the facility. Many of the remaining systems for the WR-1 are permanently shut down, and in some cases, the systems remain largely intact. All of the required service systems remain operational to maintain the WR-1 in a storage with surveillance state.

Canadian Nuclear Laboratories (CNL) is proposing a new decommissioning strategy: In Situ Decommissioning of WR-1 at the Whiteshell Laboratories Site (the Project). In situ decommissioning (ISD) is a permanent, passive decommissioning end state. The intent of this section is to provide an overview of CNL's overall waste disposal strategy, describe the purpose of the Project as it relates to the overall strategy, provide a listing of design principles that the preferred alternative must meet, and to present alternative means of carrying out the proposed Project.

2.2 CNL's Integrated Waste Strategy

In Canada, nuclear waste producers and owners are responsible for the funding, organization, management and operation of disposal and other facilities required for their wastes. CNL has developed an Integrated Waste Strategy which concisely details "cradle to grave" pathways for all CNL waste streams, from generation to final disposition. The Integrated Waste Strategy is based on CNL's waste inventory and forecast data and founded on the fundamental principles of waste avoidance, minimization and re-use. It enables the assessment of the quantities and types of waste across the spectrum of waste that CNL manages (e.g., from clearable waste to used fuel). In situ decommissioning of the WR-1 facility meets one of the CNL Integrated Waste Strategy objectives by providing a disposition route for the WR-1, components and systems. Previous WR-1 decommissioning strategies had delayed decommissioning of the reactor until future ILW disposal facilities become available. The proposed WR-1 Project ensures CNL focuses their environmental efforts on limiting nuclear legacy obligations for future generations.

2.3 Purpose of the Project

In 2013, the Government of Canada announced its intention to implement a Government-owned, Contractor-operated (GoCo) model for the management of Atomic Energy of Canada Limited (AECL's) Nuclear Laboratories. The goals are to create value and reduce risks and costs for taxpayers while continuing to fulfill AECL's core mandate.

As a result of the restructuring of AECL, the Government of Canada, through AECL, has put an increased emphasis on responsibly and safely managing AECL's radioactive waste liabilities. AECL's objective is to address risks and hazards in order to reduce risks and costs for Canada in a safe manner, consistent with international best practices (IAEA 2004, 2006). The implementation of the GoCo model provides an opportunity for AECL to leverage the

experience and expertise of the private sector to optimize work and increase efficiencies and effectiveness, including taking action to address risks sooner and advancing the commissioning of waste disposal facilities. As part of this, AECL has asked CNL to complete the decommissioning of the WL site in a manner that will protect the public, workers and the environment

The decommissioning approach for the WL site as described in the Comprehensive Study Report (CSR) was to remove all facilities entirely from the WL site with the exception of low level waste trenches in the Waste Management Area, which may be managed through on-site in situ disposal (AECL 2001). Over a 10 year period, multiple buildings and facilities at the WL site have been decommissioned and the occupied space has been remediated, in an effort to meet this objective.

CNL has evaluated other decommissioning options that allow the WR-1 Building to be decommissioned with greater safety. In Situ Decommissioning is the proposed approach and includes three main objectives:

1) Apply international best practices to safely decommission the WR-1 Building while ensuring protection to the environment (i.e., human and ecological) by:

   a) Limiting releases of radiological and other hazardous substances from the facility.

   b) Ensuring that the potential effects on the environment from the Project are within acceptable limits and in compliance with applicable regulation and do not nullify obligations previously committed to in the existing CSR (AECL 2001).

   c) Demonstrating the long-term safety of the Project through a consideration of the site characteristics and engineered design features, including implementation of a long-term monitoring and surveillance program for the site.

2) Apply CNL and international safety design principles to minimize radiation doses to the public and workers (e.g., meeting the As Low As Reasonably Achievable [ALARA] principle).

3) Significantly reduce risk to workers during the decommissioning phase by avoiding and minimizing industrial hazards.

2.4 Project Design Principles

As described in Section 2.1, one of the key objectives of the Project is to apply CNL and international safety design principles to minimize radiological and non-radiological exposure to the public and workers and to minimize the risk of industrial hazards (e.g., working at heights). The following principles and requirements are essential elements in the design of the preferred means of decommissioning the WR-1 Building. The alternatives considered in the assessment for the decommissioning the WR-1 Building must meet the design principles and requirements discussed below.

2.4.1 CNL Design Principles

The safety principles applied to the design and implementation of the preferred decommissioning strategy to confirm that safety functions and objectives can be met include:

- defence-in-depth principle;
- ALARA principle; and

- nuclear safety culture.

These principles are each described further in the following sections.

Defence-in-Depth Principle

The key aspects of defence-in-depth are layering of defensive principles by providing multiple layers of protection against abnormal events. When defence-in-depth is applied to all activities during the life cycle of the Project, it provides protection against a wide range of events (e.g., Anticipated Operational Occurrences [AOO], accident conditions, equipment failure, or human error within the facility) and from events that originate outside the facility (e.g., forest fires or floods). Defence-in-depth consists of two components: 1) equipment and administrative features that provide preventative or mitigation to a degree proportional to the hazard potential; and 2) integrated safety management programs that control operations. Section 7.0 and Section 10.0 provide an analysis of potential accidents and malfunctions identified for the Project and effects of the environment on the Project, respectively.

The application of the defence-in-depth concept to abnormal events provides that no single human or equipment failure would result in an unacceptable hazard to the workers in the facility, the public, or the environment. This strategy is centred on several barriers of protection with ascending levels of importance: accommodation, mitigation, and prevention. The level of application corresponds to the level of risk posed by the postulated event.

To effectively control a hazard, the same basic approach has been taken based on the following hierarchy of hazard control principles:

- elimination of the hazard;
- reduce/replace the hazard;
- isolate the hazard;
- control the hazard;
- personnel protective equipment & clothing (PPE&C);
- policies and procedures; and
- appropriate documentation.

Of these seven principles, the most effective is to eliminate the hazard, and wherever possible this will be the preferred method of hazard control for the Project. When a hazard cannot be eliminated, then the remaining principles are implemented to varying degrees to provide an acceptable level of defence-in-depth. The defence-in-depth strategy is used to compensate for potential mechanical and human failure and unexpected occurrences. A series of barriers will prevent or reduce the likelihood of a radioactive release to the environment. For human errors, prevention is achieved by a combination of process design and administrative controls (e.g., training and procedures), as well as by establishment of a strong safety culture.

As Low As Reasonably Achievable Principle

The ALARA principle is that the exposures to persons shall be as low as reasonably achievable, social and economic factors being taken into account. CNL's ALARA program will be followed and the essential elements include:

- demonstrated management commitment to the ALARA principle;

- implementation of ALARA through design, organization and management, selection and training of personnel, oversight of the Radiation Protection program, resources, and documentation;
- establishment of nuclear safety culture;
- planning and control of all work;
- application of task-specific dose and dose-rate radiological control hold points; and
- performance of regular operational reviews.

In addition to CNL's ALARA program, the CNSC's regulatory guide to the ALARA principle (CNSC 2004a) is taken into consideration in the design of the Project. This document outlines approaches to achieving ALARA through the management control over work practices, qualification and training for personnel, control of occupational and public exposure to radiation, and planning for unusual situations.

The ALARA principle for the Project implementation will be achieved by implementing zoning and access control measures, maintaining adequate shielding for structures and waste packages with high radiation fields, providing process equipment segregation, establishment of radiation alarms, continuous monitoring, 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.

Protective measures against the hazards of ionizing radiation will be considered to be optimized when further reductions in radiation doses are outweighed by the additional efforts and costs required for their implementation. This principle applies to all phases throughout the life cycle of the Project, from decommissioning and closure to post-closure, and is a particularly important consideration when developing the decommissioning procedures.

Nuclear Safety Culture

CNL has adopted the Institute of Nuclear Power Operations' (INPO) nuclear safety culture definition (INPO 2004)[1]. The following principles and traits are well recognized to contribute to a healthy nuclear safety culture:

- **Personal Accountability:** all individuals take personal responsibility for safety.
- **Questioning Attitude:** individuals avoid complacency and continuously challenge existing conditions and activities in order to identify discrepancies that might result in error or inappropriate action.
- **Effective Safety Communication:** communications maintain a focus on safety.
- **Leadership Safety Values and Actions:** leaders demonstrate a commitment to safety in their decisions and behaviors.
- **Decision-making:** decisions that support or affect nuclear safety are systematic, rigorous, and thorough.
- **Respectful Work Environment:** trust and respect permeate the organization.
- **Continuous Learning:** opportunities to learn about ways to ensure safety are sought out and implemented.

[1] "Nuclear safety culture" is defined as the core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment.

- **Problem Identification and Resolution:** issues potentially impacting safety are promptly identified, fully evaluated, and promptly and adequately addressed (corrected in commensurate with the potential consequences).
- **Environment for Raising Concerns:** a safety-conscious work environment is maintained where personnel feel free to raise safety concerns without fear of retaliation, intimidation, harassment, or discrimination.
- **Work Processes:** the process of planning and controlling work activities is implemented so that safety is maintained.

The CNSC has issued a draft *Regulatory Guide REGDOC-2.1.2 Management System: Safety Culture* (CNSC 2016a) that provides a definition of safety culture and highlights general safety culture requirements that apply to all licensees. The document describes the expected and suggested criteria for licensees to self-assess, establish corrective action plans, and report on safety culture.

2.4.2 Design Principles from External Sources

In addition to CNL's design principles, the design and implementation of the Project will also use Canadian and international best practices and safety fundamentals, including those from the International Atomic Energy Agency (IAEA) and the CNSC.

International Atomic Energy Agency

The IAEA's Fundamental Safety Principles (IAEA 2006) outline and describe ten 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 also published a specific safety guide for *Near Surface Disposal Facilities for Radioactive Waste* Specific Safety Guide SSG-29 (IAEA 2014). This document gives detailed guidance on the following, relating to design, including:

- containment;

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

Canadian Nuclear Safety Commission

The CNSC has published the following two documents, which describe the CNSC's licensing philosophy, and licensing requirements related to radioactive waste management. These two documents include:

- *G-320 – Assessing the Long-Term Safety of Radioactive Waste Management* (CNSC 2006); and
- *P-290 – Managing Radioactive Waste* (CNSC 2004b).

The purpose of the G-320 guidance document is to assist applicants for new licences and for licence renewals in assessing the long-term safety of radioactive waste management, including:

- long-term care and maintenance considerations;
- setting post-decommissioning objectives;
- establishing assessment criteria;
- assessment strategies and level of detail;
- selecting timeframes and defining assessment scenarios;
- identifying receptors and critical groups; and
- interpretation of assessment results.

The P-290 guidance document describes the philosophy that underlies the CNSC's approach to regulating the management of radioactive waste and the principles that are taken into account when making regulatory decisions on waste management. CNL considered these CNSC's guidance documents in the design and safety case development of the Project.

In addition to the above published documents, the CNSC is currently accepting comments on a discussion paper, *Radioactive Waste Management and Decommissioning* (CNSC 2016b), which identifies opportunities for improvement in the following areas:

- definition of waste types;
- requiring "reduce, reuse, and recycle";
- record keeping;
- licensing of waste disposal facilities, waste management facilities, and waste storage facilities;
- waste management program requirements;
- regulating remediation; and
- release from licensing post decommissioning or remediation.

The existence of this discussion paper demonstrates that the regulatory process for radioactive waste management and disposal is evolving. It is likely that the regulations for radioactive waste disposal will change, or at least become more formalized, in the near future. CNL will continue to meet and adapt to any new regulations as they develop.

2.5 Alternative Means for Carrying out the Project

2.5.1 Evaluation Approach

The *Canadian Environmental Assessment Act, 2012* requires that federal environmental assessments evaluate alternative means of carrying out the project that are technically and economically feasible and the environmental effects of any such alternative means. The Canadian Environmental Assessment Agency (the Agency) identifies in their 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 are also considered including biophysical, socio-economic, and public and worker health & safety.

The purpose of this section is to present the alternative means of decommissioning the WR-1 Building. 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 the defined criteria and the completion of a comparative evaluation to identify the preferred or most favourable option.

The decommissioning strategy for WR-1 draws upon the experiences and lessons learned from the decommissioning of similar reactors. WR-1 was defueled during previous decommissioning activities, dramatically reducing radioactivity. As a result, most remaining activity is associated with activated metals and contaminated systems and components. The vast majority of the remaining radioactivity is in the reactor core, which includes the calandria and the fuel channels. This activity must be considered when selecting a technically and economically suitable decommissioning strategy. Another key aspect of WR-1 that must be considered in assessing decommissioning strategies is that the reactor components are primarily located in the five storeys below-grade.

The alternative means evaluated in the EIS are listed in Table 2.5.1-1, and include: Deferred Decommissioning with complete dismantling and removal; immediate complete dismantling and removal; complete ISD; and partial dismantling and removal with partial ISD. These alternatives were evaluated in the context of the Project design principles (described in Section 2.2 Project Design Principles). Full dismantling and removal of the reactor building wings are encompassed by the previous Detailed Decommissioning Plan that has been accepted by the CNSC. As such, the decommissioning alternatives discussed below are specific to the decommissioning of the central portion of Building 100, which includes WR-1.

To determine the preferred or favourable means of decommissioning the WR-1 Building, each alternative is evaluated first for its technical feasibility, including safety to workers, the public and the environment. For those alternatives deemed technically feasible, a comparison of economic feasibility (i.e., cost) and environmental effects is completed. The alternatives assessment considers effects on the biophysical (i.e., atmospheric environment, geological and

hydrogeological environment, surface water environment, aquatic environment, terrestrial environment, and ecological and human health) and social (i.e., socio-economic and land and resource use) disciplines.

Each alternative is assessed and the most preferable option is selected after a systematic consideration of technical attributes, environmental effects and economic feasibility. Public and Aboriginal engagement is also an important aspect of the decision-making process. A summary of the alternative means being considered was made available to the public at open houses and meetings with First Nations communities, and input received is documented in Section 4.0 Aboriginal Engagement and Section 5.0 Public Engagement.

Table 2.5.1-1: Alternative Means Evaluated for the WR-1 Decommissioning Project

Decommissioning Parameter	Alternatives Evaluated in the EIS
Decommissioning Strategy	■ Alternative #1 – Deferred Decommissioning with Complete Dismantling and Removal ■ Alternative #2 – Complete Dismantling and Removal (no deferment) ■ Alternative #3 – Complete In Situ Decommissioning (ISD) ■ Alternative #4 – Partial Dismantling and Removal with ISD of the Remainder

Criteria used to evaluate each of the alternatives are summarized in Table 2.5.1-2, with further rationale provided in the following sections.

Table 2.5.1-2: Criteria for Evaluating Alternatives Means of Carrying Out the Project

Category	Criteria
Safety	***Worker Safety*** ■ How do the alternatives compare in terms of minimizing the mitigation required to ensure worker **radiological dose limits** are not exceeded during decommissioning? ■ How do the alternatives compare in terms of minimizing the mitigation required to protect workers from **non-radiological hazards** (e.g., lead, PCB's, asbestos)? ■ How do the alternatives compare in terms of **general worker safety** (e.g., industrial hazards such as working at heights, confined spaces and hoisting/rigging)? ■ Does the alternative reduce the number of times **hazardous waste is handled by workers**? ***Public Safety*** ■ Does the alternative **minimize the transport of hazardous waste**, thereby reducing the risk of motor vehicle accidents and public concern regarding the transport of hazardous waste? ■ How do the alternatives compare in terms of **minimizing the risk** to the public at the WL site **during post-closure**?

Table 2.5.1-2: Criteria for Evaluating Alternatives Means of Carrying Out the Project

Category		Criteria
Environmental Effects	Biophysical	■ How do the likely **effects on biophysical valued components** compare (e.g., atmospheric environment, aquatic environment, and terrestrial environment)? ■ Can it be decommissioned in a manner that provides long-term **protection of ecological and human health**?
	Social	■ How do the effects on **socio-economic valued components** compare (e.g., land and resource use, heritage resources, socio-economic)?
Technical Feasibility		■ Does the alternative require **offsite disposal of wastes** associated with the WR-1 Building? ■ Is the alternative a **proven approach and/or technology** that has been successfully deployed? ■ How do the alternatives compare in terms of **complexity of monitoring** required during closure and post-closure phases?
Economic Feasibility		■ How do the **total costs** of each alternative relatively compare in relation to each other? ▪ Ongoing storage and surveillance ▪ Decommissioning of the WR-1 Building ▪ Transportation of waste offsite ▪ Post-closure environmental and performance monitoring

The alternatives are evaluated using a reason narrative approach and described according to the above criteria (where applicable). Results are summarized in Section 2.6 in a matrix illustrating the relative preference of each alternative, as shown below. If the alternative had a high chance of successfully addressing a particular criterion, it was rated as most favourable. Similarly, if the alternative had a moderate likelihood of addressing a criterion, it was rated as favourable; while if the alternative was assessed as having a low likelihood of success or having unacceptable risk with a particular criterion, a least favourable rating was used.



Most Favorable — Favorable — Least Favorable

Safety

The following criteria were developed for the safety category.

- **Worker Safety** – For the worker safety evaluation criteria considered below, the defense-in-depth principle and ALARA principle were considered during alternative evaluation. For the criteria considered, it is often not possible to completely eliminate the hazard, but all alternatives include appropriate mitigation to reduce the hazard and protect workers.

- **Radiological Hazards during Decommissioning** – All alternatives will involve some level of radiation exposure to workers during decommissioning. However, appropriate mitigation (e.g., temporary shielding and ventilation, personal protection equipment and clothing [PPE&C]) can be put in place for all alternatives to ensure that worker dose limits are not exceeded. The amount of mitigation required will vary between the alternatives due to different types of exposure and radiation levels between the alternatives. Alternatives that minimize the need for mitigation the most were considered most favourable, while alternatives that minimize the need for mitigation the least were considered least favourable.
- **Non-radiological Hazards during Decommissioning** – The WR-1 Building also contains non-radiological hazards including lead, PCB's and extensive amounts of asbestos containing materials such as pipe insulation. Appropriate mitigation (e.g., PPE&C and ventilation) can be put in place for all alternatives to ensure the protection of worker health. The degree to which the need for mitigation is minimized determines the level of favourability of each alternative. Alternatives requiring the least amount of mitigation were considered most favourable and alternatives requiring the greatest amount of mitigation were considered least favourable.
- **General Worker Safety during Decommissioning** – Decommissioning of the WR-1 Building will introduce standard worker industrial safety hazards (e.g., working at heights, confined spaces, congested work spaces, and hoisting/rigging). These hazards will be more prevalent in some alternatives compared to others due to the nature of the decommissioning activities and the building construction. Alternatives with the lowest exposure to these worker safety issues, compared to the other alternatives, were considered most favourable. Alternatives with the highest potential exposure to these worker safety issues, compared to the other alternatives, were considered least favourable.
- **Waste Handling** – The transport of waste offsite will require additional handling by workers. Appropriate mitigation (e.g., temporary shielding and ventilation, PPE&C) can be put in place for all alternatives to ensure that worker dose limits are not exceeded during waste handling and packaging for transport. However, as an appropriate facility does not yet exist for waste disposal, interim storage of wastes will be necessary, and double handling of the waste will be required for final disposal at an unspecified future date. Alternatives that do not require the transport of wastes offsite were considered most favourable. Alternatives that do require the transport of wastes offsite but do not require interim storage (i.e., double handling) were considered favourable. Alternatives that do require the transport of wastes offsite and interim storage (i.e., double handling) were considered least favourable.

- **Public Safety**
  - **Transport of Hazardous Waste** – While transport of waste is routine and safe, the transport of wastes offsite will introduce the risk of vehicle accidents. Transport containers for nuclear waste are designed taking into account foreseeable accidents. The transport containers are designed and tested to withstand conditions associated with fire, impact, wetting, pressure, heat and cold. Therefore, the risk of public exposure during transport is extremely low. However, the transport of hazardous waste may raise perceived safety concerns amongst the public. Finally, the transportation of waste may result in increased degradation of the existing transportation infrastructure. Alternatives with the lowest volume of wastes shipped offsite for disposal were considered most favourable. Alternatives with the highest volume of wastes shipped offsite for disposal were considered least favourable.

- **Risk to Public at WL site during Post-closure** – The potential radiological risk to the public at the WL site will vary depending on whether radiological and non-radiological materials will still be present in the post-closure phase. An alternative was considered most favourable if no radioactive and non-radiological materials were left at the WR-1 Building during post-closure. An alternative was considered favourable if radioactive and non-radiological materials were left at the WR-1 Building, but these materials would be appropriately contained, thereby reducing the risk to the public during the post-closure phase to acceptable levels. An alternative was considered least favourable if there were concerns with the proposed containment method that could present a higher risk to the public.

Environmental

The evaluation of environmental effects is based on a qualitative comparison of biophysical and socio-economic effects on valued components (VCs). 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, Aboriginal peoples, or the public (Canadian Environmental Assessment Agency [the Agency] 2014). 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 Project are described in Section 6.1, and considered a number of factors, including:

- presence, abundance and distribution within, or relevance to, the area associated with the Project;
- potential for interaction with the Project and potential vulnerability to the effects of the Project;
- 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 Aboriginal peoples;
- legally recognized and afforded specific protection by law, policy, or regulation; and
- experience with similar projects.

Environmental effects are evaluated for biophysical and social 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 numerous species at risk and vegetation communities; however, for the alternatives assessment, environmental effects are evaluated for the terrestrial biodiversity discipline as a whole.

Technical

The following criteria were developed for the technical feasibility category.

- **Offsite disposal of Radioactive Wastes –**The WR-1 Building was permanently shut down in 1985 and still requires final decommissioning and disposal. All alternatives need to transfer varying volumes of radioactive waste to another facility for disposal. At present, no disposal facility currently exists. Therefore, wastes not managed at the WL site will require interim storage. Alternatives that do not require the transfer of wastes to another site for disposal were considered most favourable. Alternatives that require disposal of wastes at an

available offsite facility are considered to be favorable, and alternatives that require interim waste storage, prior to final disposal at an offsite facility were considered least favourable.

- **Proven Approach and/or Technology –** This criterion evaluated whether the overall decommissioning approach and/or technology is proven and has been implemented elsewhere. Approaches and/or technology implemented previously were most favourable, while unproven, conceptual ideas and/or technology were considered to be less favourable. An alternative was considered to be least favourable if the decommissioning approach and/or technology was disproven or outdated.
- **Complexity of Monitoring –** This criterion considered the monitoring requirements that may be needed in support of each alternative, including monitoring that is required for waste that is transferred to another site for storage or disposal. 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.

Economic

The economic feasibility was evaluated by comparing the total cost estimate for each alternative. This estimate includes costs for ongoing storage and surveillance of the WR-1 Building (prior to decommissioning), decommissioning of the WR-1 Building, transportation and storage of waste offsite and long-term monitoring and maintenance activities required during the post-closure phase, including the Institutional Control period. All alternatives are considered economically feasible since the base case of deferred dismantling is the previous approved and funded approach, and is the highest cost of all alternatives. However, cost to the public is still one of the factors that makes up a balanced review of alternative options.

2.5.2 Alternative #1 – Deferred Decommissioning with Complete Dismantling and Removal

Alternative #1 is deferred decommissioning with complete dismantling and removal of the WR-1 Building. This alternative is currently approved under the existing Decommissioning Licence for the WL site as described in CNL's previous Detailed Decommissioning Plan for Building 100 (CNL 2015). This decommissioning strategy assumes an additional prolonged period of storage and surveillance (more than 30 years) prior to completing decommissioning activities.

The major tasks included in the complete removal of the WR-1 Building are as follows (CNL 2015):

- removal of non-contaminated asbestos-containing materials and disposal at the WL asbestos landfill;
- removal of contaminated asbestos containing materials and disposal as radioactive waste;
- removal, segmentation, packaging and transport of the reactor fuel channels;
- removal, segmentation as required, packaging and transport of reactor thermal shields, the reactor vessel and components;
- removal, segmentation, packaging and transport of reactor process systems and equipment;
- decontamination of the building to meet the release criteria;
- management of materials in an approved waste storage facility or transferred to an off-site facility;

- final radiological surveys to verify that release criteria are met;
- removal of the building structure to 3 m below-ground level (rubblized concrete may be used to backfill the building location or transferred to an inactive landfill); and
- complete backfilling of the site and return to a state that blends with the surroundings.

As described in CNL's previous Detailed Decommissioning Plan for Building 100 (CNL 2015), the WR-1 Building would be decontaminated to specified release criteria to allow the bulk of the construction material to be reused, rubblized and used to backfill the WR-1 void, or transferred to an inactive landfill. Decontamination and size reduction of materials and equipment will be performed where practical, to reduce the volume of waste. Decontaminating techniques that do not produce liquid wastes are preferred, to avoid discharge of contaminants to the environment. Decontamination may produce contaminated concrete rubble and other building components, which could be stored at the WMA. Following removal and decontamination, the facility would be subjected to a radiological survey to confirm that facility release criteria have been met. The remaining building components could be reused or recycled, transferred to an inactive landfill site, or remain in-ground and backfilled over. Once decommissioning is complete, the WR-1 Building area would likely be classified as Industrial land use, with no restrictions.

2.5.2.1 Safety

2.5.2.1.1 Worker Safety

Full dismantling and removal will require sectioning of the fuel channels and reactor vessel, which represent the areas of highest radioactivity. Proper sectioning and bundling of all below-grade materials for safe hoisting will also require substantial work within the WR-1 Building. As described previously, the goal of this alternative is to allow radioactive components remaining in the WR-1 Building to decay to safer levels to reduce radiation exposure levels to workers during decommissioning. Even though full dismantling and removal will require workers to be present below-grade for prolonged periods of time, dose controls requirements (e.g., shielding and distance) to maintain worker safety will be less onerous for deferred decommissioning as compared to complete dismantling and removal (i.e., Alternative #2).

In addition to worker exposure to radioactivity, other industrial hazards are associated with the complete dismantling and removal of the WR-1 Building. Because much of the contaminated equipment and materials are located below-grade, removal requires considerable cutting and dismantlement to properly section and bundle materials for safe hoisting. This will increase worker exposure to risks associated with asbestos and working at heights, confined spaces and hoisting/rigging compared to an ISD option (i.e., ISD is less intrusive). Therefore, additional safety controls are required to protect workers in these areas.

The complete removal of the facility will require the offsite disposal of wastes which will require additional handling by workers for transport and disposal. It is assumed that an approved waste management facility will exist at the time of decommissioning (i.e., in 30 years), and that it will have the capacity to accept the wastes to be generated by the Project.

2.5.2.1.2 Public Safety

Long-term storage with surveillance will allow the radioactive components in the WR-1 Building to decay to safer levels minimizing the amount of material that would need to be disposed of as radioactive waste. Offsite disposal of wastes will still be required for Alternative #1, but the volume of waste to be transported is expected to be slightly lower compared to Alternative #2 (i.e., no deferment period). This will reduce the number of truck loads between the

WL site and the disposal facility, thereby reducing the public concern regarding the transport of hazardous waste and potential degradation of existing transportation infrastructure. This will also reduce the incremental risk of a vehicle to vehicle accident compared to Alternative #2.

The complete removal of the facility reduces risks of the WR-1 Building at the WL site. Once decommissioning is complete, the area would likely be classified as Industrial land use, with no restrictions, and require minimal long-term institutional controls. Overall, complete removal of the facility is considered the safest long term option with respect to the public near the WL site, compared to an ISD alternatives.

2.5.2.2 Environmental

The complete removal of the facility will require more extensive and intrusive decommissioning activities (e.g., dismantling, cutting, hoisting) compared to an ISD option. These more intrusive activities could result in increased air emissions, compared to an ISD alternative, from the following sources:

- Increased use of vehicles and equipment that combust fuel and emit indicator compounds.
- More vehicles travelling on paved roads that emit fugitive dust.
- Additional release of radioactive compounds during cutting and dismantling of equipment for transport off-site; however, the release of radioactive compounds is still expected to be within applicable release limits (AECL 2001).

Increased air emissions, both radiological and non-radiological, can present potential risks to the public, vegetation (exposed to atmospheric release through soil) and wildlife (exposed to atmospheric release through ingestion of terrestrial plants and other wildlife). While increased air emissions are possible for the complete removal of the facility, effective mitigation measures can be implemented so that the release of radioactive compounds are within applicable release limits (AECL 2001). These measures are described in detail in CNL's Revision 3 DDP (CNL 2015). In addition, deferred decommissioning takes place after a period of natural radioactive decay, thereby reducing the risk of radionuclides and other hazardous substances being released to the natural environment during decommissioning of the WR-1 Building. The increased vehicle use during decommissioning and the transport of wastes offsite will also result in increased greenhouse gas emissions.

An air quality assessment was completed as part of the CSR for the entire WL site (AECL 2001). This CSR included the decommissioning of the WR-1 Building where it was assumed that it would be completely removed, similar to the decommissioning approach for Alternative #1. This assessment determined that appropriate mitigation can be implemented to reduce the magnitude of the predicted residual effects associated with air emissions (release of airborne radioactive particulates during decommissioning and nuisance dust and fine particulates from demolition) and therefore, they were predicted to be not significant.

After decommissioning is complete, residual radiation may still be present, but it is expected to be of very low levels (below the clearance and release levels and the soil cleanup criteria) that will not pose a risk to the natural environment at the WL site in the post-closure phase (i.e., all radioactive and contaminated materials have been removed and disposed of off-site). The footprint for the WR-1 Building will be returned to a "natural state" that will mimic surrounding habitat which is expected to have positive effects to local wildlife. Compared to an ISD alternative, complete removal also eliminates the potential risk associated with groundwater leaching through the WR-1 ISD structure that could migrate to surface water and then adversely affect human health and the ecological the health of terrestrial and aquatic ecosystems.

While the complete removal of the facility will result in positive effects to the environment, the environmental liabilities associated with the removed wastes will be transferred to another offsite facility that has not been constructed yet. It is not yet known if this future facility will be within an industrial setting or a green-field site which could result in additional adverse environmental effects (e.g., vegetation clearing required at a green-field site).

From a social perspective, the complete removal of the facility could improve the perceived suitability of the site for future business ventures because long-lived radioactive material will no longer be present within the former WR-1 Building footprint. In addition, complete removal may allow this portion of the site to be released for unrestricted use; however, this would need to be verified against site clean-up criteria that will be established in consultation with federal and provincial regulators and the public. This could result in more diverse commercial or industrial opportunities for the site and additional traditional land use activities (e.g., hunting and berry picking).

2.5.2.3 Technical

There are numerous examples of complete decommissioning projects of nuclear reactors in the U.S., United Kingdom, Japan, France, and Germany. Canada has not performed a reactor dismantling project yet, other than simple SLOWPOKE reactors. Lessons learned from previous decommissioning work would be used in preparing and executing this decommissioning plan, including the World Association of Nuclear Operators, Institute of Nuclear Power Operations, and CNL.

The goal of this alternative is to allow radioactive components remaining in the WR-1 Building to decay to safer levels to reduce radiation exposure levels to workers and the public during decommissioning. However, the deferment means that the objective to accelerate decontamination and demolition of shutdown buildings will not be met for this alternative and that the WR-1 Building will be present for at least another 30 years. The complete removal of the facility will require the offsite disposal of wastes. However, it is assumed that an approved waste management facility will exist at the time of decommissioning (i.e., in 30 years), and that it will have the capacity to accept the wastes to be generated by the Project. Therefore, interim storage of wastes will not be required for deferred decommissioning.

Delayed decommissioning means that the radioactive material within the WR-1 Building will stay on-site for a longer period of time and continue ongoing surveillance and monitoring programs. However, these programs have been in place for over 20 years at the WL site and are effective at monitoring releases to the environment. Once decommissioning is complete, monitoring would be completed to confirm that preliminary soil clean up criteria and the non-radiological and radiological clearance and release criteria meet the target end-state of the Industrial land-use category. Long-term monitoring requirements during the Institutional Control period are expected to be relatively straightforward and include verifying that release criterial continue to be met. More intensive monitoring requirements would be focused around the WMA, inactive landfill site and sewage lagoon, where land use may be restricted.

In summary, Alternative #1 (deferment) does meet the technical feasibility criteria, as set out in Table 2.5.1-2. The technology for Alternative #1 is proven and a monitoring programs currently in place at the WL site would continue until decommissioning is complete. Monitoring during the post-closure phase for Institutional Control can be developed that meets national and international requirements.

2.5.2.4 Economic

Alternative #1 requires a prolonged deferment period (more than 30 years) and additional incremental costs associated with ongoing storage with surveillance. As long as the WR-1 Building remains in its current state, the required costs include ongoing security, fire and radiation protection, environmental monitoring and regulatory compliance programs, and maintenance and repairs to necessary infrastructure. The projected annual cost to support these ongoing activities for the WL site is between $9 million (M) and $20 M during decommissioning and $4 M in the final year after all major decommissioning has been completed. Assuming that the overall cost of storage and surveillance is related to the care and maintenance of the WR-1 Building, the cost is assumed to be about $1 M annually (i.e., a fraction of that currently projected for current storage and surveillance of the site). Deferring decommissioning a further 23 years (i.e., starting after the year 2024), would therefore entail a storage and surveillance cost of about $23 M (Table 2.5.2-1). This would be in addition to the cost of full dismantling and removal of the WR-1 Building at the end of this deferment period. The cost associated with the deferred decommissioning is anticipated to be marginally lower because of the decreased levels of radioactivity as compared to immediate decommissioning; however, these savings would be offset by the costs of a lengthy storage and surveillance period, and increased costs due to escalation.

A cost and risk estimate for packaging and transporting waste from Whiteshell Laboratories to Chalk River Laboratories has been completed as part of the overall CNL integrated waste strategy. This assessment is the basis to determine a high level cost estimate to package, transport and store wastes from the Project. Based on this assessment, the transport and packaging of waste from the WL site is expected to cost approximately $24 M (Table 2.5.2-1).

Monitoring requirements are based on the assumption that approximately 10-years of monitoring would be completed following decommissioning to verify that non-radiological and radiological clearance and release criteria in accordance with the target end-state of the Industrial land-use category.

Table 2.5.2-1: Alternative #1 Estimated Cost

Project Component	Activities	Cost ($ Million)
Storage and Surveillance after 2024	Includes ongoing security, fire and radiation protection, environmental monitoring and regulatory compliance programs.	$23
Decommissioning of WR-1 Building	Includes the complete dismantling and removal of the WR-1 Building.	<$120
Transportation and storage of waste	Waste handling, packaging and transportation of wastes to an offsite disposal facility.	$24
Monitoring Requirements	Includes environmental and performance monitoring after decommissioning is complete.	$1
	Total	$168

2.5.3 Alternative #2 – Complete Dismantling and Removal

Alternative #2 involves the complete dismantling and removal of the WR-1 Building without a deferment period and requires decommissioning activities to take place at current radiation levels. Similar to Alternative #1, this alternative involves the removal of all equipment and materials from the WR-1 Building, decontamination of building structures, demolition of the WR-1 Building and removal of the building structure to 3 m below-ground level, and removal of the WR-1. Following removal and decontamination, the facility would be subjected to a radiological survey to confirm that facility release criteria have been met. The remaining building components could be reused or recycled, transferred to an inactive landfill site, or remain in-ground and backfilled over. Once decommissioning is complete, the WR-1 Building area would likely be classified as Industrial land use, with no restrictions.

2.5.3.1 Safety

2.5.3.1.1 Worker Safety

Similar to Alternative #1, Alternative #2 will require more extensive and intrusive decommissioning compared to an ISD alternative. Full dismantling and removal will require sectioning of the fuel channels and reactor vessel, which represent the areas of highest radioactivity. Proper sectioning and bundling of all below-grade materials for safe hoisting will also require substantial work within the WR-1 Building. As decommissioning activities will be completed under current conditions of relatively high radioactivity, mitigative measures and comprehensive dose controls would be required so that regulatory worker dose limits are not exceeded. These controls would include PPE&C, specialized tools and shielding.

In addition to worker exposure to radioactivity, other industrial hazards are associated with the complete dismantling and removal of the WR-1 Building. Because much of the contaminated equipment and materials are located below-grade, removal requires considerable cutting and dismantlement to properly section and bundle materials for safe hoisting. This will increase worker exposure to risks associated with asbestos and working at heights, confined spaces and hoisting/rigging compared to an ISD option (i.e., ISD is less intrusive). Therefore, additional safety controls are required to protect workers in these areas.

The complete removal of the facility will require the offsite disposal of wastes. However, as no approved disposal facility currently exists in Canada, the wastes would need to be stored in a temporary facility and re-handled for final disposal at an unspecific future date, resulting in additional transportation and handling. In addition, the wastes transported offsite would potentially require more strenuous mitigation requirements, compared to Alternative #1 because there is no deferment period (i.e., no additional natural radiological decay).

2.5.3.1.2 Public Safety

The complete removal of the WR-1 Building without a deferment period results in the greatest volume of radioactive and hazardous waste that must be transported off-site for disposal. This would require the greatest number of truck loads between the WL site and the disposal facility resulting in an increased incremental risk of a vehicle accident. In addition, once a waste disposal facility is constructed the stored wastes may need to be transported to the facility further increasing the incremental risk of a vehicle accident.

Appropriate packaging would be used for the transport of the wastes which also takes into account foreseeable accidents. However, as the complete removal of the facility without a deferment period requires the greatest amount of transport, Alternative #2 could result in the greatest level of public concern regarding the transport of hazardous waste and potential degradation of existing transportation infrastructure.

Following the completion of decommissioning activities, the area would likely be classified as Industrial land use, with no restrictions, and require minimal long-term institutional controls. Therefore, complete removal of the facility is considered the safest long term option with respect to the public near the WL site compared to an ISD alternative.

2.5.3.2 Environmental

The potential environmental effects for Alternative #2 were assessed during the closure and post-closure phases. Similar to Alternative #1, the complete removal of the facility will require more extensive and intrusive decommissioning activities (e.g., dismantling, cutting, hoisting) compared to an ISD option. These more intrusive activities could result in increased air emissions, compared to an ISD alternative. In addition, decommissioning would take place under current conditions, where radioactivity is higher than it would be after a deferral period.

Increased air emissions, both radiological and non-radiological, can present potential risks to the public, vegetation (exposed to atmospheric release through soil) and wildlife (exposed to atmospheric release through ingestion of terrestrial plants and other wildlife). While increased air emissions are possible for the complete removal of the facility and radiological levels will be higher compared to Alternative #1 (i.e., no natural radiological decay), effective mitigation measures can be implemented to so that radioactive compounds are within applicable release limits (AECL 2001). These measures are described in detail in CNL's Revision 3 DDP (CNL 2015). The increased vehicle use during decommissioning and the transport of wastes offsite will also result in increased greenhouse gas emissions.

An air quality assessment was completed as part of the Comprehensive Study Report (CSR) for the entire WL site (AECL 2001). This CSR included the decommissioning of the WR-1 Building where it was assumed that it would be completely removed, similar to the decommissioning approach for Alternative #2. This assessment determined that appropriate mitigation can be implemented to reduce the magnitude of the predicted residual effects associated with air emissions (release of airborne radioactive particulates during decommissioning and nuisance dust and fine particulates from demolition) and therefore, they were predicted to be not significant.

As with Alternative #1, after decommissioning is complete, residual radiation may still be present but it is expected to be of very low levels (below the clearance and release levels and the soil cleanup criteria) that will not pose a risk to the natural environment at the WL site in the post-closure phase (i.e., all radioactive and contaminated materials have been removed and disposed of off-site). The footprint for the WR-1 Building will be returned to a 'natural state' that will mimic surrounding wildlife habitat which is expected to have positive effects to local wildlife. The complete removal of the WR-1 Building would also allow this portion of the site to be released for unrestricted use. This would have further positive effects related to wildlife movement (i.e., fewer workers on site and reduced sensory disturbance) and reduced wildlife habitat fragmentation (i.e., minimizes the inaccessible portions of the site to wildlife).

Compared to an ISD alternative, complete removal also eliminates the potential risk associated with groundwater leaching through the WR-1 ISD structure which could migrate to surface water and then adversely affect human health and the ecological health of terrestrial and aquatic ecosystems.

While the complete removal of the facility will result in positive effects to the environment, the environmental liabilities associated with the removed wastes will be transferred to another offsite facility which has not been constructed yet. It is not yet known if this facility will be within an industrial setting or a green-field site which could result in additional adverse environmental effects (e.g., vegetation clearing required at a green-field site).

From a social perspective, the complete removal of the facility could improve the perceived suitability of the site for future business ventures because long-lived radioactive material will no longer be present within the former WR-1 Building footprint. In addition, complete removal may allow this portion of the site to be released for unrestricted use; however, this would need to be verified against site clean-up criteria will be established in consultation with federal and provincial regulators and the public. This could result in more diverse commercial or industrial opportunities for the site and additional traditional land use activities (e.g., hunting and berry picking).

2.5.3.3 Technical

The wastes will be transported offsite for disposal and storage; however, a waste disposal facility has not yet been constructed in Canada. Therefore, wastes transported offsite will require interim storage prior to final disposal. A new storage facility may be required. Lessons learned from previous decommissioning work would be used in preparing and executing this decommissioning plan, including the World Association of Nuclear Operators, Institute of Nuclear Power Operations, and CNL.

Once decommissioning is complete, monitoring would be completed to confirm that preliminary soil clean up criteria and the non-radiological and radiological clearance and release criteria meet the target end-state of the Industrial land-use category. Long-term monitoring requirements during the Institutional Control period are expected to be relatively straightforward and include verifying that release criterial continue to be met. More intensive monitoring requirements would be focused around the WMA, inactive landfill site and sewage lagoon, where land use may be restricted.

In summary, Alternative #2 meets all technical feasibility criteria, as set out in Table 2.5.1-2. The technology for Alternative #2 is proven. Monitoring during the post-closure phase for Institutional Control can be developed that meets national international requirements. However, Alternative #2 requires that all radioactive and hazardous wastes are transported for off-site disposal and storage.

2.5.3.4 Economic

This alternative requires the implementation of comprehensive radiation protection measures so that regulatory worker dose limits are not exceeded. As such, the costs of complete dismantling are the highest of the four decommissioning alternatives. This alternative also requires a large volume of material to be removed, packaged, and transported for disposal offsite. Preliminary estimates put the cost of the work required around $120 M (Table 2.5.3-1). This estimate is at the lower end of costs experienced for complete dismantling of other reactor projects, which have ranged from $32 M to $1,094 M.

CNL has prepared a detailed cost estimate for the packaging, transportation and waste storage for the WL site. This is the basis for the waste costs associated with full dismantling of the reactor. The cost estimate for this alternative is $24M (Table 2.5.3-1).

Monitoring requirements are based on the assumption that approximately 10-years of monitoring would be completed following decommissioning to verify that non-radiological and radiological clearance and release criteria in accordance with the target end-state of the Industrial land-use category.

Table 2.5.3-1: Alternative #2 Estimated Project Cost

Project Component	Activities	Cost ($ Million)
Storage and Surveillance after 2024	Includes ongoing security, fire and radiation protection, environmental monitoring and regulatory compliance programs.	$0
Decommissioning of WR-1 Building	Includes the complete dismantling and removal of the WR-1 Building.	$120
Transportation and storage of waste	Waste handling, packaging and transportation of wastes to an offsite disposal facility.	$24
Monitoring Requirements	Includes environmental and performance monitoring after decommissioning is complete.	$1
	Total	$145

2.5.4 Alternative #3 – Complete In Situ Decommissioning

Alternative #3 involves the complete ISD of the WR-1 Building, where below-grade WR-1 systems, components and structures will be permanently encased with grout, and associated radiological and non-radiological hazards will be immobilized. The internal void spaces within the WR-1 will be grouted and the external portions of the facility are of robust construction with reinforced concrete that will provide a migration barrier between the internal contamination and the environment. The above grade uncontaminated structures will be demolished and removed. Some above grade structures will be demolished and placed within the WR-1 Building (i.e., sections of the PHT system and the ventilation system). An engineered cover will then be constructed over the grouted below-grade structure.

2.5.4.1 Safety

2.5.4.1.1 Worker Safety

The ISD approach provides significant worker safety benefits over conventional demolition. Dismantling and demolition of structures typically requires aggressive techniques to remove them, including use of hand tools to cut and downsize components. Risks to the safety of demolition personnel exist while working in close proximity to heavy equipment, from the heavy and complex lifts required to disassemble the structure, and exposure to dust from crushing and rubblization of reinforced concrete structures. Although some demolition is required with the ISD alternative, the complexity and volume is much less, therefore, reducing the safety risks to personnel (U.S. Department of Energy 2013).

Exposure to hazards is also dramatically reduced in the ISD approach. Avoidance of materials that contain asbestos, which are prevalent in the facility, provides greater safety to workers. In addition, shielding materials such as lead and reinforced concrete can produce airborne hazards during demolition, therefore these hazards are also much lower with ISD.

Along with the industrial safety benefits, the ISD approach greatly limits radiation exposure to demolition workers because it reduces the handling and movement of material and the grouting of the facility prevents migration of contaminants and radiation emissions (U.S. Department of Energy 2013). Removal, size reduction, and packaging of contaminated process equipment and legacy items contained in the structures can be an intensive operation. Under the ISD alternative, much of this equipment and material will be left within the structure and grouted in place, thereby requiring minimal handling and subsequent exposure to personnel.

Overall, the ISD alternative results in the lowest risk to workers, both from exposure to radiation and other industrial hazards, as extensive and intrusive remediation within the WR-1 Building is expected to be limited. Effective controls and mitigation can be implemented to manage worker exposure to radiation, non-radiological hazards and worker safety issues (e.g., working at heights) and these mitigation measures are expected to be less involved compared Alternatives #1 and #2.

Alternative #3 will require the transport and disposal of much smaller volumes of waste offsite. It is anticipated that the majority of wastes will be contained with the ISD structure. This will limit the volume of waste to be handled by workers.

2.5.4.1.2 Public Safety

Alternative #3 will require the lowest volume of offsite waste disposal. This is expected to have the lowest potential for vehicle accidents and public concern related to the transport of hazardous waste.

Alternative #3 represents the highest risk to the public near the WL site during the post-closure phase because most radioactive materials will still be present onsite, unlike the other alternatives where the radioactive materials are either completely or partially removed and relocated to another site for storage. However, the in situ structure will safely isolate the radioactive material that remains in the WR-1 Building, and allow the material to continue to decay naturally. In addition, an engineered cover system will be installed over the decommissioned WR-1 Building to mitigate gamma and radionuclide exposure to workers, the public and the environment. Long-term monitoring would be provided to verify that the engineered cover and the in situ structure are performing as intended. In addition, long term institutional controls and access restrictions to prevent human intrusion into the buried structure would be required (e.g., physical barriers, fencing, signage, land title instruments, deed restrictions).

2.5.4.2 Environmental

The potential environmental effects for Alternative #3 were assessed during the closure and post-closure phases. An ISD alternative will also generate air emissions, both radiological and non-radiological, during decommissioning-related vehicle use and the release of radioactive compounds as equipment is removed or prepared for ISD. However, the intensity of these emissions are expected to be lower compared to the other alternatives which involve more extensive and intrusive decommissioning activities. Effective mitigation measures can be implemented so that the release of radioactive compounds are within applicable release limits. Further, greenhouse gas emissions are expected to be the lowest for this alternative due to reduced vehicle activity during decommissioning and reduced transport of hazardous waste offsite. An ISD alternative will also require the operation of batch mixing plant for grout production and hauling of the cement and aggregate. These activities will also generate air and greenhouse gas emissions; however, these emissions are anticipated to be minor and short-term in duration and mitigation will be implemented to limit effects (e.g., use of enclosure for raw material handling).

This decommissioning alternative represents the highest risk to the environment at the WL site during the post-closure phase because the majority of radioactive materials will still be present onsite, unlike the other alternatives where the radioactive materials are either completely or partially removed. The primary effects pathway during post-closure relates to groundwater leaching through the WR-1 ISD structure which could migrate to surface water and then adversely affect human health and the ecological health of terrestrial and aquatic ecosystems. The design of the ISD will be important to minimize groundwater leaching and to protect the environment. A multi-component final cover system will be designed over the entire surface of the decommissioned WR-1 Building to mitigate moisture infiltration into the WR-1 ISD structure and hence limit leakage through the grouting to groundwater. In addition, performance

monitoring will be completed throughout the post-closure phase to confirm that the WR-1 ISD structure is functioning as intended.

Unlike alternatives #1 and #2, the presence of the WR-1 ISD structure will result in restricted land use of the WR-1 portion of the WL site. This area will require ongoing controls including Institutional Control, access restrictions, and performance monitoring; however, the amount of land associated with this area is very small relative to the size of the WL site that will have unrestricted land use. This process will require approvals from the CNSC. Through the regulatory process, stakeholders will also have an opportunity to provide input that could help shape how the WL site is used in the future.

The presence of the WR-1 ISD structure could affect the perceived suitability of the site for future business ventures due to the presence of long-lived radioactive material. This may limit potential commercial and industrial opportunities for the WL site in the future and may limit future traditional land use activities (e.g., hunting and berry picking) within this portion of the WL site. As part of the WL Closure Land-Use and End-State Plan being developed, CNL will make efforts to effectively identify and implement a path forward for economic development in the local area. While the role of the WL site may change in economic and community development in the LSA, development is expected to continue. In addition, the Community Regeneration Partnership is developing a socio-economic plan for the participating communities and rural municipalities, which is anticipated to support future economic development and subsequently community development.

2.5.4.3 Technical

Filling of structural void spaces for ISD serves the purpose of stabilizing the structure to prevent subsidence and immobilizing remaining contaminants. The introduction of fill materials, such as grout, also impedes infiltration of water and limits access to intruders (U.S. Department of Energy 2013). In addition, the advantageous functions of grout for ISD include void fill, stabilization, and shielding. Grout is used for filling void spaces and because of its flowable nature, can be introduced into the small openings of most structures easier than other fill materials. The grout formulation can be adjusted to provide structural stability to prevent subsidence of the structure over time (U.S. Department of Energy 2013). In addition, the grout is used to impede the migration of contaminants out of the confines of the structure. Various sequestering agents can be added to the grout formulation to enhance the immobilization of selected contaminants (U.S. Department of Energy 2013). Grout is also used to provide shielding for workers filling areas and/or components that contain high radiological source terms. The density of cement-based grout can provide dose reduction to gamma radiation fields, allowing workers to perform other tasks in the vicinity while maintaining exposure within ALARA guidelines (U.S. Department of Energy 2013).

Use of a cover system or final closure cap is driven primarily by local climate conditions (U.S. Department of Energy 2013). The intent of the cover system is to limit water infiltration so as to minimize the migration of contaminants to underlying aquifers. In addition, cover systems can serve as a deterrent after active Institutional Controls have ended to prevent a person who might inadvertently enter the area from being able to contact buried contamination (U.S. Department of Energy 2013).

While ISD has not yet been completed in Canada, the U.S. Nuclear Regulatory Commission (NRC) has recognized entombment as a decommissioning option since the 1970s (U.S. Department of Energy 2013). In situ decommissioning has been used or is planned to be used on a variety of projects in the United States including:

- two large reactors (P and R) and their ancillary facilities at the Savannah River Site (SRS);
- fuel processing facilities at Idaho National Laboratory (INL); and

- the below-grade portion of several small reactors facilities at INL and one at SRS.

Experience with these projects determined that ISD, in many cases, is the safest, timeliest and most cost-effective decommissioning option compared to demolishing and excavating the entire facility and transporting the rubble to a radioactive waste landfill (U.S. Department of Energy 2013).

The ISD approach provides a permanent, passive decommissioning end state, and incorporates proven technologies and best industry practices, including documented experience from the IAEA and other similar international facilities (as described above). The safety of the Project post-closure is provided by means of passive features (e.g., final cover system) that will end the need for active management, which is in alignment with IAEA Requirement 5 of SSR 5 (IAEA 2011). The performance of the combined natural and engineered barriers assure safety following the decommissioning of the WR-1. In addition, institutional controls, including restrictions on land use, and a program for monitoring will be completed in the post-closure period to demonstrate long-term safety of the public and the environment.

Alternative #3 will require the transport and disposal of small quantities of radioactive wastes offsite, although it is anticipated that the majority of wastes will be contained with the WR-1 ISD structure.

Monitoring requirements for the ISD facility may be more extensive during Institutional Control; however, these monitoring programs are relatively straight forward and similar programs are currently in place at other sites where ISD has been implemented (see above). In addition, Institutional Controls, including restrictions on land use, and a program for monitoring will be completed in the post-closure period to demonstrate long-term safety of the public and the environment. Institutional Controls will also contribute to safety by preventing or reducing the likelihood of human actions that could inadvertently interfere with the ISD facility or degrade the safety features of the facility.

In summary, Alternative #3 addresses all of the relevant Technical Feasibility criteria set out in Table 2.5.1-2. The technology for Alternative #3 is proven. Monitoring during the post-closure phase for Institutional Control can be developed that meets national international requirements. Alternative #3 is the alternative that requires the least amount of transport and disposal of wastes off site.

2.5.4.4 Economic

This alternative does not require the dismantling of the WR-1, and therefore, does not result in a large volume of waste material to be packaged, and transported for disposal at an offsite facility. Current estimates indicate costs associated with ISD activities would be about $35 M (Table 2.5.4-1). Monitoring requirements are conservatively based on the assumption that approximately 100-years of monitoring would be completed following decommissioning to verify that non-radiological and radiological clearance and release criteria in accordance with the target end-state. For Alternative #3, it is anticipated that initial monitoring costs would be higher and would decrease over time as monitoring becomes more focussed.

Table 2.5.4-1: Alternative #3 Estimated Project Cost

Project Component	Activities	Cost ($ Million)
Storage and Surveillance after 2024	Includes ongoing security, fire and radiation protection, environmental monitoring and regulatory compliance programs.	$0
Decommissioning of WR-1 Building	Includes the complete ISD of the WR-1 Building.	$35
Transportation of waste	Waste handling, packaging and transportation of wastes to an offsite disposal facility.	<$1
Monitoring Requirements	Includes environmental and performance monitoring after decommissioning is complete (i.e., 100 years).	$7
	Total	$43

2.5.5 Alternative #4 – Partial Dismantling and Removal with Partial In Situ Decommissioning of the Remainder

Alternative #4 entails the dismantling and removal of select WR-1 systems and the ISD of any remaining radioactive and hazardous materials. A series of partial ISD scenarios were examined including:

a) Dismantling and removal of fuel channels prior to ISD.

b) Dismantling and removal of fuel channels and reactor vessel prior to ISD.

c) Dismantling and removal of fuel channels, reactor vessel, and additional contaminated systems (e.g., Primary Heat Transport System and/or Moderator Systems) prior to ISD.

2.5.5.1 Safety

2.5.5.1.1 Worker Safety

This alternative results in a lower risk to workers compared to Alternatives #1 and #2 and higher than Alternative #3, both from exposure to radiation and other industrial hazards, as the extensive and intrusive remediation within the WR-1 Building is expected to be more limited. Effective controls and mitigation can be implemented to manage worker exposure to radiation, non-radiological hazards and worker safety issues (e.g., working at heights).

Alternative #4 will require the transport and disposal of radioactive and hazardous wastes offsite for disposal. The volume of waste will be less than Alternatives #1 and #2 which involve the complete removal of the facility and more than Alternative #3 which is the complete ISD of the facility. Therefore, mitigation required to protect workers from radiation exposure resulting from transport, storage and management of wastes will be less strenuous than Alternatives #1 and #2 and more extensive than Alternative #3.

2.5.5.1.2 Public Safety

Alternative #4 will require the transport and disposal of wastes offsite; however, the volume of waste will be lower compared to Alternatives #1 and #2 and higher than Alternative #3. Therefore, the risk of a vehicle to vehicle accident and public concern regarding the transport of hazardous will be lower than Alternatives #1 and #2 and higher than Alternative #3.

The level of risk to the pubic during the post-closure phase will vary depending on the reactor components removed from the WR-1 Building prior to ISD. The bulk of the remaining radioactivity in the WR-1 is situated in the reactor vessel. If the reactor vessel is removed, the potential risk to the public via groundwater leaching through the WR-1 ISD structure will decrease considerably. However, although removal of the reactor vessel reduces the radiological source term, it does not mitigate the risk from non-rad hazardous materials. Similar to Alternative #3, the in situ structure will safely isolate the radioactive material that remains in the WR-1 Building, and allow the material to continue to decay naturally. In addition, an engineered cover system will be installed over the decommissioned WR-1 Building to mitigate gamma and radionuclide exposure to the public. Long-term monitoring would be provided to verify that the engineered cover and the in situ structure are performing as intended. In addition, long term institutional controls to prevent human intrusion and access restrictions to prevent human intrusion into the buried structure would be required (e.g., physical barriers, fencing, signage, land title instruments, deed restrictions). Overall, the potential risk to the public near the WL site during the post-closure phase for Alternative #4 is expected to be higher than Alternatives #1 and #2 and similar to Alternative #3.

2.5.5.2 Environmental

The potential environmental effects for Alternative #4 were assessed during the closure and post-closure phases. Similar to all other alternatives, Alternative #4 will generate air emissions, both radiological and non-radiological, during decommissioning related vehicle use and the release of radioactive compounds as equipment is removed or prepared for ISD. The level of emissions are expected to vary depending on the number of reactor components that will be removed from the WR-1 Building which involve more extensive and intrusive decommissioning activities. Effective mitigation measures can be implemented so that radiological emissions are within applicable release limits. Alternative #4 would also require the operation of batch mixing plant for grout production and hauling of the cement and aggregate. These activities will also generate air and greenhouse gas emissions; however, these emissions are anticipated to be minor and short-term in duration and mitigation will be implemented to limit effects (e.g., use of enclosure for raw material handling).Overall, air emissions during the closure phase are expected to be lower than Alternatives #1 and #2 and higher than Alternative #3.

The level of risk to the environment during the post-closure phase will vary depending on the reactor components removed from the WR-1 Building prior to ISD. The majority of the remaining radioactivity in the WR-1 is situated in the reactor vessel. If the reactor vessel is removed, the potential risk to the environment via groundwater leaching through the WR-1 ISD structure will decrease considerably. Similar to Alternative #3, the primary effects pathway during post-closure relates to groundwater leaching through the WR-1 ISD structure which could migrate to surface water and then adversely affect human health and the ecological health of terrestrial and aquatic ecosystems that are valued by government agencies, Aboriginal peoples and/or the public. The design of the ISD will be important to minimize groundwater leaching and to protect the environment. A multi-component final cover system will be designed over the entire surface of the decommissioned WR 1 Reactor Building to mitigate moisture infiltration into the WR-1 ISD structure and hence limit leakage through the grouting to groundwater. Regardless of which reactor components are removed, the ISD of the WR-1 Building is not expected to result in a significant adverse effect to human health

and the ecological health of terrestrial and aquatic ecosystems. In addition, performance monitoring will be completed throughout the post-closure phase to confirm that the WR-1 ISD structure is functioning as intended.

Similar to Alternative #3, the presence of the WR-1 ISD structure will require a period of long-term institutional control (approximately 300 years). This will prevent this portion of the site from being released for unrestricted use by the public and Aboriginal groups. In addition, the presence of the WR-1 ISD structure could affect the perceived suitability of the site for future business ventures due to the presence of long-lived radioactive material. This may limit potential commercial and industrial opportunities for the WL site in the future and may limit future traditional land use activities (e.g., hunting and berry picking) within this portion of the WL site.

Similar to the other alternatives, a portion of the environmental liabilities and risks to the public associated with the removed radioactive waste will be transferred to another offsite facility which has not been constructed yet. It is not yet known if this facility will be within an industrial setting or a green-field site which could result in additional adverse environmental effects (e.g., vegetation clearing required at a green-field site).

2.5.5.3 Technical

Alternative #4 requires radioactive wastes to be transported offsite for disposal. An approved waste disposal facility has not yet been constructed in Canada and wastes transported offsite will require interim storage. The volume of wastes transported offsite for disposal will vary depending on what reactor components are removed, but the total volume is expected to be less than Alternatives #1 and #2, and more than Alternative #3, which is the complete ISD of the facility.

As described in Alternative #3, ISD has been implemented on a number of projects in the United States. For the small reactor facilities at Idaho National Lab and one at Savannah River National Lab, major sources of contamination was removed (i.e., reactor vessel and other components within the structures were removed), leaving below-grade small amounts of radioactivity with reasonably short half-lives that will decay to inconsequential levels in hundreds of years (U.S. Department of Energy 2013). The technical difficulty, potential personnel exposure, and cost for these projects were sufficiently low such that the reactor vessel was removed prior to grouting. For the other larger ISD projects listed in Section 2.5.4.2, the reactor vessels were grouted in place.

Monitoring requirements would be similar to that described for Alternative #3, and Institutional Controls will also contribute to safety by preventing or reducing the likelihood of human actions that could inadvertently interfere with the ISD facility or degrade the safety features of the facility.

In summary, Alternative #4 addresses all of the relevant Technical Feasibility criteria set out in Table 2.5.1-2. The technology for Alternative #4 is proven. Monitoring during the post-closure phase for Institutional Control can be developed that meets national international requirements. However, Alternative #4 requires that wastes are transported for off-site disposal and storage.

2.5.5.4 Economic

Preliminary estimates indicate that Alternative #4 will cost between $10 M and $30 M to plan and execute the sectioning, removal and packaging of the fuel channels and equipping the reactor vessel with thermal shielding (Table 2.5.5-1); however, these costs do not include the long-term storage of the fuel channels. An additional $35 M base cost for completion of the ISD is also required. The packaging, transportation and storage of wastes are estimated at $10M for fuel channel removal and $15M for the addition of the calandria. The cost of this decommissioning alternative is still lower than the estimated cost for Alternative #2 (Table 2.5.3-1). However, if

removal of additional contaminated systems is required, the cost of partial dismantling and removal with partial ISD would be the same as complete dismantling and removal.

Monitoring requirements are conservatively based on the assumption that approximately 100-years of monitoring would be completed following decommissioning to verify that non-radiological and radiological clearance and release criteria in accordance with the target end-state. For Alternative #4, it is anticipated that initial monitoring costs would be higher and would decrease over time as monitoring becomes more focussed.

Table 2.5.5-1: Alternative #4 Estimated Project Cost

Project Component	Activities	Cost ($ Million)
Storage and Surveillance after 2024	Includes ongoing security, fire and radiation protection, environmental monitoring and regulatory compliance programs.	$0
Decommissioning of WR-1 Building	Includes the partial ISD of the WR-1 Building.	$45 to $65
Transportation and storage of waste	Waste handling, packaging and transportation of wastes to an offsite disposal facility.	$10 to $15
Monitoring Requirements	Includes environmental and performance monitoring after decommissioning is complete (i.e., 100 years).	$7
	Total	$62 to $87

2.6 Summary

As described in Section 2.5.1, the alternatives are evaluated using a reason narrative approach and described according to the criteria listed in Table 2.5.1-2 (where applicable). Results are summarized in Table 2.6-1 illustrating the relative preference of each alternative, as shown below. If the alternative had a high chance of successfully addressing a particular criterion, it was rated as most favourable. Similarly, if the alternative had a moderate likelihood of addressing a criterion, it was rated as favourable; while if the alternative was assessed as having a low likelihood of success or having unacceptable risk with a particular criterion, a least favourable rating was used.



2.6.1 Safety

The extensive and intrusive decommissioning activities associated with complete removal of the facility for Alternatives #1 and #2 will require more strenuous mitigation to protect workers from radiological and non-radiological hazards, and conventional safety hazards (i.e., working at heights, confined spaces, hoisting/rigging and struck by). For Alternative #1, decommissioning activities will take place after a period of natural radioactive decay; and are therefore, considered be to more favourable than Alternative #2, which requires the most strenuous mitigation to ensure exposure/dose limits are not exceeded (i.e., ranked as least favourable). Alternative #3 is the most favourable alternative as it requires the least amount of mitigation to ensure worker exposure/dose limits are not exceeded. Alternative #3 also eliminates the need for higher exposure to other general hazards and is therefore, considered to be most favourable.

Long-term storage with surveillance associated with Alternative #1 will allow the radioactive components in the WR-1 Building to decay to safer levels minimizing the amount of material that would need to be disposed of as radioactive waste. Offsite disposal of radioactive wastes will still be required for Alternative #1, but the volume of waste to be transported is expected to be lower compared to Alternative #2 (i.e., no deferment period); and is therefore, ranked as favourable. Alternative #2 requires the greatest number of truck loads between the WL site and the disposal facility resulting in an increased incremental risk of a vehicle to vehicle accident and is therefore, considered to be least favourable. In addition, once an approved waste disposal facility is constructed the stored wastes may need to be repackaged and transported to another facility thereby increasing the amount exposure due to future handing required by workers and further increasing the incremental risk of a vehicle to vehicle accident. Alternative #3 is expected to have the lowest potential for vehicle to vehicle accidents and public concern related to the transport of hazardous waste (i.e., ranked as most favourable).

Once decommissioning is complete for Alternatives #1 and #2, the area would likely be classified as Industrial land use, with no restrictions, and require minimal long-term institutional controls. The complete removal of the facility for Alternatives #1 and #2 means that human intrusion is not considered to be a risk; as such, these alternatives were considered to be most favourable. For Alternative #3 radioactive and non-radioactive materials will still be present on-site, unlike the other alternatives where the materials are either be completely (Alternatives #1 and #2) or partially removed (Alternative #4). However, the in situ structure will safely isolate the radioactive material that remains in the WR-1 Building, and allow the material to continue to decay naturally. For both Alternatives #3 and #4, an engineered cover system will be installed over the decommissioned WR-1 Building to mitigate gamma and radionuclide exposure to workers, the public and the environment. Long-term monitoring will be provided to verify that the engineered cover and the in situ structure are performing as intended. In addition, long term institutional controls and access restrictions to prevent human intrusion into the buried structure would be required (e.g., physical barriers, fencing, signage, land title instruments, deed restrictions). As such, Alternatives #3 and #4 were considered to be favourable).

2.6.2 Environmental Effects

Increased air emissions, both radiological and non-radiological, can present potential risks to the public, vegetation (exposed to atmospheric release through soil) and wildlife (exposed to atmospheric release through ingestion of terrestrial plants and other wildlife). Alternatives #1 and #2 require more extensive and intrusive decommissioning activities, which are expected to result in increased air emissions, compared to Alternatives #3 and #4. Alternative #3 is the least extensive and intrusive decommissioning activities and are therefore, anticipated to result in lowest air emission intensity (i.e., ranked as most favourable). Although an ISD alternative also requires the operation of batch mixing plant for grout production and hauling of the cement and aggregate; emissions are anticipated to be minor and short-term in duration and mitigation will be implemented to limit effects (e.g., use of enclosure for raw material

handling). Alternative #4 requires varying amounts of intrusive decommissioning activities that can increase air emissions depending on the reactor components to be removed (i.e., ranked as favourable). While increased air emissions are anticipated for all alternatives, effective mitigation measures can be implemented so that the release of radioactive compounds are within applicable release limits.

For Alternatives #1 and #2, after decommissioning is complete, residual radiation may still be present, but it is expected to be of very low levels (below the clearance and release levels and the soil cleanup criteria) that will not pose a risk to the natural environment at the WL site in the post-closure phase (i.e., all radioactive and contaminated materials have been removed and disposed of off-site). The footprint for the WR-1 Building will be returned to a "natural state" that will mimic surrounding habitat which is expected to have positive effects to local wildlife. Complete removal also eliminates the potential risk associated with groundwater leaching through the WR-1 ISD structure that could migrate to surface water and then adversely affect human health and the ecological the health of terrestrial and aquatic ecosystems.

Alternative #3 represents the highest risk to the environment at the WL site during the post-closure phase because the majority of radioactive materials will still be present onsite, unlike the other alternatives where the radioactive materials are either completely or partially removed. The primary effects pathway during post-closure relates to groundwater leaching through the WR-1 ISD structure which could migrate to surface water and then adversely affect human health and the ecological health of terrestrial and aquatic ecosystems. The design of the ISD will be important to minimize groundwater leaching and to protect the environment. A multi-component final cover system will be designed over the entire surface of the decommissioned WR 1 Reactor Building to mitigate moisture infiltration into the WR-1 ISD structure and hence limit leakage through the grouting to groundwater. The performance of the combined natural and engineered barriers assure safety following the decommissioning of the WR-1. In addition, performance monitoring will be completed throughout the post-closure phase to confirm that the WR-1 ISD structure is functioning as intended and demonstrate long-term safety of the public and the environment. Partial dismantling and removal with partial ISD of the remaining components (Alternative #4) represents a hybrid of Alternatives #2 and #3.

Unlike Alternatives #1 and #2, the presence of the WR-1 ISD structure (Alternatives #3 and #4) will result in restricted land use of the WR-1 portion of the WL site. This area will require ongoing controls including Institutional Control, access restrictions, and performance monitoring; however, the amount of land associated with this area is negligible relative to the size of the WL site that will have unrestricted land use. This process will require approvals from the CNSC. Through the regulatory process, stakeholders will also have an opportunity to provide input that could help shape how the WL site is used in the future. While the complete decommissioning and removal of the WR-1 (Alternatives #1 and #2) removes the primary risk pathway (groundwater leaching through the WR-1 ISD structure); the environmental liabilities associated with the removed wastes will be transferred to another offsite facility. Because this offsite disposal facility is not yet constructed, it is not known if this facility will be within an industrial setting or a green-field site, which could result in additional adverse environmental effects (e.g., vegetation clearing required at a green-field site).

From a social perspective, the complete removal of the facility (Alternatives #1 and #2) could improve the perceived suitability of the site for future business ventures because long-lived radioactive material will no longer be present within the former WR-1 Building footprint. In addition, complete removal may allow this portion of the site to be released for unrestricted use; however, this would need to be verified against site clean-up criteria will be established in consultation with federal and provincial regulators and the public. This could result in more diverse commercial or industrial opportunities for the site and additional traditional land use activities (e.g., hunting and berry picking). However, it is important to note that during the Institutional Control period, there may be areas of restricted use elsewhere on the WL site (i.e., land use around the WMA will be restricted and there may be some limitations on use of the area around the inactive landfill site and sewage lagoon).

The presence of the WR-1 ISD structure (Alternative #3 and partially Alternative #4) could affect the perceived suitability of the site for future business ventures due to the presence of long-lived radioactive material. This may limit potential commercial and industrial opportunities for the WL site in the future and may limit future traditional land use activities (e.g., hunting and berry picking) within this portion of the WL site. As part of the WL Closure Land-Use and End-State Plan being developed by CNL, CNL, will make efforts to effectively identify and implement a path forward for economic development in the LSA. While the role of the WL site may change in economic and community development in the LSA, development is expected to continue. In addition, the Community Regeneration Partnership is developing a socio-economic plan for the participating communities and RMs, which is anticipated to support future economic development and subsequently community development.

2.6.3 Technical Feasibility

For the most part, all alternatives considered address the relevant Technical Feasibility criteria set out in Table 2.5.1-2. The technologies proposed are proven and have been successfully deploy at other sites for all alternatives. Monitoring requirements for Alternatives #3 and #4 will be more extensive (i.e., ranked as favourable) than for Alternatives #1 and #2 (i.e., ranked as most favourable); however, monitoring programs can be developed that meet national international requirements for all alternatives. Alternatives #1, #2, and #4 all require that wastes are transported for off-site disposal and storage. Alternative #3 will require the transport and disposal of some radioactive wastes offsite, but the majority of wastes will be contained with the WR-1 ISD structure.

2.6.4 Economic Feasibility

Alternative #1 requires a prolonged deferment period (more than 30 years) and additional incremental costs associated with ongoing storage with surveillance. The cost associated with the deferred decommissioning for Alternative #1 are anticipated to be lower than for Alternative #2 because of the decreased levels of radioactivity as compared to immediate decommissioning; however, these savings would be offset by the costs of a lengthy storage and surveillance period. Costs for waste handling, packaging and transportation of wastes to an offsite disposal facility are estimated to be similar for Alternatives #1 and #2. Decommissioning of WR-1 Building for Alternatives #3 and #4 are considerably lower than Alternatives #1 and #2, and no storage and surveillance after 2024 is required. Costs for waste handling, packaging and transportation are the lowest for Alternative #3 as most waste will be disposed of onsite.

Long-term performance monitoring is required for all alternatives to verify that non-radiological and radiological clearance and release criteria in accordance with the target end-state of the Industrial land-use category Monitoring requirements for Alternatives #1 and #2 are based on the assumption that approximately 10-years of monitoring would be completed following decommissioning; whereas, alternatives #3 and #4 are conservatively based on the assumption that approximately 100-years of monitoring would be completed following decommissioning.

Table 2.6.3-1: Summary of Estimated Project Cost for Alternatives

Project Component	Alternative #1– Deferred Decommissioning with Complete Dismantling and Removal	Alternative #2 - Complete Dismantling and Removal (no deferment)	Alternative #3 – Complete In Situ Decommissioning (ISD)	Alternative #4 - Partial Dismantling and Removal with ISD of the Remainder
Storage and Surveillance after 2024	$23	$0	$0	$0
Decommissioning of WR-1 Building	>$120	$120	$35	$45 to $65
Transportation and storage of waste	$24	$24	<$1	$10 to $15
Monitoring Requirements	$1	$1	$7	$7
Total	**$168**	**$145**	**$43**	**$62 to $87**

2.7 Conclusion

The recommended alternative for the decommissioning of the WR-1 Building based on the alternative means analysis is Alternative #3 Complete In Situ Decommissioning. The selection of the preferred alternative is based upon consideration of safety, environmental, technical and economic factors. In Situ Decommissioning is the safest technique, dramatically reducing the risk to workers compared to dismantling, and provides long-term safety to the public and the environment.

Table 2.7-1 presents a summary of the evaluation of alternatives.

Table 2.7-1: Summary of the Evaluation of Alternatives

Criteria	Alternative #1 – Deferred Decommissioning with Complete Dismantling and Removal		Alternative #2 – Complete Dismantling and Removal (no deferment)		Alternative #3 – Complete In Situ Decommissioning (ISD)		Alternative #4 – Partial Dismantling and Removal with ISD of the Remainder	
Safety								
Worker Safety								
Radiological Hazards during Decommissioning		Requires more extensive and intrusive decommissioning activities requiring more strenuous mitigation to ensure worker exposure/dose limits are not exceeded, but activities will take place after a period of natural radioactive decay		Requires the greatest amount of mitigation to ensure worker exposure/dose limits are not exceeded due to more extensive and intrusive decommissioning activities and higher levels of radioactivity		Requires the least amount of mitigation to ensure worker exposure/dose limits are not exceeded.		Requires varying amounts of mitigation to protect workers depending on the reactor components to be removed
Non-radiological Hazards during Decommissioning		Requires the greatest amount of mitigation to ensure worker health is protected due to more extensive and intrusive decommissioning activities		Requires the greatest amount of mitigation to ensure worker health is protected due to more extensive and intrusive decommissioning activities		Requires the lowest amount of mitigation to ensure worker health is protected		Requires varying amounts of mitigation to ensure worker health is protected depending on the reactor components to be removed
General Worker Safety during Decommissioning		Requires more extensive and intrusive decommissioning activities that could increase worker exposure		Requires more extensive and intrusive decommissioning activities that could increase worker exposure		Requires the least amount of intrusive decommissioning activities		Requires varying amounts of intrusive decommissioning activities depending on the reactor components to be removed
Waste Handling		Requires radioactive waste disposal offsite that is expected to be available for direct emplacement at the time of decommissioning. Interim storage will not be required		Requires the greatest volume of radioactive waste disposal offsite. The wastes will require packaging and shipment to an offsite interim storage facility; therefore the greatest amount of waste handling is required		Requires the lowest volume of radioactive waste disposal offsite; therefore the lowest amount of waste handling is required		Volume of radioactive waste to be disposed offsite will vary depending on the reactor components to be removed. The wastes will require packaging and shipment to an offsite interim storage facility.
Public Safety								
Transport of Hazardous Waste		Requires radioactive waste disposal offsite resulting in an incremental risk of a traffic accident and public concern regarding the transport of hazardous waste		Requires the greatest volume of radioactive waste disposal offsite resulting in the greatest incremental risk of a traffic accident and public concern regarding the transport of hazardous waste		Requires the lowest volume of radioactive waste disposal offsite; resulting in the lowest incremental risk of a traffic accident and lowest public concern regarding the transport of hazardous waste		Volume of radioactive waste to be disposed offsite will vary depending on the reactor components to be removed.

Table 2.7-1: Summary of the Evaluation of Alternatives

Criteria	Alternative #1 – Deferred Decommissioning with Complete Dismantling and Removal		Alternative #2 – Complete Dismantling and Removal (no deferment)		Alternative #3 – Complete In Situ Decommissioning (ISD)		Alternative #4 – Partial Dismantling and Removal with ISD of the Remainder	
Risk to Public at WL site during Post-closure	●	Institutional controls, and a program for monitoring will be completed in the post-closure period to demonstrate long-term safety of the public and the environment. However, because the WR-1 is removed, human intrusion is not considered to be a risk.	●	Institutional controls, and a program for monitoring will be completed in the post-closure period to demonstrate long-term safety of the public and the environment. However, because the WR-1 is removed, human intrusion is not considered to be a risk.	●	Institutional controls, including restrictions on land use, and a program for monitoring will be completed in the post-closure period to demonstrate long-term safety of the public and the environment.	●	Institutional controls, including restrictions on land use, and a program for monitoring will be completed in the post-closure period to demonstrate long-term safety of the public and the environment.
Environmental								
Biophysical								
Atmospheric Environment	●	More extensive and intrusive decommissioning activities will result in increased air emissions	●	More extensive and intrusive decommissioning activities will result in increased air emissions	●	Least extensive and intrusive decommissioning activities resulting in lowest air emission intensity	●	Requires varying amounts of intrusive decommissioning activities that can increase air emissions depending on the reactor components to be removed
Geological and Hydrogeological Environment	●	Results in the least amount of potential for groundwater leaching	●	Results in the least amount of potential for groundwater leaching	●	Highest potential for groundwater contamination due to leaching within the WR-1 ISD structure	●	Moderate potential for groundwater contamination (depending on the reactor components to be removed) due to leaching within the WR-1 ISD structure
Surface Water Environment	●	Results in the least amount of potential for groundwater leaching which could migrate towards surface water	●	Results in the least amount of potential for groundwater leaching which could migrate towards surface water	●	Highest potential for groundwater contamination which can migrate towards surface water	●	Moderate potential for groundwater contamination (depending on the reactor components to be removed) which can migrate towards surface water
Aquatic Biodiversity	●	Results in the least amount of potential for groundwater leaching which could migrate towards surface water and affect aquatic biodiversity	●	Results in the least amount of potential for groundwater leaching which could migrate towards surface water and affect aquatic biodiversity	●	Highest potential for groundwater contamination which can migrate towards surface water and affect aquatic biodiversity	●	Moderate potential for groundwater contamination (depending on the reactor components to be removed) which can migrate towards surface water and affect aquatic biodiversity
Terrestrial Biodiversity	●	Returned to a ‘natural state’ after decommissioning, but requires a 30 year deferment period	●	Returned to a ‘natural state’ after decommissioning	●	Long-term institutional control will limit wildlife access to the area	●	Long-term institutional control will limit wildlife access to the area

Table 2.7-1: Summary of the Evaluation of Alternatives

Criteria	Alternative #1 – Deferred Decommissioning with Complete Dismantling and Removal		Alternative #2 – Complete Dismantling and Removal (no deferment)		Alternative #3 – Complete In Situ Decommissioning (ISD)		Alternative #4 – Partial Dismantling and Removal with ISD of the Remainder	
Ecological and Human Health	●	Higher levels of air emissions during decommissioning could affect vegetation and wildlife Results in the least amount of potential for groundwater leaching which could migrate towards surface water and affect human health and the ecological health of terrestrial and aquatic ecosystems	●	Higher levels of air emissions during decommissioning could affect vegetation and wildlife Results in the least amount of potential for groundwater leaching which could migrate towards surface water and affect human health and the ecological health of terrestrial and aquatic ecosystems	●	Lower levels of air emissions during decommissioning that could affect vegetation and wildlife Highest potential for groundwater contamination which can migrate towards surface water and affect human health and the ecological health of terrestrial and aquatic ecosystems	●	Varying levels of air emissions during decommissioning (depending on the reactor components to be removed) that could affect vegetation and wildlife Moderate potential for groundwater contamination (depending on the reactor components to be removed) which can migrate towards surface water and affect human health and the ecological health of terrestrial and aquatic ecosystems
Social								
Socio-economics	●	Improves the perceived suitability of the site for future business ventures. Complete removal would allow this portion of the site to be released for unrestricted use	●	Improves the perceived suitability of the site for future business ventures. Complete removal would allow this portion of the site to be released for unrestricted use	●	Presence of nuclear facility may reduce the perceived suitability of the site for future business ventures. Long-term institutional control period prevents the release of land for unrestricted use The Community Regeneration Partnership is developing a socio-economic plan for the participating communities and RMs, which is anticipated to support future economic development and subsequently community development	●	Presence of nuclear facility may reduce the perceived suitability of the site for future business ventures. Long-term institutional control period prevents the release of land for unrestricted use. The Community Regeneration Partnership is developing a socio-economic plan for the participating communities and RMs, which is anticipated to support future economic development and subsequently community development
Land and Resource Use	●	Complete removal would allow this portion of the site to be released for unrestricted use which could include traditional resource activities (e.g., hunting and berry picking)	●	Complete removal would allow this portion of the site to be released for unrestricted use which could include traditional resource activities (e.g., hunting and berry picking)	●	Long-term institutional control period prevents the release of land for unrestricted use	●	Long-term institutional control period prevents the release of land for unrestricted use

Table 2.7-1: Summary of the Evaluation of Alternatives

Criteria	Alternative #1 – Deferred Decommissioning with Complete Dismantling and Removal		Alternative #2 – Complete Dismantling and Removal (no deferment)		Alternative #3 – Complete In Situ Decommissioning (ISD)		Alternative #4 – Partial Dismantling and Removal with ISD of the Remainder	
Technical Feasibility								
Disposal of Radioactive Wastes		Requires radioactive waste disposal offsite and assumes that an approved disposal facility will be available at the time of decommissioning and interim storage will not be required		Requires the greatest volume of radioactive waste shipment for interim storage offsite and future disposal.		Requires the lowest volume of radioactive waste shipment for interim storage offsite and future disposal.		Volume of waste disposed offsite will vary depending on the reactor components to be removed and interim storage will be required.
Proven Approach and/or Technology	The technologies proposed are proven and have been successfully deploy at other sites for all alternatives.							
Complexity of Monitoring		Delayed decommissioning means that ongoing surveillance and monitoring programs will continue; however, these programs have been in place for over 20 years at the WL site and are effective at monitoring releases to the environment. Long-term monitoring requirements during the Institutional Control period are expected to be relatively straightforward and include verifying that release criterial continue to be met.		Once decommissioning is complete, monitoring would be completed to confirm that preliminary soil clean up criteria and the non-radiological and radiological clearance and release criteria meet the target end-state of the Industrial land-use category. Long-term monitoring requirements during the Institutional Control period are expected to be relatively straightforward and include verifying that release criterial continue to be met.		Although ISD facility may require more extensive monitoring requirements during Institutional Control; these monitoring programs are relatively straight forward. Institutional Controls, including restrictions on land use, and a program for monitoring will be completed in the post-closure period to demonstrate long-term safety of the public and the environment.		Although ISD facility may require more extensive monitoring requirements during Institutional Control; these monitoring programs are relatively straight forward. Institutional Controls, including restrictions on land use, and a program for monitoring will be completed in the post-closure period to demonstrate long-term safety of the public and the environment.
Economic Feasibility								
Storage and Surveillance		Deferment of decommissioning results in the greatest storage and surveillance costs		Requires only approximately seven years of storage and surveillance		Requires only approximately seven years of storage and surveillance		Requires only approximately seven years of storage and surveillance
Decommissioning of WR-1 Building		More extensive and intrusive decommissioning results in higher decommissioning costs		More extensive and intrusive decommissioning results in highest decommissioning costs		Less extensive and intrusive decommissioning results in lowest decommissioning costs		More extensive and intrusive decommissioning results in higher decommissioning costs
Transportation of waste		Requires radioactive waste shipment offsite, but marginally lower volume due to natural radioactive decay during deferment period		Requires the greatest volume of radioactive waste shipments offsite resulting in the greatest transportation cost		Requires the lowest volume of radioactive waste disposal offsite and; resulting in the lowest transportation cost		Volume of radioactive waste to be disposed offsite will vary depending on the reactor components to be removed.

Table 2.7-1: Summary of the Evaluation of Alternatives

Criteria	Alternative #1 – Deferred Decommissioning with Complete Dismantling and Removal		Alternative #2 – Complete Dismantling and Removal (no deferment)		Alternative #3 – Complete In Situ Decommissioning (ISD)		Alternative #4 – Partial Dismantling and Removal with ISD of the Remainder	
Monitoring Requirements		It is assumed that monitoring would be required for a 10-year period following completion of decommissioning activities.		It is assumed that monitoring would be required for a 10-year period following completion of decommissioning activities.		It is conservatively assumed that 100-years of monitoring would be completed following decommissioning activities.		It is conservatively assumed that 100-years of monitoring would be completed following decommissioning activities.

Notes:



3.0 PROJECT DESCRIPTION

3.1 Introduction

This section of the Environmental Impact Statement (EIS) provides a description of the decommissioning strategy for the Whiteshell Reactor 1 (WR-1) including the WR-1 Building components, and how each component will be decommissioned through the proposed In Situ Decommissioning (ISD) approach. In Situ Decommissioning is the safest technique, dramatically reducing the risk to workers compared to dismantling, and providing long-term safety to the public and the environment. Details of the In Situ Decommissioning of WR-1 at the Whiteshell Laboratories Site (the Project) will continue to evolve during future stages of its design. At its present stage, however, the design represents a reasonable implementation scenario that is based on current engineering practice and precedents, and the experience of the engineering and environmental assessment teams and third party experts. Where there remains uncertainty around the design, conservative assumptions or options have been presented herein to provide a conservative assessment of potential effects of the Project in the environmental assessment. The final design will adhere to these assumptions and concepts.

3.1.1 Project Overview

CNL is proposing an In Situ Decommissioning (ISD) approach to decommission the WR-1 Building. The below-grade reactor systems, components and structures, and associated radiological and non-radiological hazards will be permanently disposed in situ, relying on a number of barriers, which passively resist release of contaminants such that the pubic and environment are protected. The above grade structures will be demolished and wastes will be recycled or disposed of in appropriate waste disposal facilities; although some above grade structures will be demolished and placed within the WR-1 Building. An engineered cover will then be constructed over the below-grade structure to resist intrusion and divert precipitation and surficial runoff. In situ decommissioning is a permanent, passive decommissioning end state.

The Project activities assessed in this EIS are limited to ISD of the WR-1 Building. Removal of the east wing (also referred to as east extension or east annex) and service wings of the WR-1 Complex were assessed as part of the Comprehensive Study Report (AECL 2001) and are covered under CNL's existing decommissioning licence for the Whiteshell Laboratories site (WL site; Licence No. NRTEDL-W5-8.04/2018). Activities required to prepare for ISD, such as isolation of the WR-1 Building and targeted remediation of hazardous materials, are also covered under CNL's existing decommissioning licence for the WL site. CNL is not proposing any changes to these decommissioning activities.

The general approach to ISD for the WR-1 Building involves preparing systems and structures for grouting. The below-grade structure will be filled with grout to encapsulate and immobilize radiological sources and hazardous materials for a defined period of Institutional Control. The decommissioning activities proposed as part of the Project and assessed in this EIS include:

- preparation for ISD;
- grouting of below-grade structures and systems;
- removal of above grade structures and systems (excluding the east and service wings);
- installation of an engineered cover over the grouted below-grade structures and systems;
- final site restoration;

- preparation for Institutional Control; and
- Institutional Control (includes both passive and active controls).

3.1.2 Project Schedule

CNL plans to start decommissioning activities related to the WR-1 Building in 2019. The Project site will be turned over to Institutional Control in 2024, which is assumed to last for 300 years, with active controls only required for the first 100 years. This timeframe is consistent with that required for other near surface disposal projects (range100 to 300 years), including similar projects under CNSC jurisdiction (e.g., Ontario Power Generations's Deep Geological Repository project). The proposed overall schedule, including duration, for the Project is provided in Table 3.1-1.

Table 3.1-1: Project Schedule

Description		Planned Schedule
Regulatory Schedule		
Environmental Impact Statement submitted to the Canadian Nuclear and Safety Commission (CNSC) for review		September 2017
Detailed Decommissioning Plan submitted to CNSC		September 2017
Public Review Period of EIS		October to December 2017
CNSC Licence Hearing (tentative)		October 2018
Environmental Assessment Acceptance and Site License Renewal		December 2018
Decommissioning Schedule		
Closure Phase		
1	Preparation for In Situ Decommissioning	2019 – 2021
	WR-1 Deactivation and Segregation Complete	November 2020
2	Grouting of Below-grade Systems and Structures	2021
	In Situ Decommissioning Grouting Complete	October 2021
3	Removal of Above grade Structures	2021 – 2022
	WR-1 Building Demolition and Decommissioning Complete	June 2022
4	Installation of Engineered Cover	2022 – 2023
5	Final Site Restoration	2023
6	Preparation of Institutional Control	2023
	Site Turnover for Institutional Control and Monitoring	December 2023
Post-closure Phase		
7	Institutional Control (Active)	2024 – 2124
8	Institutional Control (Passive)	2024 – 2324
9	Post-Institutional Control (Passive)	Beyond 2324

The Project phases are described as follows.

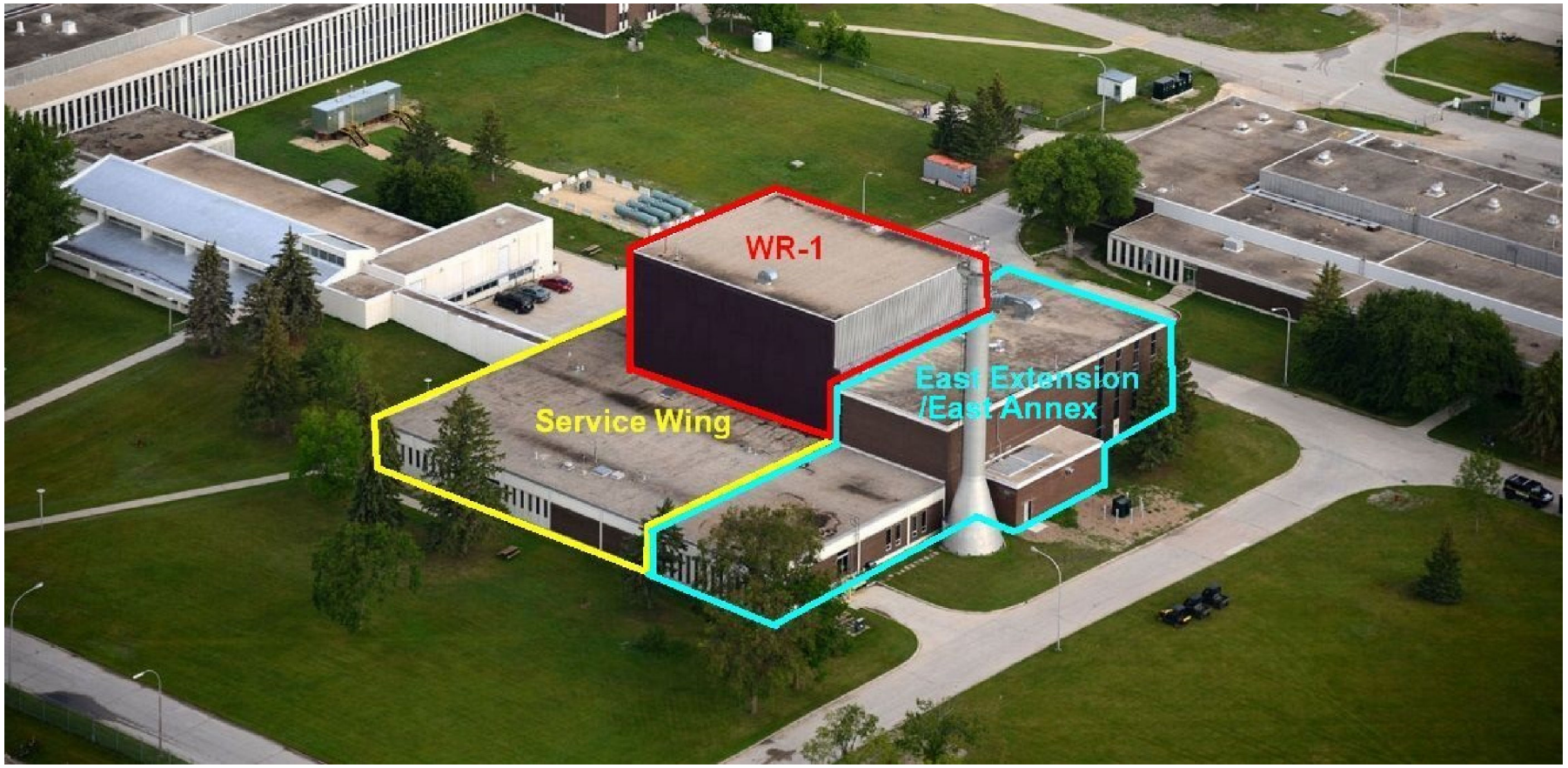
- **Closure Phase:** Preparation and implementation of ISD, which includes preparation for ISD, grouting of below-grade structures and systems, removal of above grade WR-1 structures and systems, installation of the engineered cover and environmental controls and final site restoration. These activities last from 2019 to 2024.
- **Post-closure Phase:** The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. The Institutional Control period includes implementation of both active and passive control throughout 2024 to 2324 (i.e., 300 years). During active Institutional Control, long-term performance monitoring and maintenance activities will continue through to 2124 to demonstrate compliance with the safety case assumptions. The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions) and will continue through 2024 to 2324. Post-institutional Control occurs after year 2324 and continues indefinitely.

3.2 WR-1 Building Overview

The WR-1 is housed within the WR-1 Complex, which includes the WR-1 Building and the east and service wings (Figure 1.1-1). The WR-1 Building consists of seven floors (Level 100 [bottom floor] to Level 700 [top floor]) (Figure 1.1-2), five of which are below-grade (i.e., Level 100 to 500). Level 100 (sub-basement) is located approximately 18.5 m below the main floor level (Level 600). All reactor systems are located below-grade, except for the primary coolant pumps and heat exchangers, which are contained in a shielded room protruding above the reactor hall floor. Access is restricted to the lower four levels, while the upper three floors provide office space or laboratory space for experimental programs. A portion of the 500 Level also has restricted access.

The general arrangement of the WR-1 Complex is shown in Figure 3.2.1-1. The building footprint at ground level measures 63.9 m by 52.7 m and includes the main reactor building, and east and service wings. The east annex is a two-storey extension that housed various systems, such as an experimental loop, mechanical maintenance shop, and a chemical laboratory. The service wing is a single story extension that contained offices and the reactor control room. The east annex and service wing will be decommissioned and demolished following the original decommissioning plan (AECL 2001).

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NOTE(S)

REFERENCE(S)

1. OBTAINED FROM CANADIAN NUCLEAR LABORATORIES, 2017

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	-
PREPARED	PR
REVIEWED	NR
APPROVED	-

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
GENERAL ARRANGEMENT OF THE WR-1 COMPLEX

PROJECT NO.	CONTROL	REV.	FIGURE
1656897		1	**3.2.1-1**

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3.2.1 Major Components of the WR-1 Building

3.2.1.1 The Reactor Vessel

The reactor vessel, also known as the calandria, shown in Figure 3.2.1-2, is a cylindrical stainless steel tank approximately 5 m high and 2.75 m in diameter. The reactor vessel is surrounded by thick concrete shielding (Section 3.2.1.2 Shielding). The calandria contains 54 calandria tubes; each calandria tube surrounds a pressure tube (also known as fuel channels). Between the calandria tube, and the pressure tube was an annular space filled with carbon dioxide. The pressure tubes contained the fuel and circulating organic coolant, and the calandria tubes prevented the surrounding heavy water moderator from coming into contact with the pressure tubes. The pressure tube penetrated through the top and bottom shields. Extensions of the pressure tube beyond the calandria tubes provided connections to the coolant circulation above and below the radiation shields. The reactor vessel is permanently shut down and the fuel from the pressure tubes and the circulating organic coolant was removed. Figure 3.2.1-3 show the location of the reactor vessel within the WR-1 Building.

3.2.1.2 Shielding

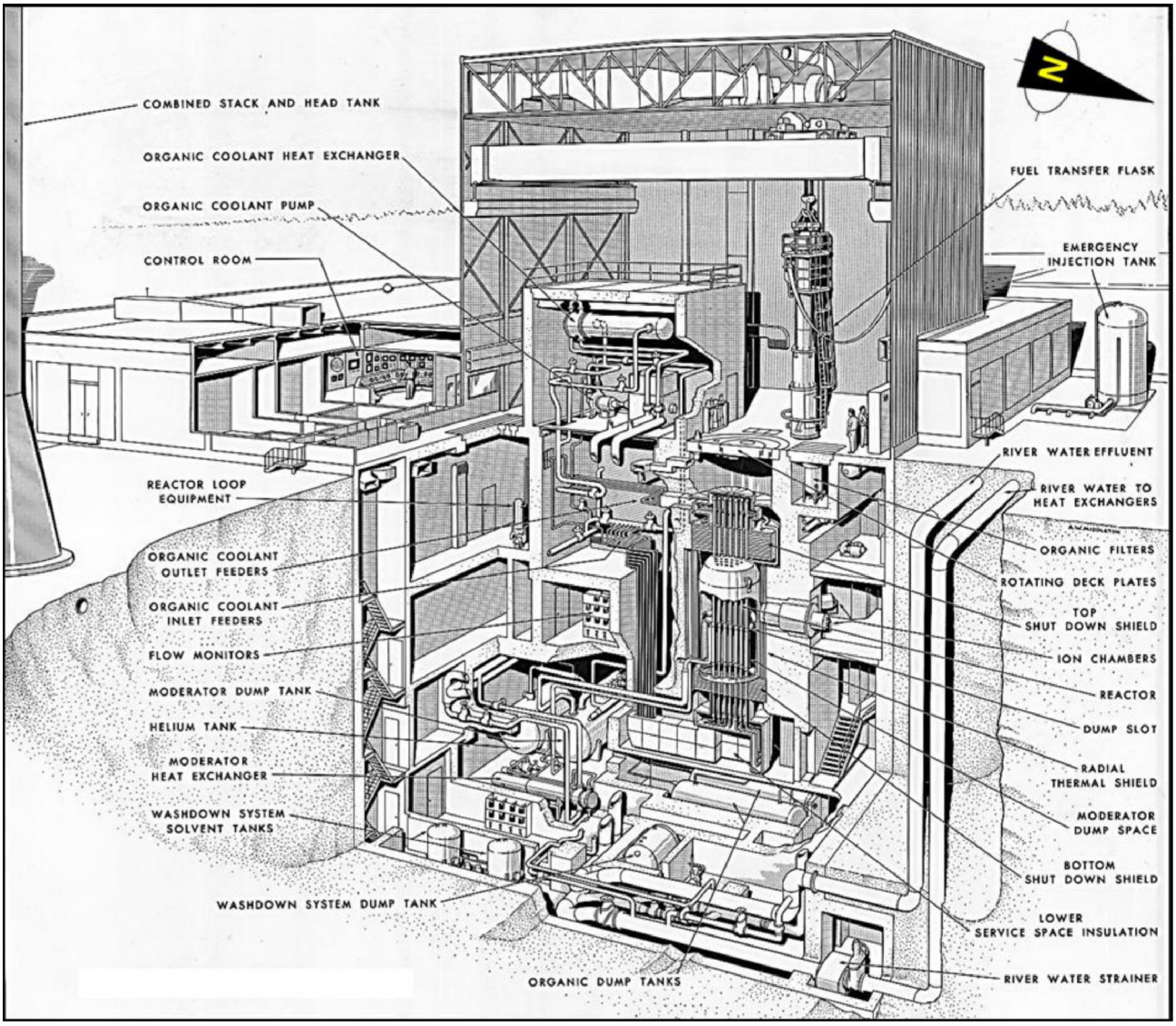
The reactor is surrounded by poured heavy concrete shielding (greater than 2 m thick), which forms the reactor vault walls (Figure 3.2.1-3). Heavy concrete (density of 3,500 kilogram per cubic metre [kg/m^3]) was also used in the vicinity of the upper and lower access rooms and the shutdown shields. Piping through the concrete provided access for heavy water and helium lines and for the reactor vault exhaust duct. There are also three penetrations for the ion chambers.

Top deck plates, which provided an operational shield between the upper access space and the reactor hall, supported the fuel transfer flask and provided the necessary radiation shielding during fueling operations. This shielding consisted of two rotating plates and an outer stationary ring. The plates are comprised of cast steel (0.45 m-thick) topped by wood fibre hardboard (Masonite; 9 centimetres [cm]-thick) and a steel cover plate (0.5 cm-thick).

3.2.1.3 Heavy Water and Helium Systems

The heavy water and helium systems provided heavy water and helium to various reactor components. The heavy water system main components are a dump tank, a helium accumulator tank, three circulation pumps, a heat exchanger, the calandria vessel, piping and instrumentation. The helium system consists of two helium pumps, two helium control valves, six reactor dump vales, a helium accumulator tank, five heavy water vapour condensers, a recombination unit, oxygen and helium addition stations, a sampling station, system piping and instrumentation. The heavy water and helium systems include the following auxiliary systems.

- **Boron addition system –** The boron addition system consists of two circuits, an initial charge circuit and a continuous addition circuit. The continuous addition circuit consists of a 45 L tank, metering pump, a mixing pump, a sample station, an addition station and a cation purification column.
- **Moderator Demineralizer system –** The moderator demineralizer system consists of three mixed bed ion exchangers. A shield flask was provided, if necessary, for the removal of highly contaminated ion-exchange columns.
- **Heavy water collection and leak detection system –** The heavy water collection system consists of a stainless steel tank, a pump, piping and instrumentation.
- **Helium Gas chromatograph –** The helium gas chromatograph consists of an analyzer, a sample conditioner, a programmer, a stream selector, and a recorder.



REFERENCE(S)

1. OBTAINED FROM CANADIAN NUCLEAR LABORATORIES, WHITESHELL LABORATORIES DETAILED DECOMMISSIONING PLAN: VOLUME 6 -WHITESHELL REACTOR #1: BUILDING 100, FIGURE 2-5 WR-1 REACTOR AT WHITESHELL, 2016

CLIENT
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PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

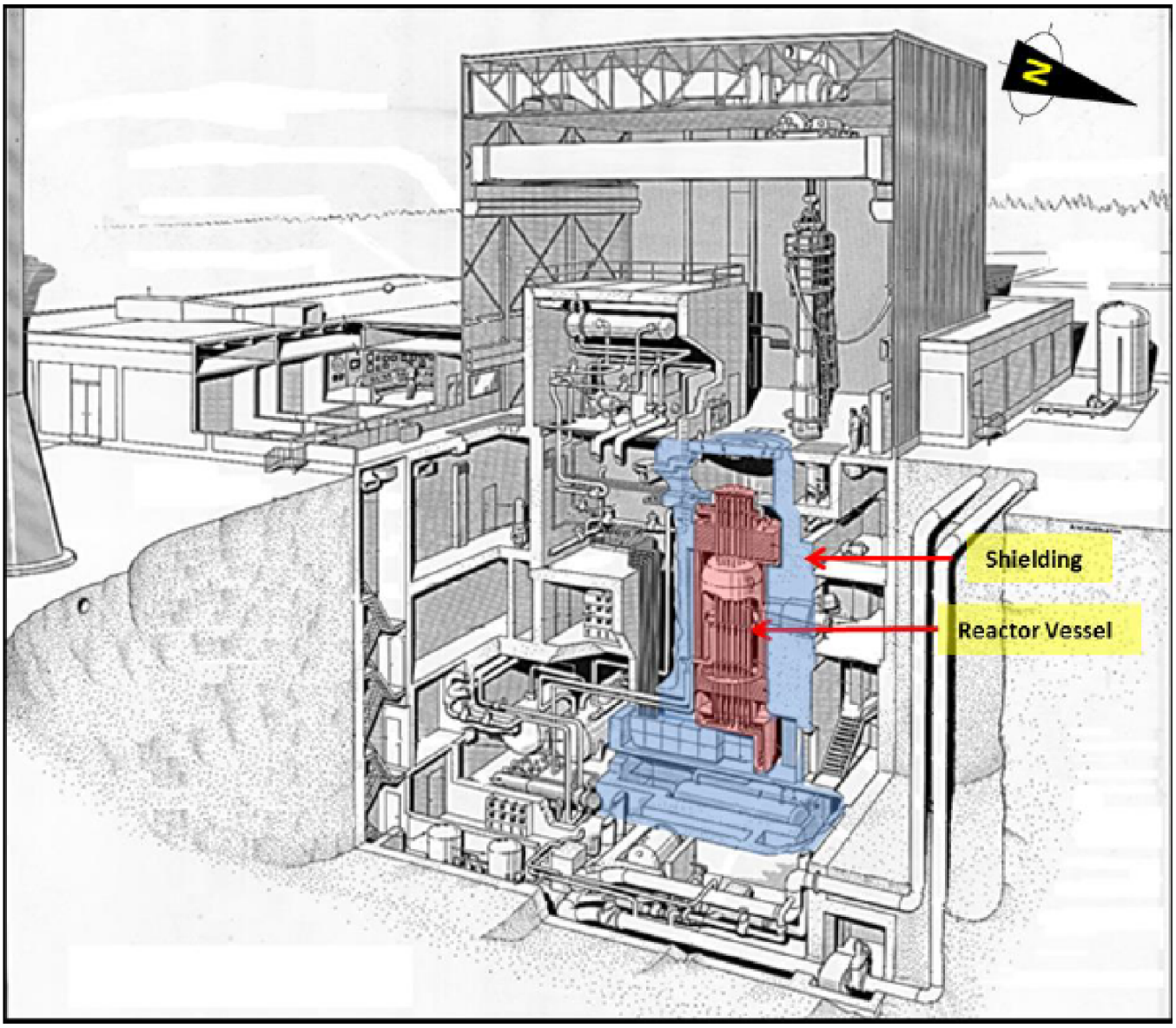
TITLE
REACTOR VESSEL

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
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PROJECT NO.	CONTROL	REV.	FIGURE
1656897		1	**3.2.1-2**

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REFERENCE(S)

1. CANADIAN NUCLEAR LABORATORIES, 2017

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PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
WR-1 BUILDING REACTOR VESSEL AND SHIELDING

CONSULTANT
Golder Associates

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PREPARED	PR/SFC
REVIEWED	RK
APPROVED	

PROJECT NO.	CONTROL	REV.	FIGURE
1656897		1	**3.2.1-3**

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3.2.1.4 Primary Heat Transport System

The Primary Heat Transport (PHT) system (shown in Figure 3.2.2-1) was designed to remove the heat produced in the reactor core. The system was divided into three circuits (A, B, and C circuits) and the heat removed was dissipated to the Winnipeg River through conventional tube-and-shell heat exchangers using an organic primary coolant and river water for the secondary coolant. With this type of heat exchanger, one fluid runs through the tubes and another fluid flows over the tubes inside the surrounding shell to transfer heat between the two fluids.

3.2.2 WR-1 Auxiliary Systems

3.2.2.1 SLOWPOKE Demonstration Reactor

The SLOWPOKE Demonstration Reactor construction was started in 1987 in the WR-1 Complex. The 2 megawatt (MW) pool-type water-cooled reactor was designed to demonstrate the viability of the reactor to provide energy for small communities or comparably-sized industrial establishments. The reactor core, hot riser duct, and primary heat exchangers were installed in a water-filled pool, inside a stainless steel-lined, below-ground concrete vault. The core consisted of four fuel bundles containing 113 kilograms (kg) of 4.9% enriched uranium oxide, surrounded by a beryllium reflector. The pool was 4.3 m in diameter by 9.8 m deep and contained 121,000 litres (L) of water. The reactor was constructed in a modular fashion to facilitate eventual decommissioning activities.

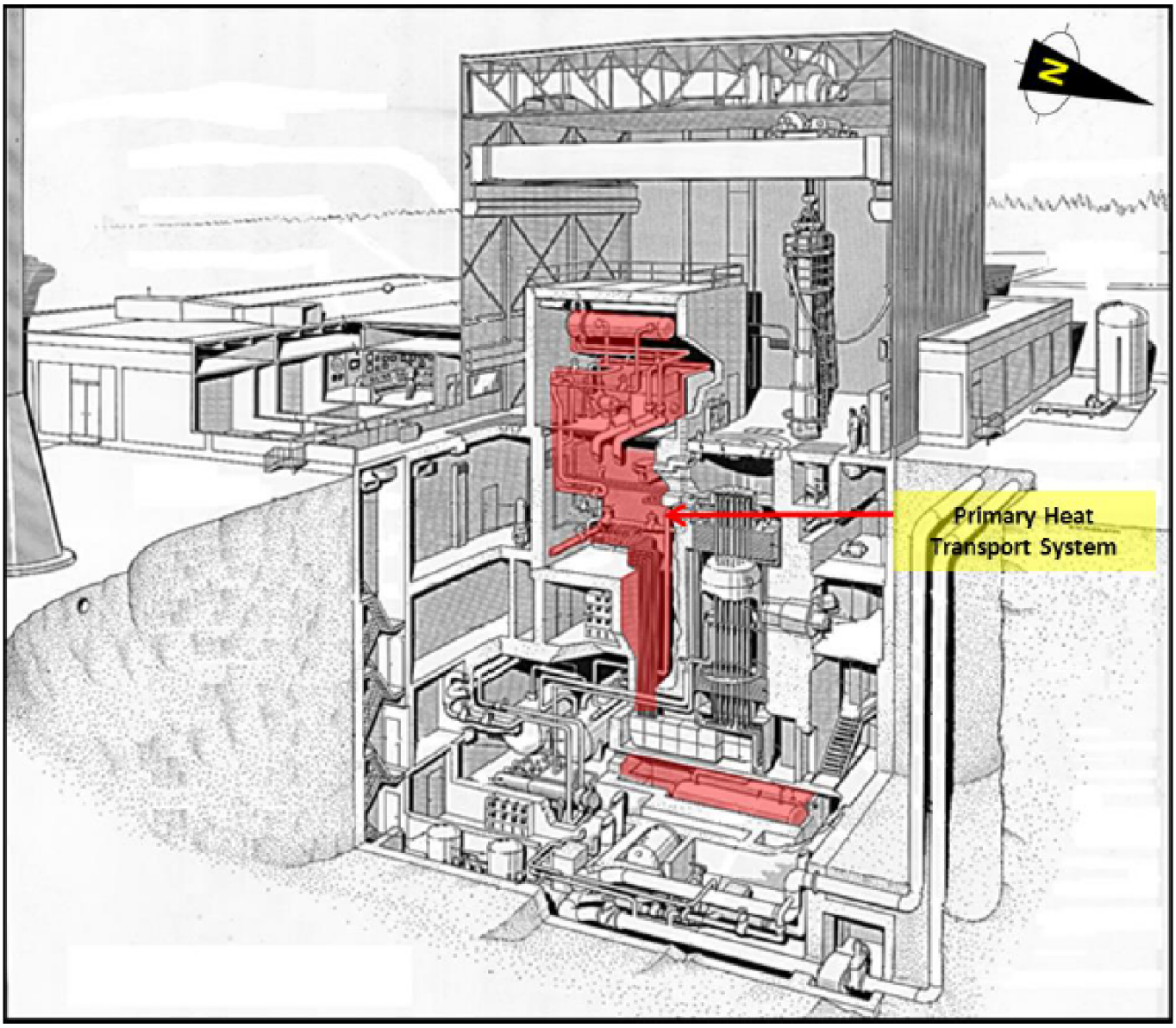
The SLOWPOKE Demonstration Reactor operated for a total of 614 hours between 1989 and 1990, at which time the reactor was permanently shut down and activities were completed to place the reactor in a secure state in preparation for decommissioning. The shutdown activities included: removing all fuel from the reactor, isolating the control systems, removing the control computer and some instrumentation, and maintaining all WR-1 Building service systems in an operating mode. In 2015, most of the remaining SLOWPOKE Demonstration Reactor systems and equipment were decommissioned. The decommissioning activities included removal of the following systems:

- Primary Cooling System;
- Secondary Cooling System;
- Reactor Control System;
- System Instrumentation; and
- Auxiliary Systems.

The reactor pool liner and the reactor cover will remain in place to be removed during the demolition of the WR-1 Complex.

3.2.2.2 Water Supply and Drainage System

Water was required as a secondary coolant for the PHT system, experimental loops, and the auxiliary systems, as well as for a primary coolant for various pumps, motors, and the WR-1 Building services. Water was also required for fire water, domestic water, and distilled water systems. The water supply system is used throughout the rest of the WL site and is sourced from the Winnipeg River via the pump house. Process and standby water was returned to the Winnipeg River through the process drainage system. An organic trap was provided on the discharge line to precipitate out any organic material carried along in the water being discharged into the river.



REFERENCE(S)

1. CANADIAN NUCLEAR LABORATORIES, 2017

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CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
WR-1 BUILDING PRIMARY HEAT TRANSPORT SYSTEM

CONSULTANT
Golder Associates

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PROJECT NO.	CONTROL	REV.	FIGURE
1656897		1	**3.2.2-1**

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3.2.2.3 Spent Fuel Handling and Storage System

Figure 3.2.2-2 shows the fuel handling and storage systems. Throughout operation irradiated fuel was removed from the reactor core with the large fuel transfer flask. The initial transfer was from the reactor to an organic coolant filled storage tube that was immersed in the water-filled fuel storage block. The fuel remained immersed in organic coolant throughout this transfer.

3.2.2.3.1 Fuel Storage Block

The fuel storage block provided a facility for storing and washing irradiated fuel, for storing irradiated fuel channels and experimental equipment, and for loading and unloading the fuel transfer flask. When the fuel had decayed sufficiently, it was transferred to the fuel storage bays using the fuel transfer dry flask.

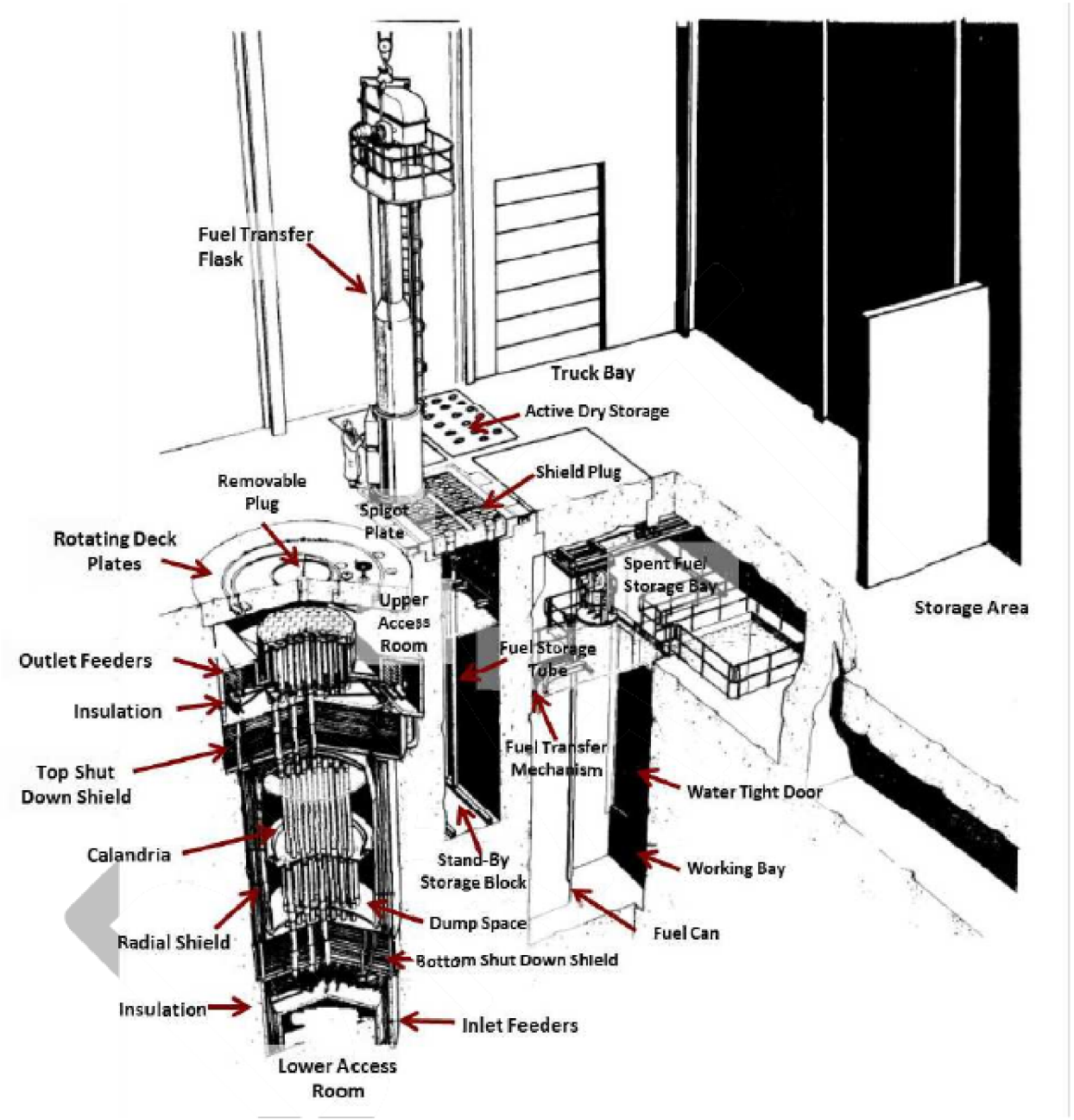
The fuel storage block consists of a concrete shielded, water-filled bay lined with stainless steel. A carbon steel operating platform is located 2 m below the top shield and was 0.3 m above the water level. The operating platform supports storage tubes and an operating walkway. A heavily shielded door controls access to the block with interlocks on the fuel transfer flask to prevent fuelling operations at the block without the door being locked shut. The top shield over the block consists of two carbon steel plates bolted together to form a 0.46 m-thick shield, flush with the reactor hall floor. Twenty-eight holes fitted with shielding plugs penetrate the shield and provide access ports to the storage tubes and the fuel channel storage racks below. Twenty-six storage tubes were provided, twenty-four tubes were for fuel storage, one as fuel washing, and one for loading and unloading the transfer flaks. The storage tubes are equipped with overflow drains and level instrumentation. The organic-filled tubes overflowed to the wash down system's used-organic coolant tank. The wash tube facility consisted of a xylene filled storage tube.

3.2.2.3.2 Spent Fuel Station

The spent fuel station provided shielding in the reactor hall during fuel transfer operations at the fuel storage block and supported the fuel transfer flask and other equipment over the block. The spent fuel station consists of a carbon steel spigot plate recessed in the reactor hall floor, with a guide tube and a fuel transfer trolley mechanism. The spigot plate was used to position the fuel transfer flask at the station. The fuel transfer trolley consists of a chain driven trolley running between two curved conveyor tracks in the fuel transfer passage. The trolley was manually powered to move spent fuel between the transfer station and the work bay. The fuel transfer flask was interlocked at the station to prevent fuel being lowered unless the trolley was in position to receive it. The guide tube is a stainless steel tube, extending between the spigot plate and the trolley station in the fuel transfer passage. Any organic dripping from the inner vessel was contained by the tube and collected by a drip tray at the base.

The spent fuel room, located one floor below the reactor hall, contains a concrete shielded work bay, two fuel storage bays and a fuel transfer passage. An electric crane for spent fuel handling, and miscellaneous tools and equipment are also located there. The work bays are constructed of light concrete with an epoxy lining. The underwater corners and joints were reinforced with fibreglass cloth. The storage bays are separated from the work bay by watertight gates. Inflatable seals on the stainless steel gates provided watertight separation of the bays for draining and maintenance. The spent fuel room crane was used to transfer fuel in the storage bay area. Storage racks were provided in each bay.

A fuel separating mechanism, for removing the hanger rod from the fuel end, and a fuel can holding station were provided in the work bay. An active fuel hanger storage facility consisting of a stainless steel tank located below floor hatch H-24 in the spent fuel room.



REFERENCE(S)

1. CANADIAN NUCLEAR LABORATORIES, 2017

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
WR-1 BUILDING FUEL HANDLING EQUIPMENT AND STORAGE BAYS

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	--
PREPARED	PR/SFC
REVIEWED	RK
APPROVED	

PROJECT NO.	CONTROL	REV.	FIGURE
1656897		1	**3.2.2-2**

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The spent fuel bay had a circulation system to remove decay heat from spent fuel, and irradiated equipment stored in the spent fuel bays and the fuel storage block. A centrifugal circulation pump forced water from the change volume tank through a tube-in-shell heat exchanger into the bottom of the storage bays, the work bay, and the storage block. A small by-pass flow from the supply line was passed through a purification circuit containing a mixed sand and gravel bed filter, and an ion-exchange column. The water returned by gravity to a change volume tank. The bay water piping was stainless steel.

3.2.2.3.3 Active Dry Storage System

The purpose of the active dry storage system was to provide a storage facility for irradiated or contaminated hardware. The storage facility consists of a concrete shielded pit. The pit is lined with stainless steel. The facility is located in the reactor hall north of the fuel storage block. The top shield consists of an 8.34 t carbon steel plate. Twenty-seven stepped access holes with carbon steel lead filled plugs are provided in three rows.

3.2.2.3.4 Fuel Wash-Down System

The fuel wash-down system provided a facility to wash fuel, encase defective fuel, and supply and drain organic coolant used by the fuel transfer flask, the fuel storage block, and the spent fuel storage bays. The wash-down system consists of a fuel wash-down station, an organic storage and pumping facility, and an organic drainage facility. The wash-down station is located in the floor of the reactor hall. It consists of a top shield, a wash tube, and an organic accumulator. The wash tube is a water-jacketed stainless steel tube with a ball valve at the top for sealing it. The external water jacket removed the decay heat from the spent fuel rod being washed.

The wash-down station was designed for washing fuel in organic coolant by moving a column in the wash tube up and down past the fuel using a free floating piston coolant accumulator. A reversible gear pump provided a supply and removal facility for coolant for the fuel transfer flask, the fuel storage block area, and the spent fuel room area. Two tanks, located in Room 109, provided a reserve supply of fresh and used organic coolant. A shielded dump tank and filter unit was provided for collecting highly active or contaminated coolant from the wash tube or the fuel transfer flask. The tank contents could also be pumped to Room 635 and drummed.

3.2.2.3.5 Transfer Flasks

A fuel transfer flask was used to transfer irradiated fuel at the reactor, the storage block, the wash-down station, and the spent fuel station. The fuel transfer flask is 10.6 m high, 1.24 m in diameter at the base, and weighs approximately 41 Mg. It consists of the following components: outer shielding with the lifting spider, inner vessel, mechanisms, and cooling system.

The outer shielding, which is the main structural member of the flask, provided support for the flask equipment and radiation shielding for active fuel carried in it. The shield is made up of three main components, the three shields rest on stepped flanged and bolted joints, which prevented radiation streaming.

The inner vessel is a stainless steel, water-jacketed tube with a ball valve and snout at the lower end. The assembly is suspended from the inner vessel hoist by a yoke attached to the upper end. The yoke travels on two screws, which will move the inner vessel in the vertical plane. The stationary tube was connected to the building ventilation system pit exhaust fan through a flexible connection during fuelling operations to remove any organic or radioactive gas released.

The cooling system consists of a stainless steel water tank mounted on the lower platform of the flask circulation pump, connection lines to and from the inner vessel water jacket and instrumentation. Steam connections were

provided to heat the cooling water or the inner vessel, if desired. In an emergency, process water could be circulated though the cooling system on a once through basis.

The fuel channel transfer flask was used to transfer irradiated fuel channels between the reactor and the storage block, to handle a fuel channel containing stuck fuel, and to transfer irradiated inserts and other radioactive assemblies not requiring cooling. The fuel channel transfer flask was similar to the fuel transfer flask except that all cable drivers were manually operated and no instrumentation or interlocks, cooling, or ventilation were provided.

A smaller transfer flask (19 Mg) was used to transfer fuel between WR-1 and the hot cells in B300. This flask consists of a shielded schedule-40 stainless steel pipe (8.1 m long), shielded with lead. Loading and unloading was done in WR-1 in a special site at the fuel storage blocking using the reactor hall crane.

The flask maintenance station was a facility for washing and maintenance of the inner vessel of the transfer flask. It was also used as a decontamination facility for the fuel handling equipment. The station is located in the reactor hall northwest of the reactor. The station consists of a base plate on the reactor hall floor to support the flask and a shaft 12 m deep with dimensions of 2.1 m by 1.8 m. Access to the platform is provided from Room 504 and Room 202, mezzanine, and from a caged ladder running the length of the shaft. A manually operated hoist served the bottom platform area. Special mechanisms were provided at the upper platform for removing the flask shutter and inner vessel assemblies.

3.2.2.4 Ventilation System

The ventilation system delivers forced air circulation throughout the WR-1 Building to provide contamination control, environment control for personnel and equipment, and air exchange necessary to maintain acceptable toxic and explosive vapor levels. The different sections of the WR-1 Building were zoned according to the degree of radioactive contamination present.

The ventilation system was designed so that air flows were always towards the zones having the higher contamination level to prevent the spread of contamination. The ventilation system was sub-divided into four systems: building, cooling, control and relay room and the building extension ventilation systems. Each system had a fresh air supply, fans, filters, heating and cooling coils and an exhaust system. All systems normally exhausted to a common stack located east of the WR-1 Building (the stack). Air flow and pressure were balanced within the zones by manual volume dampers and grilles.

For the reactor vault and the header room areas, two supply fans located in the attic above the reactor hall, supplied fresh air though an intake on the south wall of the reactor hall. The incoming air was filtered and heated or cooled by preheat and tempering coils, and distribution fans sent air to various parts of the building. A pit exhaust fan is used to remove organic vapours from the fuel transfer flask inner vessel, various flask station and organic filter cavity and the heavy water demineralizer cavity. Four banks of roll filters and absolute filter in series were monitored ahead of the exhaust fans. A smoke detector monitored the exhaust duct for smoke in the exhaust gases.

The control and relay room air conditions system drew air to replace air lost to the building ventilation system. A circulation fan drew the air through cooling coils and a bank of filters. In the event of air borne contamination entering the control room, fresh air could be supplied to flush the room. A fan was used to exhaust directly to atmosphere through a vent in the service wing roof.

The building extension ventilation system provided forced air circulation. Fresh air was drawn through an intake on the extension roof, and the air was filtered and heated/cooled as required. Various distribution fans were also part of the system. The building extension exhaust fan was located in the WR-1 service (south) wing fan room. A filter unit, consisting of roll-type pre-filters back by 12 absolute filter units in parallel, was also part of the system.

3.2.2.5 Active Drainage System

The active drainage system collects liquid effluent from the various areas of WR-1 Building and the groundwater from around the building base. The active drainage system includes five sumps:

- **active drainage sump A –** general drainage (1.68 m^3 concrete tank),
- **active drainage sump B –** heavy water drainage (2.73 m^3 concrete tank),
- **organic drainage sump A –** organic coolant leakage (1.68 m^3 concrete tank),
- **WR-1 extension active drainage sump –** general drainage WR-1 extension (3.63 m^3 concrete tank), and
- **sub-surface active drainage sump –** groundwater around WR-1 basement (15 m^3 concrete tank).

Most of the active drainage piping is welded, seamless, carbon steel pipe, where it passes through walls it is embedded in the walls and floors of the WR-1 Building. The floor traps were equipped with a back water valve, which provided a ventilation barrier to prevent the spread of airborne contamination throughout the building. All rooms near the WR-1 (other than those containing heavy water or organic piping and equipment) were drained to active drainage sump A.

Floor drains in the Moderator Room, Boron Addition Room, and Moderator Demineralization drained into the sump B concrete tank located in the floor of the Moderator Room. A sump level monitor was located to provide early warning of water in the sump. A remotely operated sampling pump was used to sample the sump effluent. Effluent was pumped from this sump to the active drainage sump A or to a drumming station.

The floor drains in rooms containing organic piping or equipment were connected to the organic drainage sump A. The drains were positioned in the rooms to handle coolant spills and the effluent could be pumped to active drainage sump A. The WR-1 extension active drainage sump collected the effluent from the control laboratory fume cabinets and sinks, the mechanical shop and the areas in the building extension. Sump contents were pumped into the active drainage sump A.

The sub-surface drainage sump is a concrete structure located outside the north wall of the WR-1 Building. A network of perforated pipe, embedded in free draining crushed stone drained the groundwater from beneath the reactor ground slab and from the periphery of the basement walls into the sump. This sump is emptied to the storm drainage system.

3.2.2.6 Other Supporting Systems

The various other ancillary systems required to support the WR-1 Building are described below.

- **Thermal Shield and Concrete Cooling System -** The thermal shield cooling system consisted of two circulation pumps, a tube-and-shell heat exchanger, a storage deaerator head tank, piping, instrumentation and miscellaneous equipment. The concrete cooling system consists of two circulation pumps, an U-tube heat exchanger, head degassing tank, six cooling coils, piping, instrumentation and miscellaneous equipment.

- **Compressed Air Systems -** The compressed air system supplies compressed air to the WR-1 Complex from the powerhouse though a carbon steel underground main, sheathed in a polyethylene protective coating. Two air receiver tanks located in the WR-1 Building provide a reserve of compressed air. Compressed air from a service air receiver tank is distributed throughout the building. Mask air is supplied from the instrument air receiver tank. A pressure reducing station supplies mask air through a humidifier bank. If the pressure regulator cannot supply the necessary volume, a second pressure reducing station is available.
- **Heating and Cooling System –** This system provides process and building heat to the WR-1 Complex and consists of several closed loop circulating heated propylene glycol solutions or water through in-duct heater coils, room heater units, or wall convectors. The main building glycol system consists of a closed loop in which a propylene glycol solution is circulated by one of two pumps. The system includes a heat exchanger and pre-heater coils. Obsolete equipment associated with the heating and cooling systems have been partially removed but the system remains operational.
- **Activity Monitoring System –** The activity monitoring system provides early detection and identification of failed fuel. The activity monitoring system consisted of 19 Geiger tube detectors, which monitored the activity of the outlet coolant from the individual fuel channel outlet feeders, and three Geiger tube detectors, which monitored the activity of the three primary heat-transport circuits. When a fuel failure occurred, the Geiger detector monitoring the affected fuel site would show an activity increase, identifying the suspected failure as one of three fuel rods.
- **Fire Protection System –** The fire protection system is operational and includes the fire detection and alarm system, the pressurized carbon dioxide fire prevention system, the fire water system, and the organic leak and smoke detection system.
- **Electrical Distribution System –** The electrical distribution system supplies power throughout the WR-1 Building and includes wiring, substations, circuits and busses. Emergency or standby electrical power is provided by four sets of diesel-driven generators located in the powerhouse. Highly reliable DC power was supplied by rectifying the normal Class IV AC power or the standby Class III AC power. Lead-acid batter banks provided backup power whenever the AC supply to the rectifiers was lost. Only one battery bank remains in the system.
- **Annunciator System –** The annunciator system is operational and consists of alarm units with lighted, engraved windows and plug-in logic circuit boards mounted in cabinets. A tone generator and associated loud speaker was mounted in each of the two control rooms to provide audible “alarm” and “clear” annunciator for the alarm units in the respective control rooms.
- **Radiological Monitoring System –** The radiological monitoring system is operational and consists of an AEP 2180 fixed radiation monitor that is used in the WR-1 Building to monitor external gamma dose rates in the work area. It provides local indication with an alarm unit mounted in the main control room.
- **Auxiliary Organic and Gas Systems –** The auxiliary organic and gas systems are those systems that supported the operation of the PHT System and included the degassing and particulate removal system, the purification system, the relief exhaust system, the organic supply system, and the nitrogen supply system. Each system generally consisted of a storage tank, service piping and instrumentation.

- **Neutron Power System –** The neutron power system consisted of the ion chambers, amplifiers, signal cables, power supplies and instrumentation.
- **Protective Systems –** There were two reactor protective systems: the Main Protective System (MPS) and the Independent Protective System (IPS). The MPS monitored all parameters in the reactor capable of leading to, or causing, a dangerous reactor accident. The IPS monitored only two parameters: the reactor flux (neutron and gamma) and the emergency coolant injection tank pressure.
- **Reactor Power Regulating System –** The reactor regulating system consisted of two regulating channels, each consisting of six blocks: instrumentation, analog control computer, a control station, a routine start-up circuit, routine test equipment and a control valve.
- **Flux Detectors –** The flux detectors consisted of a 300 cm-long co-axial cable wound around a section of a Zircaloy-2 support tube.

3.3 Current Status of WR-1 and WR-1 Building

3.3.1 Decommissioning Activities Completed to Date

The WR-1 was permanently shut down in 1985 and decommissioned to a secure state in a reduced site access-controlled area. The first stage of decommissioning of the WR-1 Building commenced in 1989 and was completed in 1994. This first stage included the removal of easily mobilized radioactivity material (e.g., fuel, fluids) and decontamination of the main floor (600 level) and first sublevel (500 level) space. The last irradiated fuel was removed from the storage bays in 1993 and transferred to dry storage at the Concrete Canister Storage Facility (CCSF) adjacent to the WL Waste Management Area (WMA). Bulk organic coolant was also removed from the reactor cooling circuits and transferred to the WL WMA for incineration or solidified for storage. The organic coolant system was drained but not flushed, therefore, it is recognized that some coolant will be present within the system, including the calandria tubes. Reactor control systems were isolated and removed, and building services systems are maintained in an operating mode. This initial decommissioning work prepared the WR-1 Building for a deferment period and substantially decreased potential hazards from the facility, reducing the monitoring and surveillance requirements for the deferment period.

Preliminary decommissioning of WR-1 included:

- defueling of the reactor following shutdown in 1985;
- draining of the organic coolant (but not flushed) from cooling circuits and transferring to the WMA and incinerated or solidified for storage, although residual quantities of organic coolant remain in the circuits;
- removing heavy water and transferring to Chalk River Laboratories for storage;
- transferring all irradiated fuel stored in the fuel storage bays to storage in the CCSF;
- decommissioning of the SLOWPOKE Demonstration Reactor; and
- maintaining all building services in an operating mode.

3.3.2 Remaining WR-1 Building Systems

Many of the remaining systems for the WR-1 are permanently shut down, and in some cases, the systems remain largely intact. Most of the electrical power has been disconnected and the systems have been placed in a safe shut down state. The only system considered as temporarily shut down is the Spent Fuel Storage Bay Water Circulation System. Decommissioning of spent fuel bays was carried out to a level where the bays were cleaned and the system drained. The bays were retained in a state where they could be placed in operation in the event that the bays were required to support future research/business programs.

Table 3.3.2-1 summarizes the operational status of the WR-1 systems, and identifies the radiological hazards of concerns for each system. All of the required service systems remain operational to maintain the WR-1 in a safe storage and surveillance state. Routine operation of these systems is documented in currently approved procedures. Building services and systems remaining in operations for the WR-1 Building include:

- Water Supply and Drainage System;
- Active Drainage System;
- Ventilation System;
- Compressed Air System;
- Activity Monitoring System;
- Fire Protection Systems;
- Electrical Distribution Systems;
- Annunciator System; and
- Contamination Monitoring System.

Since the WR-1 was shut down and preliminary decommissioning activities completed, many of the areas within the WR-1 Building have been reclassified and are no longer designated with a controlled area; this includes most of the WR-1 rooms on the 600 and 700 Levels (i.e., above-ground level) occupied by office and lab space (Figure 1.1-2). Some rooms that have been decommissioned and decontaminated at the 400 Level and lower may have systems within them that have not been completely decontaminated. These systems include some ventilation and drainage systems as well as various piping formerly connected with the WR-1 operations. Other hazards include asbestos insulating materials, residual organic coolant in piping and tanks, and building structures and service systems. Administrative controls are in place to restrict access to these areas.

The remaining hazards in the WR-1 Building are largely radiological. The currently available information on the radiological status is based on post-operation surveys, the end-state survey completed after the preliminary decommissioning work, and measurements in the reactor core taken in 2011. The bulk of the remaining radioactivity in the WR-1 is expected to be in the reactor vault.

Table 3.3.2-1: Summary of WR-1 Building Systems Status

Systems	System Description	Operational Status[(a)]	Key Hazardous Materials of Concern[(b)]
Major Components			
Reactor Vessel	Section 3.3.1.1	Permanently shut down	**AP**
Shielding	Section 3.3.1.2	Operational	**AP** (primary) – The shielding in close proximity to the reactor core, mainly the thermal and biological shields. **FP** – Cross contamination. Highest levels are expected to be the shielding in the upper and lower access rooms. Lead Potassium Hydroxide
WR-1L1 Loop	Section 3.3.1.3	Permanently shut down	Out of reactor loop, no internal contamination expected. Organic Coolant
WR-1L2 Loop	Section 3.3.1.3	Permanently shut down	**CP** (primary) **FP** – Light water cooled loop. This loop is expected to have high level of corrosion products relative to the rest of the WR-1 systems.
Fast Neutron Loops	Section 3.3.1.3	Permanently shut down, loop 1L6 removed	**FP** (primary) **CP** – 1L4 and 1L5 are contaminated (Class 1). 1L6 has been removed. Organic Coolant
SLOWPOKE Demonstration Reactor	Section 3.3.1.4	Permanently shut down. Reactor Pool has been drained.	The Reactor Pool is likely clean.
Primary Heat Transport (PHT) System	Section 3.3.2.1	Permanently shut down; Circuit C (Room 528) dismantled and removed; other systems partially removed	**FP** (Primary) **CP** **AP** – in the sections that is in the reactor core (i.e., the Pressure Tubes). Organic Coolant
Auxiliary Systems			
Water Supply and Drainage System	Section 3.3.2.2	Operational	Supply water is a MARSAME Class 3. **FP** – Process drain system is known to be contaminated (contains an organic trap).
Heavy Water System	Section 3.3.2.3	Permanently shut down	**H-3** (Primary) **CP** – Corrosion products possible from activation of structures part of the Heavy Water System in the vicinity of the reactor core and transported to the rest of the system.

Table 3.3.2-1: Summary of WR-1 Building Systems Status

Systems	System Description	Operational Status[(a)]	Key Hazardous Materials of Concern[(b)]
Helium System	Section 3.3.2.3	Permanently shut down	**H-3** (Primary) **CP** – Contamination likely in Helium sample coolers. Other parts of the system have the possibility of being cross contaminated.
Moderator Demineralizer System	Section 3.3.2.3	Permanently shut down	**H-3** (Primary) **CP**
Heavy Water Collection System	Section 3.3.2.3	Permanently shut down	**H-3** (Primary) **CP**
Helium Gas Chromatograph	Section 3.3.2.3	Dismantled and removed	**H-3** - Possible cross contamination.
Boron Addition System	Section 3.3.2.3	Partially removed	**H-3** **Boron**
Fuel Storage Block	Section 3.3.2.4	Permanently shut down	**FP** (Primary) Organic Coolant Xylene
Spent Fuel Station	Section 3.3.2.4	Permanently shut down	**FP** (Primary)
Active Dry Storage/ Fuel Wash down Systems	Section 3.3.2.4	Permanently shut down	**FP** (Primary) **CP** – Fuel wash down system coolant drainage facility is a MARSAME Class 1. Other related structures are a Class MARSAME Class 1/2.
Transfer Flasks	Section 3.3.2.4	Permanently shut down	**FP** – Internal contamination. Organic Coolant
Ventilation System	Section 3.3.2.5	Operational	Active ventilation system is MARSAME Class 1; remaining system likely clean.
Thermal Shield and Concrete Cooling System	Section 3.3.2.7	Permanently shut down	**AP** – Possible due to the close proximity to the reactor core.
Compressed Air Systems	Section 3.3.2.7	Operational	None expected.
Active Drainage System	Section 3.3.2.6	Operational	**FP** **H-3** **AP** **Mercury**
Heating and Cooling Systems	Section 3.3.2.7	Obsolete equipment partially removed; system remains operational	Likely clean, possibility of leaks from contaminated systems, most likely coolant leaks in heat exchangers in the process heating system.

Table 3.3.2-1: Summary of WR-1 Building Systems Status

Systems	System Description	Operational Status[(a)]	Key Hazardous Materials of Concern[(b)]
Activity Monitoring System	Section 3.3.2.7	Operational	None expected, possibility of cross contamination.
Fire Protection Systems	Section 3.3.2.7	Operational	None expected.
Electrical Distribution System	Section 3.3.2.7	Operational	No internal contamination expected.
Annunciator System	Section 3.3.2.7	Operational	No internal contamination expected.
Radiological Monitoring System	Section 3.3.2.7	Operational	**FP** (primary) **CP**
Emergency Injection System	Section 3.3.2.7	Mostly dismantled and removed	**FP** – Possible from cross contamination from PHT system.
Degassing and Particulate Removal System	Section 3.3.2.7	Partially removed (C Circuit; other selected equipment)	**FP** (Primary) **AP** Organic Coolant
Purification System	Section 3.3.2.7	Partially dismantled and removed	**FP** (Primary) **AP**
Relief Exhaust System	Section 3.3.2.7	Mostly dismantled and removed	**FP** (Primary) **CP**
Organic Supply System	Section 3.3.2.7	Partially removed (Bulk Storage Tank S0-TK5)	**FP** (Primary) **CP** – Cross contaminated from used organic coolant. Organic Coolant
Nitrogen System	Section 3.3.2.7	Mostly dismantled and removed	None expected.
Neutron Power System	Section 3.3.2.7	Permanently shut down	**AP** – Portions in the vicinity of the reactor core are likely to be activated. **FP** – Possibility of cross contamination.
Protective Systems	Section 3.3.2.7	Mostly dismantled and removed	None expected.
Reactor Power Regulating System	Section 3.3.2.7	Permanently shut down	Any contaminated parts of this system will remain inside the reactor core.

Table 3.3.2-1: Summary of WR-1 Building Systems Status

Systems	System Description	Operational Status[(a)]	Key Hazardous Materials of Concern[(b)]
Flux Detectors	Section 3.3.2.7	Dismantled and removed	**AP**

a) "Partially removed" means some specific equipment has been removed, but some equipment, pumps, and motors remain. "Mostly dismantled" usually means equipment removed, but associated piping remains.

b) Radiological Hazard definitions

- AP = Activation Products - Neutron activated structures and components. These will be in close proximity to the reactor core.
- FP = Fission Products.
- H-3 = Tritium - a weak beta emitter resulting from the activation of Heavy Water. Has the same chemical characteristics as water.
- CP = Corrosion products possible from activation of particles that pass through the reactor core and then get transported to the rest of the system outside of the core

MARSAME = Multi-agency Radiation Survey and Assessment of Materials and Equipment

3.4 Project Requirements

Numerous design, strategic, and regulatory requirements were considered for the development of the Project. These requirements are discussed in the following sections.

3.4.1 Design Requirements

The objective of the Project is to safely decommission the WR-1 and WR-1 Building, providing a reduction of Canada's long-term nuclear legacy liabilities through permanent, passive disposal. The Project will meet the following design requirements:

- isolate and contain contamination inside the reactor vault and limit releases of radiological and other hazardous substances from the facility;
- provide that the potential effects on humans and the environment, both during and after decommissioning, are within acceptable limits (e.g., dose limits, exposure limits, and air quality criteria);
- designed so that projections of doses to members of the public are below 0.25 millisievert (mSv)[1] per year from the long term expected evolution of the Project (i.e., all processes other than human intrusion);
- designed so that the dose to the public and to workers will be ALARA; and
- demonstrate long-term safety through a combination of site characteristics and engineered design features.

[1] Which is below the 0.3 mSv/ per year dose constraint specified in the CNSC Regulatory Guide G-320 (CNSC 2006).

3.4.2 Strategic Requirements

The Project must also meet the following strategic requirements:

- contain radioactive contamination such that risk to the public and environment is kept ALARA; and
- comply with CNL's Compliance Program requirements:
  - Radiation Protection Program;
  - Environmental Protection Program;
  - Waste Management Program;
  - Occupational Safety and Health Program;
  - Emergency Preparedness Program;
  - Nuclear Criticality Safety Program;
  - Security Program;
  - Nuclear Materials and Safeguards Management Program; and
  - Fire Protection Program.

3.4.3 Regulatory Requirements

The Project shall:

- comply, as necessary, with federal and provincial regulations, guidelines, acts, standards, and codes (see Section 1.6.1 Relevant Standards, Codes and Guidelines and CNL's Program Requirements Document [CNL 2017a]);
- provide for the long-term safety, and provide an acceptable level of protection, to the public and the environment; and
- be designed so that the effective dose rates received by and committed to a person meet the limits in Section 13(1) of the CNSC *Radiation Protection Regulations* (Table 3.4.3-1).

Table 3.4.3-1: Effective Dose Rates

Item	Person	Period	Effective Dose (mSv)
1	Nuclear energy worker, including a pregnant energy worker	(a) One-year dosimetry period	50
		(b) Five-year dosimetry period	100
2	Pregnant nuclear energy worker	Balance of the pregnancy	4
3	A person who is not a nuclear energy worker	On calendar year	1

3.4.4 Guiding Standards

In addition to considering Canadian and international safety guidance (e.g., CNSC G-320, IAEA SSR-5, IAEA SSG-23), in developing the Project, CNL considered three international standards that outline the three main stages for the decommissioning process.

- International Atomic Energy Agency, Decommissioning Nuclear Facilities: Decontamination, Disassembly and Waste Management, Technical Report No. 230, 1982.
- International Atomic Energy Agency, Factors Relevant to the Decommissioning of Land-Based Nuclear Reactor Plants, Safety Series No. 52, 1980.
- International Atomic Energy Agency, 1986 Safety in Decommissioning Research Reactors, Safety Series No. 74, STI/PUB/713.

The following three main stages are outlined in the above listed international standards for the decommissioning process.

- **Stage 1 –** Preliminary decommissioning is carried out. Fuel and easily mobilized contaminated materials are either removed from the building or placed in a stable condition. Building areas containing significant radioactive contamination are sealed against unauthorized access and maintained in a state of storage with surveillance. Premium building space may be decontaminated and released for controlled use.
- **Stage 2 –** Decommissioning activities include the removal of remaining system equipment to storage or disposal facilities, and reduction in radiation levels to an acceptance criteria level. Remaining building areas containing radioactivity above the acceptance limit are sealed against uncontrolled access and maintained in a state of storage and surveillance.
- **Stage 3 –** Reactor decommissioning is completed, allowing release of the site for alternative use. Materials, equipment, and structures in or on which radioactivity is present above authorized limits will be decontaminated, isolated or removed.

Stage 1 as outlined above is complete for WR-1, with the building currently in a safe storage with surveillance state. Activities defined in Section 3.5 Project Components are identified in a sequential fashion to meet the intent of Stages 2 (e.g., preparation for ISD, removal of above-grade structures and systems) and Stage 3 (e.g., final site restoration, preparation for Institutional Control).

3.5 Project Components

As described in Section 3.2 WR-1 Building Overview, CNL is proposing a new approach, ISD, for the decommissioning of the WR-1 Building. The decommissioning activities proposed as part of the Project include:

- preparation for ISD;
- grouting of below grade structures and systems;
- removal of above-grade WR-1 Building structures and systems;
- installation of engineered cover over grouted WR-1 Building area;
- final site restoration;
- preparation for Institutional Control; and
- Institutional Control.

A detailed description of these activities is provided in the sections below. The revised decommissioning plan for each of the WR-1 Building components described in Section 3.3 Current Status of the WR-1 and WR-1 Building are provided in Table 3.5-1.

Table 3.5-1: Decommissioning Plan for the WR-1 Building Systems

Systems	System Description	Operational Status**	Key Hazardous Materials of Concern	Decommissioning Plan
Major Components				
Reactor Vessel	Section 3.3.1.1	Permanently shut down	**AP**	Leave in place. Encapsulate in grout.
Shielding	Section 3.3.1.2	Operational	**AP** (primary) – The shielding in close proximity to the reactor core, mainly the thermal and biological shields. **FP** – Cross contamination. Highest levels are expected to be the shielding in the upper and lower access rooms. **Lead** **Potassium Hydroxide**	Leave in place. Encapsulate in grout.
WR-1L1 Loop	Section 3.3.1.3	Permanently shut down	Out of reactor loop, no internal contamination expected. **Organic Coolant**	Leave in place. Encapsulate in grout.
WR-1L2 Loop	Section 3.3.1.3	Permanently shut down	**CP** (primary) **FP** – Light water cooled loop. This loop is expected to have high level of corrosion products relative to the rest of the WR-1 systems.	Leave in place. Encapsulate in grout.
Fast Neutron Loops	Section 3.3.1.3	Permanently shut down, loop 1L6 removed	**FP** (primary) **CP** – 1L4 and 1L5 are contaminated (Class 1). 1L6 has been removed. **Organic Coolant**	Leave in place. Encapsulate in grout.
SLOWPOKE Demonstration Reactor	Section 3.3.1.4	Permanently shut down and decommissioned.	The Reactor Pool is likely clean.	To be removed during building demolition.

Table 3.5-1: Decommissioning Plan for the WR-1 Building Systems

Systems	System Description	Operational Status**	Key Hazardous Materials of Concern	Decommissioning Plan
Auxiliary Systems				
Primary Heat Transport (PHT) System	Section 3.3.2.1	Permanently shut down; Circuit C (Room 528) dismantled and removed; other systems partially removed	**FP** (Primary) **CP** **AP** – in the sections that is in the reactor core (i.e., the Pressure Tubes). **Organic Coolant**	Above-ground portion: To be relocated below grade. Below-ground portion: Leave in place. Encapsulate all in grout.
Water Supply and Drainage System	Section 3.3.2.2	Operational	Supply water should be a 3. **FP** – Process drain system is known to be contaminated (contains an organic trap).	Leave in place. Encapsulate in grout.
Heavy Water System	Section 3.3.2.3	Permanently shut down	**H-3** (Primary) **CP** – Corrosion products possible from activation of structures part of the Heavy Water System in the vicinity of the reactor core and transported to the rest of the system.	Leave in place. Encapsulate in grout.
Helium System	Section 3.3.2.3	Permanently shut down	**H-3** (Primary) **CP** – Contamination likely in Helium sample coolers. Other parts of the system have the possibility of being cross contaminated.	Leave in place. Encapsulate in grout.
Moderator Demineralizer System	Section 3.3.2.3	Permanently shut down	**H-3** (Primary) **CP**	Leave in place. Encapsulate in grout.
Heavy Water Collection System	Section 3.3.2.3	Permanently shut down	**H-3** (Primary) **CP**	Below-ground portion: Leave in place. Encapsulate in grout. Above-ground portion: To be removed during building demolition.

Table 3.5-1: Decommissioning Plan for the WR-1 Building Systems

Systems	System Description	Operational Status**	Key Hazardous Materials of Concern	Decommissioning Plan
Helium Gas Chromatograph	Section 3.3.2.3	Dismantled and removed	**H-3** - Possible cross contamination.	Has already been dismantled and removed.
Boron Addition System	Section 3.3.2.3	Partially removed	**H-3** **Boron**	Leave in place. Encapsulate in grout.
Fuel Storage Block	Section 3.3.2.4	Permanently shut down	**FP** (Primary) **Organic Coolant** **Xylene**	Leave in place. Encapsulate in grout.
Spent Fuel Station	Section 3.3.2.4	Permanently shut down	**FP** (Primary)	Leave in place. Encapsulate in grout.
Active Dry Storage/ Fuel Wash down Systems	Section 3.3.2.4	Permanently shut down	**FP** (Primary) **CP** – Fuel wash down system coolant drainage facility is a Class 1. Other related structures are a Class 1/2.	Below-ground portion: Leave in place. Encapsulate in grout. Above-ground portion: To be removed during building demolition
Transfer Flasks	Section 3.3.2.4	Permanently shut down	**FP** – Internal contamination. **Organic Coolant**	To be removed during building demolition
Ventilation System	Section 3.3.2.5	Operational	Active ventilation system is Class 1; remaining system likely clean.	Below-ground portion: Leave in place. Encapsulate in grout. Above-ground portion: To be removed during building demolition
Thermal Shield and Concrete Cooling System	Section 3.3.2.7C	Permanently shut down	**AP** – Possible due to the close proximity to the reactor core.	Leave in place. Encapsulate in grout.
Compressed Air Systems	Section 3.3.2.7	Operational	None expected.	Leave in place. Encapsulate in grout.

Table 3.5-1: Decommissioning Plan for the WR-1 Building Systems

Systems	System Description	Operational Status**	Key Hazardous Materials of Concern	Decommissioning Plan
Active Drainage System	Section 3.3.2.6	Operational	**FP** **H-3** **AP** **Mercury**	Pipes and conduits penetrating out walls to be cut to provide an air gap. Below-ground portion: Leave in place. Encapsulate in grout. Above-ground portion: To be removed during building demolition.
Heating and Cooling Systems	Section 3.3.2.7	Obsolete equipment partially removed; system remains operational	Likely clean, possibility of leaks from contaminated systems, most likely coolant leaks in heat exchangers in the process heating system.	Below-ground portion: Leave in place. Encapsulate in grout. Above-ground portion: To be removed during building demolition
Activity Monitoring System	Section 3.3.2.7	Operational	None expected, possibility of cross contamination.	Leave in place. Encapsulate in grout.
Fire Protection Systems	Section 3.3.2.7	Operational	None expected.	Below-ground portion: Leave in place. Encapsulate in grout. Above-ground portion: To be removed during building demolition
Electrical Distribution System	Section 3.3.2.7	Operational	No internal contamination expected.	Below-ground portion: Leave in place. Encapsulate in grout. Above-ground portion: To be removed during building demolition
Annunciator System	Section 3.3.2.7	Operational	No internal contamination expected.	Below-ground portion: Leave in place. Encapsulate in grout. Above-ground portion: To be removed during building demolition
Radiological Monitoring System	Section 3.3.2.7	Operational	**FP** (primary) **CP**	Below-ground portion: Leave in place. Encapsulate in grout. Above-ground portion: To be removed during building demolition

Table 3.5-1: Decommissioning Plan for the WR-1 Building Systems

Systems	System Description	Operational Status**	Key Hazardous Materials of Concern	Decommissioning Plan
Emergency Injection System	Section 3.3.2.7	Mostly dismantled and removed	**FP** – Possible from cross contamination from PHT system.	Below-ground portion: Leave in place. Encapsulate in grout.
Degassing and Particulate Removal System	Section 3.3.2.7	Partially removed (C Circuit; other selected equipment)	**FP** (Primary) **AP** **Organic Coolant**	Below-ground portion: Leave in place. Encapsulate in grout. Above-ground portion: To be removed during building demolition.
Purification System	Section 3.3.2.7	Partially dismantled and removed	**FP** (Primary) **AP**	Below-ground portion: Leave in place. Encapsulate in grout. Above-ground portion: To be removed during building demolition and encapsulate in grout.
Relief Exhaust System	Section 3.3.2.7	Mostly dismantled and removed	**FP** (Primary) **CP**	Leave in place. Encapsulate in grout.
Organic Supply System	Section 3.3.2.7	Partially removed (Bulk Storage Tank S0-TK5)	**FP** (Primary) **CP** – Cross contaminated from used organic coolant. **Organic Coolant**	Below-ground portion: Leave in place. Encapsulate in grout. Above-ground portion: To be removed during building demolition and encapsulate in grout.
Nitrogen System	Section 3.3.2.7	Mostly dismantled and removed	None expected.	To be removed during building demolition.
Neutron Power System	Section 3.3.2.7	Permanently shut down	**AP** – Portions in the vicinity of the reactor core are likely to be activated. **FP** – Possibility of cross contamination.	Leave in place. Encapsulate in grout.
Protective Systems	Section 3.3.2.7	Mostly dismantled and removed	None expected.	To be removed during building demolition.
Reactor Power Regulating System	Section 3.3.2.7	Permanently shut down	Any contaminated parts of this system will remain inside the reactor core.	Leave in place. Encapsulate in grout.

Table 3.5-1: Decommissioning Plan for the WR-1 Building Systems

Systems	System Description	Operational Status**	Key Hazardous Materials of Concern	Decommissioning Plan
Flux Detectors	Section 3.3.2.7	Dismantled and removed	**AP**	Leave in place. Encapsulate in grout.

* Location described is where most equipment of a specific system is located. Piping, pumps, motors, heaters and control equipment for a specific system are often in multiple locations in the WR-1 Building.

** "Partially removed" means some specific equipment has been removed, but some equipment, pumps, and motors remain. "Mostly dismantled" usually means equipment removed, but associated piping remains.

AP = Activation Products – Neutron activated structures and components. These will be in close proximity to the reactor core; **FP** = Fission Products; **H-3** = Tritium – a weak beta emitter resulting from the activation of Heavy Water. Has the same chemical characteristics as water; **CP** = Corrosion products possible from activation of particles that pass through the reactor core and then get transported to the rest of the system outside of the core.

3.5.1 In Situ Decommissioning

The following sections describe the general process for ISD of the WR-1 Building. They are presented in their general order of execution. However, there are opportunities to carry out portions of the work in parallel. As such, the actual order of execution may be somewhat more complex than the description implies. However, while the order of execution may vary, the overall scope of activities is not expected to vary considerably except as required to ensure safe work execution, and to ensure long term safety to the public and the environment.

3.5.1.1 Preparation for In Situ Decommissioning

Preparation for decommissioning will involve a combination of sealing penetrations in the exterior walls, penetrating internal walls and equipment to provide flow paths for grout, displaced air, and dissipated heat, and establishment of temporary infrastructure to support grout production and placement.

3.5.1.1.1 Deactivation of the Building

The first stage of decommissioning the WR-1 Building will be to transition to a 'cold and dark' state, in which all building services, including HVAC, electrical supply, water supply and drains, and data services are disconnected, and the building is completely deactivated. Temporary services will be installed to support safe occupancy of the building, and to permit physical decommissioning work to be carried out, including lighting, emergency signals, ventilation, sump water collection, and electrical power for tooling. The goal of this step is to reduce the risk of cutting into pressurized or electrified systems during grout preparation work and allow the majority of building materials to be penetrated, cut or removed as appropriate.

Deactivation of these services may require the following steps:

- isolation of building electrical supply;
- draining of all devices containing ozone-depleting substances by qualified personnel, and removal of hazardous waste materials, as necessary;
- removal of asbestos and other hazardous material;
- removal of radioactive liquids from drain lines;
- removal of remaining surplus equipment (e.g., cabinets, sinks);
- removal of utility services, systems and major components (e.g., heating boilers, chiller);
- characterization packaging and transfer of radioactive and hazardous waste material for management in an approved waste storage facility or transferred to an offsite processing facility; and
- installation of temporary services to support safe execution of the decommissioning work.

3.5.1.1.2 Seal Building Penetrations

While the exterior walls of the below grade portion of the WR-1 facility are intact, there are several locations where penetrations exist to allow mechanical and electrical services to enter the building. As part of closure activities, any perforations in the foundation will be filled and sealed, and any system components (e.g., piping or conduits) that exist within 1 m of the foundation wall and floor, or equivalent barrier, will be removed to ensure no voids are present adjacent to the foundation. The penetrations will be sealed with an engineered plug to ensure the outer wall of the below grade portion of WR-1 is a continuous and uninterrupted barrier to mitigate releases to the environment.

3.5.1.1.3 Create Grout Flow Paths

In order to permit grout to fully encapsulate the below grade systems it may be necessary to penetrate interior walls, piping systems, or tanks. For interior walls, pathways may be created between rooms to allow flow of grout into, and air and grout curing heat out of all areas of the below grade structure. For piping systems and tanks, penetrations may be made at strategic locations to allow grout to further penetrate into tanks and piping systems for a two-fold purpose:

1) Reduce buoyancy loads from empty tanks and large pipes surrounded by liquid grout.

2) Provide additional barriers to release of contamination, above and beyond that already accounted for by the planned macro-encapsulation.

3.5.1.1.4 Supporting Infrastructure

In order to provide consistent quality, and timely application of grout, CNL plans to assemble a temporary batch mixing plant onsite. Grout produced by the batch plant would be transferred to trucks, which will transport the grout to the pumping location. A water tank, piping, power and settling ponds may need to be constructed. A settling pond, for equipment wash-out, will be sampled prior to being released or recycled to the batch plant.

3.5.1.1.5 Targeted Remediation

Some hazardous materials (such as PCB containing light ballasts or removable lead shielding) may be remediated, to reduce the levels of contaminated materials within the building prior to ISD. This effort will be limited to materials that are easily accessed, and present a relatively low hazard to workers to remove. This will help to further reduce the levels of hazardous materials left within the structure for encapsulation during ISD, and keep exposures to workers, the public and the environment ALARA.

3.5.1.2 Grouting of Below Grade Structures and Systems

Filling of structural void spaces for ISD serves the purpose of stabilizing the structure to prevent subsidence and immobilizing remaining contaminants. The introduction of fill materials, such as grout, also impedes infiltration of water and limits access to intruders (U.S. Department of Energy 2013). Grout is used for filling void spaces and because of its flowable nature, can be introduced into the ‘nooks and crannies’ of most structures easier than other fill materials. In addition, the grout is used to impede the migration of contaminants out of the confines of the structure. Grout is also used to provide shielding for workers filling areas and/or components that contain high radiological source terms. The density of cement-based grout can provide dose reduction to gamma radiation fields, allowing workers to perform other tasks in the vicinity while maintaining exposure within ALARA guidelines (U.S. Department of Energy 2013).

The grout will be designed to achieve the required physical properties to provide adequate resistance to damage, and release of contamination. The design will take into account the effects of using local fill materials (e.g., sand and gravel) and the materials the grout will interact within the WR-1 below grade structure (e.g., aluminium). Multiple grout formulations may be necessary to achieve complete filling of the below grade structure, but all formulations will adhere to the same minimum requirements to ensure the final end state performs as expected.

Grouting of the below grade structure will be carried out in stages. The structure will be filled to eliminate as many void spaces as is reasonably achievable. The placement of the grout will be completed using an engineered fill schedule (i.e., grouting plan). Multiple lifts of grout will be executed to systematically encapsulate

the reactor systems and the entire below grade structure. The maximum lift size (depth of fresh grout) will be determined for each room based on the structural properties of the room, and the presence of equipment that could be crushed, filled or dislodged if grout is poured too quickly. Each lift of grout will be given sufficient time to cure before additional grout is poured. Smaller lifts may be used in specific areas, for example to fill targeted voids. Quality control measures on grouting operations will be implemented to ensure all requirements for the grout are met and the final product will perform as expected.

3.5.1.3 Removal of Above-grade WR-1 Building Structures

Removal of above-grade WR-1 Building components will consist of the dismantling and removal of remaining WR-1 Complex after encapsulation has been completed. The main reactor hall structure, the concrete room that contains the PHT, the 50-ton reactor hall bridge crane, and the ventilation stack will be demolished. Recyclable materials will be segregated where practicable and recycled as appropriate. Materials that cannot be interred without disassembly (e.g., materials containing asbestos) will be sent for storage/disposal offsite as appropriate No material or equipment from outside the WR-1 Building will be disposed of as part of the ISD of the WR-1 Building.

The balance of the WR-1 Building is expected to contain minimal radiological contamination in most areas. The above-grade building will be decontaminated to the extent practical to allow the bulk of the construction material to be reused, recycled, or disposed of to an inactive landfill. Segregation and performance of radiological surveys (i.e., characterization of material to be disposition) of the building rubble will be undertaken, if required. If the building has satisfactorily been cleared then no clearance of the rubble should be required unless there is a potential for cross contamination during the demolition process.

Hazardous substances exceeding release criteria, with the exception of asbestos, will be removed and managed in accordance with CNL's Environmental Protection and Waste Management requirements. Radiological contaminated asbestos, if present, will be packaged for storage at the Shielded Modular Above-Ground Storage (SMAGS). Some clean asbestos may be removed and will be disposed of in accordance with Environmental Protection requirements at the WL landfill or an offsite landfill. Soil surrounding the foundation will be segregated and radiological clearance surveys will be performed, and subsequent remediation will be completed as required. Decommissioning activities will be undertaken in compliance with the site license requirements and executed in a manner protecting workers, the public and the environment.

Buildings and structures will be dismantled and demolished in an orderly manner. For example, a building would likely be stripped to the bare shell, with all of the wood, plaster and room dividers removed. The metal roof would then be removed, leaving the concrete structure available for final demolition. If feasible, the building material and structure will be reused or recycled. After demolition, the area will be backfilled and graded as necessary to achieve the required drainage conditions.

3.5.1.4 Installation of Engineered Cover

After all below grade grouting has been completed, and the above-grade structures have been removed, a final engineered cover will be installed over the former footprint of the WR-1 Building. The intent of the cover system is to limit water infiltration so as to minimize the migration of contaminants to underlying aquifers. In addition, cover systems can serve as a deterrent after active Institutional Controls have ended to prevent a person who might inadvertently enter the area from being able to contact buried contamination (U.S. Department of Energy 2013). The engineered cover will be designed to resist infiltrating water, divert surface run off away from the structure, and resist intrusion, either by humans, animals or plants. The design life of the engineered cover

will be 300 years, aligning with the Institutional Control period. The area surrounding the engineered cover will be graded and drainage measures will be installed to manage precipitation.

The engineered cover will act to reduce infiltration to 0.8 mm per year, by being constructed of impermeable material (a recharge rate of 2 mm per year represents the backfill area beyond the WR-1 ISD structure footprint). Further, the cover will be graded to provide enough topographic relief to result in surface runoff from the site falling on the site to flow beyond the boundaries of the WR-1 ISD structure footprint by 2 m. The minimum top plateau slope and maximum side slope grade will be implemented to ensure drainage off the WR-1 ISD structure.

Design of the engineered cover will provide the following additional features:

- erosion protection to ensure that the rate of erosion due to action of surface water and wind is minimized;
- subsidence protection to ensure settlement of the foundation soils can be withstood;
- structural stability, specifically designed to withstand potential severe weather events and seismic events; and
- intrusion barrier to prevent accidental intrusion (e.g., excavation or drilling).

This design will meet the design criteria required, as well as provide the required service life of 300 years, aligning with the Institutional Control period.

3.5.1.5 Final Site Restoration

Upon completion of the installation of the final engineered cover, turf grass will be established and maintained. Maintenance of the engineered cover includes restricting weed establishment and preventing surface erosion and abrasion. The surrounding grounds that were disturbed during demolition and decommissioning activities will be graded and restored with a grass seed mixture compatible with the surrounding area. The drainage system for the reclaimed Project site will have the similar physical characteristics as the natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. The Project site and final cover will be graded to promote drainage from the site to the Winnipeg River.

3.5.1.6 Preparation for Institutional Control

The grouted area will be fenced as part of institutional controls. Routine surveillance of the site will likely include inspecting the engineered barrier for subsidence, erosion and animal or other intrusions. Additional groundwater monitoring wells will be installed, as required, to monitor the performance of the WR-1 ISD structure.

3.5.2 Temporary Supporting Infrastructure

Temporary infrastructure may be required to support the Project during closure activities, and may include:

- batch mixing plant for preparation of grout;
- construction trailers;
- safety and security fencing; and
- equipment paddock and lay down area.

3.5.3 Waste Generation and Management

The handling and disposal of waste material resulting from decommissioning of the WR-1 Building will be conducted in accordance with CNL company-wide requirements:

- Waste Characterization and Tracking;
- Waste Minimization Program Requirements;
- Management of Solid Waste;
- Management Liquid Waste; and
- WL Waste Materials Management.

Waste handling and disposal will be in accordance with the Waste Management Program. For a summary of the waste streams volumes anticipated to require management and clearance criteria refer to the Detailed Decommissioning Plan (DDP), specifically Table 7-9 of CNL 2015).

3.5.3.1 Radiological Wastes

Radiological wastes will be generated by decommissioning activities. The source of these wastes include:

- Preparation of reactor systems for ISD – contaminated tools and personal protection equipment will be generated.
- Removal of the WR-1 Building above-grade structure – contaminated equipment and structures will need to be handled, such as active ventilation and reactor deck plates.
- Decommissioning fueling and fuel channel flasks currently stored in the WR-1 Building Hall.
- Grouting Activities – contaminated personal protective will be generated.

Radioactive wastes such as personal protective equipment are not planned for encapsulation and will be managed in the WMA or transported offsite (e.g., CNL's Chalk River Laboratories in Ontario).

3.5.3.2 Hazardous Non-Radiological Wastes

Targeted removal of hazardous substances remaining within the WR-1 Building will generate small quantities of non-radiological hazardous wastes. Hazardous wastes will be managed in accordance with CNL's waste management practices (CNL 2017b,c) and Environmental Protection Program (CNL 2017d), and will meet all Federal, Provincial and Municipal requirements. The wastes will be shipped offsite to an appropriate hazardous waste facility, or encapsulated in the same manner as radiological wastes where it is demonstrated safe to do so.

3.5.3.3 Clean Wastes and Likely Clean Wastes

Removal of the WR-1 Building above-grade structure and decommissioning of the temporary supporting infrastructure will generate clean and likely clean waste. Likely clean wastes will be monitored for radioactivity in accordance with Radiation Protection Program and Waste Management Program requirements to confirm that these are clean. Any wastes not meeting criteria for classification as clean will be managed as radioactive waste. Disposal methods for clean waste materials will meet all Federal, Provincial and Municipal requirements. The disposition options are: reuse or recycle, disposal in an offsite landfill, and disposal in the CNL landfill.

3.5.3.4 Transporting Radioactive Waste Off-Site

The transport of radioactive waste is regulated under the *Packaging and Transport of Nuclear Substances Regulations*. Key activities consist of:

- loading the waste into an approved shipping container;
- loading the container onto the vehicle;
- monitoring the vehicle for contamination and cleaning it, if necessary; and
- driving the transport vehicle to an approved facility.

3.5.4 End-State and Post-Closure Activities

The final end-state for WR-1 will be a multilayered ISD structure that applies a Defense-in-Depth strategy through the use of numerous barriers (Figure 3.5.4-1). The primary pathway for release of contamination from the system is by groundwater that has infiltrated into the sub-surface structure, picked up contamination, and then carried it out of the sub-surface structure to the groundwater. Each layer of the WR-1 ISD structure provides an additional measure to prevent and mitigate the release of contaminants to protect the Public and the Environment. The layers of defence against contaminant release include reactor system components, grout, internal walls, outer foundation walls, the local geosphere, an engineered cover, and active environmental monitoring. Combined, they form a rigorous system of barriers to provide long term safety to the Public and the Environment.

3.5.4.1 Multilayered In Situ Decommissioning System

3.5.4.1.1 Reactor Core and Bioshield Components

The overwhelming majority (~97%) of the remaining contamination in WR-1 is located within the piping and tanks that make up the reactor systems (primarily in the calandria and fuel channels). The contamination is both on the internal surfaces (surficial contamination) as well as embedded in the material itself (activated components). In some cases, the components themselves are the contaminant (e.g. lead). These system components are the initial barrier, and must first breakdown through corrosion and dissolution in order for contamination to be released to any groundwater. Prior to their corrosion and dissolution, no contamination within them will be released. Breakdown of the reactor system components is expected to occur gradually over thousands of years.

3.5.4.1.2 Grout

The grout encapsulates all the reactor system components, as well as any small amounts of contamination that are present outside of the reactors system components at the time of grouting (shown as concrete injection on Figure 3.5.4-1). The grout provides a structural support to the building, and restricts water movement within

WR-1. This has a twofold benefit: 1) it slows down the process which will corrode the system components, extending their lifetime as the initial barrier to containment, and 2) it slows the movement of contamination from outside of the system components, as well as contamination from the degraded system components. The grout will slowly degrade over time, allowing water movement to increase as it degrades, though this is expected to occur over thousands of years, and not at all once.

3.5.4.1.3 Internal Walls

Internal building walls and floors provide an additional barrier between sections of grout. While penetrations exist in these interior walls (to allow services to pass between rooms), they are mostly sealed for operational purposes such as fire-stopping. Any remaining penetrations are plugged by grout during the grouting process, and are small in relation to the walls themselves. The internal walls and floors are largely painted or otherwise coated to seal the concrete to protect it from wear, provide traction, or for preventing internal contamination of the concrete. These sealants provide a waterproof barrier in many locations and will limit the speed at which water may move in to, and out of, the structure, further limiting the speed at which the system components or grout may degrade, and the rate at which the contamination can leave the grouted areas. The sealants on these walls must first degrade to allow more prominent water movement in the materials, before degradation of the concrete can begin. Concrete degradation, like the grout, is expected to occur over longer periods, and occur gradually.

3.5.4.1.4 Concrete Surround

The external walls or concrete surround of WR-1 provide a single, continuous, final engineered barrier to the release of contamination. Penetrations in the exterior walls are given engineered seals to ensure long term performance. Like the internal walls, the exterior walls largely have sealants that restrict water movement. As with the internal walls and grout, degradation of the exterior walls is expected to occur over long periods of time and gradually.

3.5.4.1.5 Local Geosphere

The soil conditions at WR-1 provide an additional barrier to release of contamination into the environment. The local soils are primarily clay based, and provide a natural barrier to groundwater movement. The soils provide a final barrier to groundwater movement, reducing the groundwater speed to ~5m per year, and also chemically sorb contaminants to further reduce their concentrations in any surface water emissions.

3.5.4.1.6 Engineered Cover

The engineered cover does not provide a barrier for release of contamination explicitly, but instead provides a means to limit additional water infiltration into the system, and protect the barriers that are in place by resisting intrusion into the sub-surface structure which could potentially compromise one or more barriers. The cover will consider unintentional intrusion by humans, plants and animals. The cover will degrade with time, much like the rest of the sub-surface structure.

3.5.4.1.7 Post-Closure Monitoring

The final barrier is post-closure environmental monitoring of the groundwater surrounding WR-1. Groundwater monitoring provides verification that the decommissioned WR-1, and the barriers to release, are performing their function as expected. Monitoring also provides an early warning system in the event that something unexpected has occurred, and provides the data necessary to make decisions about mitigating actions required, if at all.

3.5.4.2 Post-Closure Activities

Future use of the WL site will depend on the ability of AECL to release parts of the site for unrestricted use upon completion of the Project. CNL is developing the WL Closure Land-use and End-state Plan, along with appropriate criteria for site remediation and clean-up activities. The Plan defines the post-closure end-states, the post-closure land-use classifications and allocation, and the physical release criteria that must be met at the site closure. These end-state definitions, land-use classification and allocation, and physical release criteria are applicable to all project decommissioning activities being carried out under the WL Closure Project. Following completion of the work, the lands, including any remaining infrastructure, will enter long-term care and maintenance in accordance with the Institutional Control requirements. As the proponent of the project, CNL will be responsible for implementing and managing the proposed follow-up monitoring program. The responsible owner of the site (the Government of Canada through AECL), will be responsible for the provision of funds for the follow-up monitoring program.

In general, affected areas will be remediated to meet the WL preliminary soil cleanup and the non-radiological and radiological clearance and release criteria in accordance with the target end state of the associated land-use category. However, some lands will have restrictions of the future use and/or development of the land to ensure there are no adverse effects to the safety assessment and modelling assumptions associated with the ISD of infrastructure and facilities (i.e., the WR-1 and potentially the Waste Management Area). These areas will require ongoing controls including Institutional Control, access restrictions, and performance monitoring. These processes will require approvals from the CNSC. Through the regulatory process, stakeholders will also have an opportunity to provide input that could help shape how the WL site is used in the future.

The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. Institutional controls are requirements placed on the licensee by the CNSC to ensure long-term safety from residual contamination of a decommissioned facility. For the Project, the Institutional Control period includes implementation of both active and passive control throughout 2024 to 2324 (i.e., 300 years). During active Institutional Control, long-term performance monitoring and maintenance activities will continue through to 2124 to demonstrate compliance with the safety case assumptions. CNL operates an extensive Environmental Assessment Follow-up Program that will govern monitoring for the Project. Monitoring during the active Institutional Control period may differ in scope from that executed during closure, as the facility moves from an operational state, to a passive state. The revised Environmental Assessment Follow-up Program will reflect the priorities and requirements that are necessary to adequately assess the ongoing performance of WR-1 in an ISD state. The monitoring program will focus on groundwater quality and the functioning of the containment.

The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions) and will continue through 2024 to 2324. Post-institutional Control occurs after year 2324 and continues indefinitely.

3.5.5 Human Resource Requirements and Expenditures

The closure and post-closure phases of the Project will require administrative and supervisor staff, engineering and environmental monitoring personnel, and construction workers. There are currently about 350 employees on the WL site. Canadian Nuclear Laboratories anticipates employment to peak at 400 employees in 2021, when grouting of below grade systems and structures is anticipated to occur. The size of the workforce after 2021 is anticipated to decrease to zero by 2024. A large workforce is not required during Institutional Control.

4.0 ABORIGINAL ENGAGEMENT

4.1 Introduction

Engagement refers to the activities and processes of interaction and information sharing between a company (i.e., proponent) and the stakeholders who could be affected by a project that the company is undertaking. Public (see Section 5.0 Public Engagement), and Aboriginal (First Nation and Métis) engagement are considered important activities in the environmental assessment process. The Canadian Environmental Assessment Agency (the Agency) includes First Nation and Métis people as part of the broader public and notes “The focus of public participation is usually to share information with, and gather input from, members of the public who may have an interest in a proposed project. In the context of a federal environmental assessment, the intention of public participation is usually to ensure that those who must make decisions during and after the environmental assessment process are well informed.” (the Agency 2016).

Throughout the EIS, the terms Aboriginal, Indigenous, First Nations, and Métis have been used. Each have a specific meaning and are used in different situations. “The Canadian Constitution recognizes three groups of Aboriginal peoples: Indians (more commonly referred to as First Nations), Inuit and Métis. These are three distinct peoples with unique histories, languages, cultural practices and spiritual beliefs” (INAC 2016). In recent years, the term “Indigenous” has become used more frequently. “Indigenous peoples is a collective name for the original people of North America and their descendants” (INAC 2016). Different terms are used throughout the EIS, consistent with the source from which the term is drawn. The term Aboriginal is often used and reflects the language used by the CNSC’s regulatory guidance materials (CNSC 2016).

This section summarizes Canadian Nuclear Laboratories’ (CNL) past and proposed First Nation, Métis and agency engagement initiatives. It demonstrates how it has engaged with First Nation and Métis communities of interest that are likely to be affected by the proposed In Situ Decommissioning of WR-1 at the Whiteshell Laboratories Site (the Project), including documentation of meetings, discussion topics and outcomes. Supporting documentation for this section includes:

- CNL’s *Aboriginal Engagement Report* (CNL 2017). This includes CNL’s Aboriginal Engagement Plan, in addition to the outcomes of all results from CNL-led engagement activities, including meeting notes and material distributed at engagement activities completed at the time of filing of the EIS. Records of engagement that occurs post-filing of the EIS will be provided as a supplementary filing.
- **Appendix 4.0-1:** Detailed contact tracker that records the efforts of CNL and its contractor to confirm interest in the Project by First Nation and Métis organizations that may have an interest in the Project. This tracker includes all correspondence up to July 29, 2017.

Issues, interests and concerns raised through the First Nations and Métis engagement process were considered as part of the environmental assessment process. For example, the Winnipeg River was added as a Valued Component (VC) due to the concerns expressed by various participants. These are described in tabular format at the outset of each subsection of Section 6.0 Environmental Effects (Sections 6.2 Atmospheric Environment through 6.9 Socio-economic Environment).

4.1.1 Corporate Social Responsibility

CNL recognizes that it must conduct its business in a manner that is both socially and environmentally responsible. One way CNL demonstrates this commitment is through its ongoing Public Information Program. The Public Information Program aims to inform groups about ongoing activities at CNL sites and the potential effects of these activities on the health and safety of workers, members of the public, Aboriginal communities and on the environment. The Public Information Program builds public awareness, understanding and a supportive appreciation of CNL's value and relevance to Canadians. The Public Information Program, coupled with the Aboriginal Engagement Report (CNL 2017), form the basis of the communication efforts with First Nations and Métis communities and help to direct the establishment of long-term mutually beneficial working relationships with communities in proximity to CNL sites.

CNL regularly reviews the Public Information Program to incorporate input from the public and/or Aboriginal communities, to adapt to changing needs or circumstances, to accommodate new information, or in response to other factors. The program includes the following objectives to provide wide accessibility of fact-based information to the public and Aboriginal communities regarding CNL's activities, including the Project.

1) Initiate and maintain two-way communication channels between CNL, the public and First Nation and Métis communities to determine the best methods for communicating project information and to facilitate the receipt of input at appropriate junctures in the Project schedule.
2) Develop meaningful, user-friendly information and communication products geared for the public and First Nation and Métis communities, and provide accessible and current information on Project activities.
3) Demonstrate CNL's long-term commitment and approach to the reduction of Canada's nuclear legacy liabilities in a safe and cost effective manner.
4) Inform and educate the public and First Nation and Métis communities about nuclear decommissioning, environmental remediation and radioactive waste management.
5) Meet all regulatory-based communication and engagement requirements.

To meet these objectives, CNL has developed specific strategies to increase the effectiveness of the program so that public and First Nation and Métis engagement requirements for the Project are met. These strategies include:

- Presenting information in an easy to understand format through a variety of communications channels using targeted key messaging.
- Use of technical experts to communicate information through a variety of channels.
- Accomplishing all required activities in a timely manner.
- Providing various means for accessibility of information for use by public and First Nation and Métis communities.

4.1.2 Regulatory Requirements

Project information distribution and First Nation and Métis participation are important aspects of the environmental assessment process. Canadian Nuclear Laboratories' approach to First Nation and Métis engagement complies with the *Public Information and Disclosure* (RD/GD-99.3; CNSC 2012) and the *Aboriginal Engagement* (REGDOC-3.2.2; CNSC 2016) regulation documents. Additional information on Canadian Nuclear Safety Commission's (CNSC) (2012) RD/GD-99.3 is provided in Section 5.1.2 Regulatory Requirements. REGDOC-3.2.2 notes that when a licensee's activities could adversely affect potential or established First Nation and Métis and/or treaty rights, that the licensee shall identify and engage with potentially affected First Nation and Métis groups, and develop/maintain any Aboriginal Engagement Reports to support a project's activities.

Consideration was also given to CNSC's Generic Guidelines for the Preparation of an Environmental Impact Statement, along with REGDOC 2.9.1 (CNSC 2016) which explains that the CNSC determines the requirements for public and Aboriginal engagement on a case-by-case basis, including consideration of:

- "interests of the public and Aboriginal groups";
- "complexity of the facility or activity and its potential interactions with the environment and the public"; and
- "additional factors such as other jurisdictional mandates or types of decision".

4.2 Relevant First Nation and Métis Engagement Activities Completed for the Whiteshell Laboratories Site

First Nation and Métis engagement occurred as part of the previous Comprehensive Study Report (CSR) process associated with the overall decommissioning of the Whiteshell Laboratories site (WL site). First Nation and Métis communities were identified as potentially interested in the CSR work, based on their proximity to the site and the boundaries of Treaty 1 and Treaty 3. Sagkeeng First Nation, Brokenhead Ojibway Nation, and Treaty 3 First Nations in Ontario were notified of the Project and engagement occurred on the basis of each group's interest level. As part of this process, a communication protocol between Sagkeeng First Nation and the WL site was established in 1990. Although the protocol was specific to the CSR process, the overall intent of the agreement is still honoured, with communication with Sagkeeng First Nation on-going since that time.

Decommissioning of the WL site has been ongoing since 2003. At this time, a Public Liaison Committee (PLC) was formed, including terms of reference for communication and ongoing engagement (see Section 5.2 Relevant Public Engagement Activities Completed for the Whiteshell Laboratories Site). The PLC focused on communities, rural municipalities and other relevant stakeholders in proximity to the Project; however, there was no explicit inclusion of First Nations and Métis groups in the committee.

Sagkeeng First Nation was also engaged during a preliminary round of engagement activities through a teleconference in April 2016 and a meeting with Chief and Council members in May 2016. The intent of these activities was to provide an overall site update, an overview of the new Government-Owned Contractor-Operated (GoCo) governance model and new site closure schedule.

4.3 Project-specific First Nation and Métis Engagement Activities

Canadian Nuclear Laboratories recognized that some First Nations and the Manitoba Metis Federation had not been extensively engaged in relation to the overall site and site closure. As such, it approached overall engagement activities with the intent to provide sufficient background information and context, to establish relationships for future engagement efforts and to support the overall environmental assessment process. This included providing overall background information about the WL site, the previously approved WL Closure Project, and the Project itself. The process was designed to reflect the interest, issues and concerns expressed by First Nations and Métis and to be adaptive in nature. Engagement with First Nations and the Manitoba Metis Federation was designed based on feedback from the communities, and included the following types of mechanisms:

- meetings with leadership;
- community meetings;
- tours of the WL site; and
- Industry days.

4.3.1 Overview of First Nation and Métis Engagement

The Aboriginal Engagement Report (CNL 2017) provided CNL's overall approach to First Nation and Métis engagement. In consultation with the CNSC (CNL and CNSC 2016) and using tools provided through the Aboriginal and the Treaty Rights Information System (ATRIS),[1] CNL identified a broad list of First Nation and Métis groups with potential interest in the Project. The list (Table 4.3.1-1) included First Nation and Métis groups on the basis of potential interest in the Project based on possible or established First Nation and Métis use and/or treaty rights in the vicinity of the project. A map of First Nation and Métis Groups is provided in Figure 6.8.4-3.

Table 4.3.1-1: First Nation and Métis Groups Identified as Having Potential Interest in the Project

First Nation or Métis Group	Location
Sagkeeng First Nation (Treaty #1)	Fort Alexander, Sagkeeng First Nation, is the closest community to the Whiteshell Laboratories. This first Nation reservation is located approximately 66 kilometres (km) directly downriver from the Whiteshell Laboratories (WL) site.
Manitoba Metis Federation	The Manitoba Metis Federation is the official democratic and self-governing political representative for the Métis Nation's Manitoba Métis Community.
Brokenhead Ojibway Nation (Treaty #1)	The Brokenhead Ojibway Nation is located near the southern basin of Lake Winnipeg, approximately 73 km from the WL site.

[1] Aboriginal and Treaty Rights Information System (ATRIS) https://www.aadnc-aandc.gc.ca/eng/1100100014686/1100100014687.

Table 4.3.1-1: First Nation and Métis Groups Identified as Having Potential Interest in the Project

First Nation or Métis Group	Location
Black River First Nation (Treaty #5)	The Black River First Nation is situated approximately 92 km from the WL site, 36 km north of Fort Alexander along the east shore of Lake Winnipeg.
Hollow Water First Nation (Anishinaabe (Ojibwa)) (Treaty #5)	Hollow Water First Nation is located 136 km north of Whiteshell Laboratories along the eastern shore of Lake Winnipeg.
Wabaseemoong Independent Nations	Treaty 3 territory includes parts of eastern Manitoba, including the WL site. Includes the communities of One Man Lake, Swan Lake and Whitedog.
Shoal Lake 40 (Ontario) (Treaty #3)	Treaty 3 territory includes parts of eastern Manitoba, including the WL site.
Iskatewizaagegan #39 Independent First Nation (Shoal Lake #39 First Nation)	Treaty 3 territory includes parts of eastern Manitoba, including the WL site.
Grand Council of Treaty 3	Treaty 3 territory includes parts of eastern Manitoba, including the WL site.
Northwest Angle No. 33	Treaty 3 territory includes parts of eastern Manitoba, including the WL site.
Chiefs of Ontario	Advocacy and secretariat group for the 133 First Nations communities located throughout Ontario.

Each of the groups listed in Table 4.3.1-1 were provided written notification regarding the Project and efforts were made to follow-up with each via telephone to determine their relative interest in participating in engagement activities. A record of communication with each group is provided in Appendix 4.0-1 Contact Tracker. Although efforts were placed on reaching out to all of the communities and organizations identified, particular effort was placed on outreach to groups who expressed interest or provided comments during the federal Project description process. These groups were Sagkeeng First Nation, Black River First Nation, Brokenhead Ojibway Nation, Hollow Water First Nation, Wabaseemoong Independent Nations and the Manitoba Metis Federation. Their participation on the Project description process was interpreted by CNL as the communities' expressing direct interest in the Project and Project activities.

4.3.2 Summary of First Nation and Métis Engagement Activities

This section provides an overview of Project engagement activities with First Nations and Métis, in addition to the key issues, interests and concerns.

4.3.2.1 Sagkeeng First Nation

Table 4.3.2-1 presents Project engagement activities undertaken by CNL with Sagkeeng First Nation during Round 1. Supporting material, including meeting notes and material distributed by CNL at each activity are included in the Aboriginal Engagement Report (CNL 2017).

Table 4.3.2-1: Summary of Engagement Activities with Sagkeeng First Nation

Activity	Location	Date	Times	Attendance
Meeting with Chief and Council	Sagkeeng First Nation Government Office, Fort Alexander, MB	January 25, 2017	1:30pm – 3:00pm	■ 4 representative from Sagkeeng First Nation ■ 3 representatives from CNL
Open House	Sagkeeng Mino Pimatiziwin Family Treatment Centre Gym, Fort Alexander, MB	January 25, 2017	6:00pm – 8:00pm	■ 3 First Nations members ■ 2 members of the public
CNSC-led engagement*	Private Tom Chief Memorial Hall, Scanterbury, MB.	May 17, 2017	1:00-6:00pm	■ 5 representatives from Sagkeeng First Nation ■ 2 representatives from Wabaseemong Independent Nations ■ 4 representatives from CNSC ■ 6 representatives from CNL ■ 2 representatives from AECL ■ 1 CNL contractor
Site Tour	Whiteshell Laboratories Site	2017 July 4		■ 7 representatives from Sagkeeng First Nation ■ 9 First Nation students ■ 4 representatives from CNL ■ 1 CNL contractor
Industry Day	Sagkeeng Arena, Fort Alexander, MB	2017 July 6	10:00 am – 12:00 pm	■ 2 contractors ■ 3 representatives from CNL

* Documentation of CNSC-led engagement is limited to inclusion of interests and concerns as summarized in Table 4.3.2-2.

The key interests and concerns for Sagkeeng First Nation are presented in Table 4.3.2-2.

Table 4.3.2-2: Summary of Key Interests and Concerns for Sagkeeng First Nation

Topic	Key Interests and Concerns
Business and Employment Opportunities	■ Sagkeeng First Nation requested more detailed information about potential contracting opportunities with CNL, including qualifications. ■ Sagkeeng First Nation raised the possibility of a certain percentage of the work going to Aboriginal companies.
Future Land Use and Tenure	■ Sagkeeng First Nation requested more information regarding future compensation for the Local Government District of Pinawa and the First Nation since portions of the WL site is located in Treaty 1 territory. ■ Sagkeeng First Nation expressed concern about the future of the WL site, noting that the Province of Manitoba will eventually need to come and discuss the future of the WL site with the First Nation.
Waste Management	■ Sagkeeng First Nation were interested in more detailed information about how much radioactive waste would remain on the WL site and where the radioactive waste that was being transported off-site would be stored. ■ Sagkeeng First Nation asked about the methods used to transport waste and how it will be communicated to potentially affected communities. ■ The group discussed the decision making process used to determine how radioactive waste will be transported. ■ Sagkeeng First Nation expressed concern about In Situ Decommissioning (ISD) and thought that it would be best if all waste and the WR-1 were removed from the WL site. ■ Sagkeeng First Nation was curious about how water treatment on the WL site worked.
Future Communication	■ It was noted that technical results are difficult to understand and that CNL should consider methods to ensure that future updates about the Project will be understandable to community members. ■ It was suggested that CNL work with Chief and Council in the future to promote future engagement activities with the community. In addition, it would make sense to invite on-reserve members by going door to door. ■ Consultation still needs to occur on a nation-to-nation basis. ■ Sagkeeng First Nation would like to participate in the Learning Community Workshop that is being planned for September 2017.
Canadian Nuclear Laboratories	■ Sagkeeng First Nation expressed interest in the history of CNL and how it is related to AECL and the WL site.
Future Monitoring	■ Sagkeeng First Nation expressed interest in future monitoring of the site, including the duration of monitoring activities and where monitoring would occur. In particular, Sagkeeng First Nation thought that there should be monitoring at locations where members fish and monitoring locations closer to the community. ■ Sagkeeng First Nation expressed concern about the long-term effects of the Project on water quality and fish, especially in light of the environmental effects that the paper mill is believed to have had on the water. ■ Sagkeeng First Nation wanted to know who would monitor the WL site after decommissioning ends.

Table 4.3.2-2: Summary of Key Interests and Concerns for Sagkeeng First Nation

Topic	Key Interests and Concerns
Fish and Fish Habitat and Winnipeg River	Sagkeeng First Nation expressed concern about the perceived deterioration of fish quality in the Winnipeg River.
Regulatory Process	■ Canadian Nuclear Safety Commission provided a relatively low level of participant funding to Sagkeeng First Nation. ■ What would happen to the Project and the WL site if the regulator did not approve the Project? ■ Who determines if the Project proceeds? ■ What are the opportunities for First Nation input? ■ Sagkeeng First Nation wanted to understand why CNSC uses the term "Aboriginal" when the Federal Government has moved to using "Indigenous".
Project Description	■ Sagkeeng First Nation was interested in understanding how the grouted encapsulation would maintain its integrity into the future. Topic included the potential for climate change and natural disasters to affect the integrity of the grouted encapsulation and how it would be constructed to ensure that it is safe. ■ The proposed decommissioning method is not trusted. ■ Participants at the community open house were interested in various aspects of ISD. Questions were asked regarding the existence of similar projects, the differences in costs between the original removal decommissioning plan and the ISD and the safety of ISD in connection with the environment. ■ Sakgeeng First Nation expressed interest in how materials from demolished buildings on the WL site would be disposed of?
Traditional Knowledge	■ Wild rice and medicinal plants are collected by Sakgeeng First Nation members in the Whiteshell area. Harvested medicinal plants include calamus root, Labrador tea, wild ginger and waterlily root. ■ Sagkeeng First Nation expressed interest in conducting a traditional knowledge study to support fish sampling and was curious about the potential timing for a traditional knowledge study. ■ Sakgeeng First Nation believed that traditional knowledge would be a good addition to the Species-at-Risk Field Guide.

4.3.2.2 Black River First Nation, Brokenhead Ojibway Nation and Hollow Water First Nation

Black River First Nation, Brokenhead Ojibway Nation and Hollow Water First Nation requested that engagement activities with CNL be coordinated, and as such are presented collectively. Table 4.3.2-3 presents a summary of engagement activities to date undertaken by CNL with these First Nations. Supporting material, including meeting notes and material distributed by CNL at each activity are included in the Aboriginal Engagement Report (CNL 2017).

Table 4.3.2-3: Summary of Engagement Activities with Black River First Nation, Brokenhead Ojibway Nation and Hollow Water First Nation

Activity	Location	Date	Times	Attendance
Meeting with Leadership	Swan Lake Office, Headingly, MB	December 15, 2016	10:00am – 3:00pm	■ 7 representatives from the First Nations ■ 4 representatives from CNL ■ 1 representative from CNL contractor
Community Meeting	South Beach Casino, Scanterbury, MB Tour of WL site	Febuary 21, 2017 February 22, 2017	9:00 am – 3:00pm	■ 13 members of Brokenhead Ojibway Nation ■ 11 members of Black River First Nation ■ 13 members of Hollow Water First Nation ■ 6 representatives from CNL ■ 1 representative from CNL Contractor
CNSC-led meeting with Black River First Nation*	Black River First Nation Office, 856 Main Street, Winnipeg	June 27, 2017	10:30am-12:00pm	■ 5 representatives from Black River First Nation ■ 2 representatives from CNSC ■ 1 representative from AECL ■ 2 representatives from CNL
CNSC-led meeting with Brokenhead Ojibway Nation*	Brokenhead Ojibway Nation Band office, Scanterbury, MB.	June 28, 2017	9:00am – 12:00pm	■ 5 representatives from Brokenhead First Nation ■ 2 representatives from CNSC ■ 1 representative from AECL ■ 1 representative from CNL

* Documentation of CNSC-led engagement is limited to inclusion of interests and concerns as summarized in Table 4.3.2-4

The key interests and concerns for Black River First Nation, Brokenhead Ojibway Nation and Hollow Water First Nation are presented in Table 4.3.2-4.

Table 4.3.2-4: Summary of Key Interests and Concerns for Black River First Nation, Brokenhead Ojibway Nation and Hollow Water First Nation

Topic	Key Interests and Concerns
Business and Employment Opportunities	■ The First Nations wanted to know if there are any Indigenous procurement requirements associated with the Project. ■ The First Nations raised the possibility of CNL using direct negotiated contracts with First Nations in decommissioning and overall closure processes. ■ The First Nations suggested other employment opportunities for community members related to the environmental assessment process. ■ The First Nations expressed concern that they would not be competitive with larger businesses in the tender process. ■ The First Nations were curious about the employment opportunities that are currently available on the WL site.
Future Land Use and Tenure	■ Brokenhead Ojibway Nation was interested in knowing if the land currently occupied by the WL site would be available for other uses in the future. ■ Participants noted that the site occupies a large parcel of land that was removed from Treaty 1 territory without adequate consultation. There will need to be discussions with the Federal Government about the future of the WL site and potentially accommodation. ■ There has been talk about using the WL site to build small modular reactors and the First Nations wanted to know more about small modular reactors and if there will be any First Nation and Métis engagement as part of the process.
Accidents and Malfunctions	■ There was discussion about past releases and the potential for future releases of hazardous and radioactive material into the Winnipeg River. ■ The First Nations were interested in how releases could be contained in the soil. They were also interested in how CNL detects spills.
Waste Management	■ The First Nations asked about which material will be sent to Chalk River for disposal and how it will be transported.
Future Communication	■ The First Nations were interested in CNL's planned engagement activities.
Monitoring	■ The First Nations requested more information about CNL's current monitoring activities, including activities related to the contamination in the river bed of Winnipeg River. ■ The First Nations would like to know more about future monitoring activities that will occur after the WL site is fully decommissioned. ■ Black River First Nation expressed interest in having students involved in monitoring activities.

Table 4.3.2-4: Summary of Key Interests and Concerns for Black River First Nation, Brokenhead Ojibway Nation and Hollow Water First Nation

Topic	Key Interests and Concerns
Project Description	■ There was interest in understanding the decommissioning method better, including how long radioactive materials will require to decay, what precisely will happen to the Whiteshell Reactor 1 (WR-1), and how safe In Situ Decommissioning (ISD) is. ■ The First Nations expressed interest in understanding how ISD was chosen as the preferred decommissioning methods for the WR-1 and wanted to know if nearby communities would have an opportunity to provide input on the chosen decommissioning method. ■ There was discussion about whether climate change or natural disasters could affect the integrity of the grouted encapsulation and how it would be constructed to ensure that it is safe.
Regulatory Process	■ Questions were raised about why communities had not been previously consulted on the WL site. ■ Questions were raised about the duty to consult. ■ Canadian Nuclear Safety Commission provided a relatively low level of participant funding to Brokenhead Ojibway Nation, Black River First Nation and Hollow Water First Nation. ■ The First Nations were curious about the Canadian Environmental Assessment Act 2012 and its requirements for soliciting information from nearby communities. ■ Brokenhead Ojibway Nation wanted to understand how the regulator works, and how the independent commission is selected.
Traditional Knowledge	■ There are petroforms in the Whiteshell area, which were given to Black River First Nation by Nanabush. ■ Black River First Nation typically held ceremonies in the Whiteshell region in the fall around the period of the Harvest Moon. ■ Black River Fist Nation picked wild rice, which was a dietary staple, in the area. ■ Brokenhead Ojibway Nation noted the importance of traditional and cultural perspectives with regards to the Project.

4.3.2.3 Wabaseemoong Independent Nations

Table 4.3.2-5: Summary of Engagement Activities with Wabaseemoong Independent Nations

Activity	Location	Date	Times	Attendance
CNSC-led engagement*	Private Tom Chief Memorial Hall, Scanterbury, MB.	May 17, 2017	1:00-6:00pm	■ 2 representatives from Wabaseemoong Independent Nations ■ 5 representatives from Sagkeeng First Nation ■ 4 representatives from CNSC ■ 6 representatives from CNL ■ 2 representatives from AECL ■ 1 CNL contractor
Meeting with Leadership and Site Tour	Whiteshell Laboratories Site	June 28, 2017	10:00-12:00	■ 6 representatives from Wabaseemoong Independent Nations ■ 2 representatives from CNSC (part-time) ■ 2 representatives from AECL (1 part-time) ■ 4 representatives from CNL ■ 1 CNL contractor

* Documentation of CNSC-led engagement is limited to inclusion of interests and concerns as summarized in Table 4.3.2-6.

Table 4.3.2-6: Summary of Key Interests and Concerns for the Wabaseemoong Independent Nations

Topic	Key Interests and Concerns
Regulatory Process	■ Wabaseemoong Independent Nations expressed concern with the communication methods used by the CNSC, noting that they were not aware of the Project until Chief Henderson from Sagkeeng First Nation mentioned it. ■ Wabaseemoong Independent Nations wanted to understand why they were only recently contacted since the WL site was established and began operations in the 1960s.
Future Communications	■ Wabaseemoong Independent Nations expressed interest in having an engagement event in their home community with CNL, AECL and CNSC.
Business and Employment Opportunities	■ Wabaseemoong Independent Nations requested more details about employment opportunities at the WL site, including the availability of seasonal employment and the proportion of the workforce that is Aboriginal. ■ Wabaseemoong Independent Nations noted that employment at the WL site may be difficult for members because it is not located within commuting distance of the community.

Table 4.3.2-6: Summary of Key Interests and Concerns for the Wabaseemoong Independent Nations

Topic	Key Interests and Concerns
Traditional Knowledge	■ Wabaseemoong Independent Nations noted that animals do not obey the same sort of boundaries as humans and could come into contact with hazardous materials.
Monitoring	■ Wabaseemoong Independent Nations expressed interest in knowing more about monitoring fish, including how fish are tested and if contaminants can accumulate over time. ■ Wabaseemoong Independent Nations asked about air emissions monitoring practices.
Future Land Use and Tenure	■ Wabaseemoong Independent Nations requested more information about the proportion of the WL site
Canadian Nuclear Laboratories	■ Wabaseemoong Independent Nations expressed interest in the history of CNL and how it is related to AECL and the WL site.
Waste Management	■ Wabaseemoong Independent Nations were interested in more detailed information about how much radioactive waste would remain on the WL site and where the radioactive waste that was being transported off-site would be stored. ■ Wabaseemoong Independent Nations asked about the methods used to transport waste and how it will be communicated to potentially affected communities.
Accidents and Malfunctions	■ There was discussion about past releases and the potential for future releases of hazardous and radioactive material into the Winnipeg River. ■ Wabaseemoong Independent Nations were interested in how releases could be contained in the soil. They were also interested in how CNL detects spills.
Project Description	■ There was discussion about whether climate change or natural disasters could affect the integrity of the grouted encapsulation and how it would be constructed to ensure that it is safe.

4.3.2.4 Manitoba Metis Federation

Table 4.3.2-5 presents a summary of engagement activities with the Manitoba Metis Federation (MMF) undertaken by CNL to date. Supporting material, including meeting notes and material distributed by CNL at each activity are included in the Aboriginal Engagement Report (CNL 2017).

Table 4.3.2-7: Summary of Engagement Activities with the Manitoba Metis Federation

Activity	Location	Date	Times	Attendance
Meeting	Manitoba Metis Federation Offices, Winnipeg, Manitoba	November 30, 2016	10:00 am – 12:00 pm	■ 4 representatives from MMF ■ 3 representatives from CNL ■ 2 representatives from CNL contractor
Meeting	Conference Call	February 9, 2017	1:30 pm – 2:30 pm	■ 3 representatives from MMF ■ 4 representatives from CNL ■ 1 representative from CNL contractor
CNSC-led engagement*	Conference Call	July 26, 2017	3:00 pm – 3:30 pm	■ 2 representatives from MMF ■ 2 representatives from CNSC ■ 2 representatives from CNL ■ 1 CNL Contractor

* Documentation of CNSC-led engagement is limited to inclusion of interests and concerns as summarized in Table 4.3.2-8.

The key interests and concerns for the MMF are presented in Table 4.3.2-8.

Table 4.3.2-8: Summary of Key Interests and Concerns for the Manitoba Metis Federation

Topic	Key Interests and Concerns
Winnipeg River	The MMF had a series of questions on the WL site's discharge in to the Winnipeg River, including the potential for their discharge licence to trigger an environmental assessment and if the site's discharge has any effects on Manitoba Hydro operations.

Table 4.3.2-8: Summary of Key Interests and Concerns for the Manitoba Metis Federation

Topic	Key Interests and Concerns
Regulatory Process	■ The MMF noted that participant funding from the CNSC was lower than anticipated and covers activities following EIS submission and not before. They requested clarification on MMF's opportunities to comment on the EIS. ■ The MMF requested a list of valued components for the Project and asked if Indigenous rights would be included as a valued component. ■ The MMF noted that regulators may notice and flag the absence of Traditional Knowledge in the EIS. The MMF has a catalogue of Traditional Knowledge but does not have the capacity to analyze it for gaps and relevance to the WL site. The MMF notes that a Traditional Knowledge study should be undertaken as neither the previous Comprehensive Study Report nor the current monitoring reports consider Métis harvesting. ■ The MMF noted that it had concerns about ensuring that citizens pay attention to the Project and engagement activities because they would likely occur at the same time as the local meetings in advance of the Annual General Assembly and the Annual General Assembly.

4.3.3 Future Engagement Activities Planned

Canadian Nuclear Laboratories will continue to engage with interested First Nation and Métis organizations after submission of the EIS. Future activities are expected to focus on the draft EIS, project effects, and how people can provide feedback to the CNSC. The anticipated activities will be guided by what interested First Nations and Métis organizations consider the most effective means for engaging with their communities. Activities could include in-community information sessions, site tours for interested stakeholder groups, and presentations and meetings with leadership. These activities will be documented and included in a supplemental filing.

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5.0 PUBLIC ENGAGEMENT

5.1 Introduction

Project information distribution and public participation are important aspects of the environmental assessment process. Public engagement will comply with the *Public Information and Disclosure* (RD/GD-99.3; CNSC 2012) regulation document. This section of the Environmental Impact Statement (EIS) will summarize Canadian Nuclear Laboratories' (CNL) past and proposed public engagement initiatives in accordance with the above mentioned document.

In preparing the EIS, CNL has included information within this section to demonstrate how it has engaged with local communities of interest that are likely to be affected by the proposed In Situ Decommissioning of WR-1 at the Whiteshell Laboratories Site (the Project), as well as communication initiatives with regulatory agencies. The section includes a description of engagement activities, including documentation of meetings, discussion topics and outcomes and relevant agreements. There are a number of supporting documents within the *Section 5 Supporting Materials* report (CNL 2017a), which includes the four following appendices:

- **Appendix A:** Ongoing Communication Material includes supporting material used for CNL's ongoing communication with stakeholders. Material includes issues of *Contact*, screen shots of the WL site's webpage and sample posts from social media.
- **Appendix B:** Preliminary Engagement Material includes material used in public engagement from March 2016 through August 2016.
- **Appendix C:** Round 1 Engagement Material includes material used and distributed during Round 1 of public engagement.
- **Appendix D:** Round 2 Engagement Material includes material used and distributed during Round 2 of public engagement.

Issues, interests and concerns raised through the public engagement process were considered as part of the environmental assessment process. For example, the future use of the Whiteshell Laboratory site was identified as important for local municipalities and rural municipalities. As such, the importance of continued economic development was considered under the context of Community Well-being, and included as a Valued Component (VC) for the assessment. These are described in tabular format at the outset of each subsection of Section 6.0 Environmental Effects (Sections 6.2 Atmospheric Environment through 6.9 Socio-economic Environment).

5.1.1 Corporate Social Responsibility

CNL recognizes that it must conduct its business in a manner that is both socially and environmentally responsible. One way CNL demonstrates this commitment is through its ongoing Public Information Program. The Public Information Program aims to inform groups about ongoing activities at CNL sites and the potential effects of these activities on the health and safety of workers, members of the public, Aboriginal communities and on the environment. The Public Information Program builds public awareness, understanding and a supportive appreciation of CNL's value and relevance to Canadians. The Public Information Program, coupled with the Aboriginal Engagement Report (CNL 2017b), form the basis of the communication efforts with Aboriginal communities and help to direct the establishment of long-term mutually beneficial working relationships with communities in proximity to CNL sites.

CNL regularly reviews the Public Information Program to incorporate input from the public and/or Aboriginal communities, to adapt to changing needs or circumstances, to accommodate new information, or in response to other factors. The program includes the following objectives to provide wide accessibility of fact-based information to the public and Aboriginal communities regarding CNL's activities, including the Project.

1) Initiate and maintain two-way communication channels between CNL, the public and Aboriginal communities to determine the best methods for communicating project information and to facilitate the receipt of input at appropriate junctures in the Project schedule.
2) Develop meaningful, user-friendly information and communication products geared for the public and Aboriginal communities, and provide accessible and current information on Project activities.
3) Demonstrate CNL's long-term commitment and approach to the reduction of Canada's nuclear legacy liabilities in a safe and cost effective manner.
4) Inform and educate the public and Aboriginal communities about nuclear decommissioning, environmental remediation and radioactive waste management.
5) Meet all regulatory-based communication and engagement requirements.

To meet these objectives, CNL has developed specific strategies to increase the effectiveness of the program so that public and Aboriginal engagement requirements for the Project are met. These strategies include:

- Presenting information in an easy to understand format through a variety of communications channels using targeted key messaging.
- Use of technical experts to communicate information through a variety of channels.
- Accomplishing all required activities in a timely manner.
- Providing various means for accessibility of information for use by the public and Aboriginal communities.

5.1.2 Regulatory Requirements

Public engagement was guided by Canadian Nuclear Safety Commission's (CNSC) *Public Information and Disclosure* (RD/GD-99.3; CNSC 2012), which states:

> The primary goal of the public information program, as it relates to the licensed activities, is to ensure that information related to the health, safety and security of persons and the environment, and other issues associated with the lifecycle of nuclear facilities are effectively communicated to the public. As a component, where the public has indicated an interest to know, the program shall include a commitment to and protocol for ongoing, timely communication of information related to the licensed facility during the course of the licence period.

Consideration was also given to CNSC's Generic Guidelines for the Preparation of an Environmental Impact Statement, along with REGDOC-2.9.1 (CNSC 2017) which explains that the CNSC determines the requirements for public and Aboriginal engagement on a case-by-case basis, including consideration of:

- "interests of the public and Aboriginal groups";
- "complexity of the facility or activity and its potential interactions with the environment and the public"; and
- "additional factors such as other jurisdictional mandates or types of decision".

5.2 Relevant Public Engagement Activities Completed for the Whiteshell Laboratories Site

5.2.1 Ongoing Engagement

There are several forums and activities that have supported ongoing engagement activities regarding the Whiteshell Laboratories site (WL site) and overall decommissioning plan.

5.2.1.1 Ongoing Communication Mechanisms

CNL shares information about the Project with the public through a number of activities including media releases, website updates, newsletters, and through involvement in community events. CNL employees are kept informed of developments so that they can also share information with their relatives, friends and neighbours in a timely way. Some of these methods are described below:

- **Community newsletter:** *Contact* is CNL's community newsletter, which is issued annually and highlights CNL's people, projects, achievements and environmental performance. It is distributed to approximately 9,000 residents in areas in proximity to the WL site and is part of CNL's ongoing efforts to reach out to its communities, stakeholders and area residents.
- **Website:** CNL maintains a website with content about the Project and information about upcoming events such as open houses and a conceptual video of the In Situ Decommissioning process. The Uniform Resource Locator (URL) for the Project page on the CNL website is **www.cnl.ca/wr-1**. Sample pages are included in Appendix A of the *Section 5 Supporting Materials* report (CNL 2017a).
- **Social media:** CNL maintains a page on Facebook, Twitter and YouTube account. Neither the Facebook page, Twitter nor the YouTube account is specific to the WL site but do include information posts about the

WL site and announcements for engagement events. The YouTube account includes an overview video of the Project.

- **Alumni:** Former employees of CNL have a keen interest in the nuclear industry and in the operations of CNL sites, programs and projects. The Alumni Network was set up in 2011 as a simple email subscription service. Alumni receive a monthly package that includes electronic copies of the employee newsletter, Voyageur, as well as a selection of clippings from my CNL (internal intranet site). Alumni are also provided email notification of Project-related public events.
- **Community involvement:** CNL is recognized as a strong community partner and is actively involved in memberships on Chambers of Commerce, support for the United Way, local food banks, Manitoba Fire Fighters Burn Fund and the Relay for Life. Employees participate in the Royal Canadian Legion's Poppy campaigns and the company provides representatives at community-based Remembrance Day ceremonies.

5.2.1.2 Public Liaison Committee

The Public Liaison Committee (PLC) was formed in 2003 with a Terms of Reference for communications and consultation. The committee meets approximately every 6 months and is comprised of community and stakeholder representatives (outlined below), consisting of elected officials and community interest groups. Its mandate is to provide an opportunity for open dialogue between community stakeholders and WL senior management on WL's various environmental and decommissioning projects. The committee also provides members with an opportunity to report on input and questions received from their constituents and CNL provides the committee members with timely, accurate information to share back to constituents. The PLC's membership includes:

- The Local Government District of Pinawa;
- The Rural Municipality (RM) of Lac du Bonnet;
- Town of Lac du Bonnet;
- Town of Beausejour;
- RM of Brokenhead;
- RM of Whitemouth;
- RM of Alexander;
- Acsion Industries Inc; and
- Manitoba Sustainable Development (formerly Manitoba Conservation and Water Stewardship).

5.2.1.3 Whiteshell Laboratories Community Regeneration Partnership

The Whiteshell Laboratories Community Regeneration Partnership (the Partnership) was formed in 2015 to address the economic concerns of the municipalities and rural municipalities that have historically had a proportion of their population working at the WL site. The Partnership is funded and facilitated by CNL. According to the Terms of Reference from October 21, 2015: "The proposed mandate of the Community Regeneration Partnership will be to develop a Socio Economic Plan for the region impacted by the WL decommissioning activities, to subsequently implement the Plan and to review, update and report on the Plan annually" (as quoted in Skinner

2016). Overall, the goal of the Partnership's activities is to replace the positions lost in the past, along with the jobs that will be lost by the time decommissioning is complete. The Project has presented to and accommodated Partnership tour requests on several occasions.

As a result of the Partnership a regional business incubator program funded annually by CNL (North Forge East) has been set up in the LGD of Pinawa. CNL regularly meets and participates in the business incubator activities which have included onsite events, presentations and tours related to the Project.

CNL has introduced First Nation and Métis groups participating in the Aboriginal engagement program to the Partnership. To date, Sagkeeng First Nation, Black River First Nation, Brokenhead Ojibway Nation, Hollow Water First Nation and the Manitoba Metis Federation have been introduced to the Partnership.

5.2.1.4 Public Events

CNL representatives attend local community events, where appropriate, as another opportunity to initiate two way communication with the public and to inform and educate the public about the Project. CNL had attendance at the Lac du Bonnet Trade Fair held on May 27, 2017. This event, which is held annually, is an opportunity for local businesses and organizations to showcase at a well-advertised and attended event adjacent to the popular Lac du Bonnet Farmers Market. The Whiteshell Laboratories Closure Project (WLCP) had a booth to discuss closure activities, the WR-1 Project, and employment and contracting opportunities. The Trade Fair was an opportunity for the WLCP to raise public awareness and demonstrates a commitment to informing local stakeholders of the project. Eight individuals signed up for the WR-1 Project information mailing list.

5.2.1.5 Employee Information Sessions

Employee information session were held on August 23, 24 and November 24, 2016 for the Project to reach internal stakeholders. Similar to the public information sessions, various communications products were used (e.g., poster boards, fact sheet, presentation and internal newsletter) and subject matter experts were available to answer questions. Approximately sixty employees we're in attendance over the two session in August and 43 employees attended the session in November.

5.2.2 Preliminary Engagement

Preliminary engagement related to the Project occurred as a part of CNL's efforts to maintain communication with stakeholders between March and August of 2016. This included updates about the overall closure of the site, ongoing environmental monitoring and the upcoming environmental assessment process associated with the Project.

Mechanisms to communicate with stakeholders in this time period are detailed in Appendix B Preliminary Engagement Material of the *Section 5 Supporting Materials* report (CNL 2017a). This included the presentation to the PLC, use of *Contact* (CNL's quarterly newsletter distributed to approximately 9,000 residents in the Lac du Bonnet region), web page materials (in addition to use of CNL's Facebook and Twitter accounts), and public open houses. Advertising and social media promotion of public open houses is detailed in Appendix B Preliminary Engagement Material of the *Section 5 Supporting Materials* report (CNL 2017a).

5.2.2.1 Public Open Houses

Table 5.5.2-1 provides a summary of the public open houses, which featured a combination of storyboards, fact sheets and comment forms to solicit feedback from participants. The material distributed at the open houses and

advertising and social media promotion is provided in Appendix B Preliminary Engagement Material of the *Section 5 Supporting Materials* report (CNL 2017a).

Table 5.5.2-1: Public Open House Summary for Preliminary Engagement

Location	Date	Times	Signed in Attendance	Estimated Attendance	Comment Cards Received
Pinawa	August 29, 2016	6:00 p.m. to 8:00 p.m.	38	55	5
Whitemouth	August 30, 2016	6:00 p.m. to 8:00 p.m.	10	12	0
Beausejour	August 31, 2016	6:00 p.m. to 8:00 p.m.	12	15	3
Powerview Pine Falls	September 1, 2016	6:00 p.m. to 8:00 p.m.	14	20	4
Lac du Bonnet	September 2, 2016	6:00 p.m. to 8:00 p.m.	26	35	5

The key issues and concerns that emerged during preliminary engagement through formal feedback mechanisms and question and answer sessions and the public open houses are summarized in Table 5.2.2-2.

Table 5.2.2-2: Summary of Issues from Preliminary Engagement

Topic	Issue/Concern Raised
Overall decommissioning	■ Participants were interested in the rationale for choosing In Situ Decommissioning as the decommissioning method as opposed to the method described in the earlier Comprehensive Study Report. ■ Participants requested additional information on the other decommissioning methods considered, including associated costs.
Monitoring Plans	■ Interest was expressed in knowing more about water quality monitoring for groundwater and the Winnipeg River. ■ Interest was expressed in knowing more about monitoring plans after decommissioning is complete.
Future Land Use and Tenure	■ Participants were interested in knowing if the site would be available for future economic activities.
Waste Management	■ Questions around where used fuel would be stored were asked.

5.2.2.2 Media Coverage

During the preliminary engagement stage, local and provincial media covered the Project. Table 5.2.2-3 presents a summary of the media coverage. Copies of the letters to the editor and articles are included in Appendix B Preliminary Engagement Material of the *Section 5 Supporting Materials* report (CNL 2017a).

Table 5.2.2-3: Media Coverage Summary for Preliminary Engagement

Date	Article	Publication
June 11, 2016	Letter to Editor: Generations Saddled with Pinawa Nuclear Burial	*Winnipeg Free Press*
June 22, 2016	Shut Down Safe (re: Generations Saddled with Pinawa Nuclear Burial)	*Winnipeg Free Press*
June 30, 2016	CNL Proposes Entombing Reactor	*The Clipper*
July 5, 2016	À quad le démantèlement complet du Laboratoire nucléaire de Pinawa?	CBC Radio Canada
July 6, 2016	L'après nucléaire augure un avenir incertain pour Pinawa	CBC Radio Canada
September 1, 2016	CNL Decommissioning Plans on Display	*The Clipper*

5.3 Project-specific Public Engagement

5.3.1 Overview of Public Information Engagement Program

The Project public engagement plan was organized into two broad rounds of activity:

- Round 1 focused on introducing the environmental assessment process and providing participants the opportunity for participants to identify issues of interest or concern, including thoughts about the preliminary list of VCs.
- Round 2 focused on providing preliminary results of the assessment, along with proposed mitigation and enhancement measures.

5.3.2 Summary of Round 1 Activities

Below is a summary of activities undertaken by CNL for Round 1 of public engagement, which included public open houses, media outreach and coverage, direct contact with additional stakeholder groups, and a meeting of the PLC dedicated to discussing the Project.

5.3.2.1 Public Open Houses

Round 1 activities included open houses. Table 5.3.2-1 provides a summary of open houses, including the location, time and date, and number of comments received. The open houses featured a combination of storyboards, fact sheets and comment forms to solicit feedback from participants. The material distributed at the open houses, notes from the question and answer period, responses to formal comments, and advertising for the open houses is provided in Appendix C Round 1 Engagement Material of the *Section 5 Supporting Materials* report (CNL 2017a).

Table 5.3.2-1: Summary of Round 1 Open Houses

Location	Date	Times	Signed in Attendance	Estimated Attendance	Comment Cards Received
Pinawa	November 29, 2016	6:00 p.m. to 8:00 p.m.	43	45	8
Whitemouth	November 28, 2016	6:00 p.m. to 8:00 p.m.	8	10	4
Beausejour	January 4, 2017	6:00 p.m. to 8:00 p.m.	8	8	1
Powerview Pine Falls	December 8, 2016	6:00 p.m. to 8:00 p.m.	3	3	0
Lac du Bonnet	December 1, 2016	6:00 p.m. to 8:00 p.m.	19	25	7

Each open house included a question and answer session and an opportunity for participants to interact with CNL staff one-on-one. The key issues and concerns shared during the public open houses are presented in Table 5.3.2-2 by community. Some concerns were expressed by multiple communities. When an issue or concern was raised at three or more of the open houses, it is summarized at the beginning of the table.

Table 5.3.2-2: Summary of Issues from Round 1 Open Houses

Community	Topic	Key Interests and Concerns
Multiple communities	Project Description	■ Participants were interested in knowing more about the grout being used for encapsulating the WR-1. More information was requested about its composition, longevity, and plans for monitoring the grout in the future. ■ Participants requested more detail about In Situ Decommissioning (ISD). Concerns included general ones about where radioactive material would be located on the WL site and more specific concerns about how long it would take for the radioactive material to decay. ■ Participants wanted to understand the rationale for choosing ISD as opposed to alternative decommissioning methods. ■ Several participants expressed a preference for dismantling the WR-1 completely. ■ Requests for material were made, including copies of the previous Comprehensive Study Report.
	Future Land Use and Land Tenure	Participants were interested in potential future uses of the site and how future land tenure for the site would be determined. Multiple parties have noted potential interest in future use the WL site, including municipalities, rural municipalities, First Nations, land owners who had their land expropriated in the 1960s when the site was founded, and industry. There was also discussion about using the WL site for developing small modular reactors.
	Water Quality	Participants raised concerns about the water quality in various waterbodies, including the Winnipeg River, the Lee River and Lac du Bonnet, as a result of ISD.
	Future Monitoring	Participants requested more information about monitoring activities during Institutional Control and what would occur if there was a release of hazardous/radioactive material.
	Waste Management	Participants were interested in what would happen with radioactive material currently stored on the WL site and the amount of material that would be transported to the Chalk River site.
Pinawa	Local Economy	Participants expressed concern about the future of the grant-in-lieu of taxes Atomic Energy Canada Limited currently pays to the Local Government District of Pinawa and economic regeneration activities being undertaken.
	Regulatory Process	The question was raised as to what would happen to the Project and the WL site if the regulator did not approve the Project.
Whitemouth	Project Description	More information about comparable projects in Canada and the US was requested.
Beausejour	Regulatory Process	Who will be assessing the Project and will the documents be available for public review?
	Local Economy	What is the nature of the workforce once the Project is completed?
	Water quality	Participants requested more detail about site hydrology and the aquifer.
	Accidents and Malfunctions	Questions were raised about earlier releases of contaminants on the WL site and how they were handled.

Table 5.3.2-2: Summary of Issues from Round 1 Open Houses

Community	Topic	Key Interests and Concerns
Powerview Pine Falls	Project Description	Participants requested updated timelines for the Project.
Lac du Bonnet	Future Engagement	Suggestions were made to make engagement more accessible, including helping interested parties interpret technical reports and holding open houses in different locations, including in Winnipeg, and at different times to improve attendance.
	Environmental Assessment	Participants requested more information on the experts working on the decommissioning process, including the selection process and company names.
	Accidents and Malfunctions	Questions were raised about earlier releases of contaminants on the WL site and how they were handled.

5.3.2.2 Media Coverage

CNL engaged in outreach with media organizations as part of the Round 1 activities. Five media outlets were invited to tour the WL site: *The Clipper*, Canadian Broadcasting Corporation (CBC) Radio, CBC Radio-Canada, the *Winnipeg Free Press* and the *Winnipeg River Advocate*. Of the organizations, two participated. Radio-Canada toured the full site. *The Clipper* toured the WR-1 Building and watched a video on the WR-1 and a presentation by CNL staff.

Table 5.3.2-3 provides a summary of media coverage that occurred during Round 1. Copies of media coverage that occurred during Round 1 engagement are included in Appendix C Round 1 Engagement Material of the *Section 5 Supporting Materials* report (CNL 2017a).

Table 5.3.2-3: Summary of Media Coverage during Round 1

Date	Article	Publication
October 16, 2016	CNL continues to review public feedback	*The Clipper*
December 8, 2016	CNL consultations continue	*The Clipper*
December 9, 2016	North Forge opens second site	*Winnipeg Free Press*
December 12, 2016	Dead and maybe buried	*Winnipeg Free Press*
December 13, 2016	Interview with Dan Coyne	Radio Noon (CBW-AM)
December 14, 2016	Whiteshell reactor must be sealed below bedrock: expert	*Winnipeg Free Press*
January 12, 2017	CNL staff give back	*The Clipper*
January 19, 2017	North Forge East opens in Pinawa	*The Clipper*
January 27, 2017	CNL Promises to Answer Questions	*Winnipeg River Advocate*
February 2, 2017	Wayne's Worldly View	*The Clipper*
February 10, 2017	Q & A With Canadian Nuclear Laboratories' Mitch McKay	*Winnipeg River Advocate*

5.3.2.3 Outreach to Stakeholder Groups

As part of Round 1 public engagement, CNL undertook broad outreach to inform local and regional stakeholders about upcoming open house events. Table 5.3.2-4 presents the additional groups to which CNL sent open house notifications. A copy of the announcement is included in Appendix C Round 1 Engagement Material of the *Section 5 Supporting Materials* report (CNL 2017a).

Table 5.3.2-4: Summary of Round 1 Engagement Outreach to Stakeholder Groups

Stakeholder Group	Location
Acsion Industries	Pinawa
Association of Community Living	Beausejour
Auglen Park and District Community Association	Lac du Bonnet
Beausejour and District Chamber of Commerce	Beausejour
Beausejour Brokenhead Development Corporation	Beausejour
Beausejour Co-op	Beausejour
Beausejour Lions Club	Beausejour
Black Bear Co-op Ltd	Lac du Bonnet
Blue Water Chamber of Commerce	St. Georges
Cold Granite Spring	Lac du Bonnet
Community Futures Winnipeg River	Lac du Bonnet
Community of Bissett	Bissett
Eastman Tourism Association	Whitemouth
Falcon and West Hawk Chamber of Commerce	Falcon Beach
Grand Beach and Area Development Corporation	Grand Marais
Lac du Bonnet and District Chamber of Commerce	Lac du Bonnet
Lac du Bonnet Lions Club	Lac du Bonnet
Local Government District of Pinawa	Pinawa
Manitoba Hydro	Winnipeg
Manitoba Model Forest	Powerview-Pine Falls
Milner Correctional Centre	Beausejour
Pinawa Chamber of Commerce	Pinawa
Pinawa Community Development Corporation	Pinawa
Royal Canadian Legion	Lac du Bonnet
Royal Canadian Legion	Beausejour
RM of Brokenhead	Beausejour
RM of Lac du Bonnet	Lac du Bonnet
RM of Reynolds	Hadashville
RM of Springfield	Oakbank
RM of St. Clements	East Selkirk
RM of Victoria Beach	Winnipeg
RM of Whitemouth	Whitemouth

Table 5.3.2-4: Summary of Round 1 Engagement Outreach to Stakeholder Groups

Stakeholder Group	Location
South Beach Casino	Scanterbury
Sun Gro Horticulture Canada Ltd.	Elma
Sunrise School Division	Beausejour
Tantalum Mining Corporation of Canada Ltd.	Lac du Bonnet
Town of Beausejour	Beausejour
Town of Lac du Bonnet	Lac du Bonnet
Town of Powerview-Pine Falls	Powerview
Whiteshell Cottagers Association	Winnipeg
Whiteshell Community Regeneration Partnership	Pinawa
Whiteshell School District	Pinawa
Winnipeg River Arts Council	Lac du Bonnet
Winnipeg River Learning Centre	Powerview-Pine Falls

5.3.2.4 Public Liaison Committee Meetings

While the PLC meets twice annually to discuss overall WL site decommissioning, its meeting on October 24, 2016 focused primarily on the Project. The meeting included an update on the overall decommissioning timelines, an update on the environmental assessment for the Project and a discussion on communication and community engagement. Table 5.3.2-5 provides a summary of the topics raised during discussion. Meeting notes are included in Appendix C Round 1 Engagement Material of the *Section 5 Supporting Materials* report (CNL 2017a).

Table 5.3.2-5: Summary of Discussion Topics for the Public Liaison Committee

Topic	Issue/Concern Raised
Local economy	■ Participants requested more detail on future levels of employment and how CNL will handle current employees whose skill sets may not match future employment opportunities at the WL site.
Future Land Use and Tenure	■ Participants were interested in future uses and land tenure for the WL site. It was noted that there are multiple parties who may want to use the WL site in the future, including First Nations, land owners who had their land expropriated in the 1960s when the site was founded, and industry. ■ Participants requested information about the future of the infrastructure currently on the site, such as buildings and the access road.
Communication and community engagement	■ Participants wanted to ensure that CNL was using appropriate media to engage the local communities, including articles in The Clipper and social media. ■ Participants shared additional ideas to help CNL reach more community members.

5.3.3 Summary of Round 2 Activities

5.3.3.1 Public Open Houses

Round 2 activities included open houses. Table 5.3.2-1 provides a summary of open houses, including the location, time and date, and number of comments received. The open houses featured a combination of storyboards, fact sheets and comment forms to solicit feedback from participants. The material distributed at the open houses, notes from the question and answer period, responses to formal comments, advertising for the open houses is provided in Appendix D Round 2 Engagement Materials of the *Section 5 Supporting Materials* report (CNL 2017a).

Table 5.3.3-1: Summary of Round 2 Open Houses

Location	Date	Times	Signed in Attendance	Estimated Attendance	Comments Received
Whitemouth	July 10, 2017	6pm-8pm	5	5	0
Pinawa	July 12, 2017	6pm-8pm	14	19	0
Lac du Bonnet	July 15, 2017	10am-1pm	24	28	10
Beausejour	July 18, 2017	6pm-8pm	3	3	0
Powerview – Pine Falls	July 20, 2017	6pm-8pm	8	8	0

Each open house included a question and answer session and an opportunity for participants to interact with CNL staff one-on-one. The key issues and concerns shared during the public open houses are presented in Table 5.3.3-2 by community. Some concerns were expressed by multiple communities. When an issue or concern was raised at three or more of the open houses, it is summarized at the beginning of the table.

Table 5.3.3-2: Summary of Issues from Round 2 Open Houses

Community	Topic	Key Interests and Concerns
Multiple Communities	Project Description	■ Participants wanted to understand the rationale for choosing ISD as the preferred decommissioning method, especially since many of them felt that CNL had chosen a method other than originally proposed (i.e., dismantling). While participants appreciated that CNL had found examples of projects in the United States that had used ISD, they were concerned that the environments were not completely analogous to the WL site. ■ Participants had questions about the composition of the grout, including its longevity. ■ Participants were interested in the process for filling the below grade structure with grout to ensure structural integrity and ensure that there are no voids. ■ Multiple participants expressed a desire that CNL dismantle WR-1 and remove all waste from the WL site.

Table 5.3.3-2: Summary of Issues from Round 2 Open Houses

Community	Topic	Key Interests and Concerns
	Regulatory Process	■ Participants requested more information on the timing for the review process, including the length of the public review period. ■ Some participants were curious about the authority of provincial regulators and the applicability of provincial regulations. Participants wanted to know if the *High-level Radioactive Waste Act* was applicable to the WL site. ■ Who is the responsible authority in the future?
Multiple Communities	Modelling	■ Participants requested details regarding the modelling, including what scenarios were considered and what variables were used. ■ Concerns were expressed about exposure to radiation.
Pinawa	Waste Management	■ The request was made for more details regarding radioactive waste, including the top 10 radionuclide contributors to final dose at different points in time, peak release rates, and the timing of the peak releasers. ■ What are the non-radioactive contaminants of interest? ■ What is going to happen to the waste management areas?
	Regulatory Process	■ Concern that the current timelines for review and approval of the Project were unrealistic in light of how long the licencing process for Ontario Power Generation's Deep Geologic Repository has taken.
Beausejour	Waste Management	■ Participants were curious about how many truck trips would be required to haul the waste.
	Future Land Use and Tenure	■ Participants requested more information about what will happen to the remainder of the WL site.
Lac du Bonnet	Regulatory Process	■ What happens if the regulator does not approve the Project?
	Future Land Use and Tenure	■ Participants wanted a better understanding of the future prospects of the WL site and if it will be possible to use it for another purpose to help replace the 300 jobs that will be lost when the overall decommissioning process is completed.
	Emergency Response	■ Participants requested more information about the emergency response plan the CNL is developing.
Powerview – Pine Falls	Regulatory Process	■ What happens if the regulator does not approve the Project?

5.3.3.2 Media Coverage

CNL engaged in outreach with media organizations as part of the Round 2 activities.

Table 5.3.3-3 provides a summary of media coverage that occurred during Round 2. Copies of media coverage that occurred during Round 2 engagement are included in Appendix D Round 2 Engagement Materials of the *Section 5 Supporting Materials* report (CNL 2017a).

Table 5.3.3-3: Summary of Media Coverage during Round 2

Date	Article	Publication
May 5, 2017	CNL Whiteshell Laboratories to Host Industry Day	*Winnipeg River Advocate*
May 25, 2017	Nuclear Regulators Visit North Eastman	*The Clipper*
June 8, 2017	LdB Trade Fair Well Attended	*The Clipper*
July 13, 2017	Plan to Bury Whiteshell Reactor Faces questions	*Winnipeg Free Press*
July 28, 2017	Another CNL public info session	*Winnipeg River Advocate*
August 2, 2017	Questions raised over burying WR-1	*The Clipper*

5.3.3.3 Outreach to Stakeholder Groups

As part of Round 2 public engagement, CNL undertook broad outreach to inform local and regional stakeholders about upcoming open house events. Table 5.3.3-4 presents the groups to which CNL sent open house notifications for Round 2 (consistent with notifications sent during Round 1 public engagement). Table 5.3.3-4 presents the additional groups to which CNL sent open house notifications and/or invitations to tour the site for Round 2. A copy of the announcement is included in Appendix D Round 2 Engagement Materials of the *Section 5 Supporting Materials* report (CNL 2017a).

Table 5.3.3-4: Summary of Round 2 Engagement Outreach to Stakeholder Groups

Stakeholder Group	Location
Manitoba Aboriginal and Northern Affairs	Winnipeg
Manitoba Cottagers Association	Winnipeg
Manitoba Jobs and the Economy	Selkirk
Manitoba Sustainable Development	Lac du Bonnet
Northwatch (received CNSC participant funding)	Ontario
Concerned citizen	Winnipeg (cottage property north of the WL site)

Site tours were also offered to various federal and provincial organizations, as summarized in Table 5.3.3-5.

Table 5.3.3-5: Site Tours to Federal and Provincial Organizations

Date	Participating Organizations
May 15, 2017	CNSC
May 18, 2017	Manitoba Infrastructure and Transportation, Manitoba Infrastructure Emergency Measures Organization; Commercial Vehicle Safety and Permits, Motor Carrier Division, Manitoba Infrastructure and Transportation; Manitoba Infrastructure and Services Policy Division; Manitoba Sustainable Development; The Executive Council (Manitoba); Manitoba Growth, Enterprise and Trade
June 15, 2017	Manitoba Sustainable Development
June 30, 2017	CanAsia, Manitoba Trade and Investment
July 17, 2017	Manitoba Sustainable Development, Green Manitoba

5.3.3.4 Public Liaison Committee Meetings

While the PLC meets twice annually to discuss overall WL site decommissioning, its meeting on May 18, 2017 focused primarily on the Project with representatives from the CNSC, Atomic Energy Canada Limited (AECL), and Provincial and Federal governments invited to attend. The meeting included an update on the overall decommissioning process, an update on the environmental assessment for the Project and a discussion on emergency response. Table 5.3.3-6 provides a summary of the topics raised during discussion. Meeting notes are included in Appendix D Round 2 Engagement Material of the *Section 5 Supporting Materials* report (CNL 2017a).

Table 5.3.3-6: Summary of Discussion Topics for the Public Liaison Committee

Topic	Issue/Concern Raised
Future Land Use and Tenure	Participants were interested in future land use and tenure of the WL site. There were questions about: ■ The total area of land that will be available for future use. ■ Who currently owns the land and who may own the land once decommissioning is complete, including land that was expropriated from Lac du Bonnet residents when the WL site was originally established?
Waste Disposal	Participants requested additional information about storage facilities for radioactive waste, including the activities of the Nuclear Waste Management Organization and permanent storage facilities for low and intermediate-level waste.
Emergency Response	Participants were interested in the organizations that CNL intends to work with regarding transporting waste and emergency response.
Economic Development	Participants discussed economic development activities related to the WL site, which included a progress report for North Forge East activities and activities related to using the site as a staging area for small modular reactors.

5.3.4 Future Engagement Activities Planned

There will be an additional round of engagement once the draft EIS has been filed with regulators. Future activities are expected to focus on the draft EIS and how stakeholders can provide feedback to the CNSC. The anticipated activities currently include public open houses, site tours for interested stakeholder groups, presentations and meetings with elected municipal and regional government officials, and a public open house day where members of the public can attend site tours and information sessions. Engagement activities will be summarized and shared with the regulator as a supplemental filing.

6.0 ENVIRONMENTAL EFFECTS

6.1 Environmental Assessment Approach

The environmental assessment process is an important tool that is used to integrate environmental and social factors into project planning and decision-making. The goal of the environmental assessment process is:

- to promote sustainable development;
- to engage First Nation and Métis communities, the public and government agencies: and
- to reduce the overall biophysical, economic, social, heritage and health effects of the project.

This section describes the scope and the environmental assessment approach implemented for the Canadian Nuclear Laboratories (CNL) In Situ Decommissioning of Whiteshell Reactor 1 (WR-1) at the Whiteshell Laboratories site (the Project). The environmental assessment approach applied to disciplines (e.g., atmospheric environment, hydrogeology, terrestrial environment, human health and socio-economic environment) includes the following main steps (where applicable), with further detail on each step provided in following subsections:

- define the scope of the assessment including input received from regulatory agencies, engagement and consultation activities, and guidance documents;
- identify the valued components (VCs) for each discipline upon which the assessment will focus and the associated measurement indicators and assessment endpoints for VCs;
- define spatial and temporal boundaries used to quantitatively evaluate effects;
- describe existing conditions, including the cumulative effects of previous and existing developments for each VC;
- conduct a pathway analysis to identify Project components or activities with a potential to create a residual effect and identify mitigation for removing pathways or limiting effects;
- conduct an assessment for each VC to predict residual effects from the Project;
- conduct an assessment for each VC to predict the cumulative effects of previous and existing projects and activities, the Project and potential future projects that have been proposed, but not yet approved (if applicable);
- evaluate and describe the level of certainty that can be placed on predicted residual effects;
- determine the significance of cumulative effects from the Project and potential future projects that have been proposed, but not yet approved (if applicable); and
- identify monitoring and follow-up programs to address uncertainty.

Generally, elements of the approach can be consistently applied to all disciplines, with some modifications to disciplines, where appropriate. For example, the definition of a VC can be applied to all disciplines and there is consistency in the approach to determining the spatial and temporal boundaries for the effects analysis. Similarly, the approaches for identifying interactions that link the Project to potential effects on VCs are consistent.

In contrast, the methods for analyzing, classifying (e.g., magnitude and duration) and predicting environmental significance of residual effects can differ between discipline components. For example, human effects from a specific project are difficult to isolate from the ongoing 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 effects of the Project. Biophysical disciplines (e.g., hydrogeology, aquatic environment and terrestrial environment) are influenced simultaneously by natural and human related factors. However, for many biophysical disciplines, Project-specific effects 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 positive aspects and negative aspects. An effect on a biophysical discipline is typically constrained to being negative or positive.

Each of the steps identified above are described in the following sections; details specific to each discipline are provided in their respective sections of the EIS.

6.1.1 Scope of the Assessment

The decommissioning approach for the Whiteshell Laboratories (WL) site as described in the Comprehensive Study Report was to remove all facilities entirely from the WL site with the exception of low level waste trenches in the Waste Management Area, which may be managed through on-site in situ disposal (AECL 2001). The new preferred approach for decommissioning of the WR-1 Building is In Situ Decommissioning (ISD), which allows CNL to decommission the WR-1 Building in a safe, cost effective manner and in a shorter timeframe without interim storage. The Project activities are limited to ISD of the WR-1 Building (i.e., the Project). ISD is the safest technique, dramatically reducing the risk to workers compared to dismantling, and providing long-term safety to the public and the environment. Other decommissioning activities for the WL site, documented in the Comprehensive Study Report, are assumed to be unmodified. Removal of the east annex and service wings of the WR-1 Complex were assessed as part of the Comprehensive Study Report and are covered under the CNL's existing decommissioning licence for the WL site (Licence No. NRTEDL-W5-8.04/2018). Activities required to prepare for ISD, such as isolation of the WR-1 Building and targeted remediation of hazardous materials, are also covered under CNL's existing decommissioning licence for the WL site.

The scope of the environmental assessment incorporates advice provided in guidance documents relevant to environmental assessment practice (Section 1.6 Federal Review Process) and input received from regulatory agencies, First Nation and Métis communities, and the public (Section 4.0 Aboriginal Engagement and Section 5.0 Public Engagement). As described in Section 1.6, the 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.

Input from engagement for the Project is used to identify the key issues that were raised during the consultation process (Section 4.0 Aboriginal Engagement and Section 5.0 Public Engagement). Issues identified during engagement activities and considered in the development of the EIS are summarized in the *Section 5 Appendices Supporting Material* report (CNL 2017). Comments received, the responses prepared, and the degree to which these comments are considered resolved are also presented in the *Section 5 Appendices Supporting Material* report (CNL 2017). These issues and the response to these issues are presented in the "Scope of the Assessment" heading within each discipline section, and helped to guide the scope and development of the assessment for each discipline.

6.1.2 Valued Components

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, First Nation and Métis communities, or the public (the Agency 2014). 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 Project considered a number of factors, including:

- presence, abundance and distribution within, or relevance to, the area associated with the Project;
- potential for interaction with the Project and potential vulnerability to the effects of the Project;
- 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 First Nation and Métis communities;
- legally recognized and afforded specific protection by law, policy, or regulation; and
- experience with similar projects.

Valued components 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 final list of VCs that are included in the effects assessment for the Project, including rationale for their selection, is provided in Table 6.1.2-1.

Table 6.1.2-1: Valued Components Selected for the Effects Assessment

Discipline	Valued Component	Rationale
Atmospheric Environment	Air Quality	Air quality is selected as a VC as it has been identified as an important aspect of the environment by the regulators. In addition, emissions from the Project activities have the potential to alter the existing air quality regime.
	Climate Change	This valued component, assessed through incremental changes in emissions of greenhouse gases, considers the potential of the Project to contribute to climate change.
Physical 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 Project activities could affect terrestrial and aquatic biodiversity.
	Hydrogeology (groundwater quality and quantity)*	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 Project activities could affect terrestrial and aquatic biodiversity and human health.
Surface Water Environment	Hydrology*	■ The Project may affect existing availability of the spatial and temporal distribution of water quantity for aquatic and terrestrial biodiversity, which can subsequently affect land and resource use. ■ Public and First Nation and Métis communities concerns regarding changes in water quantity in the Winnipeg River are an important consideration in understanding potential effects of the Project.
	Surface Water Quality*	■ Water quality to support aquatic and human health is defined by the concentration of various constituents, such as major ions (e.g., chloride, potassium), nutrients (e.g., nitrogen, phosphorus), metals 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 biodiversity and the use of water as a drinking water source for people or for recreational purposes. ■ Public and First Nation and Métis communities concerns regarding changes in water quality in the Winnipeg River are an important consideration in understanding potential effects of the Project.

Table 6.1.2-1: Valued Components Selected for the Effects Assessment

Discipline	Valued Component	Rationale
Aquatic Environment	Fish and fish habitat	The Winnipeg River supports a diverse fish community, including species-at-risk and species that support recreational fisheries. The migration of radionuclides to the Winnipeg River via groundwater may potentially affect fish and fish habitat.
Terrestrial Environment	Barn swallow	■ Barn swallow (*Hirundo rustica*) is listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), but is not currently listed under the *Species at Risk Act* (*SARA*). As a migratory bird, barn swallow has legal individual and nest protection under the *Migratory Birds Convention Act* (*MBCA)*. ■ There is the potential for barn swallow to be indirectly and directly affected by the Project through sensory disturbance, habitat loss, and mortality (i.e., loss of eggs in nests during building demolition – if there are nests located on the building). Barn swallows have been observed nesting in numerous structures within the WL site.
	Golden-winged warbler	■ Golden-winged warbler (*Vermivora chrysoptera*) is federally listed as Threatened under SARA and listed under the *MBCA*. It has legal individual and habitat protection provisions under SARA and individual and nest protection under *MBCA*. ■ As the Regional Study Area (RSA) is federally-owned, 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 affected by the Project through sensory disturbance (i.e., noise created by decommissioning activities). ■ Avian species with the potential to occur within the RSA (no confirmed observation records to-date), that represents a guild of edge habitat specialists.

Table 6.1.2-1: Valued Components Selected for the Effects Assessment

Discipline	Valued Component	Rationale
Terrestrial Environment	Bats ■ Little brown myotis ■ Northern myotis	■ Little brown myotis (*Myotis lucifugus*) and northern myotis (*M. septentrionalis*) have observation records within the area. Both bat species are federally listed as Endangered and have legal individual protection provisions under the federal *SARA*. ■ As the WL site is federally-owned, these bat species are afforded protection of critical habitat because they are listed as Endangered on Schedule 1 of *SARA*. ■ Critical habitat has only been "partially identified", for one life history requirement and habitat type (overwintering habitat), as the largest threat to these species is associated with that habitat type. No active hibernacula have been identified at the WL site and the geological conditions make the presence of caves or exposed bedrock highly unlikely. ■ Other critical habitat types that are identified, but not yet legally defined and protected as "critical habitat", include: roosting, foraging, and swarming habitat. ■ Maternity roost habitat for little brown myotis and northern myotis is potentially present in the treed areas surrounding the WL site. There is the potential for both species to be indirectly affected by the Project through sensory disturbance and related habitat avoidance (caused by noise associated with decommissioning activities and potential roost abandonment). ■ Maternity roost habitat for little brown myotis is potentially present in the WR-1 Building, and little brown myotis have the potential to be indirectly and directly affected by the Project through disturbance, habitat loss, and mortality (i.e., loss of pre-volant juveniles in maternity roosts during building demolition). ■ Represents small mammal species recorded in the area that may utilize buildings for part of their life history (maternity roosting, diurnal roosting, and evening roosting).
	Snapping turtle	■ Snapping turtle (*Chelydra serpentina*) has been observed within the area. They are federally listed as Special Concern under *SARA*, but they do not have legal individual protection provisions under the Act, nor do they receive protection of critical habitat. ■ There is the potential for snapping turtle to be indirectly and directly affected by the Project through sensory disturbance (noise) and mortality (i.e., vehicle strike on roads). All snapping turtle observations to-date have been on roads. ■ Represents herpetile species that are vulnerable to mortality on roadways.

Table 6.1.2-1: Valued Components Selected for the Effects Assessment

Discipline	Valued Component	Rationale
Socio-economic Environment	Employment and Income	Local communities recognize that the decommissioning of the WL site will result in changes to local employment and income opportunities. There are concerns that the change in approach to decommissioning the WR-1 Building may result in challenges to attracting new businesses to the WL site and creating future opportunities.
	Business Opportunities	The proposed changes in decommissioning activities for the WR-1 Building create a different set of opportunities for contractors than the previous decommissioning plan.
	Government Finances	The Local Government District (LGD) of Pinawa relies on a grant-in-lieu of taxes from the AECL associated with the presence and operation of the WL site. The proposed changes in decommissioning activities will accelerate changes to the grant-in-lieu of taxes, which would change Pinawa's municipal revenue streams.
	Community Infrastructure and Services	A wide range of essential human needs are fulfilled by infrastructure and services in communities. Projects can place additional demands on them and their ability to meet community needs. The Project may also affect how community infrastructure and services are funded in Pinawa as AECL pays the LGD a grant-in-lieu of taxes, which is used to fund infrastructure and services, including the School District of Whiteshell.
	Community Well-being	Community well-being is affected by a variety of factors, including consideration of economic well-being, physical well-being, social well-being and the environment. Communities have expressed concern that attracting a new business/industry to the WL site is important for their continued viability, both in terms of employment/income and in terms of their long-term sustainability. The change in approach to decommissioning the WR-1 Building may restrict access to more of the WL site than previously anticipated and limit its subsequent development for other economic activities. Public perception of buried radioactive waste may further limit the ability to attract other economic activities.
	Public Safety	Public Safety has been a concern for the overall decommissioning of the WL site, which included medium-term storage of radioactive waste and eventual transport of radiological waste to permanent disposal facilities. The Project will reduce the amount of radiological waste being transported to disposal facilities, which will reduce one public safety hazard; however the shift to ISD will create a new public concern as additional waste will be stored on the WL site permanently.

Table 6.1.2-1: Valued Components Selected for the Effects Assessment

Discipline	Valued Component	Rationale
Land and Resource Use	Land Tenure	Land tenure considers the uses, allocations, and ownership of lands in proximity to the Project, including the WL site itself. The change in decommissioning for WR-1 Building will change the proportion of the WL site available for future land tenure by private or public entities. The use of ISD may also change the perceived suitability of land use surrounding the WL site.
	Outdoor Recreation and Tourism	The WL site is located in an area with several provincial parks, including the Whiteshell Provincial Park, that offer a variety of outdoor recreation opportunities while also being located near municipalities and RMs that rely on cottagers and tourism to contribute to their local economies.
	Cultural and Archaeological Sites	Cultural and archaeological sites are important for revealing past and present land use, cultural identity and relationships with other cultures and the social and biophysical environments. Potential alteration or loss of cultural and archaeological sites can have an effect on Aboriginal people. Consideration of physical and cultural heritage is a requirement under Section 5 of the *Canadian Environmental Assessment Act, 2012* (*CEAA, 2012)*.
	Traditional Land and Resource Use by Aboriginal People	Traditional land and resource use by Aboriginal people is important for maintaining meaningful connections with cultural identity and community history. Traditional land and resource use can also promote intergenerational connections within communities as knowledge is passed down from elders to community members, including youth. Potential changes to traditional land and resource use by Aboriginal people can have an adverse effect on Aboriginal people by preventing them from fully expressing their cultural identity and Treaty rights. Consideration of current land and resources use for traditional purposes is a requirement under Section 5 of *CEAA, 2012*.
	Winnipeg River	The public and First Nation and Métis communities identified the importance of the Winnipeg River. A number of communities depend on the river for drinking water, recreation, and food. The river flows into the Lake Winnipeg, one of the largest lakes in the world. The eastern shore of the lake is included in a United Nations World Heritage Site proposal (UNESCO 2016). This watershed is valued for many reasons by many people and groups.

Table 6.1.2-1: Valued Components Selected for the Effects Assessment

Discipline	Valued Component	Rationale
Human and Ecological Health	Public Health ■ Farms A and F ■ Harvesters ■ On-site farmer	■ Farms A and F includes year-round occupants, with livestock, located near the east bank of the Winnipeg River. Farm A is the closest existing farm downstream on the east bank and is the most conservative potential water user. Farm F is the closest farm that could be affected by air emissions from the Project. ■ Harvesters represent Traditional users of the area who may be exposed through harvesting of country foods. ■ In the long-term, during post-Institutional Control, there is the potential that a farmer may inhibit the site using the Winnipeg River as a water source. The on-site farmer also bounds the effects of a new closer off-site farm than Farm A and Farm F.
	Worker Health	Workers are potentially exposed to both radiological and non-radiological hazards.
	Earthworm	Detritivore. Exposed to atmospheric release through soil.
	American Robin	Observed on-Site. Exposed to atmospheric release through the ingestion of soil invertebrates. A surrogate for insect eating birds including various species at risk under COSEWIC, *ESEA* or *SARA*.
	Loggerhead Shrike	Observed on-Site. Exposed to atmospheric release through the ingestion of soil invertebrates, small mammals and birds. Identified as a species at risk under COSEWIC, *ESEA* or *SARA*. A surrogate for other predatory birds identified as SAR under COSEWIC, *ESEA* or *SARA*.
	Grass and Shrubs	Present on-Site. Exposed to atmospheric release through soil. Food source for other VCs.
	Berries	Present in the area. Exposed to atmospheric release through soil. Food source for VCs.
	Meadow Vole	Common in the area. Exposed to atmospheric release through ingestion of terrestrial plants. A food source for VCs.
	Common Shrew	Common in the area. Exposed to atmospheric release through ingestion of soil invertebrates. A food source for VCs.
	Snowshoe Hare	Common in the area. Exposed to atmospheric release through ingestion of terrestrial plants. A game species.

Table 6.1.2-1: Valued Components Selected for the Effects Assessment

Discipline	Valued Component	Rationale
Human and Ecological Health	White-tailed Deer	Common in the area. Over winters on-site. Exposed to atmospheric release through ingestion of terrestrial plants. A game species. An important game species for traditional communities.
	Red Fox	Common in the area. Exposed to atmospheric release through the ingestion of small mammals and birds. A surrogate for the Grey Fox identified as a species at risk under COSEWIC, *ESEA* or *SARA*.
	Little Brown Myotis	Bats observed roosting in forested areas of the Site. Exposed to atmospheric release through ingestion of soil invertebrates. Exposed to aquatic release through ingestion of aerial stages of benthic invertebrates. Identified as a species at risk under COSEWIC, *ESEA* or *SARA*. A surrogate for other bats identified as species at risk under COSEWIC, *ESEA* or *SARA*.

Note:

Those valued components denoted with an "*" indicate a valued component that does not have an assessment endpoint.

Farm A = Easting (m): 709547, Northing (m): 5565803; Farm F = Easting (m): 708772, Northing (m): 5564710

VC = valued component; *SARA* = *Species at Risk Act*; COSEWIC = Committee on the Status of Endangered Wildlife in Canada; *ESEA* = *Endangered Species and Ecosystems Act*; CSA = Canadian Standards Association; WL = Whiteshell Laboratories; ISD = In Situ Decommissioning; RM = Rural Municipality; *MBCA* = *Migratory Birds Convention Act*; *CEAA* = *Canadian Environmental Assessment Act*; AECL = Atomic Energy of Canada Limited; LGD = Local Government District.

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). 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 and radioactivity 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.

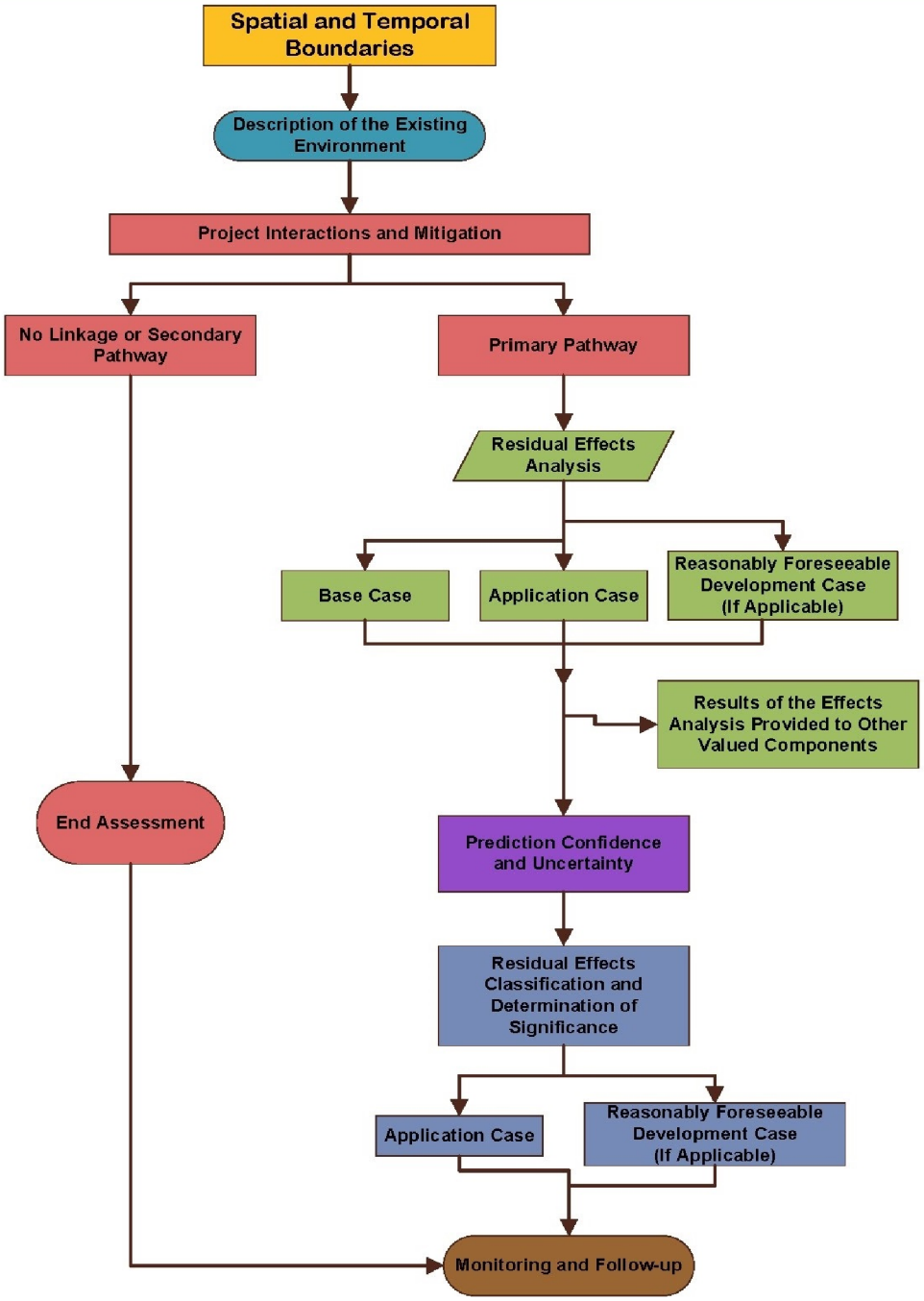
The significance of effects from the Project on VCs is evaluated by linking **changes** in measurement indicators to **effects** on the assessment endpoints. For example, changes in habitat quantity and quality (measurement indicators) are used to assess the significance of residual effects from the 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 are considered as measurement indicators for other VCs, and do not have an assessment endpoint (i.e., may be referred to as pathway or intermediate components). Intermediate component VCs 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.

Valued components 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; however, 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 nor evaluated for significance. The environmental assessment approach for VCs with assessment endpoints is illustrated on Figure 6.1.2-1, and the approach for VCs with no assessment endpoints is illustrated on Figure 6.1.2-2. The assessment approach is described further in Section 6.1.3 Assessment Boundaries to Section 6.1.9 Monitoring and Follow-up.

Valued Component with an Assessment Endpoint



REFERENCE(S)
1. GOLDER, 2017

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
ENVIRONMENTAL ASSESSMENT APPROACH FOR VALUED COMPONENTS WITH AN ASSESSMENT ENDPOINT

CONSULTANT
Golder Associates

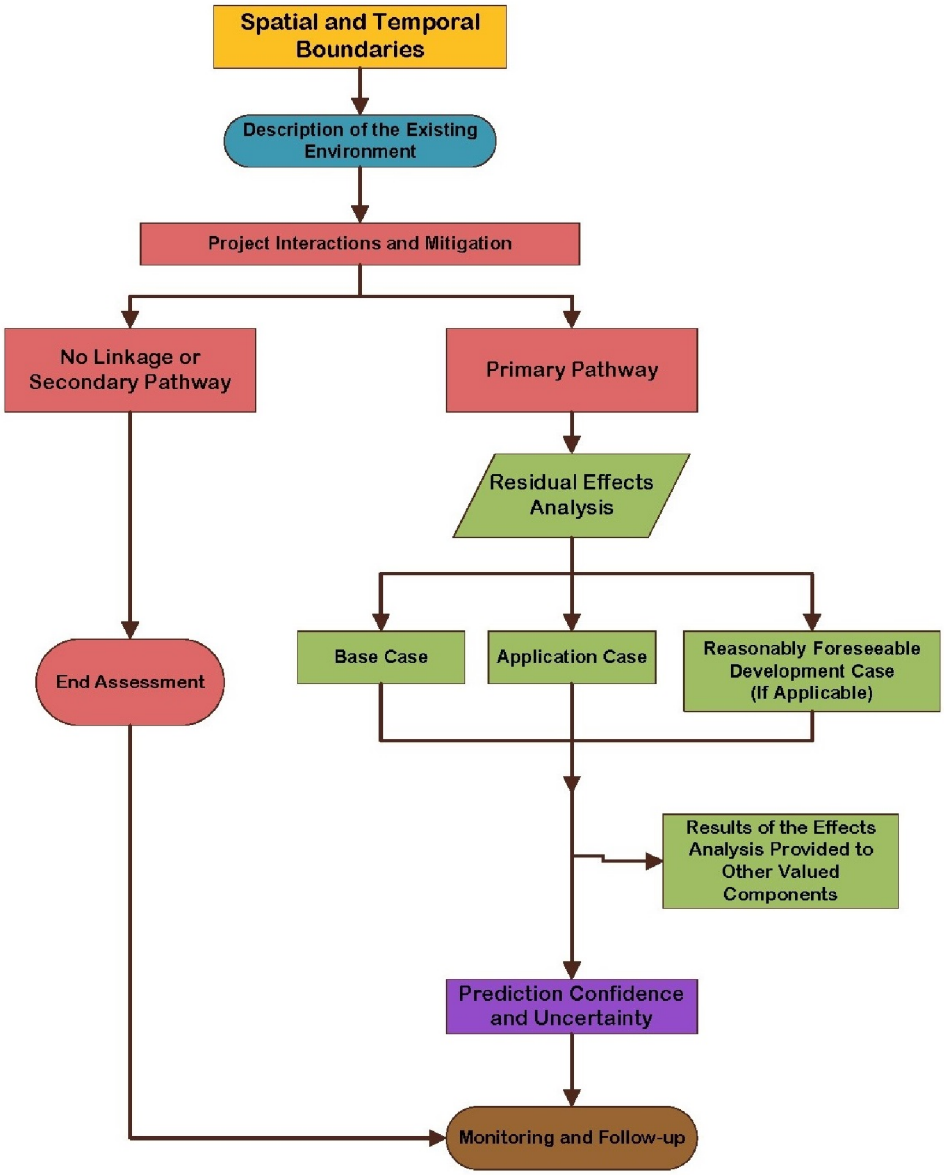
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DESIGNED	--
PREPARED	PR/SFC
REVIEWED	RK
APPROVED	

PROJECT NO.	CONTROL	REV.	FIGURE
1656897		1	**6.1.2-1**

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Valued Component without an Assessment Endpoint



REFERENCE(S)

1. GOLDER, 2017

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
ENVIRONMENTAL ASSESSMENT APPROACH FOR VALUED COMPONENTS WITHOUT AN ASSESSMENT ENDPOINT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	--
PREPARED	PR/SFC
REVIEWED	RK
APPROVED	

PROJECT NO.	CONTROL	REV.	FIGURE
1656897		1	**6.1.2-2**

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6.1.3 Assessment Boundaries

Assessment boundaries define the geographic and temporal scope or limits of the analysis of effects from the Project on the environment. These boundaries encompass the areas within (spatial boundaries) and times during (temporal boundaries) which the Project, and in combination with previous, existing and reasonably foreseeable developments, is expected to interact with the VCs.

6.1.3.1 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 (i.e., hydrogeology, aquatic environment, terrestrial environment and socio-economics), and associated VCs, using the following criteria:

- physical extent of the 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 multi-scale approach for describing baseline conditions (existing environment) and predicting effects from the 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.

As indicated in the CNSC Generic EIS Guidelines (2016), the following spatial scales will be considered by each discipline.

- **Site Study Area (SSA):** the Site Study Area is the Project footprint (i.e., where Project activities would be undertaken including the Project's proposed facilities, buildings and infrastructure).
- **Local Study Area (LSA):** The Local Study Area is defined as the area existing outside the Site Study Area boundary, where measurable changes to the environment resulting from the proposed activities may be anticipated.
- **Regional Study Area (RSA):** The Regional Study Area is defined as the area within which the potential effects of the Project may interact with the effects of other projects.

The spatial boundary for the study areas considered by each discipline and the rationale for their selection are identified in Section 6.2 Atmospheric Environment through Section 6.9 Socio-economic Environment under the "Assessment Boundaries" heading. The study areas are illustrated on maps of appropriate scale, which are also included in Section 6.2 Atmospheric Environment through Section 6.9 Socio-economic Environment under the "Assessment Boundaries" heading.

6.1.3.2 Temporal Boundaries

The temporal boundary of the assessment includes effects observed under existing conditions, the timeframe during which Project activities are actively occurring, and 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 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 environmental assessment was designed to evaluate the short- and longer-term changes from the Project and associated effects on the biophysical and human environments. Projects are defined by phases, which typically includes construction, operations, and reclamation and closure; however, given the nature of this Project, only the closure (which includes decommissioning and reclamation) and post-closure phases are relevant. These phases are described as follows.

- **Closure Phase:** Preparation and implementation of In Situ Decommissioning (ISD), which includes preparation for ISD, grouting of below-grade structures and systems, removal of above-grade WR-1 Reactor structures and systems, installation of the engineered cover and environmental controls and final site restoration. These activities last from 2019 to 2024.
- **Post-closure Phase:** The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. The Institutional Control period includes implementation of both active and passive control throughout 2024 to 2324 (i.e., 300 years). During active Institutional Control, long-term performance monitoring and maintenance activities will continue through to 2124 to demonstrate compliance with the safety case assumptions. The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions) and are assumed to continue through 2024 to 2324. Post-institutional Control occurs after year 2324 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 Project. The final selection of temporal boundaries is discipline-specific and include consideration of the phases described above. For some VCs, residual effects are assessed for all phases of the Project, but not necessarily for each specific phase. For example, effects on wildlife begin during the closure phase with the removal and alteration of habitat (i.e., results in direct and indirect changes) and continue through the post-closure phase and for a period after the post-closure phase until reversed, unless determined to be irreversible or permanent. Therefore, effects on wildlife are analyzed and predicted from closure through to post-closure, which generates the maximum potential spatial and temporal extent of effects, and provides confident and ecologically relevant effects predictions.

Alternately, for some VCs, the assessment was completed for those phases of the Project where predicted effects would be expected to peak (e.g., most air quality effects from emissions occur during closure) or at several key points in time. These points in time may include several periods within or among Project phases. Examples include comparing the maximum extent of disturbance to vegetation during closure to the amount that will be reclaimed, or evaluating surface water quality predictions at specific times that represent key milestones throughout the life of the Project. For other VCs, the assessment of effects may continue beyond the post-closure phase.

Similarly, 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 Project, and the period during which the residual effects from reasonably foreseeable developments will overlap with residual effects from the Project. The temporal boundaries considered by each discipline are identified in Section 6.2 Atmospheric Environment through Section 6.9 Socio-economic Environment under the "Assessment Boundaries" heading.

6.1.3.3 Assessment Cases

This section will provide a brief description the assessment cases considered in the EIS. The assessment cases are discipline-specific and include 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, and residential and recreational development. Current effects from the existing WL site facilities and operations, for example, are considered part of the Base Case. In addition, effects from the decommissioning and reclamation activities already completed at the WL site are also considered as 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 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. Effects from the future decommissioning and reclamation activities to be completed at the WL site are also considered as part of the RFD Case.

6.1.4 Description of the Environment

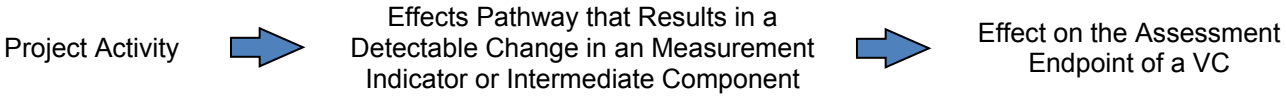
To provide a basis for evaluating potential changes of the Project, each discipline assessment includes a description of the baseline conditions in the "Description of the Environment" subsection. The baseline studies are completed to develop an understanding of the existing physical, biological and social conditions that may be influenced by the 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., agricultural activities, forestry, traditional and sport hunting and fishing). Existing conditions are described recognizing that baseline conditions typically fluctuate within a range of variation through time and space depending on which selection pressures are currently driving changes to the VC and system. The Base Case thus describes the existing environment without the implementation of the Project, and is used to provide an understanding of the physical, biological and social conditions that may be influenced by the Project.

Information sources included published and unpublished material, consultation with appropriate government staff (e.g., Manitoba Sustainable Development), and baseline and other monitoring data collected by CNL. This information is reviewed and analyzed to determine the presence of data gaps. Baseline field studies are 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 Aboriginal 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 "Project Setting and Characterization" sub-sections in Section 6.2 Atmospheric Environment through Section 6.9 Socio-economic Environment.

6.1.5 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. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. 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.



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 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 Project and the VC, or the pathway is removed by environmental design features or mitigation so that the 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 –** 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; or
- **primary –** 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 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 Project effects on VCs. A matrix table is included in Appendix 6.1 Project-Environment Interactions Matrix summarizing Project interactions for each VC that are determined to be no linkage, secondary, or primary, after consideration of environmental design features and mitigation.

6.1.6 Residual Effects Analysis

The residual effects analysis is based on the Project 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 Project, as well as previous, existing and reasonably foreseeable developments. The residual effects analysis is completed for the Application Case and the RFD Case.

6.1.6.1 Application Case

This Application Case scenario represents predictions of the cumulative effects of the existing environment combined with the effects that may result from the 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 6.1.5 Project Interactions and Mitigation 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 scenario represents effects predictions of the projects represented in the existing environment (Base Case) combined with the effects that may result from the Project.

The Application Case represents predictions of the cumulative effects of the developments in the Base Case combined with the effects from the Project. Where relevant, this case was used to identify the incremental changes from the 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 6.1.5 Project Interaction and Mitigation.

The temporal boundary of the Application Case begins with the anticipated first year of the 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 Project because the effects will not be reversible until beyond closure. For other VCs, the effects may be determined to be irreversible within the temporal boundary of the assessment 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).

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 or 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 Project and the spatial extent of effects is typically expressed in area or distance from the 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.

6.1.6.2 Reasonably Foreseeable Development Case

The RFD Case scenario includes the Application Case plus additional reasonably foreseeable developments in the region that have not yet been approved. Developments and activities that are currently under application review, or that 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 Project, in combination with existing, previous 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 2014). Cumulative effects such as those that are likely from a reviewable project, combined with the effects from prior development, existing activities 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 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 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 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 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 Project-specific effects analysis (Section 6.1.6.1 Application Case).

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.

6.1.7 Prediction Confidence and Uncertainty

The purpose of an environmental assessment is to conservatively 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 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 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 a development, and the timing 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 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.

6.1.8 Residual Effects Classification and Determination of Significance

6.1.8.1 Residual Effects Classification

The purpose of the residual effects classification is to describe the residual incremental and cumulative adverse effects from the 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 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 following criteria, which follows the Environmental Assessment Guidelines provided by the CNSC (CNSC 2016) and the Agency's "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 2015). 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 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 Project activity or stressor, reversibility is the likelihood that the 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 Project). 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.

6.1.8.2 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 Project and other existing, approved, 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 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 future developments, including the 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 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 and likelihood are considered as modifiers 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 Project footprint, 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.

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 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 Project overall, for the cumulative residual adverse effects from the Project and previous and existing developments (Application Case), and for the 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.

- Results from the residual effects classification of primary pathways and associated predicted changes in measurement indicators are classified.
- 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 might be either significant or not significant, the assessment conservatively identified the effect as significant and provided additional follow-up actions to reduce uncertainty.

6.1.9 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. Monitoring is used to 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 Project.

- **Compliance Inspections –** 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 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 Winnipeg River for water quality 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 and coordinated with the existing Environmental Assessment Follow-up Program (EAFP) being conducted as specified in the Comprehensive Study Report (AECL 2001), where practical. Where relevant, conceptual monitoring programs will be proposed to deal with the uncertainties associated with the effect predictions and mitigation.

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6.2 Atmospheric Environment

This section of the Environmental Impact Statement (EIS) for the Canadian Nuclear Laboratories (CNL) In Situ Decommissioning of WR-1 at the Whiteshell Laboratories Site (the Project) seeks to understand and characterize potential residual effects of the Project and other past, present and reasonably foreseeable developments on the atmospheric environment. Section 6.2.1 focuses on air quality and Section 6.2.2 focuses on greenhouse gas (GHG) emissions.

A quantitative noise assessment has not been completed for inclusion in this EIS as it is not anticipated that there are sensitive human receptors in the vicinity of the Project that would experience nuisance effects from the closure and post-closure phases of the Project. A qualitative discussion of potential effects from noise (i.e., sensory disturbance) on wildlife is provided in Section 6.6 Terrestrial Environment and on community well-being in Section 6.9 Socio-economic Environment.

6.2.1 Air Quality

6.2.1.1 Scope of the Assessment

The scope of the air quality assessment focuses on predicting changes in indicator compounds emissions and comparison of these changes to the applicable guidelines and standards. The indicator compounds emissions from the 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) and 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 also be a nuisance issue over which the public is concerned. The assessment of air quality focused on predicting changes in the concentrations of above mentioned indicators compounds emissions; radiological parameters are considered in Section 6.7 Human and Ecological Health.

The air quality assessment follows the overall environmental assessment approach and methods described in Section 6.1 Environmental Assessment Approach. The assessment is completed in the following primary steps.

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries, and assessment cases** (refer to Sections 6.2.1.2 Valued Components and Section 6.2.1.3 Assessment Boundaries) for the air quality assessment. The VCs, assessment endpoints, and measurement indicators used to assess Project related changes to air quality; the spatial and temporal boundaries at which the assessment occurred; and, the assessment cases considered.
- **Step 2 – Describe the existing conditions** (refer to Section 6.2.1.4 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).
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 6.2.1.5 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 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. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. 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 described. Primary pathways that may lead to residual effects to air 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 6.2.1.6 Residual Effects Analysis). This section outlines the methods used to predict and characterize residual effects to air quality from primary effect pathways. The analysis results are also presented including the characterization of incremental effects from the 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 6.2.1.7 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 6.2.1.8 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 the Project for the air quality VC is made.
- **Step 7 - Identify monitoring and follow-up** (refer to Section 6.2.1.9 Monitoring and Follow-up) required to confirm effects predictions and address uncertainty.
- **Step 8 - Present a consolidated summary of conclusions and outcomes of the assessment** (refer to Section 6.2.1.10 Conclusions) of residual effects on air quality.

This section also describes how the input from engagement influenced the scope of the air quality assessment. Information and concerns raised by the public, communities of interest, regulators and First Nation and Métis communities during engagement that influenced the scope of the air quality assessment are summarized in Table 6.2.1-1. Other general concerns and questions raised during the engagement are documented in Section 4 Aboriginal Engagement and Section 5 Public Engagement.

Table 6.2.1-1: Summary of Issues Raised During Engagement Activities that Influenced the Scope of the Air Quality Assessment

Issue	How the Issue Was Included in the Assessment
Concerns were raised with respect to downwind effects of air emissions associated with the operations at the WL site.	The assessment included consideration existing air quality, as well as predicted changes in air quality. The maximum predicted air quality results presented and are considered to be representative of the highest concentrations expected outside the study area from Project activities.

6.2.1.2 Valued Components

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, First Nation and Métis communities, or the public (the Agency 2014). Air quality was selected as a VC as there is a potential for the Project activities to release air emissions that could affect the local air quality (Table 6.2.1-2). Meteorology is also important as it governs the transport, dispersion, and deposition of air emissions from the Project.

Table 6.2.1-2: Valued Components for Air Quality Assessment

Valued Component	Rationale for Selection
Air Quality	Air quality is selected as a VC as it has been identified as an important aspect of the environment by the regulators. In addition, emissions from the Project activities have the potential to alter the existing air quality regime.

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 (Table 6.2.1-3). 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 two categories:

- **particulate matter**: SPM, PM_{10}, and $PM_{2.5}$; and
- **combustion gases**: NO_X represented by NO_2, SO_2, and CO.

These indicator compounds are associated with various Project activities. Particulate matter is typically associated with airborne dust from demolition and decommissioning activities including the mobile concrete batching plant, construction equipment, and vehicles travelling over on-site paved roads, as well as material handling activities. Products of combustion (NO_2, SO_2, and CO) are associated with the exhaust from on-site vehicles.

While ozone (O_3) is not directly emitted into the atmosphere from the Project, it is associated with the reaction of NO_X and volatile organic compounds (VOCs) to create NO_2 (MOECC 2015). Ozone baseline data will be used to calculate the NO_2 emissions from the Project. The VOCs while a criteria air contaminant are not considered indicator compounds for this Project. The VOCs are not expected to be emitted from the decommissioning activities with the exception of some VOC emissions from fuel combustion; and there are no provincial or federal standards for total VOCs to compare predicted concentrations, therefore, were not retained for the air quality baseline assessment.

The measurement indicator used for assessing the effects of the Project on the air quality VC considers a combination of indicator compounds and their associated averaging period(s) where federal and/or provincial air quality objectives and criteria are available. A single measure is used when evaluating effects, namely the maximum predicted concentration resulting from the 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 to the disciplines listed in Table 6.2.1-3.

Table 6.2.1-3: 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 criteria air contaminants (SPM, PM_{10}, $PM_{2.5}$, NO_2, SO_2, and CO).	■ Surface Water Quality (Section 6.4.2); ■ Aquatic Environment (Section 6.5); ■ Terrestrial Environment (Section 6.6); and ■ Human and Ecological Health (Section 6.7) ■ Land and Resource Use (Section 6.8).

SPM = suspended particulate matter; PM_{10} = particles nominally smaller than 10 µm in diameter; $PM_{2.5}$ = particles nominally smaller than 2.5 µm in diameter; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; CO = carbon monoxide.

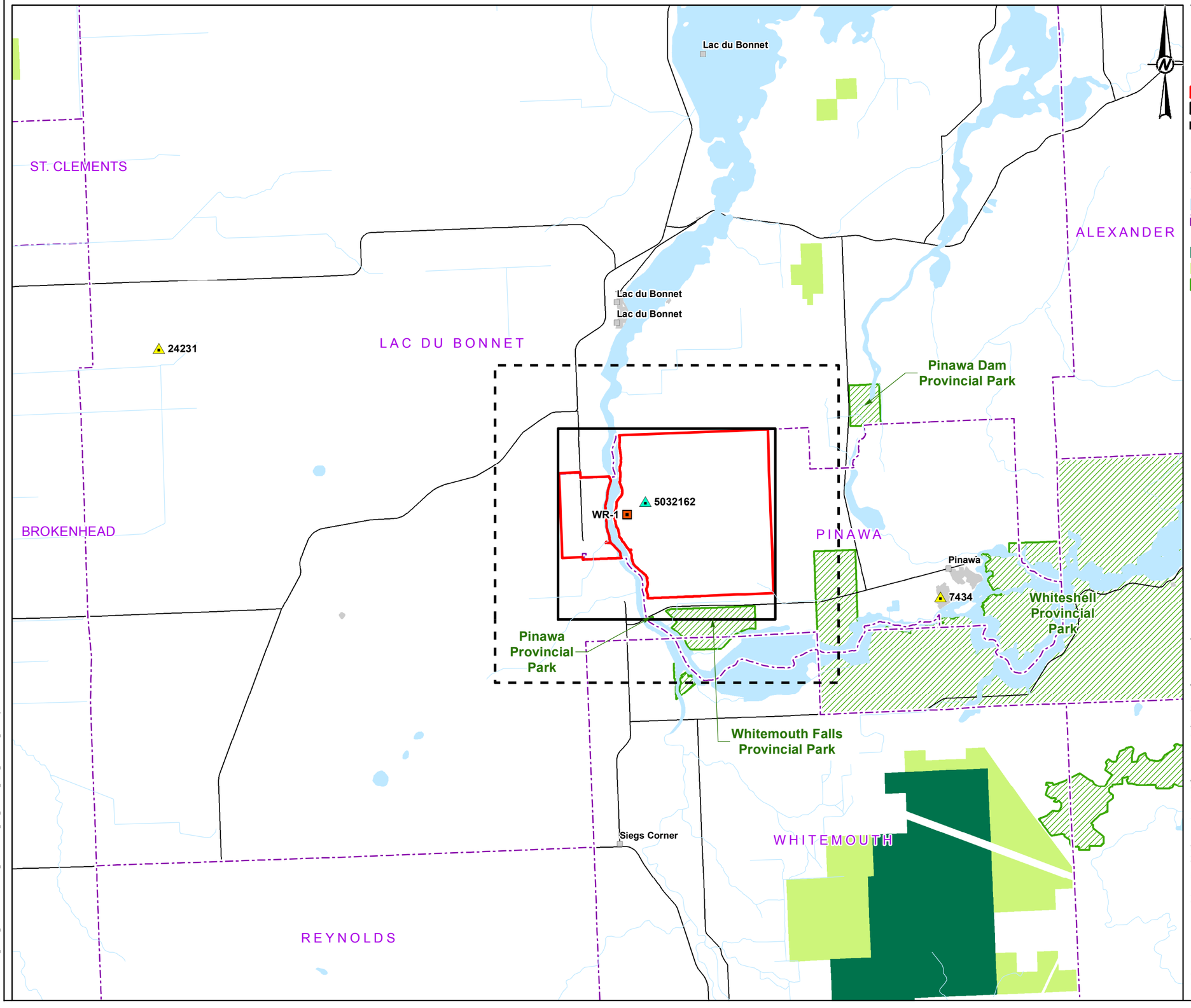
6.2.1.3 Assessment Boundaries

6.2.1.3.1 Spatial Boundaries

The spatial boundaries selected for the air quality assessment are presented on Figure 6.2.1-1 and are described below.

- **Site Study Area (SSA):** is the WR-1 Building and represents the Project footprint (i.e., where Project activities will be undertaken).
- **Local Study Area (LSA):** is defined as the area within which there is potential for measurable changes resulting from the proposed Project activities. The LSA is defined to encompass activities and sources of emissions associated with the Project and is equivalent to approximately 8 kilometre (km) by 8 km rectangle that includes the SSA and the WL site.
- **Regional Study Area (RSA):** is defined as the area within which the potential effects of the Project may interact with the effects of other existing or reasonable foreseeable projects. The RSA is equivalent to approximately a 12 km by 12 km rectangle surrounding the LSA (Figure 6.2.1-1). This area was selected to include the entire Pinawa Provincial Park to support the land use assessment.

To provide a conservative assessment, the maximum predicted air quality results at the LSA boundary are presented and are considered to be representative of the highest concentrations at ground-level of contaminants expected outside the LSA from Project activities.



LEGEND

- WR-1
- METEOROLOGY STATION
- NAPS STATION
- NPRI FACILITY
- SITE STUDY AREA (WHITESHELL LABORATORIES SITE)
- LOCAL STUDY AREA
- REGIONAL STUDY AREA

BASE FEATURES

- CITY/TOWN
- MAJOR ROAD
- WATERCOURSE
- WATERBODY
- MUNICIPAL BOUNDARY

PROTECTED AREAS

- ECOLOGICAL RESERVE
- WILDLIFE MANAGEMENT AREA
- PROVINCIAL PARK

0 5 10
1:150,000 KILOMETRES

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. TOPOGRAPHIC MAP -
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
SPATIAL BOUNDARIES FOR THE AIR QUALITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE/PR
REVIEWED	KL/CST
APPROVED	CS

PROJECT NO.	CONTROL	REV.	FIGURE
1656897		1	**6.2.1-1**

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6.2.1.3.2 Temporal Boundaries

The temporal boundary of the assessment includes effects observed under existing conditions, the timeframe during which Project activities are actively occurring and 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 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 Project consists of two phases: closure and post-closure.

The stages and associated activities during the closure phase of the Project are presented in Table 6.2.1-4. Project stages 1 to 3 involve overlapping years of activities and include the following sources of emissions:

- on-road vehicles exhaust and dust from paved roads;
- non-road vehicles exhaust;
- material handling (grouting and demolition);
- batch mixing plant; and
- emergency power generators.

Project stages 1 to 3 are considered to involve the highest level of emissions compared to the remaining stages. Project Stages 4 to 6 will include less road and non-road activities and will not include the batch mixing plant; therefore, only activities associated with stages 1 to 3 are considered in the air quality assessment as they represent the most conservative air emission scenario. Details on the sources of emissions are provided in Appendix 6.2-2.

The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. The Institutional Control period includes implementation of both active and passive controls. During active Institutional Control, long-term performance monitoring and maintenance activities will continue through to 2124 to demonstrate compliance with the safety case assumptions. The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions) and will continue through 2024 to 2324. Post-institutional Control occurs after year 2324 and continues indefinitely. No sources of indicator compound emissions are expected during the post-closure phase as a result of the Project; therefore, has not been evaluated in the air quality assessment.

Table 6.2.1-4: Project Stages and Associated Activities during the Closure Phase

Project Stage	Activity Description	Duration	Number of Years
1	Preparation for In Situ Decommissioning	2019 to 2021	3
2	Grouting of below-grade structures and systems	2021	1
3	Removal of above-grade WR-1 structures and systems	2021 to 2022	2
4	Installation of engineered cover over grouted WR-1 area	2022 to 2023	2
5	Final site restoration	2023	1
6	Preparation for Institutional Control	2024	1

6.2.1.3.3 Assessment Cases

The assessment cases considered in the air quality assessment include the Base Case, Application Case, and the Reasonably Foreseeable Development (RFD) 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, and residential and recreational development. Current effects from the existing WL facilities and operations, for example, 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 Project. The Application Case includes Project phases 1 to 3, and therefore, the emissions and associated effects during these phases of the Project represent the bounding cases.
- **RFD Case** – This scenario represents the predictions of the cumulative effects of the Application Case, plus projects that are currently under application review or that have officially entered a regulatory application process and which overlap with the air quality RSA. Foreseeable developments in the air quality RSA that are expected to overlap with residual effects on air quality from the Project includes the decommissioning of the remaining infrastructure and support facilities at the WL site as per the existing decommissioning licence. A Comprehensive Study Report (AECL 2001) under the *Canadian Environmental Assessment Act* (1992) was completed for the decommissioning of the WL site. The Environmental Assessment decision to approve the project was announced by the Minister of the Environment in March 2002 and a decommissioning licence was issued to AECL and subsequently to CNL.

6.2.1.4 Description of the Environment

6.2.1.4.1 Methods

This section documents the methods, data, and results that were used to describe the background air quality at the Project and in the LSA and RSA for indicator compounds. For each indicator compound identified in Section 6.2.1.2 Valued Components, the assessment was carried out by:

- identifying and comparing air quality guidelines in Manitoba and/or Canada for the indicator compounds;
- assessing air quality data sources for use in the background air quality assessment; and
- comparing air quality monitored data to the applicable air quality guidelines.

These steps are detailed in the following sections.

Applicable Criteria

The relevant air quality criteria used for screening air quality effects in the region include Manitoba Air Quality Criteria. The Province of Manitoba, Department of Sustainable Development, Climate Change and Air Quality Branch (Manitoba) has set guidelines related to ambient air concentrations and are summarized in the *Manitoba Ambient Air Quality Criteria* (AAQC) document (Manitoba 2005). The Manitoba AAQCs are maximum concentration levels set for the protection and preservation of ambient air quality within Manitoba. The criteria are classified as objectives, guidelines or make reference to Canada-wide Standards. The Canada-wide Standards were updated in 2012 and are now known as Canadian Ambient Air Quality Standards (CAAQSs). The Manitoba AAQC are characterized as maximum tolerable, acceptable or desirable level concentrations in ambient air, and intend to serve as guidance for air quality assessments.

The Manitoba AAQC document states the following:

- Maximum Acceptable Levels are not to be exceeded in any urban centre including areas that are in the vicinity of industries with atmospheric emissions;
- within rural areas, the goal is to maintain concentrations at or below Maximum Desirable Levels; and
- Maximum Tolerable Levels are only for evaluation purposes to identify the severity of an anthropogenic or natural phenomenon in order to protect human health and institute appropriate corrective action.

As the Project is located in a rural area, the Maximum Desirable Levels were used to assess background air quality conditions, if available; where the Maximum Desirable Levels were not available, the Maximum Acceptable Levels were used.

There are two sets of federal objectives and criteria: the National Ambient Air Quality Objectives (NAAQOs) and the Canadian Ambient Air Quality Standards (CAAQSs; formerly Canada Wide Standards or National Ambient Air Quality Standards [NAAQS]). Similar to the Manitoba 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 NAAQOs are not regulatory criteria rather the federal government has established the following levels of NAAQOs (Health Canada 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*, and include standards for $PM_{2.5}$ 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). Similar to the NAAQOs, the CAAQSs are not regulatory limits, but rather, are used as national targets for $PM_{2.5}$ and ozone (CCME 2014).

Monitoring data in Canada periodically exceeds these criteria, objectives and standards at different locations for different periods of time. Measured concentrations above these values does not necessarily result in immediate adverse effects, but serves as a guidance for areas where air quality could potentially be improved and to take actions to reduce or limit exposure.

A summary of the applicable Manitoba and federal objectives and criteria for the Project are listed in Table 6.2.1-5.

Table 6.2.1-5: Summary of the Applicable Manitoba and Federal Objectives and Criteria

Contaminant	Criteria Classification	Averaging Period	Manitoba AAQC[a] (µg/m³)			Canada-wide Standards[b] (µg/m³)	Canadian Ambient Air Quality Standards[c] (µg/m³)	National Ambient Air Quality Standards and Objectives[d] (µg/m³)	
			Tolerable	Acceptable	Desirable			Desirable	Acceptable
SPM	Objective	24-hr	400	120	—	—	—	—	120
SPM	Objective	Annual	—	70	60	—	—	60	70
PM_{10}	Guideline	24-hr	—	50	—	—	—	—	—
$PM_{2.5}$	Guideline	24-hr	—	—	—	30	27[e]	—	—
$PM_{2.5}$	Guideline	Annual	—	—	—	—	8.8[e]	—	—
CO	Objective	1-hr	—	35,000	15,000	—	—	15,000	35,000
CO	Objective	8-hr	20,000	15,000	6,000	—	—	6,000	15,000
NO_2	Objective	1-hr	1000	400	—	—	—	—	400
NO_2	Objective	24-hr	—	200	—	—	—	—	200
NO_2	Objective	Annual	—	100	30	—	—	60	100
O_3	Objective	1-hr	400	160	100	—	—	100	160
O_3	Objective	Annual	—	30	—	—	—	—	—
O_3	Guideline	8-hr	—	—	—	128	122[f]	—	—
SO_2	Objective	1-hr		900	450	—	—	450	900
SO_2	Objective	24-hr	800	300	150	—	—	150	300
SO_2	Objective	Annual	—	60	30	—	—	30	60

a) Manitoba AAQC (Government of Manitoba 2005).
b) Canada-wide Standard as published in the Manitoba AAQC (2005) document (updated in 2012 to CAAQS).
c) CAAQS published in the Canada Gazette Volume 147, No. 21 - May 25, 2013. Final standard phase in date of 2020 used.
d) CCME (1999).
e) The 24-hour CAAQS for $PM_{2.5}$ is based on the three-year average of the annual 98th percentile of the daily averaged monitored data. The annual CAAQS for $PM_{2.5}$ is based on the three-year average of annual averaged monitored data.
f) The 8-hour CAAQS for O_3 is based on the fourth highest 8-hour value annually, averaged over a 3-year period.
µg/m³ = micrograms per cubic metre; SPM = suspended particulate matter; PM_{10} = particles nominally smaller than 10 µm in diameter; $PM_{2.5}$ = particles nominally smaller than 2.5 µm in diameter; CO = carbon monoxide; NO_2 = nitrogen dioxide; O_3 = ozone; SO_2 = sulphur dioxide; — = No guideline available.

Baseline Air Quality Data

In Manitoba, regional air quality is monitored through a network of air quality monitoring stations operated by the Environment and Climate Change Canada (ECCC) National Air Pollution Surveillance Network (NAPS). These stations are operated under strict quality assurance and quality control procedures. Existing air quality was characterized using background air concentrations from monitoring data sources near the Project. The Comprehensive Study Report (see Section 5.4.1 and Section 5.4.2 of AECL 2001) included an air quality baseline assessment that used monitoring stations that are no longer in operation or have been relocated (i.e., Winnipeg's station ID 9119); therefore, the data from these stations was not considered in this assessment.

There are no air quality monitoring stations within the RSA; however, three air quality monitoring stations are located within 300 km of the Project: Winnipeg (65 Ellen Street), Experimental Lakes, and Brandon (Assiniboine Community College). The Winnipeg (65 Ellen Street) monitoring station was the only air quality monitoring station located within 100 km of the Project[1]. The Winnipeg (65 Ellen Street) monitoring station includes indicator compounds with the exception of SPM. The Winnipeg (65 Ellen Street) monitoring station is located approximately 84 km from the Project, in an urban area and approximately 60 km to 70 km away from two large bodies of water.

The second closest station, Experimental Lakes, is located approximately 180 km away from the Project, and is situated in one of the largest research areas for fresh water lakes that is managed by the International Institute for Sustainable Development (IISD 2016). The data from this station is heavily influenced by the more than 50 surrounding fresh water lakes and the station only monitors ozone, which makes it difficult to compare with the other data sets. The limited data from this station are not considered representative of the air quality within the LSA and RSA, and therefore, were not used in the air quality assessment.

The next closest air quality monitoring station is located in Brandon (Assiniboine Community College) and includes indicator compounds with the exception of CO, SO_2 and SPM. The Brandon Station (Assiniboine Community College) is located approximately 280 km from the Project.

Ideally, an air quality monitoring station would be within close proximity of the Project with a similar geographical siting and similar influences; however, the NAPS program focuses on areas that are impacted by local sources and not on remote un-impacted areas like the WL site. Therefore for the Project, the Winnipeg (65 Ellen Street) monitoring station is considered to be the most representative station of the RSA due to proximity, although there are differences in the geographical siting. While the Brandon (Assiniboine Community College) monitoring station is farther away and has less indicator compounds compared to the Winnipeg (65 Ellen Street) monitoring station, it was selected to be included in the background air quality assessment for comparison to the Winnipeg (65 Ellen Street) monitoring station. Its geographical siting is not as remote as the Project, has little influence from water bodies, is located within an industrial setting and is not considered to be as representative as the Winnipeg station for the WL site.

The relative locations of the two air monitoring stations selected to describe the background air quality for the LSA and RSA (i.e., Winnipeg [65 Ellen Street] and Brandon Station [Assiniboine Community College]) are provided in Table 6.2.1-6 and the station locations are shown on Figure 6.2.1-1. Other stations are located more than 400 km away from the Project, and therefore, were not retained for the assessment given the distance to the Project. For this assessment, data from 2009 to 2013 was used, which is the most recent five year period at the time of this assessment for which all data is available and quality assured by Environment Canada.

[1] The second monitoring station in Winnipeg was not selected for this assessment as it monitors fewer indicator compounds.

Table 6.2.1-6: Location of Background Air Monitoring Stations Selected for the Project

City	NAPS Station ID	Location	Latitude and Longitude	Distance to the Project[(a)] (km)	Direction
Winnipeg	70119	Outside Regional Study Area	49.89809, -97.14652	84	Southwest
Brandon	70203	Outside Regional Study Area	49.83918, -99.9206	280	Southwest

a) Approximate distance from Project.

NAPS = National Air Pollution Surveillance Network; km = kilometre.

The air flow into the WL site varies in direction, but is predominantly blowing from the south and south-southeast and slightly less predominantly from the north-northwest and northwest. The Project is located in a fairly remote area, with very few industrial emission sources that influence the airshed surrounding the Project. The air flow into the Winnipeg area is from the south, thereby, including local and transboundary industrial influences. As the selected monitoring stations are located in more industrial and urban areas, the air quality data from the selected stations can be considered to provide conservative air quality estimates and are likely to be greater than the existing conditions in the RSA.

Table 6.2.1-7 provides a summary of the monitoring data available from each of the two selected stations for the period from 2000 through 2013. At the time of this assessment, complete datasets were available up until 2013, with only partial information available for 2014 and 2015. Not all compounds have the same data availability period for a given station, as additional compounds are added to the station at different dates as required by the ECCC (e.g., SO_2 was only monitored starting in 2008).

Table 6.2.1-7: Availability of Ambient Air Quality Data

Compound	Winnipeg Station (65 Ellen Street)	Brandon Station (Assiniboine Community College)
SPM[(a)]	—	—
PM_{10}	2006 - 2013	2006 - 2013
$PM_{2.5}$	2000 - 2002, 2013	2001 - 2002, 2013
NO_2	2000 - 2013	2000 - 2010, 2012 - 2013
NO	2000 - 2013	2000 - 2013
SO_2	2008 - 2013	—
CO	2006 - 2013	—
O_3	2000 - 2013	2000 - 2013

a) SPM values may be calculated from the monitored values of PM_{10}.

SPM = suspended particulate matter; PM_{10} = particles nominally smaller than 10 µm in diameter; $PM_{2.5}$ = particles nominally smaller than 2.5 µm in diameter; NO_2 = nitrogen dioxide; NO = nitrogen oxide; CO = carbon monoxide; SO_2 = sulphur dioxide; O_3 = ozone; — = data for the parameter were not available at that station.

6.2.1.4.2 Results

Table 6.2.1-8 provides a summary of the existing air quality data for the RSA based on data from the Winnipeg (65 Ellen Street) monitoring station. The comparison of the Winnipeg Station and the Brandon Station is provided in Appendix 6.2-1.

The data presented in Table 6.2.1-8 represent the 90th percentile of the 1-hour, 8-hour and 24-hour measurements, which are typically used to represent the background air quality value when conducting an impact assessment, as this value is exceeded only 10% of the time (Alberta Environment 2013). The annual average concentration is used for annual background levels and based on the measurement data. 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 6.2.1-8: Background Air Quality Values (90th Percentile, Average for Annual Only) [(a)]

Indicator	Averaging Period	Winnipeg Station (65 Ellen Street) (µg/m³)	Background Air Quality (Base Case) (µg/m³)
SPM[(b)]	24-hour	22.46	**22.46**
	Annual	13.72	**13.72**
PM_{10}	24-hour	11.23	**11.23**
$PM_{2.5}$[(c)]	24-hour	11.58	**11.58**
	Annual	6.64	**6.64**
NO_2	1-Hour	39.50	**39.50**
	24-Hour	35.41	**35.41**
	Annual	18.48	**18.48**
SO_2	1-Hour	2.62	**2.62**
	24-Hour	2.62	**2.62**
	Annual	0.75	**0.75**
CO	1-Hour	801.67	**801.67**
	8-Hour	916.19	**916.19**
O_3[(c)]	1-Hour	74.57	**74.57**
	8-Hour	86.35	**86.35**

Bolded values represent the Base Case air quality.

a) Data measured in parts per billion (ppb) or parts per million (ppm), were converted to µg/m³ assuming standard temperature and pressure (25°C and one atmosphere of pressure).

b) The 24-hour CAAQS for $PM_{2.5}$ is based on the three-year average of the annual 98th percentile of the daily averaged monitored data. The annual CAAQS for $PM_{2.5}$ is based on the three-year average of annual averaged monitored data. Please note, the table does not present the values to compare to the relevant CAAQS due to insufficient data.

c) The 8-hour CAAQS for O_3 is based on the fourth highest 8-hour value annually, averaged over a 3-year period. Please note, the table does not present the values to compare to the relevant CAAQS.

µg/m³ = microgram per cubic metre; SPM = suspended particulate matter; PM_{10} = particles nominally smaller than 10 µm in diameter; $PM_{2.5}$ = particles nominally smaller than 2.5 µm in diameter; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; CO = carbon monoxide; O_3 = ozone.

6.2.1.5 Project Interactions and Mitigation

6.2.1.5.1 Methods

This section describes the process by which interactions between Project components and activities and air quality were identified and evaluated. Potential effect 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 Project and the environment by evaluating the different effect pathways to assess 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 Section 6.2.1.6 Residual Effects Analysis. 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 Project. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. The next step in the analysis was the development of environmental design features and mitigation practices that could be incorporated into the 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 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 pathway –** pathway is removed by environmental design features or mitigation such that the 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 past, present 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 s relative to the Base Case and/or guideline values that could contribute to residual effects to air quality.

Environmental design features and mitigation that have been or could be incorporated into the 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 Project on air quality.

6.2.1.5.2 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 Project phases. Activities that use vehicles, mobile equipment, or stationary combustion sources would emit indicator compounds. Material handling activities would emit fugitive dust, as would vehicle movements on paved roads. Each activity 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 the Project may interact with and result in changes to concentrations of indicator compounds is provided in Table 6.2.1-9.

Table 6.2.1-9: Pathways Analysis for the Air Quality Valued Component

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Closure Phase ■ Stage 1: Preparation for In Situ Decommissioning ■ Stage 2: Grouting of below-grade structures and systems ■ Stage 3: Removal of above-grade WR-1 structures and systems	Closure activities will alter concentrations of indicator compounds, including: ■ use vehicles and equipment that combust fuel and emit indicator compounds; ■ material handling, for grouting and demolition; ■ vehicles travelling on paved roads; ■ operation of batch mixing plant for grout production.	■ Implementation of CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring, air verification monitoring and environmental monitoring. ■ Implementation of dust management techniques to control dust generated by the Project, consistent with the current Environmental Assessment Follow-up Program. ■ Road watering and chemical dust suppressant when necessary. ■ Removal of accumulations of particulates (e.g., dirt) on road as soon as possible. ■ On-site vehicles and equipment engines will meet Tier 3 emission standards, where possible, and be maintained in good working order. ■ Limit idling of vehicles on-site and speed on roads. ■ Use of enclosure for raw material handling.	Primary

Table 6.2.1-9: Pathways Analysis for the Air Quality Valued Component

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Closure Phase ■ Stage 1: Preparation for In Situ Decommissioning ■ Stage 2: Grouting of below-grade structures and systems ■ Stage 3: Removal of above-grade WR-1 structures and systems	Closure activities for the Project will overlap with decommissioning of the remaining infrastructure and support facilities at the WL site as per the existing decommissioning licence.	■ Use of dust control measure (e.g., containment and suppression) to control generation of airborne emissions and nuisance dust. ■ Curtailment of activities during periods of adverse meteorological conditions (e.g., during periods of high winds). ■ Maintenance of on-site access routes. ■ Continued implementation of the Environmental Assessment Follow-up Program for the WL site.	Secondary

CNL = Canadian Nuclear Laboratories; km/hr = kilometre per hour.

6.2.1.5.2.1 No Linkage Pathways

There are no pathways identified as having no linkages to effects to the air quality VC.

6.2.1.5.2.2 Secondary Pathways

In some cases, a Project source of effect and an interaction with an assessment endpoint exists but mitigation is expected to cause minor changes to the environment and a negligible effect on air quality relative to the existing Base Case and/or guidelines. The following pathway is expected to result in negligible effects on the air quality VC and will not be evaluated further in the EIS.

- **Closure activities for the Project will overlap with decommissioning of the remaining infrastructure and support facilities at the WL site as per the existing decommissioning licence.**

The Comprehensive Study Report (see Section 6.3.1 of AECL 2001) evaluated the effects of physical works/activities on the atmospheric environment from closure of the WL site. Physical work/activities evaluated for indicator compounds included:

- disconnecting of nuclear facility services and maintenance of buildings;
- removal of hazardous materials from facilities;
- methane pollution from organic material that may be in the inactive landfill;
- retrieval and repackaging of waste from existing storage facilities and construction of new storage area;
- demolition of facilities and disposal of rubble as clean fill; and
- site restoration (AECL 2001).

Results of the air quality assessment completed as part of the Comprehensive Study Report indicated that from time to time nuisance dust will be generated. Mitigation practices will be implemented to limit potential effects to air quality, including dust control measures (e.g., containment and suppression), curtailment of activities during periods of high winds and maintenance of on-site access routes (see Section 6.3.1 of AECL 2001). Special enclosures to cover large areas may also be required to contain airborne emissions from decommissioning activities in some cases (e.g., decommissioning of the WMA). The evaluation of effects to air quality from decommissioning and reclamation activities for the entire WL site concluded that release of air emissions is negligible; consequently, no significant effects were predicted.

The Comprehensive Study Report included consideration of the WR-1 Building in the original evaluation of residual effects to air quality (see Section 6.3.1 of AECL 2001). Although the decommissioning strategy has changed for the WR-1, activities related to the decommissioning of the WR-1 are expected to less than previously approved. Consequently, the Project is not anticipated to result in a change in the conclusions of the 2001 Comprehensive Study Report related to air quality (see Section 6.2.1.6.2 Application Case Results for the Project air quality predictions). As such, the Project is not expected to contribute cumulatively to the effects of decommissioning of the remaining infrastructure and support facilities at the WL to cause a significant effect; consequently, this pathway is considered to be secondary.

6.2.1.5.2.3 Primary Pathways

Project activities completed during Stage 1, 2, and 3 of the closure phase were identified as having a residual effect on the air quality VC, and therefore, are carried forward to the residual effects analysis. Closure activities for the Project include:

- vehicles and equipment combust fuel and emit indicator compounds;
- material handling for grouting and demolition;
- vehicles travelling on paved roads emit fugitive dust; and
- batch mixing plant for grout production emits fugitive dust.

6.2.1.6 Residual Effects Analysis

6.2.1.6.1 Methods

Residual effects of the Project are those effects that remain after implementation of all mitigation. The assessment of effects of the Project on air quality involves two steps, namely the calculation of emission rates, which include the implementation of mitigation, and use of dispersion modelling to predict the resulting concentrations of indicator compounds. These steps are described below.

Emissions Quantification

The method used for calculating and quantifying air emissions resulting from the Project involved the following steps:

- **Identifying emissions sources:** Emission sources were identified based on the Project conceptual design and the project information provided in Section 3.0 Project Description.
- **Calculating emission rates:** Air emission rates were calculated using accepted methods, such as emission factors, and were based on activity data provided in Section 3.0 Project Description, as well as MOBILE6.2.C modelling results provided in Appendix 6.2-2. Emission rates were calculated for the Application Case scenario.
- **Summarizing overall emissions:** The calculated emissions were summarized by Project stage for the closure phase.

The emission estimation methods used in the air quality assessment follow generally accepted practices for conducting environmental assessments and, where appropriate, guidance in Appendix C of REGDOC 2.9.1 (CNSC 2017). Scientifically accepted by Manitoba Sustainable Development (Draft Guidelines) and well-documented emission factors, such as AP-42 from the United States Environmental Protection Agency (EPA) were used to estimate maximum and average emission rates. Details of the specific emission calculation methods and resulting emissions are provided in Appendix 6.2-2.

Dispersion Modelling

The modelling approach used to evaluate the likely environmental effects for the air quality indicators followed generally accepted practices for conducting environmental assessments and modelling guidance. It should be noted that the Manitoba Sustainable Development, Climate Change and Air Quality Branch, has limited dispersion modelling guidance included in the *Draft Guidelines for Air Dispersion Modelling in Manitoba* from the Manitoba Conservation (2006) – Air Quality Section. Therefore, the Draft Guidelines and the following guidance documents were followed as appropriate: the Ontario Ministry of the Environment and Climate Change (MOECC) document titled *Air Dispersion Modelling Guideline for Ontario* (MOECC 2017), the Saskatchewan Ministry of the Environment (SK MOE) document titled *Saskatchewan Air Quality Modelling Guideline* (2012) and in the National Stone, Sand and Gravel Association document titled *Modeling Fugitive Dust Sources* (2004). The air dispersion modelling for the Project included the following approach:

- SCREEN3 dispersion modelling for emissions sources other than paved roads; and
- CALINE3HQ dispersion modelling for paved roads.

The selection of the SCREEN3 and CAL3QHC models were based on the 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 source configurations and indicator compounds associated with the Project;
- the terrain surrounding the Project is relatively simple;
- allows for the use of worst-case meteorological data; and
- long-range transport of compounds is not anticipated.

Details regarding the dispersion modelling, including receptor grids and source input parameters are provided in Appendix 6.2-3.

6.2.1.6.2 Application Case Results

Average and Maximum Emission Rates

In accordance with REGDOC 2.9.1 (CNSC 2017), average and maximum emission rates have been provided for the Application Case. Table 6.2.1-10 and Table 6.2.1-11 summarize the average and maximum daily emission rates in grams per second (g/s) for the Application Case. The largest contributors to the emissions of the contaminants are as follows:

- SPM: paved roads;
- PM_{10}: demolition activities;
- $PM_{2.5}$ and NOx (as NO_2): non-road equipment exhaust; and
- SO_2 and CO: emergency power generators fuel combustion.

Details of the specific emission calculation methods and resulting emissions estimates used for dispersion modelling are provided in Appendix 6.2-2.

Table 6.2.1-10: Maximum Scenario Summary of Daily Emissions Rates during the Closure Phase

Project Stage	Project Activity	Duration	Project Component		Emission Source Type	Daily Emission Rates (g/s)					
						SPM	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO
1	Preparation for In Situ Decommissioning	2019 to 2021	1.1	Create pathways between rooms	Non-road Equipment Exhaust	4.38E-03	4.38E-03	4.24E-03	7.29E-02	1.46E-04	2.46E-02
			1.2	Batch mixing plant (temporary)	Process	6.63E-02	1.83E-02	4.75E-03	—	—	—
					Non-road Equipment Exhaust	2.08E-03	2.08E-03	2.02E-03	4.08E-02	4.81E-05	2.05E-02
					Raw Material Handling	1.22E-03	5.79E-04	8.77E-05	—	—	—
					Road Exhaust	7.63E-05	7.63E-05	4.53E-05	2.11E-03	1.39E-05	1.11E-03
					Paved Roads	6.02E-01	1.16E-01	2.80E-02	—	—	—
					Propane Combustion	4.13E-04	4.13E-04	4.13E-04	2.69E-02	3.10E-03	1.55E-02
2	Grouting of below-grade structures and systems	2021	2.1	Fill below-grade areas with grout according to engineered fill schedule (multiple lifts of grouting pours)	Non-road Equipment Exhaust	7.88E-03	7.88E-03	7.64E-03	1.31E-01	2.62E-04	4.26E-02
					Material Handling	1.55E-04	7.35E-05	1.11E-05	—	—	—
3	Removal of above-grade WR-1 structures and systems	2021 to 2022	3.1	Demolition of main reactor hall, the above-grade portion of the Primary Heat transport System, the 50T reactor hall bridge crane, and the Ventilation Stack	Non-road Equipment Exhaust	6.10E-02	6.10E-02	5.92E-02	1.02E+00	2.03E-03	3.39E-01
					Demolition	1.83E-01	1.83E-01	1.83E-02	—	—	—
			3.2	Removal of hazardous waste	Road Exhaust	3.20E-06	3.20E-06	1.90E-06	8.82E-05	5.84E-07	4.64E-05
					Paved Roads	2.52E-02	4.84E-03	1.17E-03	—	—	—
			3.3	Recycling of materials	Road Exhaust	9.59E-06	9.59E-06	5.70E-06	2.65E-04	1.75E-06	1.39E-04
					Paved Roads	7.56E-02	1.45E-02	3.51E-03	—	—	—
			3.4	Disposal of asbestos at the WL landfill[(a)]	Road Exhaust	4.64E-06	4.64E-06	2.76E-06	1.28E-04	8.48E-07	6.73E-05
					Paved Roads	3.66E-02	7.03E-03	1.70E-03	—	—	—
Miscellaneous				Emergency Power Generators	Combustion	—	—	—	2.18E-01	3.46E-01	1.13E+00
					Total	**1.07E+00**	**4.20E-01**	**1.31E-01**	**1.51E+00**	**3.52E-01**	**1.57E+00**

a) For the emissions estimate, it was assumed that clean asbestos would be disposed of at the WL Landfill; however, some clean asbestos may be disposed of offsite.
g/s = grams per second; WL = Whiteshell Laboratories; SPM = suspended particulate matter; PM_{10} = particles nominally smaller than 10 µm in diameter; $PM_{2.5}$ = particles nominally smaller than 2.5 µm in diameter; NO_x = oxides of nitrogen; SO_2 = sulphur dioxide; CO = carbon monoxide.

Table 6.2.1-11: Average Scenario Summary of Emissions Rates during the Closure Phase

Project Stage	Project Activity	Duration	Project Component		Emission Source Type	Daily Emission Rates (g/s)					
						SPM	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO
1	Preparation for In Situ Decommissioning	2019 to 2021	1.1	Create pathways between rooms	Non-road Equipment Exhaust	3.28E-03	3.28E-03	3.18E-03	5.47E-02	1.09E-04	1.84E-02
			1.2	Batch mixing plant (temporary)	Process	4.14E-02	1.15E-02	2.97E-03	—	—	—
					Non-road Equipment Exhaust	1.56E-03	1.56E-03	1.52E-03	3.06E-02	3.61E-05	1.54E-02
					Raw Material Handling	7.66E-04	3.62E-04	5.48E-05	—	—	—
					Road Exhaust	4.96E-05	4.96E-05	2.95E-05	1.37E-03	9.06E-06	7.20E-04
					Paved Roads	3.91E-01	7.51E-02	1.82E-02	—	—	—
					Propane Combustion	4.13E-04	4.13E-04	4.13E-04	2.69E-02	3.10E-03	1.55E-02
2	Grouting of below-grade structures and systems	2021	2.1	Fill below-grade areas with grout according to engineered fill schedule (multiple lifts of grouting pours)	Non-road Equipment Exhaust	7.88E-03	7.88E-03	7.64E-03	1.31E-01	2.62E-04	4.26E-02
					Material Handling	7.99E-05	3.78E-05	5.72E-06	—	—	—
3	Removal of above-grade WR-1 structures and systems	2021 to 2022	3.1	Demolition of main reactor hall, the above-grade portion of the Primary Heat transport System, the 50T reactor hall bridge crane, and the Ventilation Stack	Non-road Equipment Exhaust	4.58E-02	4.58E-02	4.44E-02	7.63E-01	1.52E-03	2.54E-01
					Demolition	4.81E-02	4.81E-02	4.81E-03	—	—	—
			3.2	Removal of hazardous waste	Road Exhaust	3.20E-06	3.20E-06	1.90E-06	8.82E-05	5.84E-07	4.64E-05
					Paved Roads	2.52E-02	4.84E-03	1.17E-03	—	—	—
			3.3	Recycling of materials	Road Exhaust	9.59E-06	9.59E-06	5.70E-06	2.65E-04	1.75E-06	1.39E-04
					Paved Roads	7.56E-02	1.45E-02	3.51E-03	—	—	—
			3.4	Disposal of asbestos at the WL landfill[(a)]	Road Exhaust	4.64E-06	4.64E-06	2.76E-06	1.28E-04	8.48E-07	6.73E-05
					Paved Roads	3.66E-02	7.03E-03	1.70E-03	—	—	—
Miscellaneous				Emergency Power Generators	Combustion	—	—	—	2.18E-01	3.46E-01	1.13E+00
					Total	**6.78E-01**	**2.20E-01**	**8.96E-02**	**1.23E+00**	**3.51E-01**	**1.48E+00**

a) For the emissions estimate, it was assumed that clean asbestos would be disposed of at the WL Landfill; however, some clean asbestos may be disposed of offsite.
g/s = grams per second; WL = Whiteshell Laboratories; SPM = suspended particulate matter; PM_{10} = particles nominally smaller than 10 µm in diameter; $PM_{2.5}$ = particles nominally smaller than 2.5 µm in diameter; NO_X = oxides of nitrogen; SO_2 = sulphur dioxide; CO = carbon monoxide.

Negligible Emissions from the Project

There are many activities associated with the Project that produce 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 can be excluded from the assessment:

- the emission rates of certain compounds are very small relative to the overall emissions at the 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 6.2.1-12 lists the activities that were not assessed and the accompanying rationale.

Table 6.2.1-12: Emissions Not Included in the Air Quality Assessment

Activity/Compound	Rationale for Excluding from the Air Quality Assessment
Emergency power equipment	Emissions from the emergency power equipment were only included for contaminants with an averaging period of 1 hour (NO_2, CO, SO_2). Other averaging periods for NO_2, CO and SO_2 exclude the generators emissions. Other contaminants with longer averaging periods (particulates) are excluded from the emergency power equipment assessment. The generators only operate periodically during monthly routine maintenance testing and a duration of one hour per month, rather than continuously. Additionally, the emergency power generators will only be used to supply electricity during power outage when other equipment is not in operation. Therefore, only routine maintenance of one hour per month is included in the representative scenario.
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.
Operations support activities, such as maintenance activities	Emissions from these sources are infrequent, relatively small, 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 vehicles maintenance.

NO_2 = nitrogen dioxide; CO = carbon monoxide; SO_2 = sulphur dioxide.

Predicted Modelling Concentrations

Ground level concentrations resulting from the Application Case for the air quality indicator compounds were predicted with the aid of the estimated emission rates (Table 6.2.1-10 and Table 6.2.1-11) and SCREEN3 and CAL3QHC dispersion models. The Maximum Scenario predicted ground level concentrations at the LSA boundary for the Application Case are presented in Table 6.2.1-13 (Average Scenario predicted concentrations are not presented as they are lower than the Maximum Scenario). The maximum predicted incremental ground level concentration represents the incremental effect of the Project, without taking into consideration existing Base Case concentrations. The predicted ground level concentrations for the Application Case represent the combined concentrations of the Base Case plus the incremental concentrations from the Project. Predicted ground level concentrations for the Application Case are below applicable air quality guidelines and/or standards (Table 6.2.1-13).

Table 6.2.1-13: Concentrations at the Local Study Area Boundary for the Base Case and Application Case

Contaminant		CAS Number	Averaging Period	Applicable Air Quality Guideline or Standard [a] (µg/m³)	Base Case Concentration[b] (µg/m³)	Maximum Scenario Maximum Predicted Incremental Concentration (µg/m³)	Application Case Concentration (µg/m³)	Application Case Concentration Percent of Applicable Air Quality Guideline of Standard
Suspended Particulate Matter	SPM	N/A-1	24-hour	120	22.46	22.18	44.64	37%
Suspended Particulate Matter	SPM	N/A-1	Annual	60	13.72	3.28	17.00	28%
Particulate Matter <10 µm	PM_{10}	N/A-2	24-hour	50	11.23	14.82	26.05	52%
Particulate Matter <2.5 µm	$PM_{2.5}$	N/A-3	24-hour	27[c]	11.58	5.10	16.68	62%
Particulate Matter <2.5 µm	$PM_{2.5}$	N/A-3	Annual	8.8[c]	6.64	0.69	7.33	83%
Nitrogen Dioxide[d]	NO_2	10102-44-0	1-Hour	400	39.5	113.12	152.62	38%
Nitrogen Dioxide[d]	NO_2	10102-44-0	24-Hour	200	35.41	74.32	109.73	55%
Nitrogen Dioxide[d]	NO_2	10102-44-0	Annual	30	18.48	9.78	28.26	94%
Sulfur Dioxide	SO_2	7446-09-5	1-Hour	450	2.62	43.94	46.56	10%
Sulfur Dioxide	SO_2	7446-09-5	24-Hour	150	2.62	17.88	20.50	14%
Sulfur Dioxide	SO_2	7446-09-5	Annual	30	0.75	2.39	3.14	10%
Carbon Monoxide	CO	630-08-0	1-Hour	15,000	801.67	257.17	1,058.84	7%
Carbon Monoxide	CO	630-08-0	8-Hour	6,000	916.19	143.67	1,059.86	18%

a) Table 13 in Appendix 6.2-1 identifies which guideline or standard was used in the screening of effects to air quality.

b) The 90th percentile background concentrations; values for SPM are calculated from the PM_{10} values as described in Appendix 6.2-1. Data measured in parts per billion (ppb) or parts per million (ppm), were converted to µg/m³ assuming standard temperature and pressure (25°C and one atmosphere of pressure). Although ozone was assessed as part of baseline conditions to calculate the NO_2 emissions from the Application Case, these are not presented in this table as emissions of ozone are not quantified for the Project's activities since they are not directly emitted into the atmosphere from the Project

c) The 24-hour CAAQS for $PM_{2.5}$ is based on the three-year average of the annual 98th percentile of the daily averaged monitored data. The annual CAAQS for $PM_{2.5}$ is based on the three-year average of annual averaged monitored data. Please note, the table does not present the values to compare to the relevant CAAQS due to insufficient data.

d) Calculated using the Ozone Limiting Method. Refer to Appendix 6.2-3 for methodology.

µg/m³ = microgram per cubic metre.

6.2.1.7 Prediction Confidence and Uncertainty

Potential sources of uncertainty in the assessment of air quality include:

- the accuracy and representativeness of the activity data and emission factors used to estimate emissions;
- the accuracy and representativeness of the meteorological data used in the SCREEN3 dispersion model;
- the accuracy of formulations within the SCREEN3 and CAL3QHC dispersion modelling systems;
- 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 input parameters. Considerable effort was undertaken by the U.S. EPA during the development and testing of the dispersion models, such that the model predictions can be relied on as reasonable estimates of the likely concentrations. SCREEN3 and CAL3QHC are based on known theory and proven to reliably produce repeatable results (Section 6.2.1.6). To limit the uncertainty associated with emissions input to the model, assumptions that are likely to over predict emissions or concentrations were made where practical. These conservative assumptions were used to manage the above uncertainties and are described as follows below.

- The Application Case (i.e., Closure phase stages 1 to 3) were assumed to occur simultaneously. It is conservatively assumed that all non-road equipment is operating simultaneously during the daytime operating hours for Project Stages 1 to 3 and for the entire duration of these three stages. In reality, it is unlikely that all equipment would operate simultaneously and that the same type of equipment will operate simultaneously for different components of these stages. The modelling assessment includes all operations occurring simultaneously and continuous over the entire modelling period.
- It is assumed that all equipment will comply with U.S. EPA Tier 3 emissions standards, where possible. Tier 3 standards have begun being phased-out in Canada (variable depending on the engine sizes) and new equipment will be required to comply with interim Tier 4 or Tier 4 emissions standards starting in 2014 (ECCC 2012).
- Combustion emissions from the propane-fired boiler were based on an assumed maximum equipment firing rate.
- Project activities were modelled as a volume source. Modelling the emissions as a volume source is conservative since this model source type does not take advantage of favourable dispersion characteristics such as plume buoyancy and initial exit velocity of emissions from the propane-fired boiler or batch mixing plant. Further, the dispersion modelling source dimensions selected for the volume source result in a dispersion modelling source which is smaller than the corresponding real-life source. This is conservative since estimated emissions occur over a smaller area, and thus, are more concentrated (and therefore less dispersed) at the point of release.

- The emission estimates for fugitive road dust from paved roads are conservative and overestimate emissions from facility roadways for the following reasons:
  - The U.S. EPA AP 42 equations were developed from measured emissions from public roadways and as a result will tend to overestimate low speed vehicle traffic from construction and industrial sites.
  - All roadways at the Project were modelled assuming simultaneous and continuous use; however, it is unlikely that this situation will occur in reality.
  - As the dust best management practices are revised through continuous improvements, the emissions from the on-site roadways are likely to decrease.
- Site-specific meteorological data was not used as SCREEN3 and CAL3QHC used the worst-case meteorological conditions possible for each model. The worst-case meteorological conditions are those that produce the lowest dispersion of emissions over the distances considered by the model and, therefore, resulting in conservative predictions of concentrations.
- The combined effect from road and non-road emission sources is estimated by adding the maximum predicted concentrations from the SCREEN3 and CAL3QHC models. This is conservative as it is assumed that each model's worst-case meteorological conditions occur at the same time and the same receptor.
- The modelling assessment includes all operations occurring simultaneously and continuous over the entire modelling period. Variable emission rates were not used for the material handling activities and vehicle traffic although these activities are planning to only occur during the daytime and weekdays. Seasonal variability for fugitive dust emissions was also not considered in the assessment.
- The influence of natural mitigation from events such as rainfall, snowfall, residual moisture, or snow cover was not considered in estimating fugitive dust emission rates. The modelling will likely yield higher concentrations since contaminants will be deposited from the air by dry or wet depletion and deposition processes.
- The parameters that were required for fugitive dust modelling from paved roads include site geometry inputs, locations and dimension of the roadway segments, worst-case meteorological conditions, receptor locations and vehicle emission rates. This is a conservative approach to estimate the maximum off-property concentrations.

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.

6.2.1.8 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.

6.2.1.8.1 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.

Residual adverse effects were classified using the criteria and definitions outlined in Table 6.2.1-14. For air quality, residual effects stop almost immediately when the 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.

Table 6.2.1-14: Definitions of Assessment Criteria for Classifying Predicted Residual Adverse Effects to Air Quality

Criteria	Description	Definition
Direction	Direction relates to the "value" of the effect in relation to the environment.	**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.
Magnitude	Magnitude is the intensity of the effect or a measure of the degree of change from existing (baseline) conditions or guidelines expected to occur in the criterion.	**Negligible:** Maximum concentration for an indicator compound is <5% of the corresponding criteria[(a)]
		Low: Maximum concentration for an indicator compound is less than 50% of the corresponding criteria[(a)]
		Moderate: Maximum concentration for an indicator compound is between 50% and 100% of the corresponding criteria[(a)]
		High: Maximum concentration for an indicator compound is above the corresponding criteria[(a)]

Table 6.2.1-14: Definitions of Assessment Criteria for Classifying Predicted Residual Adverse Effects to Air Quality

Criteria	Description	Definition
Geographic extent	Geographic extent refers to the spatial area over which an effect will occur/can be detected (distance covered or range).	**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
Duration	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 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.	**Short-term:** Effects are not evident beyond all Project phases
		Medium-term: Effects are not evident beyond all Project phases
		Long-term: Effects are not evident beyond the completion of all Project phases
		Permanent: Effects are not reversible
Frequency	Frequency refers to the occurrence of the environmental effect over the duration of the assessment.	**Infrequent:** Effects are confined to a specific discrete period
		Frequent: Effects occur intermittently, but repeatedly, or continuous over the assessment period
Reversibility	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.	**Reversible:** Change of state in environment is not permanent
		Irreversible: Change of state in the environment is permanent
Likelihood	Likelihood is a measure of the probability that an activity will result in an environmental effect.	**Low:** Effect is unlikely to occur
		Medium: Effect is likely to occur
		High: Effect is highly likely to occur

a) Table 13 in Appendix 6.2-1 identifies which guideline or standard was used in the screening of effects to air quality.
LSA = Local Study Area; RSA = Regional Study Area.

6.2.1.8.2 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 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 on an indicator compound must be adverse (negative in direction), exceed relevant guideline/standard (high in magnitude), extend beyond the local study area, but contained within the regional study area (regional in geographic extent) and reversible following completion of the Project phases (long term in duration). As part of the determination of significance, confidence in the assessment identified in Section 6.2.1.7 was considered for the air quality VC.

As presented in Table 6.2.1-15, the direction is negative for all indicator compounds as there are emissions during the Application Case. However, the magnitude of changes to indicator compound emissions are predicted to be low to moderate as the predicted concentrations of each indicator compound from the Application Case are below their relevant guideline/standard. The predicted effects are limited to the RSA, and therefore the geographic extent of changes to all indicator compounds is regional for the Application Case. Although there are planned stages for the closure phase, emissions of indicator compounds will be lower; therefore the duration of effect is conservatively considered to be short-term. Criteria air contaminants will be emitted continuously or near-continuously during the Application Case, and therefore the frequency of effect is frequent. The likelihood of emissions from the Project changing indicator compound concentrations for the Application Case phases is high.

Based on the low to moderate magnitude, the limited geographical extent of the effect and the medium-term duration, the overall residual adverse effect of the Application Case on air quality is determined to be not significant.

Table 6.2.1-15: Classification of Predicted Residual Adverse Effects on Air Quality for the Application Case

Indicator Compound	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
SPM	Negative	Low	Regional	Short-term	Frequent	Reversible	High
PM_{10}	Negative	Moderate	Regional	Short-term	Frequent	Reversible	High
$PM_{2.5}$	Negative	Moderate	Regional	Short-term	Frequent	Reversible	High
NO_2	Negative	Moderate	Regional	Short-term	Frequent	Reversible	High
SO_2	Negative	Low	Regional	Short-term	Frequent	Reversible	High
CO	Negative	Low	Regional	Short-term	Frequent	Reversible	High

SPM = suspended particulate matter; PM_{10} = particles nominally smaller than 10 µm in diameter; $PM_{2.5}$ = particles nominally smaller than 2.5 µm in diameter; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; CO = carbon monoxide.

6.2.1.9 Monitoring and Follow-up

CNL's Environmental Protection Program (CNL 2017) requires air quality concerns related to the Project be addressed. As part of this program, CNL requires contractors to conform to Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities (ECCC 2005). In addition, this program provides air quality monitoring during decommissioning work to meet the applicable criteria.

Implementation of CNL's Procedure for Management and Monitoring of Emissions (CNL 2013), which includes operational control monitoring, air verification monitoring and environmental monitoring, will continue for the Project. In addition, air quality monitoring activities for the Project will be incorporated into the Environmental Assessment Follow-up Program for WR-1 (Table 6.2.1-16) with the purposes 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.

This monitoring will be integrated with monitoring outlined in the existing Environmental Assessment Follow-up Program for the WL Site, where practical.

Table 6.2.1-16: 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	Closure activities will result in fugitive dust emissions.	■ Verify that the following mitigation measures are being incorporated as planned, and are effective. ■ Verify predictions are within air quality criteria. ■ Demonstrate compliance with regulatory requirements.	■ Application of aggregate to unpaved roads – a record will be kept of the date of each application of aggregate to unpaved roads. ■ Dust Control on Roads – a record will be maintained of dust control treatment for roads. ■ 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 measures will be recommended. Environmental conditions will be recorded.	Through the closure phase.	Captured through the implementation of CNL's Procedure for Management and Monitoring of Emissions, which includes operational control monitoring and verification monitoring.

km/hr = kilometre per hour; SSA = Site Study Area.

6.2.1.10 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, scientists, government agencies, First Nation and Métis communities, or the public (Canadian Environmental Assessment Agency 2014). Air quality was selected as a VC as emissions from the Project activities have the potential to alter the existing air quality regime. The assessment endpoint for the air quality assessment are performance 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 in comparison to the provincial or federal ambient air quality criteria.

Residual effects from activities that occur during the Application Case have been identified as the primary linkage to potentially affect ambient air quality. During the Application Case, Project activities will result in emissions associated with the operation of vehicles and equipment, as well as material handling emissions from the demolition and grouting and temporary batch mixing plant. A summary of the predicted residual adverse effects for air quality, including associated mitigation, are provided and examples of mitigation practices implemented to limit predicted residual effects to air quality include:

- implementation of CNL's Environmental Protection Program (CNL 2017) and Procedure for Management and Monitoring of Emissions (CNL 2013), which includes operational control monitoring, air verification monitoring and environmental monitoring;
- on-site vehicles and equipment engines will meet a minimum of Tier 3 emission standards, where possible, and be maintained in good working order;
- limit idling of vehicles on-site and limit speed on roads; and
- use of enclosure for batch mixing plant and raw material handling.

The predicted residual effects air quality were estimated to increase because of the Project. Fugitive dust from paved roads is the largest contributor to SPM emissions. Material handling from demolition is the largest contributor to PM_{10} emissions. Non-road equipment exhaust emissions are the largest contributors to $PM_{2.5}$ and NOx (as NO_2) emissions. Finally, the largest contributor to SO_2 and CO emissions is fuel combustion for emergency power generators. Predicted concentrations for the Application Case are below applicable air quality guidelines and/or standards. Following the methodology described above, the residual effects from the Project on air quality was determined to be not significant (Table 6.2.1-17). The Procedure for Management and Monitoring of Emissions (CNL 2013) outlines the key management practices that limit air quality emissions effects, as well as the current monitoring requirements.

Table 6.2.1-17: Summary of Predicted Residual Adverse Effects for Atmospheric Environment Valued Components

Valued Compound	Assessment Endpoint	Residual Adverse Effects	Phase the 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	Closure activities will alter concentrations of indicator compounds, including: ■ use vehicles and equipment that combust fuel and emit indicator compounds; ■ material handling, for grouting and demolition; ■ vehicles travelling on paved roads; ■ operation of batch mixing plant for grout production.	Closure Phase	■ Stage 1: Preparation for In Situ Decommissioning ■ Stage 2: Grouting of below-grade structures and systems ■ Stage 3: Removal of above-grade WR-1 structures and systems	■ Implementation of CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring, air verification monitoring and environmental monitoring. ■ Implementation of the appropriate management techniques to control dust generated by the Project. ■ Road watering and chemical dust suppressant when necessary. ■ Removal of accumulations of particulates (e.g., dirt) on road as soon as possible. ■ On-site vehicles and equipment engines will meet Tier 3 emission standards, where possible, and be maintained in good working order. ■ Limit idling of vehicles on-site and speed on roads. ■ Use of enclosure for batch mixing plant and raw material handling.	Not Significant

CNL = Canadian Nuclear Laboratories; km/hr = kilometre per hour.

6.2.2 Greenhouse Gases

6.2.2.1 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 environmental assessment approach and methods described in Section 6.1. The assessment is completed in the following primary steps.

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries, and assessment cases** (refer to Sections 6.2.2.2 Valued Components and Section 6.2.2.3 Assessment Boundaries) for the GHG assessment. 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 6.2.2.4 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 6.2.2.5 Project Interactions and Mitigation). Project components and/or activities with the potential to release 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 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. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. 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 described. Primary pathways were not identified for climate change; therefore no residual effects are carried forward for further analysis and characterization.
- **Step 4 – Identify monitoring and follow-up** (refer to Section 6.2.2.6 Monitoring and Follow-up) required to confirm effects predictions and address uncertainty.
- **Step 5 – Present a consolidated summary of conclusions and outcomes of the assessment** (refer to Section 6.2.2.7 Conclusions) for GHG.

This section also describes how the input from engagement influenced the scope of the GHG assessment. To date, no areas of interest have been raised by the public, communities of interest, regulators, and First Nation and Métis communities during engagement activities specific to GHG or climate change. Other general concerns and questions raised during the engagement are documented in Section 4 Aboriginal Engagement and Section 5 Public Engagement.

6.2.2.2 Valued Components

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, First Nation and Métis communities, or the public (the Agency 2014). Climate change was selected as a VC for the GHG assessment as there is a potential for the Project activities to release GHG emissions that could contribute incrementally to climate change (Table 6.2.2-1). The mechanism by which the Project has the potential to contribute to global climate change is by the addition of GHG emissions. Greenhouse gasses refer to a group of gases that build up in the atmosphere and have the potential to contribute incrementally to climate change.

Table 6.2.2-1: Valued Components for Greenhouse Gas Assessment

Valued Component	Rationale for Selection
Climate Change	This valued component, assessed through incremental changes in emissions of greenhouse gases, considers the potential of the 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 climate change is comparison to provincial and national totals. 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 climate change assessment include changes in concentrations of the following GHG emissions:

- carbon dioxide (CO_2);
- methane (CH_4); and
- nitrous oxide (N_2O).

There are no 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 equivalent CO_2 (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 Project activities in tonnes of CO_2e. The assessment endpoints and measurement indicators used in the climate change assessment are listed in Table 6.2.2-2.

Table 6.2.2-2: Assessment Endpoints and Measurement Indicators for the Greenhouse Gas Assessment

Valued Component	Assessment Endpoints	Measurement Indicators
Climate Change	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.

6.2.2.3 Assessment Boundaries

6.2.2.3.1 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.

6.2.2.3.2 Temporal Boundaries

Temporal boundaries (i.e., project phases) establish the timeframe during which Project effects are assessed. The temporal boundaries for the GHG assessment are the same as those defined for the air quality assessment (see Section 6.2.1.3.2 Temporal Boundaries).

6.2.2.3.3 Assessment Cases

The assessment cases are defined in the air quality assessment (Section 6.2.1.3.3 Assessment Cases). The GHG assessment includes evaluation of the Base Case and Application Case.

6.2.2.4 Description of the Environment

6.2.2.4.1 Methods

This section documents the methods, data, and results that were used to assess the GHG emissions in the LSA and RSA.

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.

Technical Guidance on Reporting Greenhouse Gas Emissions, Environment and Climate Change Canada (November 2015)

The *Technical Guidance on Reporting Greenhouse Gas Emissions* (November 2015; the GHG Reporting Program [GHGRP] Guideline) provides direction in identifying if facilities are required to submit a GHG report to ECCC under the 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. 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 (IPCC). 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 50,000 tonnes of carbon dioxide equivalent (CO_2e).

There is no GHG regulatory program specific to Manitoba currently in place; however, Manitoba is in the process of developing a regulation for mandatory reporting of GHG emissions (IISD 2015). While the regulation is under development, Manitoba continues to rely on the federal GHGRP to collect GHG data for the large emitters and other GHG sources Manitoba covered through the National Inventory Report for Canada (ECCC 2014).

Baseline GHG Emissions Data

Existing GHG emissions are monitored by ECCC through the National Atmospheric Chemistry Database at nine stations across Canada (ECCC 2013); however, no stations are present in Manitoba. In addition to the monitored data, GHG emissions can be quantified. For the purposes of this GHG assessment, federal and provincial reported GHG data is used to describe the GHG emissions. ECCC reported facility GHG data (ECCC 2015a) was used to characterize the existing GHG emissions. The reported emissions are quantified for direct sources of emissions only (e.g., stationary combustion), which is consistent with the quantification methodology used for the Project's GHG emissions.

6.2.2.4.2 Results

In 2012, Canada represented less than 2% of total global GHG emissions (ECCC 2015c). Therefore, any GHG emissions from the Project may be considered negligible on a global scale. The latest available federal and provincial facility reported GHG data was used to describe the background GHG emissions. The latest available federal and provincial data is from the 2014 reporting year (ECCC 2015a). The WL main campus located approximately 13 km southeast from the Project (according to distance reported to NPRI) and was not required to report GHG emissions in 2014 under the Federal GHG Reporting Program; however, these numbers are reported within the CNL Annual Safety Review Report. Total federal and provincial GHG emissions are provided in Table 6.2.2-3.

Table 6.2.2-3: Baseline Greenhouse Gas Emissions

Source	GHG Emissions[(a)] (tonnes CO_2e)
Canada-wide 2014 GHG Emissions Reporting Facilities	263,935,802
Manitoba-wide 2014 GHG Emissions Reporting Facilities	1,961,438

GHG = greenhouse gases; CO_2e = carbon dioxide equivalent.

a) GHG emissions obtained from ECCC's GHGRP data for 2014 (ECCC, 2015a).

6.2.2.5 Project Interactions and Mitigation

6.2.2.5.1 Methods

This section describes the process by which interactions between Project components and activities and GHG were identified and evaluated. Potential effect 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 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 stages of the Project. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. The next step in the analysis was the development of environmental design features and mitigation practices that could be incorporated into the Project to eliminate and/or reduce releases of 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 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 pathway –** pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change to concentrations of GHG emissions relative to Base Case values, and therefore would have no residual effects to climate change.
- **Secondary pathway –** the pathway could result in a measurable minor change to GHG emissions, but would have a negligible residual effect on climate change 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 past, present or reasonably foreseeable developments to cause a significant effect.
- **Primary pathway –** the pathway is likely to result in an environmental change to GHG emissions relative to the Base Case and/or guideline values that could contribute to residual effects to climate change.

Environmental design features and mitigation that have been or could be incorporated into the Project to eliminate and/or reduce adverse effects to climate change 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 climate change through simple qualitative or semi-quantitative 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 Project on climate change.

6.2.2.5.2 Results

Pathways through which all components of the Project may interact with and result in releases of GHG emissions are provided in Table 6.2.2-4. The GHG emissions were estimated by taking into account the mitigation considered to be integral to the design and implementation of the Project activities. These mitigation, which are considered to be typical and consistent with best practices are presented in Table 6.2.2-4.

Table 6.2.2-4: Pathways Analysis for Greenhouse Gas Emissions

WR-1 Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Closure Phase ■ Stage 1: Preparation for In Situ Decommissioning ■ Stage 2: Grouting of below-grade structures and systems ■ Stage 3: Removal of above-grade WR-1 structures and systems	Vehicles and equipment used for closure activities combust fuel and emit GHGs.	■ Implementation of CNL's Environmental Protection program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring and environmental monitoring. ■ On-site vehicles and equipment engines will be maintained in good working order. ■ Limit idling of vehicles on-site.	Secondary

GHG = greenhouse gasses; CNL = Canadian Nuclear Laboratories.

6.2.2.5.2.1 No Linkage Pathways

There are no pathways identified as having no linkages to effects on climate change.

6.2.2.5.2.2 Secondary Pathways

In some cases, a Project interaction exists, but mitigation is expected to cause minor changes to the environment relative to the existing Base Case and/or guidelines. The following pathway is expected to result in a negligible release of GHG emissions and will not be evaluated further in the EIS.

- **Vehicles and equipment used for closure activities combust fuel and emit GHGs.**

The assessment of effects of releases of GHG from the Project on climate change involves two steps, namely the calculation of emission rates, which include the implementation of mitigation, and comparison to provincial and federal emissions. Details of the specific GHG emission source identification, calculation methods, and sample calculations are provided in Appendix 6.2-2; a summary is provided below.

Identification of emission sources was completed by defining a reporting inventory boundary, which frames the GHG emission sources that are included in the assessment for the Project. The reporting inventory boundary is based on the GHGRP; and therefore, stationary fuel combustion emissions and on-site mobile emissions have been included in the GHG assessment. The source categories included in the GHG assessment are:

- on-site stationary fuel combustion sources;
- on-site stationary fuel combustion for generators; and
- on-site mobile fuel combustion sources.

The emission estimation methods follow the following guidance:

- ECCC's Technical Guidance on Reporting GHG Emissions (ECCC 2015b);
- Part 2 of ECCC's National Inventory Report 1990-2013[2] (ECCC 2015c); and
- ON.20 (General Stationary Combustion) of the Ontario Guideline for Greenhouse Gas Emissions Reporting (MOECC 2015).

Table 6.2.2-5 summarizes the annual emission rates in tonnes per year for each activity at the Project. The GWP used to calculate GHG emissions in CO_2e correspond to ECCC's GWPs (ECCC 2015c).

Table 6.2.2-5: Summary of Annual Greenhouse Gas Emissions.

Source	Annual GHG Emissions (tonnes CO_2e/year)			Annual GHG Emissions (tonnes CO_2e/year)
	CO_2	CH_4	N_2O	CO_2e
Mobile Equipment (Road and Non-Road)	12,054	17	738	12,808
Propane Combustion	125	0.05	0.06	125
Emergency Power Generators	3	0.004	0.13	3
Total	12,182	17	738	**12,936**

[2] The ECCC National Inventory Report (1990-2013) was used as it presents a higher emission factor for N_2O from off-road diesel combustion.

Table 6.2.2-6 summarizes the annual overall emissions in tonnes of CO_2e for the Application Case. Project GHG emissions represent less than 0.01% of the Canada-wide total and less than 1% of the provincial total.

Table 6.2.2-6: Comparison of GHG Emissions from the Project to Manitoba and Canadian Emission Totals

Source	Annual GHG Emissions (tonnes CO_2e)
Project Emissions	12,936
Canada-wide GHG Emissions	263,935,802
Manitoba-wide GHG Emissions Reporting Facilities	1,961,438
Comparison of Project to Canada-wide GHG Emissions	<0.01%
Comparison of Project to Manitoba-wide GHG Emissions	<1%

Based on the comparison between the estimated annual emission to both the federal and provincial greenhouse gas emissions, the Project will result in minor releases of GHG emissions, but is predicted to have a negligible residual effect on climate change.

6.2.2.5.2.3 Primary Pathways

No primary pathways are identified for the GHG assessment. Subsequently, there is no further residual effects classification and determination of significance.

6.2.2.6 Monitoring and Follow-up

Implementation of CNL's Procedure for Management and Monitoring of Emissions (CNL 2013), which includes operational control monitoring, emissions verification monitoring and environmental monitoring, will continue for the Project (Table 6.2.2-7). In addition, air quality monitoring activities for the Project will be implemented as outlined in Section 6.2.1.6.

Table 6.2.2-7: 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	Closure activities will result in increased greenhouse gas 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 Project.	Annual estimations and GHG reporting, as required during the closure phase.	Captured through the implementation of CNL's Procedure for Management and Monitoring of Emissions, which includes operational control monitoring and verification monitoring.

6.2.2.7 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, scientists, government agencies, First Nation and Métis communities, or the public (the Agency 2014). Climate change was selected as a VC as there is a potential for the Project activities to release GHG emissions that could contribute incrementally to climate change. The measurement indicator for the assessment include changes in emissions of CO_2e and comparison to provincial and national GHG totals.

Project activities will result in GHG emissions associated with the operation of vehicles and equipment during the closure phase, the GHG emissions are estimated to be less than 1% increase in total provincial GHG emissions and less than 0.01% increase in total national GHG emissions. Based on the comparison between the estimated annual emission to both the federal and provincial greenhouse gas emissions, the Project will result in minor releases of GHG emissions, but is predicted to have a negligible residual effect on climate change.

Examples of mitigation practices implemented to limit GHGs include:

- implementation of CNL's Environmental Protection program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring and environmental monitoring;
- on-site vehicles and equipment engines will be maintained in good working order; and
- limit idling of vehicles on-site.

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6.3 Geological and Hydrogeological Environment

6.3.1 Geology

This section of the Environmental Impact Statement (EIS) provides understanding of the potential residual effects of the Project and other past, present and reasonably foreseeable developments on the physical aspects of the geological environment (Section 6.3.1 Geology) and hydrogeological environment (Section 6.3.2 Hydrogeology).

6.3.1.1 Scope of the Assessment

This section focuses on geology, which includes bedrock, soils and geomorphology. The geology assessment follows the overall environmental assessment approach and methods described in Section 6.1 Environmental Assessment Approach. The assessment is completed in the following steps.

- **Step 1 – Identify Valued Components (VCs)** (refer to Section 6.3.1.2 Valued Components and Section 6.3.1.3 Assessment Boundaries) and define the spatial boundaries, temporal boundaries and assessment cases for the geology assessment. The VCs and measurement indicators used to assess Project-related changes to geology; 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 6.3.1.4 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).
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 6.3.1.5 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 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. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. 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 described.
- **Step 4 – Identifying monitoring and follow-up** (refer to Section 6.3.1.6 Monitoring and Follow-up) required to confirm effects predictions and address uncertainty.
- **Step 5 – Present a consolidated summary of conclusions and outcomes of the assessment** (refer to Section 6.3.1.7 Conclusions) of residual effects on geology.

To date no areas of interest have been raised by the public, communities of interest, regulators, and First Nation and Métis communities during engagement activities specific to geology, which could influence the scope of the geology assessment or the sources of information used to support the assessment. Other general concerns and questions raised during the engagement are documented in Section 4 Aboriginal Engagement and Section 5 Public Engagement.

6.3.1.2 Valued Components

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, First Nation and Métis communities, or the public (the Agency 2014). Geology, which includes bedrock, soils and geomorphology, is recognized as an important component of the environment that may be affected by the 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 a large 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 Project activities could affect terrestrial and aquatic ecosystem structure and function (Table 6.3.1-1).

Table 6.3.1-1: 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 Project activities could affect terrestrial and aquatic biodiversity.

Acknowledging that changes to geology are considered to be 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 6.3.1-2). The assessment of geology focused on predicting changes in the concentrations of selected non-radiological compounds; radiological parameters are considered in Section 6.7 Human 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 6.3.1-2).

Table 6.3.1-2: Measurement Indicators for the Geology Assessment

Valued Component	Measurement Indicators	Discipline Assessments where Effects on Geology are Considered
Geology	■ Bedrock ■ Soil quality ■ Soil quantity ■ Geomorphology	■ Section 6.3.2 Hydrogeology ■ Section 6.4.2 Surface Water Quality ■ Section 6.5 Aquatic Environment ■ Section 6.6 Terrestrial Environment ■ Section 6.8 Land and Resource Use

6.3.1.3 Assessment Boundaries

6.3.1.3.1 Spatial Boundaries

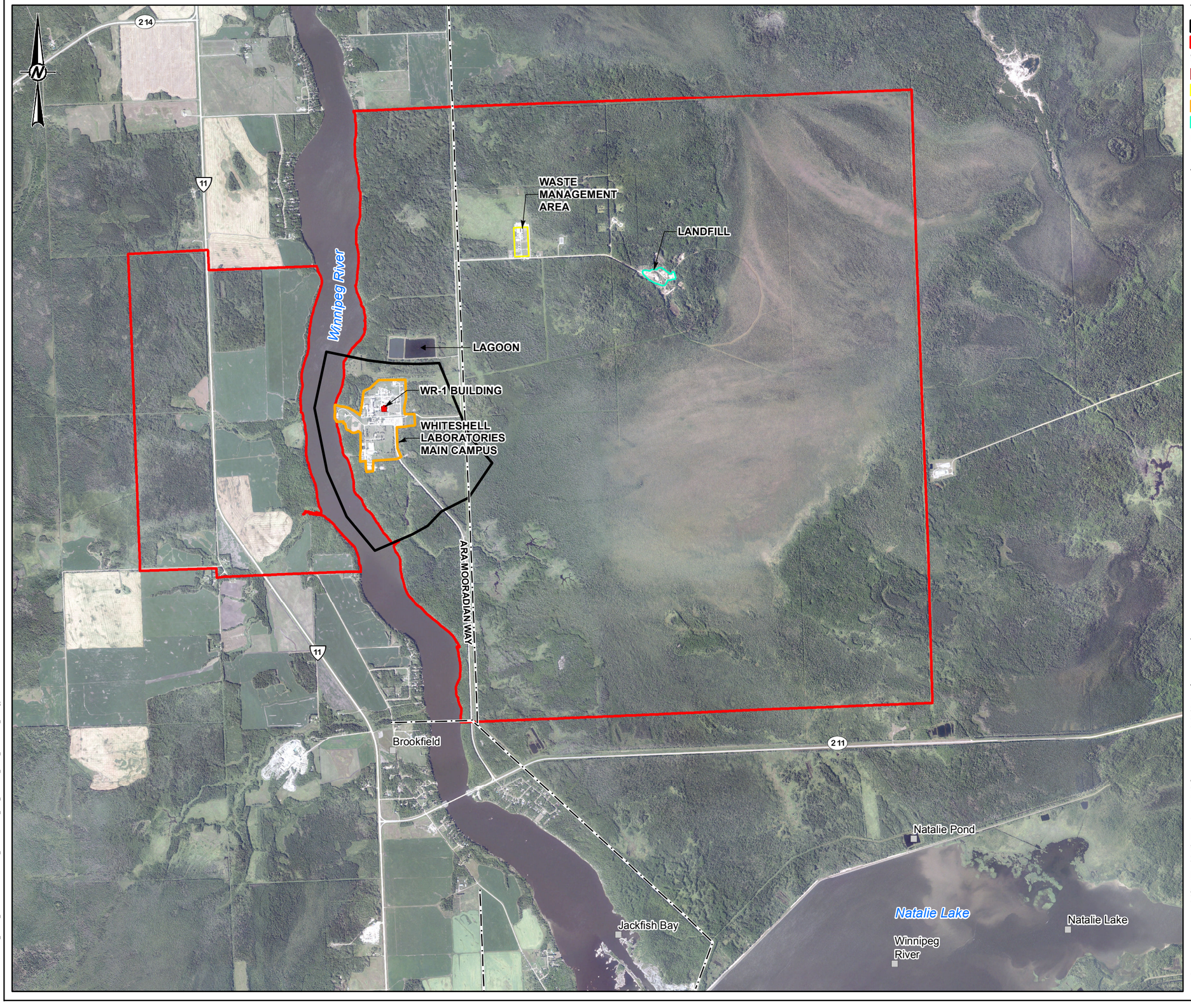
The spatial boundaries selected for the geology assessment are presented on Figure 6.3.1-1 and described below:

- **Site Study Area (SSA)** is the WR-1 Building and represents the Project footprint (i.e., where Project activities will be undertaken).
- **Local Study Area (LSA)** is defined as the area within which there is potential for measurable changes resulting from the proposed Project activities. The LSA is delineated by the boundaries of the groundwater model for the Project, which were selected based on groundwater elevation data and topography. The western boundary of the LSA coincides with the inferred groundwater flow divide at the centre of the Winnipeg River. The northern boundary of the LSA is approximately 450 metres (m) north of WR-1, and is parallel to the inferred direction of groundwater flow. The location of this boundary was selected as it follows a topographic divide and is south of the Lagoon Area. The southern boundary of the LSA is approximately 1,400 m south of the WR-1, and is parallel to the inferred direction of groundwater flow. The location of this boundary was selected as it coincides with a topographic divide and an inferred divide in groundwater flow. The eastern boundary of the LSA is located approximately 700 m east of the WR-1 and approximately 500 m east of the Whiteshell Laboratories (WL) main campus. This boundary is perpendicular to the inferred direction of groundwater flow, and upgradient of WR-1.
- **Regional Study Area (RSA)** is defined as the area within which the potential effects of the Project may interact with the effects of other existing or reasonable foreseeable projects. The RSA is delineated by the WL site boundary (Figure 6.3.1-1).

6.3.1.3.2 Temporal Boundaries

The temporal boundary of the assessment includes effects observed under existing conditions, the timeframe during which Project activities are actively occurring and 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 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 Project:

- **Closure Phase:** Preparation and implementation of In Situ Decommissioning (ISD), which includes preparation for ISD, grouting of below-grade structures and systems, removal of above-grade WR-1 structures and systems, installation of the engineered cover and environmental controls and final site restoration. These activities last from 2019 to 2024.
- **Post-closure Phase:** The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. The Institutional Control period includes implementation of both active and passive control throughout 2024 to 2324 (i.e., 300 years). During active Institutional Control, long-term performance monitoring and maintenance activities will continue through to 2124 to demonstrate compliance with the safety case assumptions. The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions) and will continue through 2024 to 2324. Post-institutional Control occurs after year 2324 and continues indefinitely.



LEGEND

- LOCAL STUDY AREA
- REGIONAL STUDY AREA (WHITESHELL LABORATORIES SITE)

WHITESHELL LABORATORIES

- WR-1 BUILDING
- WASTE MANAGEMENT AREA
- WHITESHELL LABORATORIES MAIN CAMPUS
- LANDFILL

BASE FEATURES

- CITY/TOWN
- TRANSMISSION LINE

0 1,000 2,000
1:40,000 METRES

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
SPATIAL BOUNDARIES SELECTED FOR THE GEOLOGY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE
REVIEWED	CS
APPROVED	MM

PROJECT NO. 1656897 | CONTROL | REV. 1 | FIGURE **6.3.1-1**

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6.3.1.3.3 Assessment Cases

The geology assessment has three assessment cases:

- **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, and residential and recreational development. Current effects from the existing WL facilities and operations, for example, are considered part of the Base Case. In addition, effects from the decommissioning and reclamation activities already completed at the WL site are also considered as part of the Base Case.
- **Application Case**: the Application Case represents predictions of the effects of the Base Case combined with the effects that may result from the Project. The Application Case considers potential effects from the Project during closure through to the post-closure phase.
- **Reasonably Foreseeable Developments (RFD) Case**: this scenario represents the predictions of the cumulative effects of the Application Case, plus projects that are currently under application review or that have officially entered a regulatory application process and which overlap with the geology RSA. There are no RFDs expected in the RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). Results of the Comprehensive Study Report indicated that existing effects on soils are limited to contaminated soils within affected lands on the WL site (see Section 6.3.4 of AECL 2001). Affected lands and associated contaminated soils in these lands will be remediated and/or removed during the WL site decommissioning. As such, decommissioning of these structures is anticipated to positively affect geology. The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. Because RFDs are likely to positively affect the geology, an RFD Case is not presented as part of this assessment.

6.3.1.4 Description of the Environment

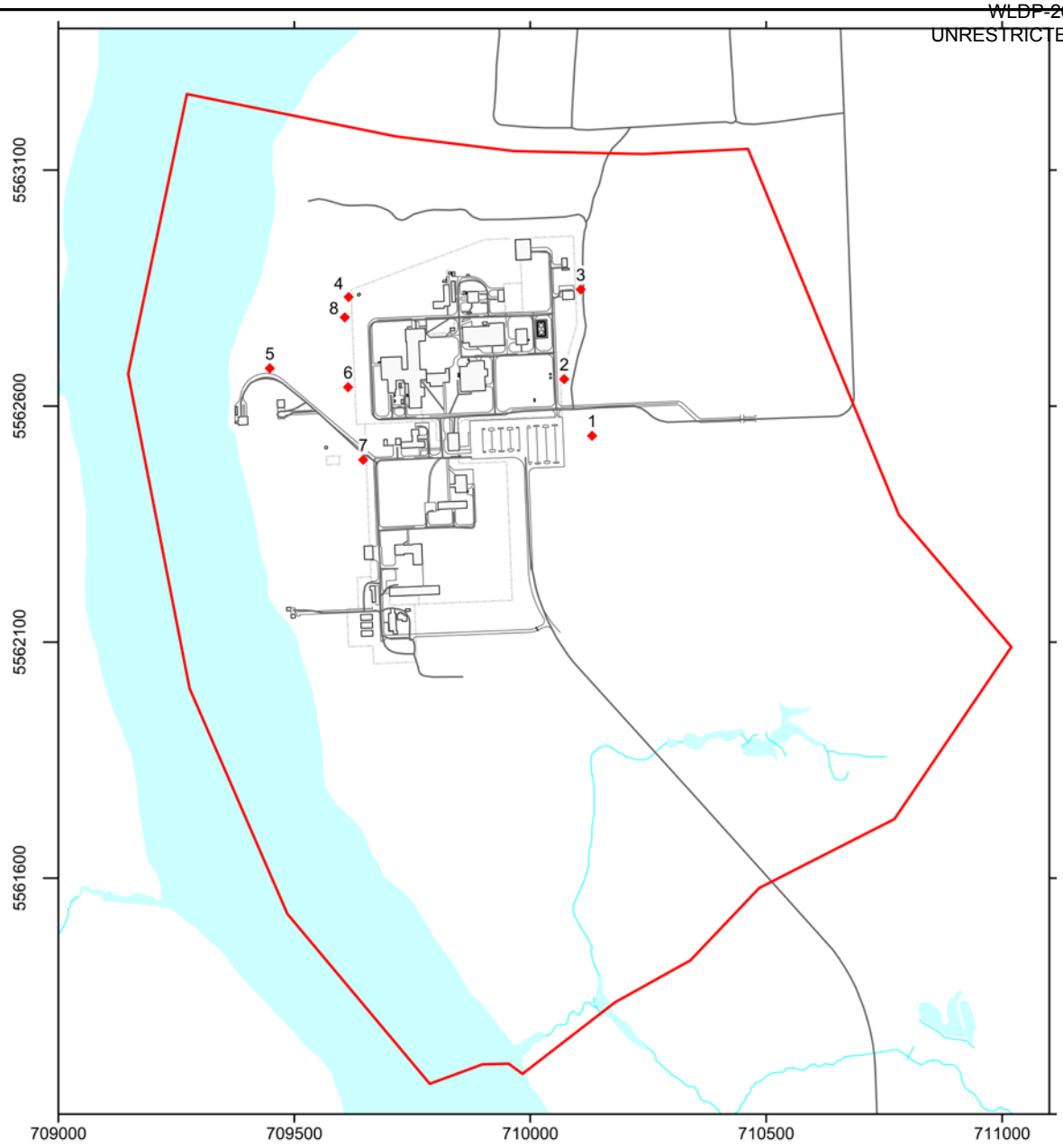
6.3.1.4.1 Methods

Baseline geology data were collected from the results of recent drilling and core logging at the WL main campus. Four new bedrock monitoring wells were installed in 2016 at depths ranging from 24 m to 42 m below ground surface (10 m to 30 m below the top of the bedrock surface). Details on the drilling program, monitoring well installation and the borehole logs are described in Dillon (2017). The stratigraphic data collected from these boreholes were supplemented through the review of the following existing reports on the WL site.

- Load Bearing Test on Glacial Till, Test Pile and Bench Mark Locations, Whiteshell Nuclear Research Establishment, D-901-A-1, Atomic Energy of Canada Limited, September 1961.
- Hydrogeologic Regime of the Environmental Control Area and Vicinity, Whiteshell Nuclear Research Establishment, Manitoba, Preliminary Progress Report, Cherry, J.A., Beswick, B.T., and W.E. Clister, November 1970.
- Hydrogeological Studies at a Subsurface Radioactive-Waste-Management Site in West-Central Canada, Cherry, J.A., Grisak, G.E., and W.E. Clister, May 1973.

- Review of the Hydrogeology of the Radioactive Waste Management Site, Robertson, W.D., and J.A. Cherry, February 1985.
- Whiteshell Laboratories Decommissioning Project, Comprehensive Study Report, WLDP-03702-041-000, Atomic Energy of Canada Limited, March 2001.
- Hydrogeology of the Waste Management Area, Lagoon and Landfill-Enhanced Monitoring Program, WL Decommissioning, WLDP-03704-ENA-009, Atomic Energy of Canada Limited, March 2008.
- Whiteshell Laboratories Projects Branch Comprehensive Final Report on Installation of 7 Groundwater Monitoring Wells Nests, WLDP-35000-041-000-0014, KGS Group, March 2016.

Dillon (2017) provides details on recent geological and hydrogeological investigations of the LSA, which (in part) involved drilling and instrumentation of seven monitoring well nests, and a single monitoring well (16-8) that encompass a total of 33 monitoring wells. The monitoring well nests are named numerically (i.e., monitoring well nest 1 through monitoring well nest 7). Each monitoring well nest includes between 4 and 6 monitoring wells. Individual monitoring wells are named using the installation year, the monitoring well nest number, and a letter indicating the relative depth (with “A” assigned to the shallowest monitoring interval). In the following sections, the term monitoring well nest is used to refer to the conditions observed throughout the group of monitoring wells, while individual monitoring well names are used to refer to conditions at a specific depth interval. The monitoring well names and geological units for each monitoring well nest are summarized in Table 6.3.1-3. Monitoring well nest locations are shown on Figure 6.3.1-2.



LEGEND

- Local Study Area
- Roads
- Buildings
- Fence
- Stream
- Waterbody
- Monitoring Well Nest Location

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

CONSULTANT
Golder Associates

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TITLE
MONITORING WELL NEST LOCATIONS

PROJECT No. **1656897** | CONTROL | Rev. **1** | FIGURE **6.3.1-2**

S:\Clients\Canadian_Nuclear_Laboratories\Manitoba\99_PRO\1656897_CNL_Whiteshell_EA\40_PROD\0015_Groundwater_Modelling_Report\1656897-0015-G-0009_Figure 6.3.1-2 Monitoring Well Nest Location EDITED.pdf

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Table 6.3.1-3: Monitoring Well Nest Details

Monitoring Well Nest	Monitoring Well	Hydrostratigraphic Unit
1	15-1A	Basal Sand
	15-1B	Clay Till
	15-1C	Clay
	15-1D	Clay
2	15-2A	Basal Sand
	15-2B	Clay Till
	15-2C	Clay Till
	15-2D	Clay
	16-2E	Bedrock
3	15-3A	Basal Sand
	15-3B	Clay Till
	15-3C	Clay
	15-3D	Clay
4	15-4A	Basal Sand
	15-4B	Clay Till
	15-4C	Clay Till
	15-4D	Clay
	15-4E	Clay
	16-4F	Bedrock
5	15-5A	Basal Sand
	15-5B	Clay Till
	15-5C	Clay
	15-5D	Clay
6	15-6A	Clay Till
	15-6B	Clay Till
	15-6C	Clay Till
	15-6D	Clay
7	15-7A	Clay Till
	15-7B	Clay Till
	15-7D	Clay
	16-7E	Bedrock
8	16-8A	Bedrock

General descriptions of the geological setting and hydrostratigraphic units were formulated based on the information contained in these reports along with publicly available literature. Borehole logs and cross sections contained in these reports were also used to infer stratigraphic boundary points (i.e., contact elevations between geological surfaces). This information was then used to construct overburden and stratigraphic unit thickness maps (isopachs), and to construct a cross-section for the RSA (Figure 6.3.1-7).

6.3.1.4.2 Results

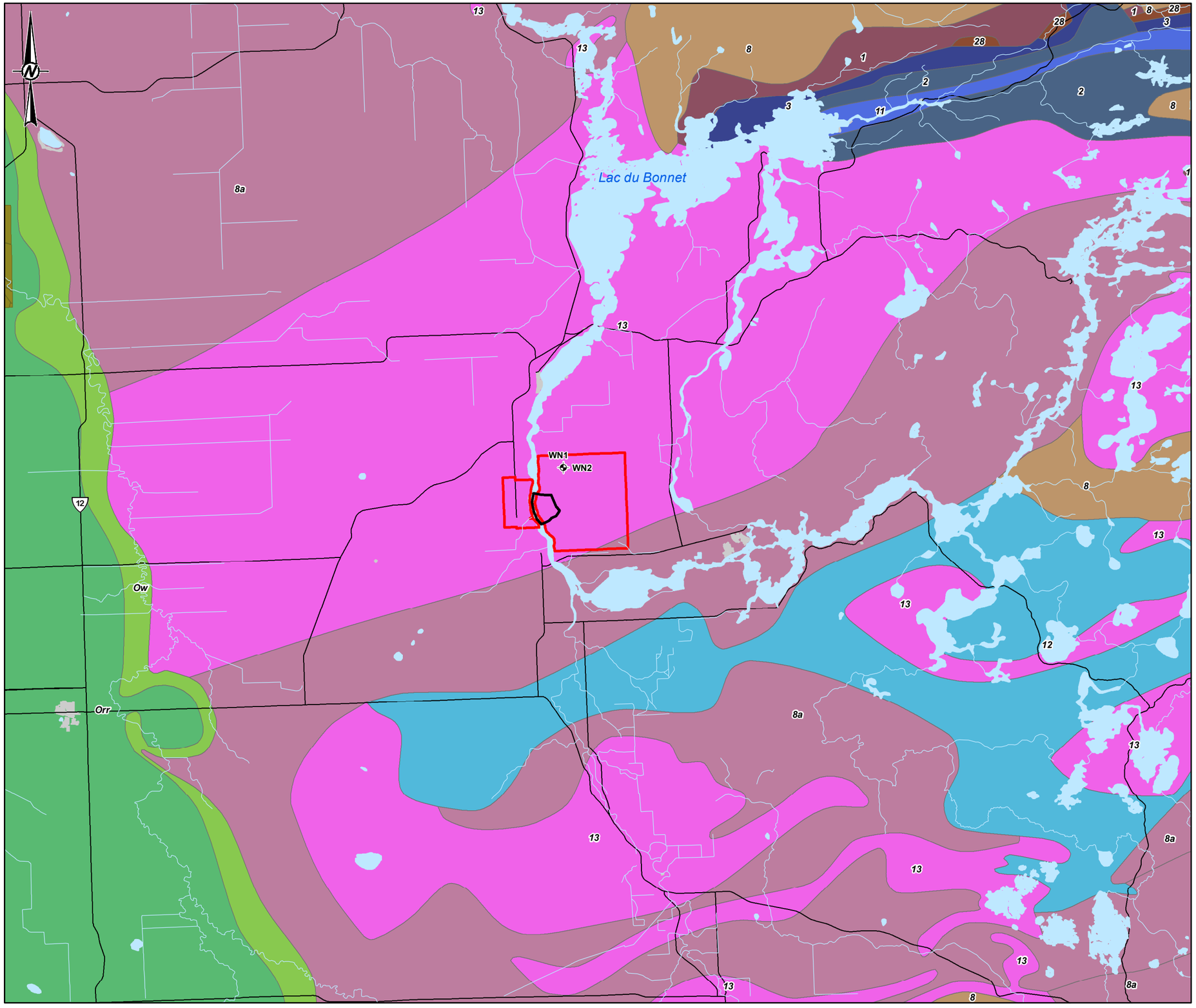
6.3.1.4.2.1 Regional Geological Conditions

The region surrounding the RSA is underlain by the Precambrian rock of the Lac Du Bonnet Batholith, part of the Superior Province of the Canadian Shield. The Lac Du Bonnet Batholith consists of undifferentiated and partly foliated porphyritic granite and granodiorite (Everitt et al. 1996). The batholith trends southwest to northeast. The upper 200 m of the batholith consists primarily of pink hematite-bearing granite, underlain by a grey magnetite-bearing granite (Everitt et al. 1996). The Batholith covers an approximate area of 1,400 square kilometres (km²) (Chandler 2003). At the northeastern extent of the Lac Du Bonnet Batholith (approximately 20 kilometres (km) north of the RSA) there is a sharp contact with the metavolcanic and metasedimentary rocks of the Bird River Greenstone Belt. The southern boundary of the Lac Du Bonnet Batholith (approximately 4 km south of the RSA) is a gradational transition to gneisses and migmatites of the Winnipeg River Subprovince of the Canadian Shield. Approximately 25 km west of the RSA, the batholith becomes overlain by Paleozoic sedimentary rocks of the Western Canadian Sedimentary Basin. Regional bedrock geology is shown on Figure 6.3.1-3.

Jointing and fracturing has been observed at various locations within the batholith, and additional details are provided in the following sections pertaining to observations made in the LSA. Two fracture lineations within the batholith have been identified based on outcrop mapping and air photo interpretation, as trending northeast to southwest and northwest to southeast, respectively (Davidson 1980). Fracture zones within the batholith have been noted at depths up to 300 metres below ground surface (Stevenson et al. 1996).

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UNRESTRICTED / ILLIMITÉE



LEGEND

- BOREHOLE LOCATION
- LOCAL STUDY AREA
- REGIONAL STUDY AREA (WHITESHELL LABORATORIES SITE)

BASE FEATURES

- CITY/TOWN
- MAJOR ROAD
- WATERCOURSE
- WATERBODY
- MUNICIPAL BOUNDARY
- FIRST NATION RESERVE

BEDROCK GEOLOGY

- 1 MAFIC VOLCANICS
- 11 GREYWACKE, ARKOSE
- 12 GRANODIORITE, GNEISS
- 13 GRANITE
- 2 FELSIC VOLCANICS
- 28 ULTRAMAFIC INTRUSIVES
- 3 GREYWACKE
- 8 TONALITE
- 8A TONALITE GNEISS
- ORR LIMESTONE, DOLOMITE
- OW SANDSTONE

0 10 20

1:260,000 KILOMETRES

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT

CANADIAN NUCLEAR LABORATORIES

PROJECT

EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE

BEDROCK GEOLOGY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-09-13
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PROJECT NO.	CONTROL	REV.	FIGURE
1656897		1	**6.3.1-3**

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The surficial geology in the RSA consists of glaciofluvial tills and outwash deposits and glacial lacustrine deposits associated with Glacial Lake Agassiz. Surficial deposits have been documented to be up to 25 m-thick (AECL 2008). In the area surrounding the Winnipeg River, these deposits have been regionally subdivided into four main stratigraphic units by McPherson (1964). The units described by McPherson (1964) are listed from the top of bedrock, with the description used in the LSA in brackets, as follows:

- Glacial Till (Basal Sand and Basal Till);
- Glacio-Lacustrine Clay (Clay Till);
- Transitional Glacio-Lacustrine Clay (Clay); and,
- Glacio-Fluvial and Glacio-Lacustrine Sandy Silt (Interbedded Silt and Clay).

Organic deposits are present at surface over a much of the RSA (Figure 6.3.1-4) and range in thickness from 0.25 m to 2 m (AECL 2008). The thickness of the overburden deposits decreases to the east of the RSA where bedrock outcrops are more prevalent, and glacial till is present at surface in some areas (approximately 15 km east of the eastern boundary of the LSA) (Figure 6.3.1-4). The units described above within the RSA are consistent in composition with those observed during the recent drilling program within the LSA as refined and described in the following sections; however, the thickness of these units can vary as a function of bedrock topography.

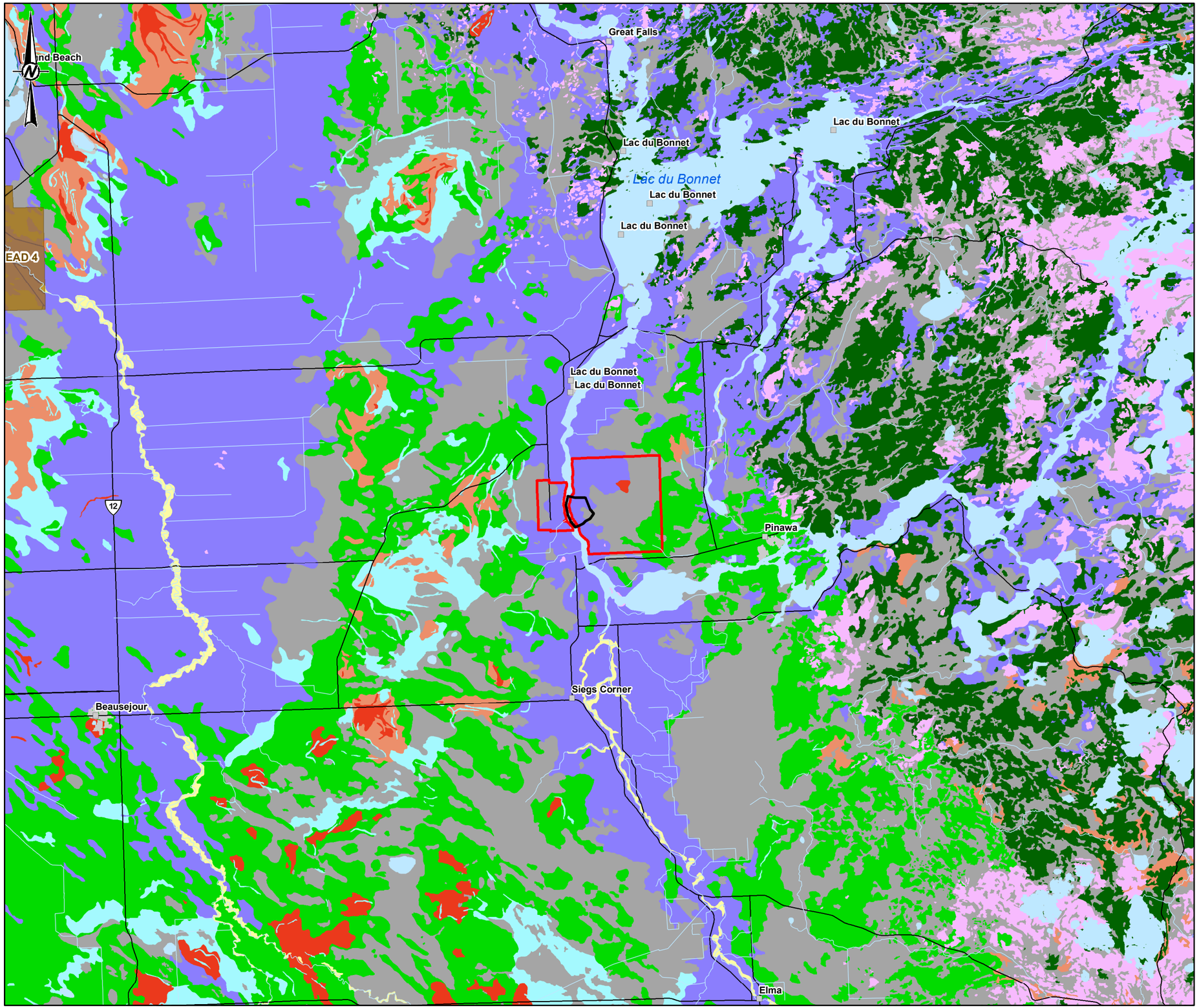
6.3.1.4.2.2 Local Geological Conditions

Local geological conditions are described generally for the RSA (based on historical information) to provide context, and are described in more detail for the LSA (based on site-specific data from recent boreholes).

Bedrock Geology

Detailed information on bedrock lithology is available from the area adjacent to the Waste Management Area (WMA), and north of the WL main campus. As the bedrock lithology within the LSA is expected to be consistent with the lithology observed near the WMA, this detailed information is presented here to supplement the information from the LSA. In this area bedrock lithology has been generalized based on borehole observations at WN-1 and WN-2 (Figure 6.3.1-3). At these locations the bedrock is predominately a medium to coarse grained pink granite (typical of the upper surface of the Lac du Bonnet Batholith) to a depth of approximately 300 m, where it transitions to a pink granite to granodiorite. At both locations a zone of mixed granodiorite, granite and pegmatite with xenoliths of tonalite was noted between depths of approximately 50 m to 100 m. Fractures zones were noted between 20 m and 150 m and between 395 m to 400 m, with fractures generally absent outside of these zones. Elsewhere on the WL site, fracture frequency is generally consistent, with lower fracture frequency in the upper 300 m and a highly fractured zone present at depths in the 300 m to 400 m range as described in Lau and Bisson (1980a, 1980b, 1980c), Lau, Bisson and Auger (1982) and Lau, Auger and Bisson (1985a, 1985b).

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LEGEND

- LOCAL STUDY AREA
- REGIONAL STUDY AREA (WHITESHELL LABORATORIES SITE)

BASE FEATURES

- CITY/TOWN
- MAJOR ROAD
- WATERCOURSE
- WATERBODY
- MUNICIPAL BOUNDARY
- FIRST NATION RESERVE

SURFICIAL GEOLOGY

- ORGANIC
- LACUSTRINE - MODERN SHORELINE
- ALLUVIUM
- GLACIOLACUSTRINE - LITTORAL
- GLACIOLACUSTRINE - SILT AND CLAY
- GLACIOFLUVIAL - OUTWASH
- GLACIOFLUVIAL - ICE CONTACT
- TILL - SAND-RICH
- TILL - SILT-RICH
- ROCK - PRECAMBRIAN

0 10 20
1:260,000 KILOMETRES

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

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TITLE
SURFICIAL GEOLOGY

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE
REVIEWED	CS
APPROVED	MM

PROJECT NO. 1656897 | CONTROL | REV. 1 | FIGURE **6.3.1-4**

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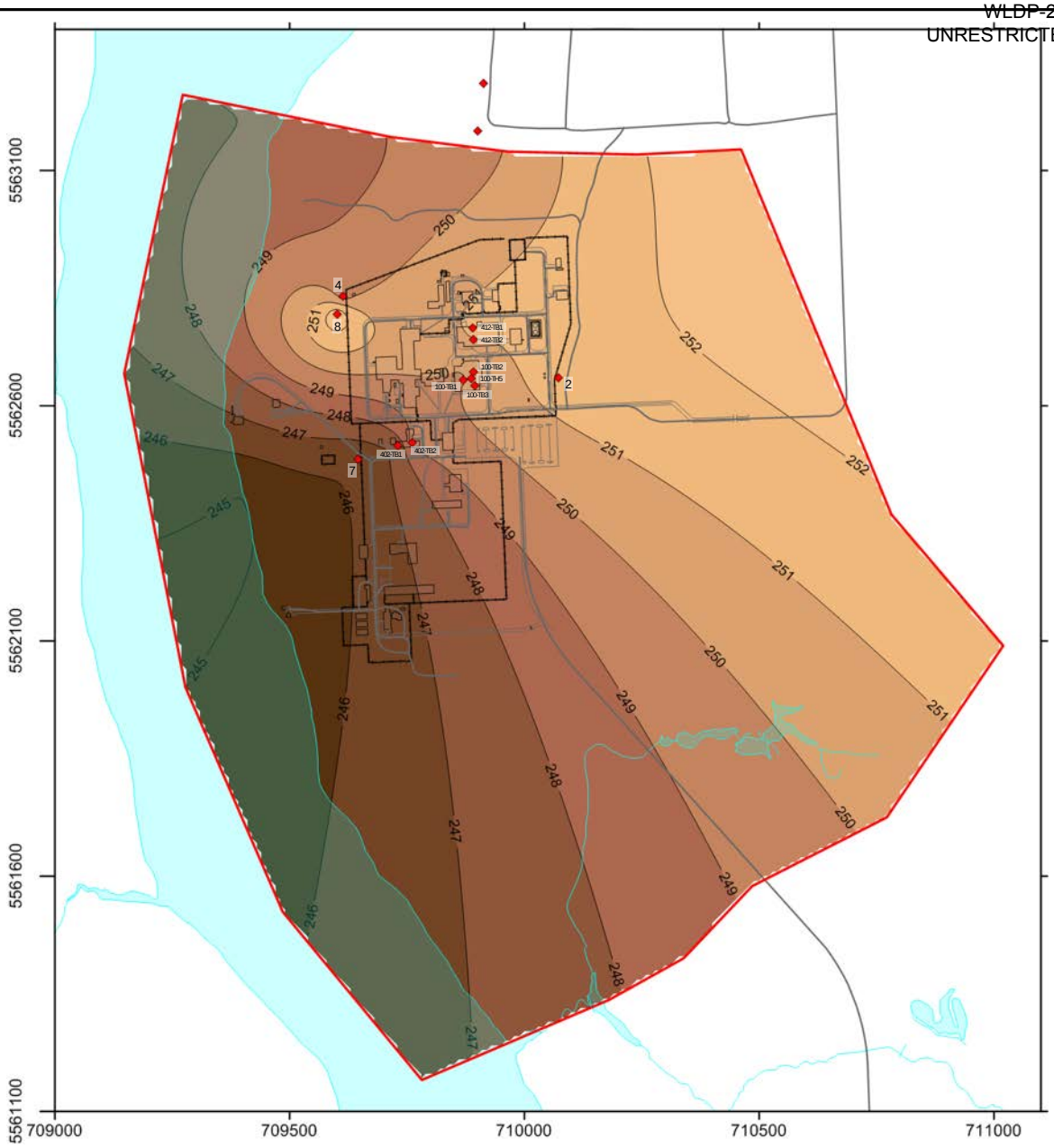
Path: S:\Clients\Canadian_Nuclear_Laboratories\Manitoba\99_PROJ\1656897_CNL_Whiteshell_EA\40_PROD\0001_Geology\1656897-0001-BP-0004.mxd

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Within the WL main campus area and surrounding the SSA, bedrock geology encountered during borehole drilling at 15-2E, 15-4F, 15-7E and 16-8A is similar to that observed in the WN-series boreholes. Pink to red pegmatite granite was the predominant lithology logged in rock core from these boreholes. Dark Grey, fine grained, biotite schist (3m in thickness) and dark grey, fine grained, tonalite schist (1 m in thickness) was observed in rock core from 16-2E, similar to the mixed zones observed in WN-1 and WN-2. In core retrieved from borehole 16-4F, a mixed zone of dark grey fine to medium grained amphibolite schist and pink granite was noted throughout. Both open and closed factures were noted throughout the length of core logged for each borehole.

Bedrock Topography

Bedrock topography at the LSA has been determined based on boreholes extended through the full overburden thickness to confirmed bedrock. These boreholes include the BHS 500-series wells in the Lagoon Area (AECL 2008), and the recently drilled boreholes in the WL main campus area (LSA), supplemented with the historical data (AECL 1961). Depth to auger refusal has not been found to be a reliable surrogate for depth to the bedrock surface at the WL site given the prevalence of large boulders in the basal till unit (Robertson and Cherry 1985). Bedrock topography varies from 245 to 257 metres above sea level (masl) and is generally gradually sloped towards the south west (and the Winnipeg River). A local bedrock high in the vicinity of boreholes 16-8 and 15-4 has been identified though recent coring. Bedrock topography mapping for the LSA is shown on Figure 6.3.1-5.



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Golder Associates

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DESIGN	NFB
REVIEW	MIB
APPROVED	AM

TITLE
BEDROCK TOPOGRAPHY

PROJECT No. **1656897** CONTROL Rev. **1** FIGURE **6.3.1-5**

S:\Clients\Canadian_Nuclear_Laboratories\Manitoba\89_PRO\1656897_CNL_Whiteshell_EA\0_PRO\DO\015_Groundwater_Modelling_Report\656897-015-G-0004_Figure 6.3.1-5 - Bedrock Topography.pptx

Surficial Soils

The LSA and RSA are located largely within the Agriculture Interpretation Block Area of Pinawa, and a small portion within the Lac Du Bonnet Block Area (Manitoba Land Initiative [MLI] 2003). In general, the historic surficial soil distribution within the LSA and RSA is comprised of organics in areas of poor drainage and Glysolic and Chernozemic soils in areas with improved drainage. Soils developed on outwash sands and alluvial materials are typically Luvisolic (MLI 2003). Precambrian bedrock outcrops generally only have partial lichen and moss cover, although peat soil is common in depressions (AECL 2001). The majority of the soils within the LSA have been disturbed.

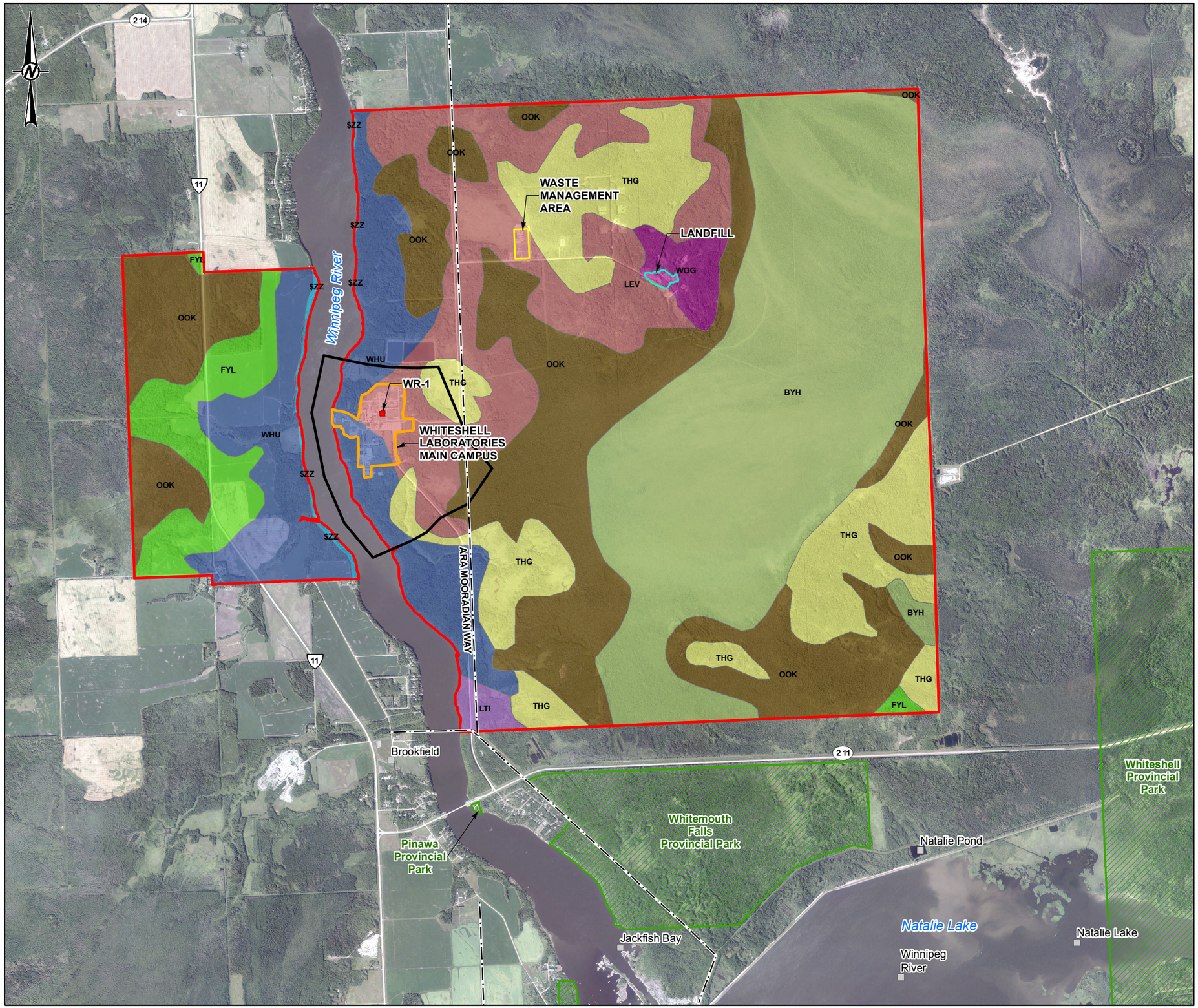
A summary of the dominant baseline soil types and substrates within the LSA and RSA are outlined in Table 6.3.1-4 and presented on Figure 6.3.1-6.

Table 6.3.1-4: Baseline Soil Types and Substrates within the LSA and RSA

Soil Series	Soil Subgroup	Substrate/Parent Material	Area (ha)
LSA			
$ZZ	Undifferentiated	Active Fluvial River Bed	35.0
LEV	Peaty Humic Luvic Gleysol	Moderately Calcareous Lacustrine Clay	98.6
OOK	Terric Mesisol	Shallow Organic	14.7
THG	Gleyed Solinetzic Dark Gray Chernozem	Weakly Calcareous Lacustrine Clay	28.5
WHU	Dark Gray Luvisol	Strongly Calcareous, Moderately Fine Textured Alluvial Sediments	83.3
RSA			
$ZZ	Undifferentiated	Active Fluvial River Bed	16.2
BYH	Typic Mesisol	Deep Organic	1,290.5
FYL	Peaty Rego Humic Gleysols	Weakly to Moderately Calcareous Lacustrine Clay	206.1
LEV	Peaty Humic Luvic Gleysol	Moderately Calcareous Lacustrine Clay	574.2
LTI	Solinetzic Gray Luvisol	Moderately to Strongly Calcareous Lacustrine Clay	27.3
OOK	Terric Mesisol	Shallow Organic	1,084.5
THG	Gleyed Solinetzic Dark Gray Chernozem	Weakly Calcareous Lacustrine Clay	590.8
WHU	Dark Gray Luvisol	Strongly Calcareous, Moderately Fine Textured Alluvial Sediments	491.1
WOG	Orthic Gray Luvisol	Coarse Grained Outwash	60.7

Table Information obtained from MLI 2003.

Drainage ranges from well-drained, coarse-textured soils to poorly and very poorly-drained organic soils in lower elevation positions. Coarse-textured soils, with higher initial total porosity (e.g., WOG), are relatively resistant to compaction compared to finer textured soils (e.g., THG, LEV, WHU); these soils are, however, prone to wind erosion. 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). In areas of Organic soils that are not deep (e.g., OOK) and organic surface horizons are removed and subsurface materials and exposed, the water erosion potential of the underlying material would be low if sandy, and moderate if silty. Areas containing Organic materials will have a low sensitivity to wind erosion.



LEGEND

- LOCAL STUDY AREA
- REGIONAL STUDY AREA (WHITESHELL LABORATORIES SITE)

WHITESHELL LABORATORIES

- WR-1
- WASTE MANAGEMENT
- WHITESHELL LABORATORIES MAIN CAMPUS
- LANDFILL

BASE FEATURES

- CITY/TOWN
- TRANSMISSION LINE
- PROVINCIAL PARK

SOIL SERIES, SUBSTRATE/PARENT MATERIAL

- $ZZ, ACTIVE FLUVIAL RIVER BED
- LEV, MODERATELY CALCAREOUS LACUSTRINE CLAY
- OOK, SHALLOW ORGANIC
- THG, WEAKLY CALCAREOUS LACUSTRINE CLAY
- WHU, STRONGLY CALCAREOUS, MODERATELY FINE TEXTURED ALLUVIAL SEDIMENTS
- BYH, DEEP ORGANIC
- FYL, WEAKLY TO MODERATELY CALCAREOUS LACUSTRINE CLAY
- LTI, MODERATELY TO STRONGLY CALCAREOUS LACUSTRINE CLAY
- WOG, COARSE GRAINED OUTWASH

0 1,000 2,000
1:40,000 METRES

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

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TITLE
SOIL SERIES AND PARENT MATERIAL TYPES WITHIN THE LOCAL AND REGIONAL STUDY AREAS

CONSULTANT
Golder Associates

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PREPARED	CGE
REVIEWED	CS
APPROVED	MM

PROJECT NO. 1656897 | CONTROL | REV. 1 | FIGURE 6.3.1-6

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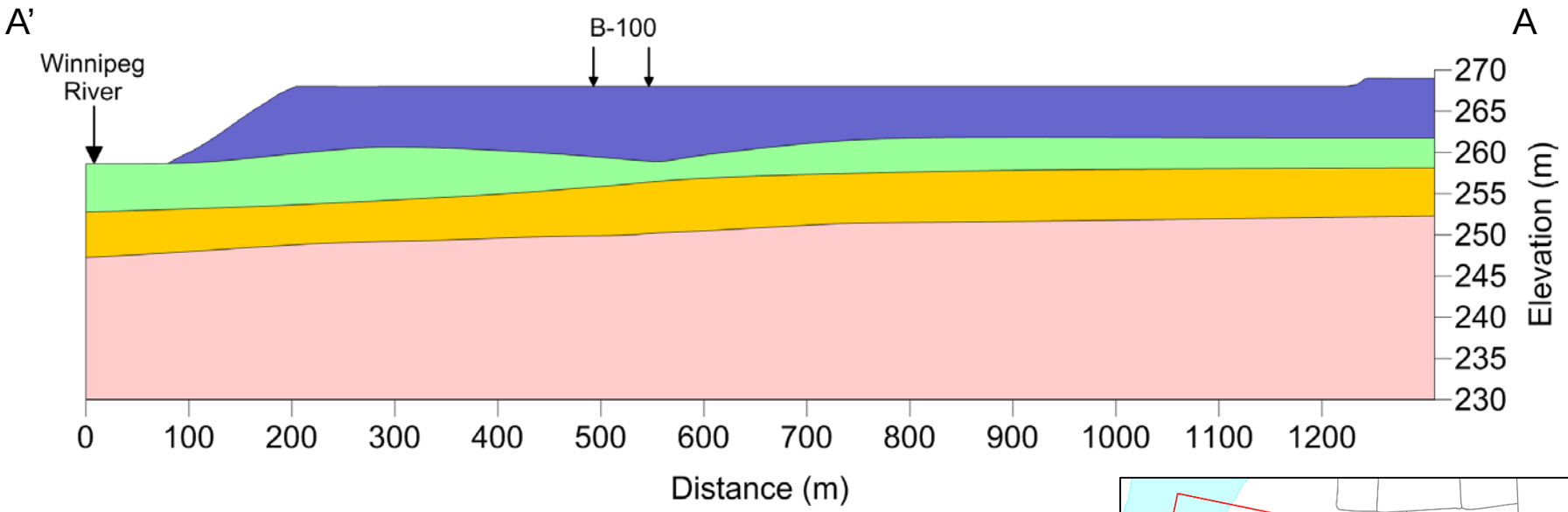
Surficial Geology

The surficial geology of the LSA is similar to that observed in the RSA, consisting of (from the bedrock upwards):

- Basal sand (basal till);
- Clay till;
- Clay; and
- A thin deposit of interbedded silt and clay.

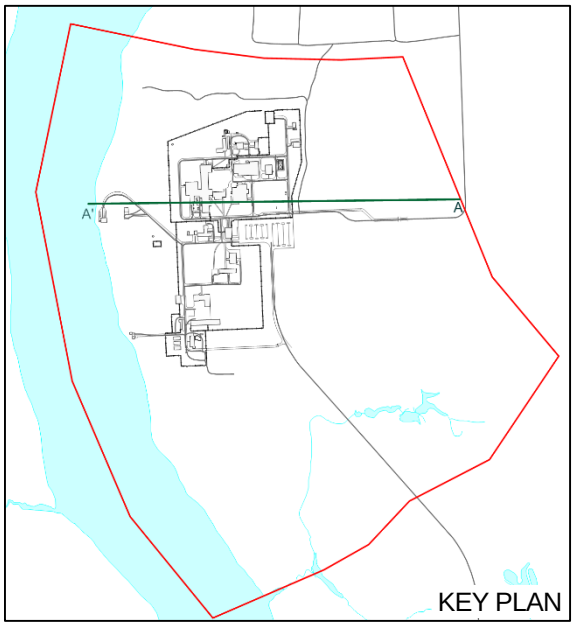
A cross-section through the LSA is shown on Figure 6.3.1-7.

S:\Clients\Canadian_Nuclear_Laboratories\Manitoba\99_PROJ\1656897_CNL_Whiteshell_EA\40_PROD\0015_Groundwater_Modelling_Report\1656897-0015-G-00005_Figure 6.3.1-7 - Geological Cross Section.pptx



LEGEND

- Bedrock
- Basal Sand
- Clay Till
- Lacustrine Clay / Interbedded Silt and Clay



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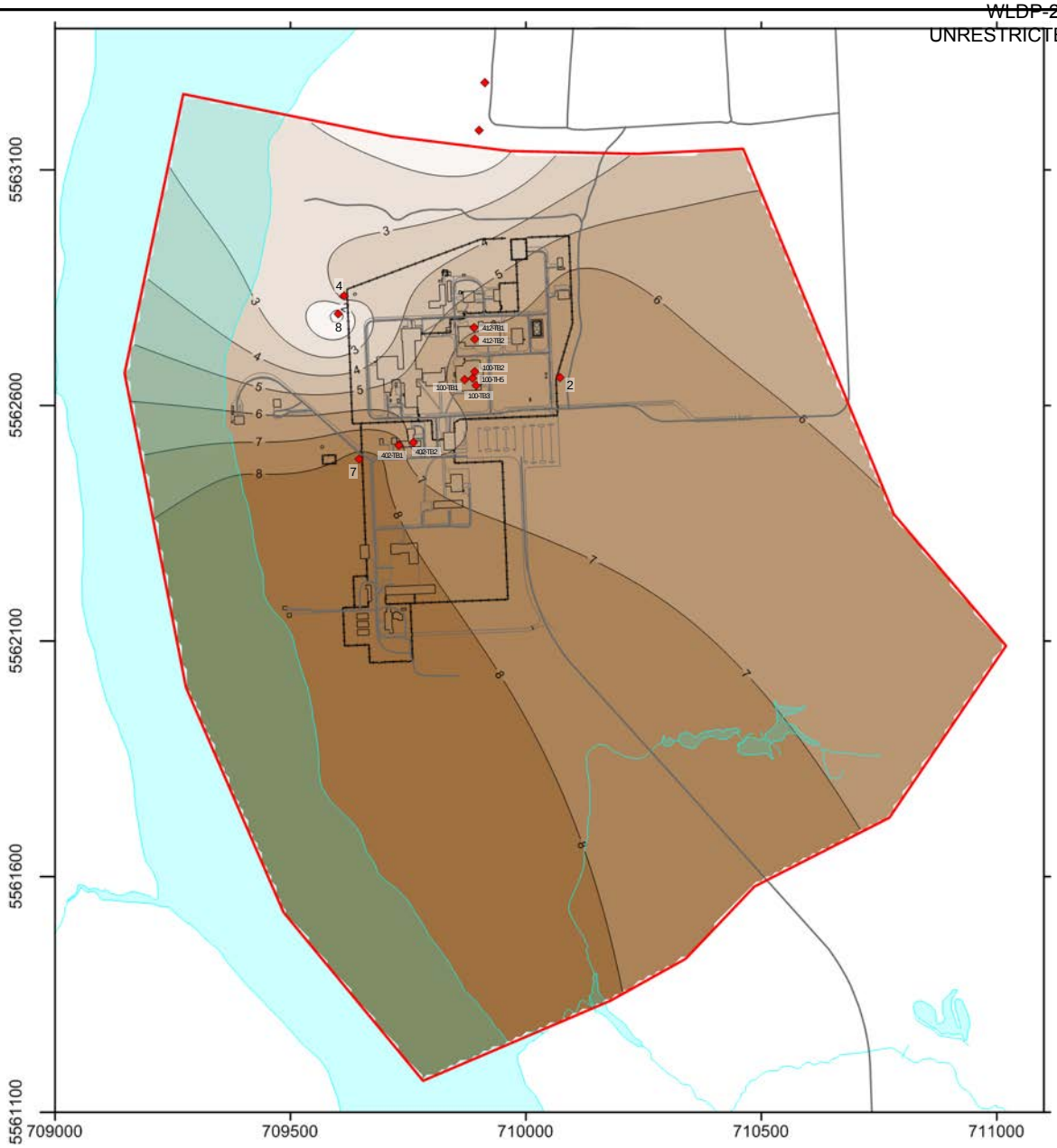
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REVIEW	NFB
APPROVED	AM

TITLE
GEOLOGICAL CROSS SECTION

PROJECT No.	CONTROL	Rev.	FIGURE
1656897		**1**	**6.3.1-7**

Silty Sand Till (Basal Sand)

Bedrock is overlain by a silty sand till (basal sand or basal till) throughout the majority of the RSA. The till varies from a silty coarse sand till to a clean medium to coarse sand (Cherry et al. 1970), and boulders are common above the bedrock surface. This unit is referred to as the basal sand in the area of the WR-1 Building (as in Dillon [2017]) due to the increased sand content observed in this unit in the SSA. In the WMA to the north of the LSA, this unit has been found to vary in thickness from 1 to 7 m thick (AECL 2008). At the LSA, this unit varies in thickness from 3.6 m to 8.3 m. In other areas of the RSA this unit appears to thin towards the Winnipeg River. However, surrounding the SSA this unit appears to be thickest to the southwest, and thins to the north. This unit is thinnest over the local bedrock high in the vicinity of monitoring well nest 4 and borehole 16-8. A basal sand isopach is shown on Figure 6.3.1-8.



Basal Sand Thickness (m)

10
9
8
7
6
5
4
3
2
1

LEGEND

- Local Study Area
- Roads
- Buildings
- Fence
- Stream
- Waterbody
- Geological Surface Data Point

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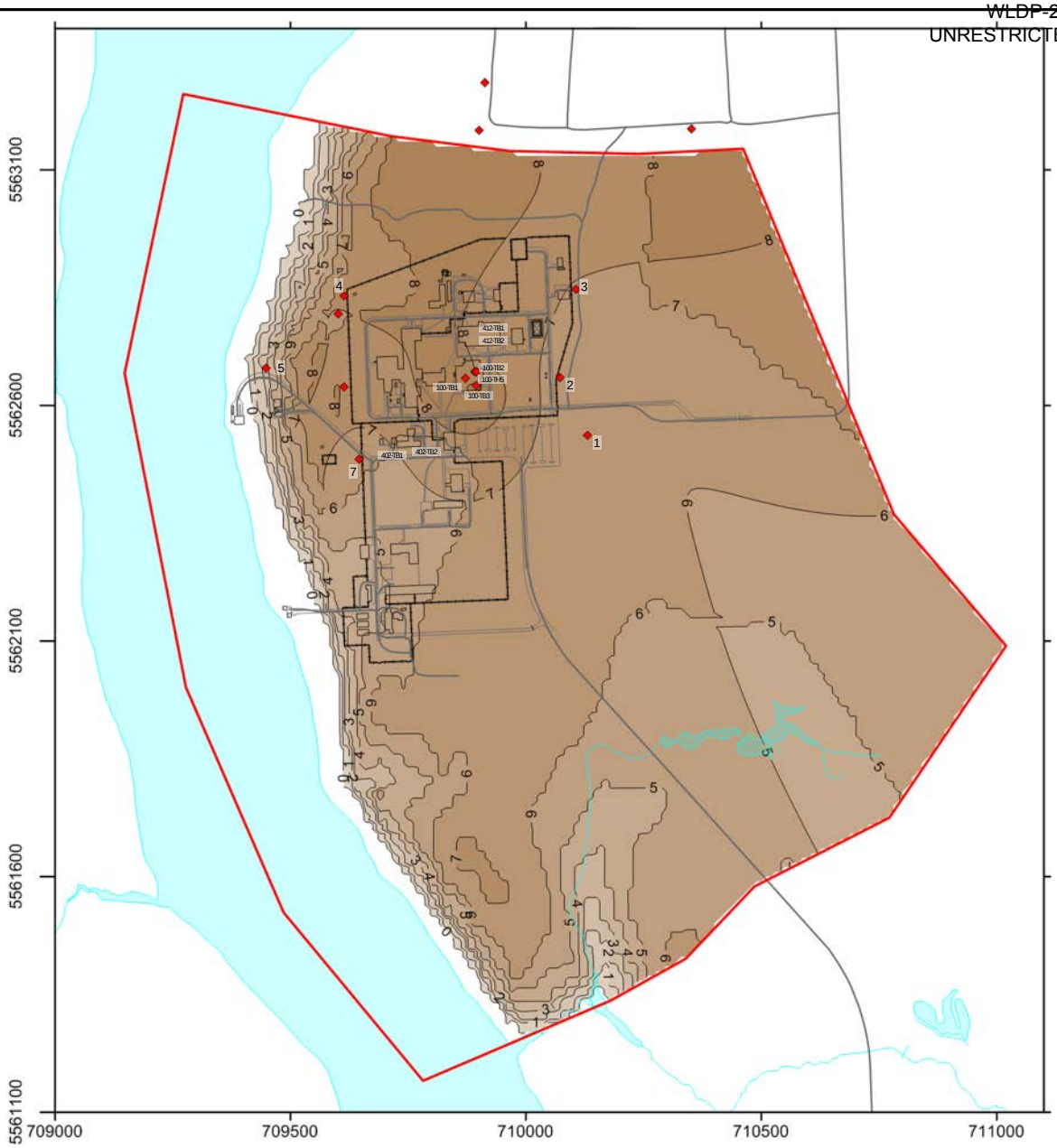
TITLE
ISOPACH MAP – BASAL SAND

PROJECT No. **1656897** CONTROL Rev. **1** FIGURE **6.3.1-8**

S:\Clients\Canadian_Nuclear_Laboratories\Manitoba\89_PRO\1656897_CNL_Whiteshell_EA\40_PRO\DO\015_Groundwater_Modelling_Report\656897-0015-G-00006_Figure 6.3.1-8 - Basal Sand.mxd

Clay Till

The basal sand is overlain by a clay till unit containing sand and silty sand seams. The bulk porosity of this unit in the WMA was determined to be 0.23 indicating a high degree of consolidation (Robertson and Cherry 1985). This value is based on three samples of “clay loam” collected from the WMA Area as documented in Gilham et al. (1981). No porosity measurements have been completed in the LSA. In the WMA, this unit has been found to vary in thickness from 2 m to 5 m (AECL 2008). In the LSA, this unit varies in thickness from 3.0 m to 7.0 m. The clay till is generally thinnest in the central portion of the LSA and thickens to the northwest and southwest towards the Winnipeg River. A clay till isopach is shown on Figure 6.3.1-9.



Clay Till Thickness (m)

10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1

LEGEND

- Local Study Area
- Roads
- Buildings
- Fence
- Stream
- Waterbody
- Geological Surface Data Point

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APPROVED	AM

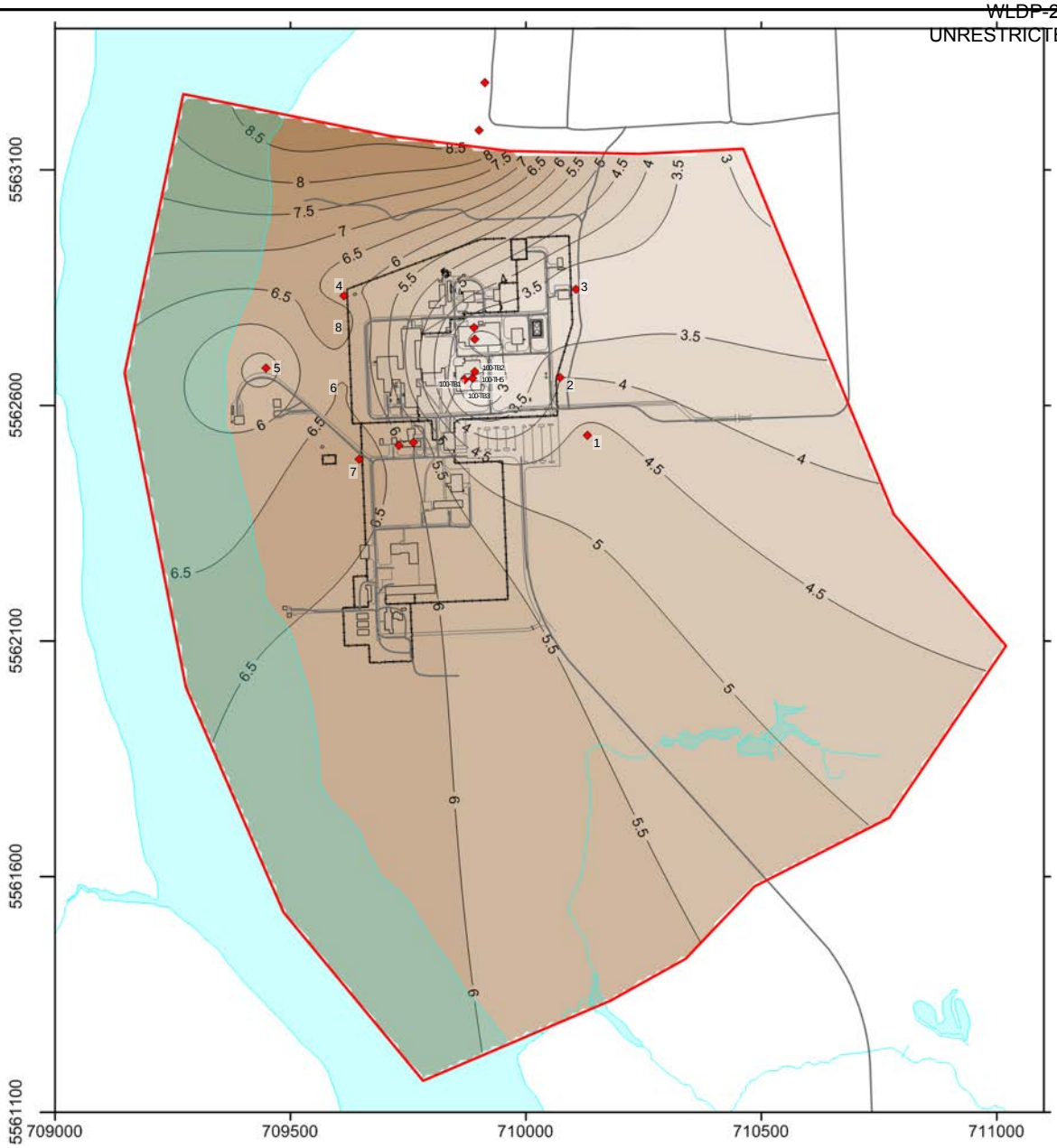
TITLE
ISOPACH MAP – CLAY TILL

PROJECT No. **1656897** CONTROL Rev. **1** FIGURE **6.3.1-9**

S:\Clients\Canadian_Nuclear_Laboratories\Manitoba\89_PRO\1656897_CNL_Whiteshell_EA\0_PROD\0015_Groundwater_Modelling_Report\1656897-0015-G-00007_Figure 6.3.1-9 - Clay Till Isopatx

Lacustrine Clay and Surficial Interbedded Silt and Clay (Clay)

A lacustrine clay unit has been found to overlie the clay till unit throughout the LSA. This unit is transitional, with the lower portion more laminated with silty interbeds, and the upper portion more massive. A thin surficial interbedded silt and clay unit overlies these clays. These units have been grouped given their similar properties, and relative thinness of the surficial unit. In the WMA this unit has been found to vary in thickness from 2 m to 8 m and is thickest in the lagoon area (AECL 2008). In the LSA, this unit is relatively uniform in thickness, varying from 5.5 m to 7.3 m. This unit is inferred to be absent adjacent to the Winnipeg River due to the erosional drop in topography towards the river. An isopach of the clay till and surficial silt and clay unit is shown on Figure 6.3.1-10. Contouring of this isopach is affected by the nature of the Digital Elevation Model (DEM) for the LSA.



Lacustrine Clay Thickness (m)

11
10
9
8
7
6
5
4
3
2
1
0

LEGEND

- Local Study Area
- Roads
- Buildings
- Fence
- Stream
- Waterbody
- Geological Surface Data Point

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
PREPARED	MIB
DESIGN	NFB
REVIEW	MIB
APPROVED	NFB

TITLE
ISOPACH MAP – LACUSTRINE CLAY

PROJECT No. **1656897** CONTROL Rev. **1** FIGURE **6.3.1-10**

S:\Clients\Canadian_Nuclear_Laboratories\Manitoba\69_PRO\1656897_CNL_Whiteshell_EA\0_PROD\0015_Groundwater_Modelling_Report\656897-0015-G-00008_Figure 6.3.1-10 - Lacustrine Clay Isoppx

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6.3.1.5 Project Interactions and Mitigation

6.3.1.5.1 Methods

This section describes the process by which interactions between Project components and activities and geology were identified and evaluated. Potential effect 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 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 Project. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. The next step in the analysis was the development of environmental design features and mitigation that could be incorporated into the 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 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 pathway –** 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 to 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 past, present 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 geology.

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 geology through simple qualitative or semi-quantitative 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 Project.

6.3.1.5.2 Results

Pathways through which all stages of the Project may interact with and result in changes to measurement indicators for geology is provided in Table 6.3.1-5. As mentioned previously, geology includes bedrock, soils, and geomorphology. Below ground, no decommissioning activities will extend beyond the outer wall of the WR-1 Building. As such, the Project is not expected to interact with bedrock or geomorphology; therefore, no pathways are identified in Table 6.3.1-5 for bedrock or geomorphology.

Table 6.3.1-5: Pathways Analysis for Geology Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Construction of temporary supporting infrastructure during decommissioning (e.g., batch mixing plant for preparation of grout)	Loss or alteration of soil quantity and quality from construction of temporary supporting infrastructure.	■ Temporary supporting infrastructure will be located within the WL main campus (i.e., previously disturbed and developed). ■ Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the WL site will be used during decommissioning activities around disturbed areas, where appropriate.	Secondary
General Project activities during the closure phase	Changes in soil quality from changes in air quality. General activities that require the use of vehicles and equipment that combust fuel and emit 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.	■ Implementation of CNL's Procedure for Management and Monitoring of Emissions, which includes operational control monitoring, air verification monitoring and environmental monitoring. ■ Implementation of the dust management techniques for the Project. ■ On-site vehicles and equipment engines will meet a minimum of Tier 3 emission standards, where possible, and be maintained in good working order. ■ Limit idling of vehicles on site. ■ Use enclosure for the raw material handling.	Secondary
Long-term performance during the post-closure phase.	Changes to groundwater quality during the post-closure phase.	The engineered cover to be placed over the decommissioned WR-1 Building is designed to limit infiltration.	Secondary

6.3.1.5.2.1 No Linkage Pathway

There were no "no linkage" pathways identified to effects on geology.

6.3.1.5.2.2 Secondary Pathways

- **Changes to groundwater quality during the post-closure phase.**

After all below-grade grouting has been completed, an engineered cover will be installed over the footprint of the WR-1 ISD structure. The engineered cover design will include an appropriate slope to achieve drainage off the surface, which will limit infiltration, surficial erosion, and enhance the stability of the engineered cover. The engineered cover will be designed to mitigate moisture infiltration into the WR-1 ISD structure and hence limit leakage through the grouting to groundwater and subsequent changes in soil quality. The engineered cover will be designed for an estimated effective service life of approximately 300 years. Performance monitoring will be completed throughout the post-closure phase (i.e., active Institutional Control period) to confirm that the engineered cover is functioning as intended. This monitoring will be completed in accordance with the Effluent Verification Monitoring Program (EVMP) outlined in CNL's Procedure for Management and Monitoring of Emissions. Overall, changes to soil quality from groundwater quality are predicted to have a negligible residual effect on geology relative to the Base Case.

- **Loss or alteration of soil quantity and quality from construction of temporary supporting infrastructure.**

The Project will require the construction of temporary infrastructure (e.g., batch mixing plant for preparation of grout) to support the ISD of the WR-1 Building. Temporary infrastructure will be located within the WL main campus which is previously disturbed and developed, limiting potential effects to soil quality and quantity. Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the WL site will be used during decommissioning activities around disturbed areas, where appropriate. As such, changes to soil quality and quantity from construction outside the WR-1 Building are predicted to have a negligible residual effect on geology relative to the Base Case.

- **Changes in soil quality from changes in air quality. General activities that require the use of vehicles and equipment that combust fuel and emit 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.**

Deposition of particulates has the potential to affect local soil quality. Decommissioning activities from the Project will generate air and dust emissions such as carbon monoxide (CO), oxides of sulphur (SO_x includes sulphur dioxide [SO_2]), oxides of nitrogen (NO_x includes nitrogen dioxide NO_2), particulate matter ($PM_{2.5}$) 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 decommissioning activities.

Examples of mitigation practices implemented to limit predicted residual effects to air quality (and subsequently surface water quality) include:

- implementation of CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring, air verification monitoring and environmental monitoring;
- implementation of the dust management techniques;

- on-site vehicles and equipment engines will meet a minimum of Tier 3 emission standards, where possible, and be maintained in good working order;
- limit idling of vehicles on-site and limit speed on roads; and
- use of enclosure for batch mixing plant and raw material handling.

With the implementation of CNL's Management and Monitoring of Emissions Procedure and through the implementation of the dust management techniques for the Project, concentrations of particulate matter (SPM, PM_{10}, $PM_{2.5}$), SO_2, NO_2, and carbon monoxide are all predicted to be lower than applicable air quality guidelines/standards during the closure phase of the Project (Section 6.2.1.6.2 Application Case Results). As such, 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 a negligible residual effect on geology.

6.3.1.5.2.3 Primary Pathways

No primary pathways were identified as having residual effect on geology. As such, the residual effects analysis and determination of significance is not completed for the assessment of geology.

6.3.1.6 Monitoring and Follow-up

CNL will implement an Environmental Assessment Follow-up Program for WR-1 to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. Monitoring and follow-up programs are not specifically identified for geology; rather, monitoring will be implemented for other disciplines to verify effects predictions for geology. For example, visual inspections of the temporary construction areas and surface water management systems will be completed to confirm erosion control practices are effective. In addition, following closure, monitoring will be implemented to confirm long-term performance of the engineered cover and the WR-1 ISD structure.

6.3.1.7 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, scientists, government agencies, First Nation and Métis communities, or the public (the Agency 2014). Geology, which includes bedrock, soils and geomorphology, is recognized as an important component of the environment that may be affected by the Project and changes to geology could, in turn, lead to effects on other VCs selected for assessment. Acknowledging that changes to geology are considered to be 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.

Potential effects on geology are limited to changes in soil quantity and quality as a result of construction of temporary supporting infrastructure (e.g., batch mixing plant for preparation of grout) for the Project, and changes to soil quality from air emissions and leakage from the WR-1 ISD structure. Mitigation and environmental design features implemented for the Project are well-understood and include existing practices at the WL site. In addition, performance monitoring will be completed throughout the post-closure phase to confirm that the engineered cover is functioning as intended. Consequently, no residual effects on geology are predicted as a result of the Project.

6.3.2 Hydrogeology

This section of the Environmental Impact Statement (EIS) for the Canadian Nuclear Laboratories (CNL) In Situ Decommissioning of WR-1 at the Whiteshell Laboratories Site (the Project) provides understanding of the potential residual effects of the Project and other past, present and reasonably foreseeable developments on the hydrogeological environment.

6.3.2.1 Scope of the Assessment

This section focuses on hydrogeology and follows the overall environmental assessment approach and methods described in Section 6.1 Environmental Assessment Approach. The assessment is completed in the following steps.

- **Step 1 –** Identify Valued Components (VCs) (refer to Sections 6.3.2.2 Valued Components and 6.3.2.3 Assessment Boundaries) and define the spatial boundaries, temporal boundaries and assessment cases for the hydrogeology assessment. The VCs and measurement indicators used to assess Project-related changes to hydrogeology; 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 6.3.2.4 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).
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 6.3.2.5 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 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. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. 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 described. 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 6.3.2.6 Residual Effects Analysis). This section outlines the methods used to predict and characterize residual effects to hydrogeology from primary effect pathways. The analysis results are also presented including the characterization of: (i) residual incremental effects of the Project and the effects of the Project in combination with past and present developments on hydrogeology (Application Case); and (ii) residual effects of the Project in combination with past and present developments, as well as other reasonably foreseeable developments (Reasonably Foreseeable Development 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 6.3.2.7 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 – Identifying monitoring and follow-up** required to confirm effects predictions and address uncertainty (refer to Section 6.3.2.8 Monitoring and Follow-up).
- **Step 7 – Present a consolidated summary of conclusions and outcomes of the assessment** of residual effects on hydrogeology (refer to Section 6.3.2.9 Conclusions).

This section also describes how the input from engagement activities influenced the scope of the hydrogeology assessment. Information and concerns raised by the public, communities of interest, regulators and First Nation and Métis communities during engagement activities that influenced the scope of the hydrogeology assessment are summarized in Table 6.3.2-1.

Table 6.3.2-1: Summary of Issues Raised During Engagement Activities that Influenced the Scope of the Hydrogeology Assessment

Issue	How the Issue Was Included in the Assessment
Groundwater quality and monitoring	Groundwater quality and groundwater quantity are included as VCs in the assessment, and predictions of changes in water quality identified for further consideration potential effects.

6.3.2.2 Valued Components

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, First Nation and Métis communities, or the public (the Agency 2014). Hydrogeology is recognized as an important component of the environment that may be affected by the 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 from release of solutes as the grout and reactor components gradually deteriorate over time may have a large influence on surface water quality, which in turn can affect terrestrial and aquatic biodiversity, and human health (Table 6.3.2-2).

Table 6.3.2-2: Valued Components for Hydrogeology Assessment

Valued Component	Rationale for Selection
Hydrogeology (groundwater quality and quantity)	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 Project activities could affect terrestrial and aquatic biodiversity and human health.

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 (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 6.3.2-3). The changes are characterized in terms of magnitude, duration and geographic extent, but are not classified using rankings for effects criteria. The hydrogeology assessment also 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 6.3.2-3).

Table 6.3.2-3: Assessment Endpoints and Measurement Indicators for the Hydrogeology Assessment

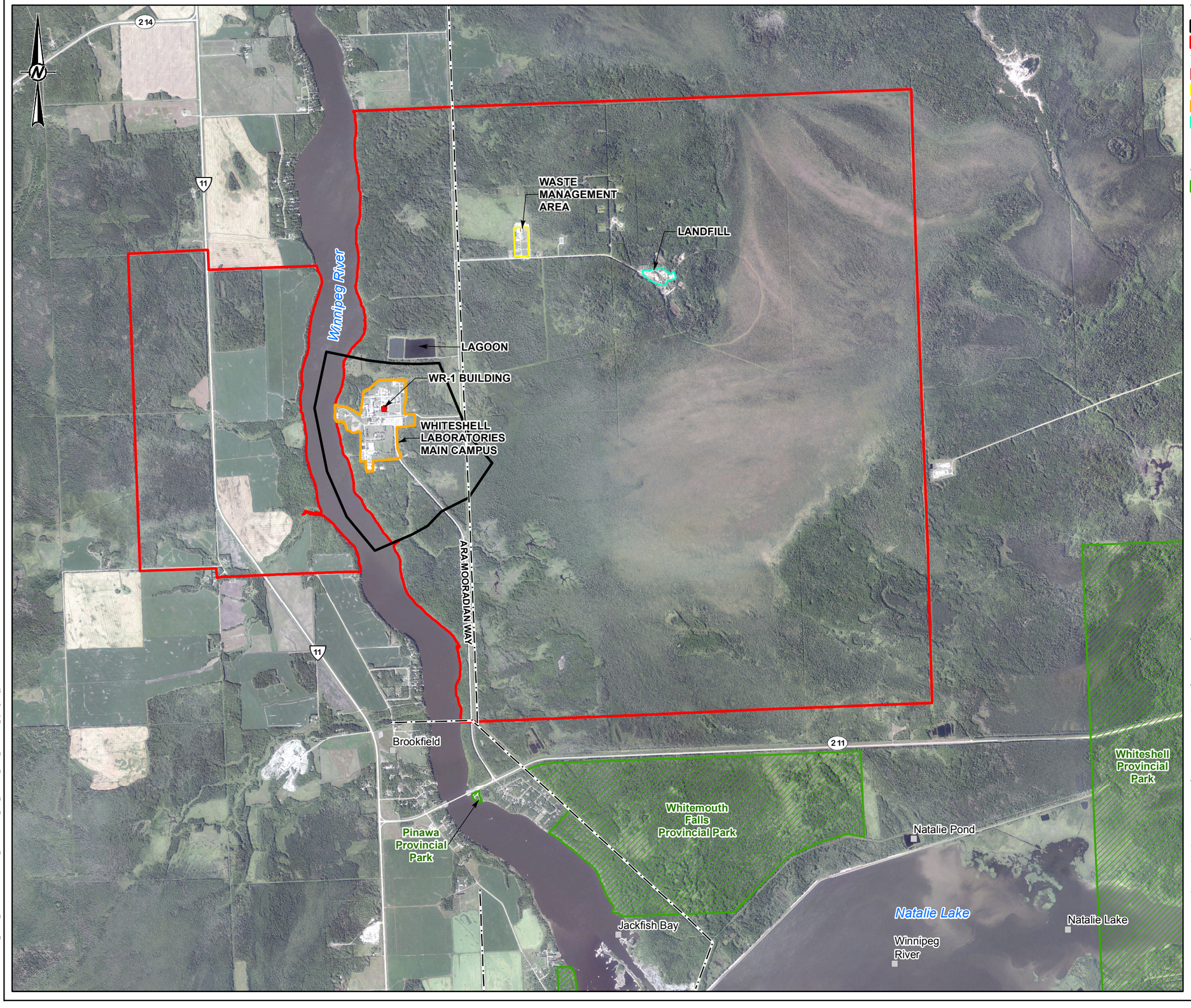
Valued Component	Measurement Indicators	Discipline Assessments where Effects on Hydrogeology are Considered
Groundwater quantity	■ Groundwater flow patterns and discharge rates. ■ Groundwater table elevations.	■ Section 6.4 Surface Water Environment. ■ Section 6.5 Aquatic Environment. ■ Section 6.6 Terrestrial Environment. ■ Section 6.7 Human and Ecological Health.
Groundwater quality	Peak solute mass loadings of contaminants in groundwater to the Winnipeg River.	

6.3.2.3 Assessment Boundaries

6.3.2.3.1 Spatial Boundaries

The spatial boundaries selected for the hydrogeology assessment are presented on Figure 6.3.2-1. These boundaries coincide with those used in the geology assessment and are described below:

- **Site Study Area (SSA)** is the WR-1 Building and represents the Project footprint (i.e., where project activities will be undertaken).
- **Local Study Area (LSA)** is defined as the area within which there is potential for measurable changes resulting from the proposed Project activities. The LSA is delineated by the boundaries of the groundwater model for the Project, which were selected based on groundwater elevation data and topography. The western boundary of the LSA coincides with the inferred groundwater flow divide at the centre of the Winnipeg River. The northern boundary of the LSA is approximately 450 metres (m) north of the WR-1 Building, and is parallel to the inferred direction of groundwater flow. The location of this boundary was selected as it follows a topographic divide and is south of the Lagoon Area. The southern boundary of the LSA is approximately 1,400 m south of the WR-1 Building, and is parallel to the inferred direction of groundwater flow. The location of this boundary was selected as it coincides with a topographic divide and an inferred divide in groundwater flow. The eastern boundary of the LSA is located approximately 700 m east of the WR-1 Building and approximately 500 m east of the WL main campus. This boundary is perpendicular to the inferred direction of groundwater flow, and upgradient of the WR-1 Building.
- **Regional Study Area (RSA)** is defined as the area within which the potential effects of the Project may interact with the effects of other existing or reasonable foreseeable projects. The RSA is delineated by the WL site boundary.



LEGEND

- LOCAL STUDY AREA
- REGIONAL STUDY AREA (WHITESHELL LABORATORIES SITE)

WHITESHELL LABORATORIES

- WR-1 BUILDING
- WASTE MANAGEMENT AREA
- WHITESHELL LABORATORIES MAIN CAMPUS
- LANDFILL

BASE FEATURES

- CITY/TOWN
- TRANSMISSION LINE
- PROVINCIAL PARK

0 1,000 2,000
1:40,000 METRES

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

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TITLE
SPATIAL BOUNDARIES SELECTED FOR THE HYDROGEOLOGY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE
REVIEWED	CS
APPROVED	MM

PROJECT NO. 1656897 | CONTROL | REV. 1 | FIGURE **6.3.2-1**

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6.3.2.3.2 Temporal Boundaries

The temporal boundary of the assessment includes effects observed under existing conditions, the timeframe during which Project activities are actively occurring and 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 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 Project:

- **Closure Phase:** Preparation and implementation of In Situ Decommissioning (ISD), which includes preparation for ISD, grouting of below-grade structures and systems, removal of above-grade WR-1 Building structures and systems, installation of the engineered cover and environmental controls and final site restoration. These activities last from 2019 to 2024.
- **Post-closure Phase:** The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. The Institutional Control period includes implementation of both active and passive control. During active Institutional Control, long-term performance monitoring and maintenance activities will continue through to 2124 to demonstrate compliance with the safety case assumptions. The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions) and will continue through 2024 to 2324. Post-institutional Control occurs after year 2324 and continues indefinitely. Effects modelling envelops the point during post-closure when the maximum releases are predicted to occur.

6.3.2.3.3 Assessment Cases

The hydrogeology assessment has three assessment cases:

- **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, and residential and recreational development. Current effects from the existing WL facilities and operations, for example, are considered part of the Base Case. In addition, effects from the decommissioning and reclamation activities already completed at the WL site are also considered as part of the Base Case.
- **Application Case**: the Application Case represents predictions of the effects of the Base Case combined with the effects that may result from the Project. The Application Case considers potential effects from the Project during closure through to the post-closure phase.
- **Reasonably Foreseeable Developments (RFD) Case**: this scenario represents the predictions of the cumulative effects of the Application Case, plus projects that are currently under application review or that have officially entered a regulatory application process and which overlap with the RSA. Foreseeable developments in the RSA that are expected to overlap with residual effects on groundwater quality from the Project includes the decommissioning of the remaining infrastructure and support facilities at the WL site as per the existing decommissioning licence. A Comprehensive Study Report (AECL 2001) under the *Canadian Environmental Assessment Act* (CEAA, 1992) was completed for the decommissioning of the WL site. The Environmental Assessment decision to approve the project was announced by the Minister of the Environment in March 2002 and a decommissioning licence was issued to AECL and subsequently to CNL.

There are no other foreseeable developments in the RSA that are expected to overlap with changes to groundwater quality

6.3.2.4 Description of the Environment

6.3.2.4.1 Methods

Baseline hydrogeological data were summarized from the review of the following reports:

- Hydrogeologic Regime of the Environmental Control Area and vicinity, Whiteshell Nuclear Research Establishment, Manitoba, Preliminary Progress Report, Cherry, J.A., Beswick, B.T., and W.E. Clister, November 1970.
- Hydrogeological Studies at a Subsurface Radioactive-Waste-Management Site in West-Central Canada, Cherry, J.A., Grisak, G.E., and W.E. Clister, May 1973.
- W.D. Robertson, and J.A. Cherry (1985). Review of hydrogeology of the radioactive waste management site, Final Report, Prepared for: Atomic Energy of Canada Limited, 1985.
- Whiteshell Laboratories Decommissioning Project, Comprehensive Study Report, WLDP-03702-041-000, Atomic Energy of Canada Limited, March 2001.
- Atomic Energy of Canada Limited (2007). Follow-Up Program, Summary Report: Hydrogeology of the WMA, Lagoon and Landfill-Enhanced Monitoring Program. WL Decommissioning. WLDP-03704-ENA-009 Revision 0D2, dated March, 2007.
- Whiteshell Laboratories Projects Branch Comprehensive Final Report on Installation of 7 Groundwater Monitoring Wells Nests, WLDP-35000-041-000-0014, KGS Group, March 2016.
- Dillon Consulting (2017). Canadian Nuclear Laboratories WR-1 Hydrogeological Study Report. February 2017.

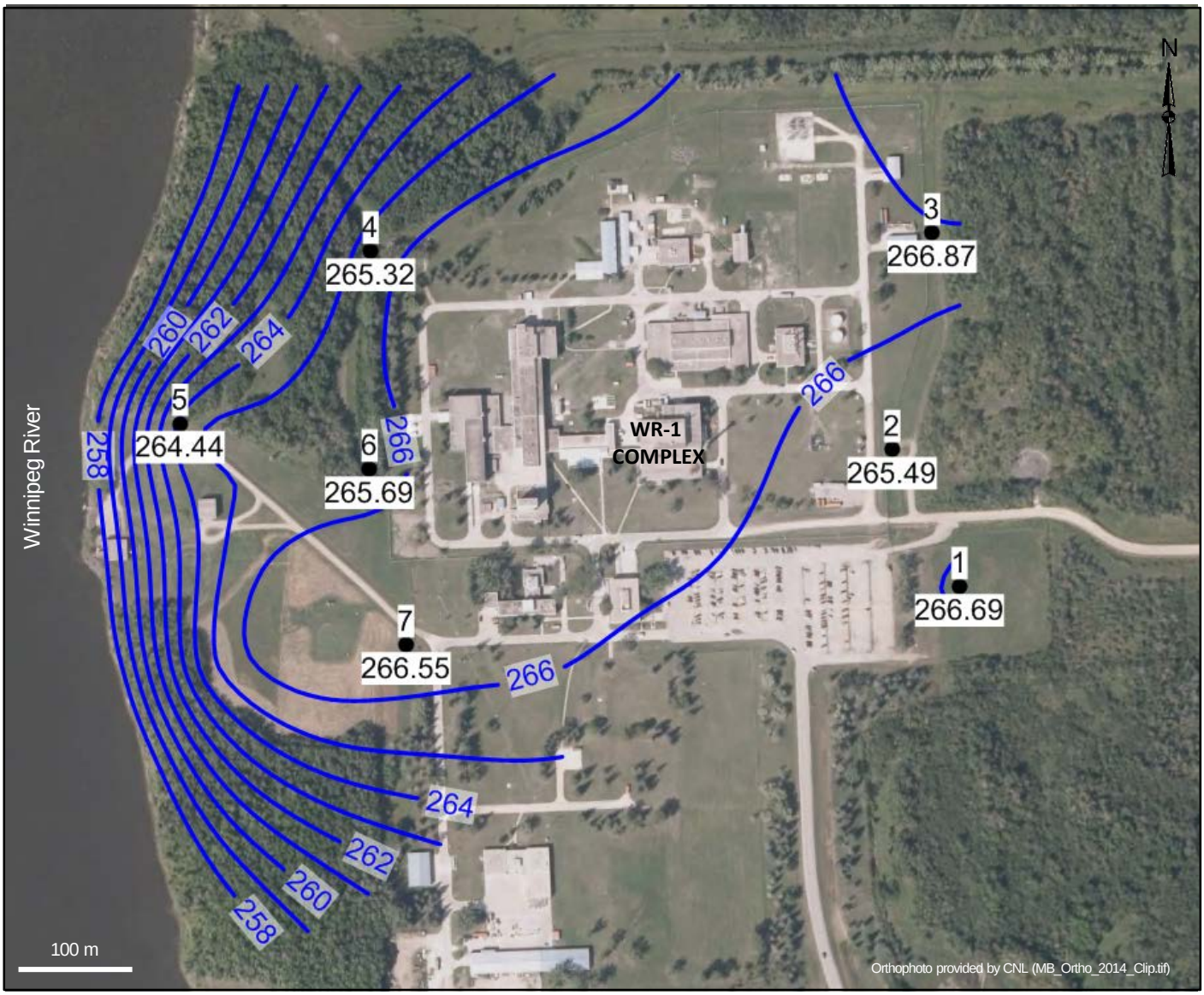
Dillon (2017) provides details on recent geological and hydrogeological investigations of the LSA, which (in part) involved drilling and instrumentation of 7 monitoring well nests, and a single monitoring well (16-8A) that encompass a total of 33 monitoring wells. The monitoring wells are named numerically (i.e., monitoring well nest 1 through monitoring well nest 7). Each monitoring well nest includes between 4 and 6 monitoring wells. Individual monitoring wells are named using the installation year, the monitoring well nest number, and a letter generally indicating the relative depth (with A assigned to the deepest monitoring well within the overburden, and the final letter assigned to the bedrock interval). In the following sections, the term monitoring well nest is used to refer to the conditions observed throughout the group of monitoring wells, while individual monitoring well names are used to refer to conditions at a specific depth interval. The monitoring well names and geological units, and the inferred top and bottom of each unit for each monitoring well nest are summarized in Table 6.3.2-4 with information from Dillon (2017). The locations of the monitoring wells nests are shown in Figure 6.3.2-2.

Table 6.3.2-4: Monitoring Well Nest Details

Monitoring Well Nest	Monitoring Well	Hydrostratigraphic Unit	Top of Unit Elevation (m ASL)	Bottom of Unit Elevation (m ASL)
1	15-1A	Basal Sand	257.23	—
	15-1B	Clay Till	261.90	257.23
	15-1C	Clay	268.03	261.90
	15-1D	Clay	268.03	261.90
2	15-2A	Basal Sand	257.50	251.52
	15-2B	Clay Till	261.50	257.50
	15-2C	Clay Till	261.50	257.50
	15-2D	Clay	267.30	261.50
	16-2E	Bedrock	251.52	—
3	15-3A	Basal Sand	258.10	—
	15-3B	Clay Till	261.10	258.10
	15-3C	Clay	267.24	261.10
	15-3D	Clay	267.24	261.10
4	15-4A	Basal Sand	253.10	249.48
	15-4B	Clay Till	259.10	253.10
	15-4C	Clay Till	259.10	253.10
	15-4D	Clay	266.40	259.10
	15-4E	Clay	266.40	259.10
	16-4F	Bedrock	249.48	—
5	15-5A	Basal Sand	253	—
	15-5B	Clay Till	258.20	253
	15-5C	Clay	265.37	258.20
	15-5D	Clay	265.37	258.20
6	15-6A	Clay Till	260.29	—
	15-6B	Clay Till	260.29	—
	15-6C	Clay Till	260.29	—
	15-6D	Clay	266.99	260.29
7	15-7A	Clay Till	261.55	254.55
	15-7B	Clay Till	261.55	254.55
	15-7D	Clay	267.05	261.55
	16-7E	Bedrock	246.26	—
8	16-8A	Bedrock	252.83	—

Groundwater level measurements have been periodically taken from these monitoring wells since December 2015. Using the data provided by Dillon (2017), groundwater elevations were interpreted within the LSA for the clay, clay till, and combined basal sand/upper bedrock units. The interpretations were based on measurements of groundwater elevation on September 14, 2016 and September 26, 2016, as this period represented the most complete set of groundwater elevation data (i.e., the time period for which data were available for the greatest number of wells) at the time the work was completed. The basal sand and upper bedrock units were combined for the purpose of generating potentiometric surface maps due to the similar groundwater elevations and neutral vertical gradients observed between these units (Dillon 2017). Further, it should be noted that the influence of the other WL main campus buildings on the groundwater flow system (e.g., due to removal of water from building sumps, and preferential drainage pathways) was not considered in the interpretation of the groundwater elevations presented herein. While water level measurements collected may have been influenced by these buildings, the monitoring wells are generally located too distant to confirm this influence. It should be noted that water levels can be expected to rise to some degree as the existing sumps, and storm and sewer drains are removed.

Groundwater samples were collected from each monitoring well in monitoring wells nests 2, 4, and 7 in October 2016 as part of the Dillon (2017) hydrogeological investigation (see Figure 6.3.2-2). These samples were analyzed for select major ions and radiological constituents. Groundwater quality in the LSA is based on the results and interpretation provided by Dillon (2017).



LEGEND

- Interpreted Groundwater Elevation (mASL)
- Monitoring Well Nest

Notes:

1. Groundwater elevations taken between September 14, 2016 and September 26, 2016.

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WR-1 AT THE WHITESHELL LABORATORIES SITE

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
PREPARED	MIB
DESIGN	NFB
REVIEW	MIB
APPROVED	AM

TITLE
GROUNDWATER ELEVATIONS IN CLAY UNIT

PROJECT No. **1656897** | CONTROL | Rev. **1** | FIGURE **6.3.2-2**

S:\Clients\Canadian_Nuclear_Laboratories\Manitoba\69_PRO\1656897_CNL_Whiteshell_EA\40_PROD\0015_Groundwater_Modelling_Report\1656897-0015-G-0015_Figure 6.3.2-2 - Groundwater Elevation in Clay.pptx

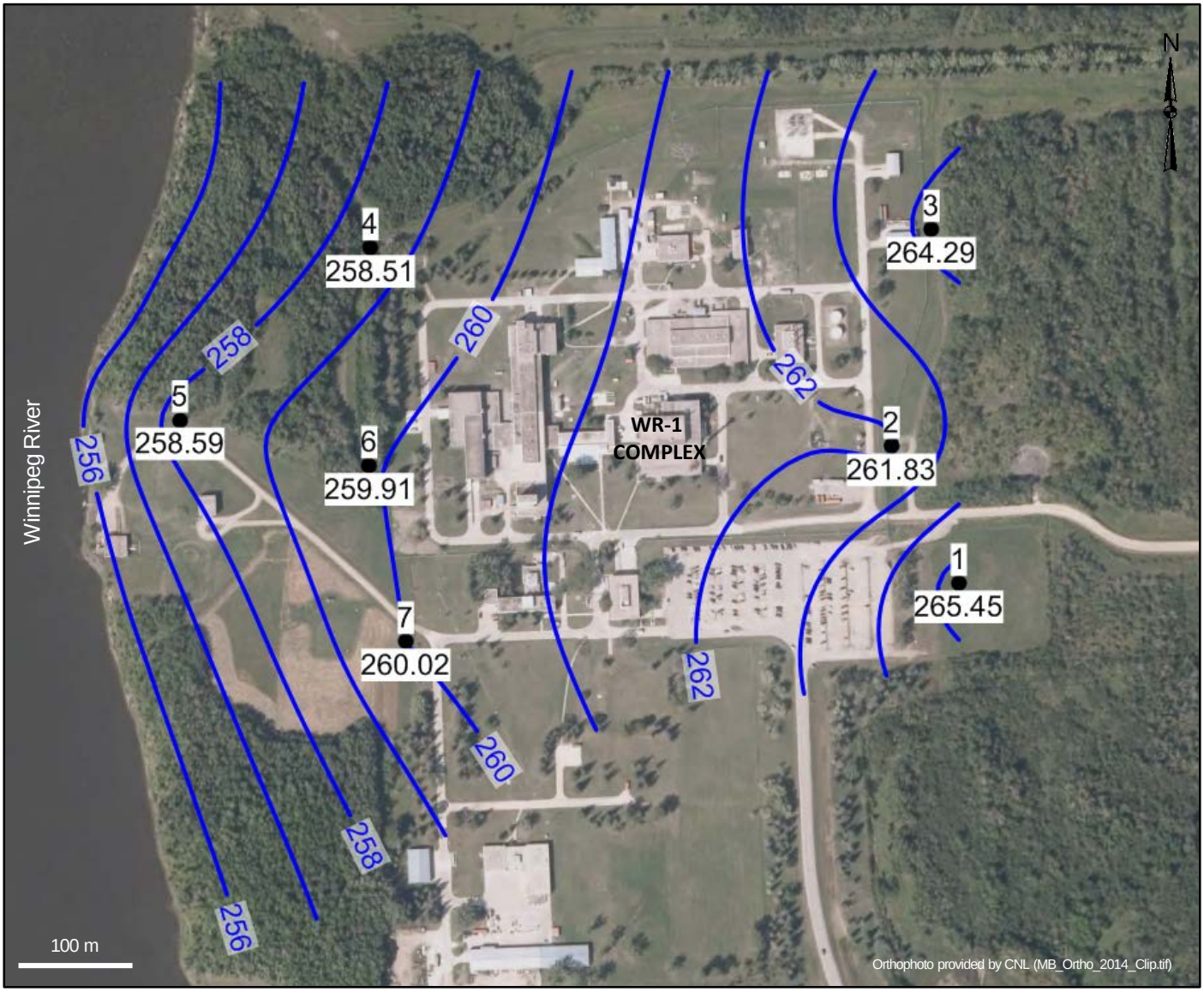
6.3.2.4.2 Results

6.3.2.4.2.1 Groundwater Elevations and Flow Directions

Groundwater flow in the unconsolidated sediments and bedrock within the RSA generally follows topography, with the predominant direction of groundwater flow occurring from east to west. Within the Precambrian bedrock groundwater flow occurs primarily within fractures (AECL 2001). Based on the available information from previous hydrogeological investigations (Robertson and Cherry 1985) groundwater recharge primarily occurs in the local topographic high located approximately 3 km east of the WL main campus (where the geological conditions at surface allow for greater infiltration), and groundwater discharge ultimately occurs at the Winnipeg River.

The interpreted groundwater elevations for the LSA are illustrated on Figures 6.3.2-2 through 6.3.2-4, the groundwater elevation data is plotted through time on Figure 6.3.2-5A through Figure 6.3.2-5D, and the measured groundwater elevation data are provided in Table 6.3.2-5. The following observations are made based on a review of these figures and table.

- As shown on Figure 6.3.2-2 through Figure 6.3.2-4, the groundwater flow direction in the LSA was consistent with the existing conceptualization for the RSA in that flow generally occurs from east to west (i.e., towards the Winnipeg River) for all hydrostratigraphic units.
- Groundwater elevations at monitoring well nest 2 were consistently low compared to nearby monitoring wells, potentially indicating an enhanced degree of hydraulic connection between monitoring well nest 2 and the sump in WR-1 Building (as noted in Dillon 2017).
- Groundwater elevations at individual monitoring wells typically varied within 1 m to 3 m over the data record, following a period of recovery data from drilling and instrumentation of the well. At monitoring well 15-4B, 15-5B, 15-5C, and 15-6B (situated in the clay and clay till) groundwater elevations varied by approximately 5 m to 6 m, with the highest groundwater elevation occurring on May 27, 2016, and the lowest groundwater elevation occurring in either December 2015 or November 2016. As indicated by Dillon (2017), it is uncertain whether these trends can be attributed to slow groundwater recovery following groundwater sampling, or seasonal variation.
- The variability in groundwater levels observed at 16-2E and 16-4F (situated in the bedrock) is indicative of recovery following drilling and hydraulic testing. It is inferred that the bedrock in which these wells are screened has a very low hydraulic conductivity, resulting in long periods of recovery from drilling and hydraulic testing. This long recovery time is more apparent for 16-2E. Based on the more recent measurements at these monitoring locations, the groundwater-level recovery appeared to be complete by November 9, 2017.
- No groundwater elevation measurements were available between March 7, 2016 and May 27, 2016, which is anticipated to correspond to the time period when groundwater elevations are highest. As such, seasonal variation in groundwater elevation is potentially greater than that noted at some locations.



LEGEND

- Interpreted Groundwater Elevation (mASL)
- Monitoring Well Nest

Notes:

1. Groundwater elevations taken between September 14, 2016 and September 26, 2016.

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DESIGN	NFB
REVIEW	MIB
APPROVED	AM

TITLE
GROUNDWATER ELEVATIONS IN CLAY-TILL UNIT

PROJECT No.	CONTROL	Rev.	FIGURE
1656897		**1**	**6.3.2-3**

S:\Clients\Canadian_Nuclear_Laboratories\Manitoba\99_PROJ\1656897_CNL_Whiteshell_EA\0_PROJ\0015_Groundwater_Modelling_Report\1656897-0015-G-0016_Figure 6.3.2-3 - Groundwater Elevation in Clay-till.pptx



LEGEND

- Interpreted Groundwater Elevation (mASL)
- Monitoring Well Nest

Notes:

1. Groundwater elevations taken between September 14, 2016 and September 26, 2016.

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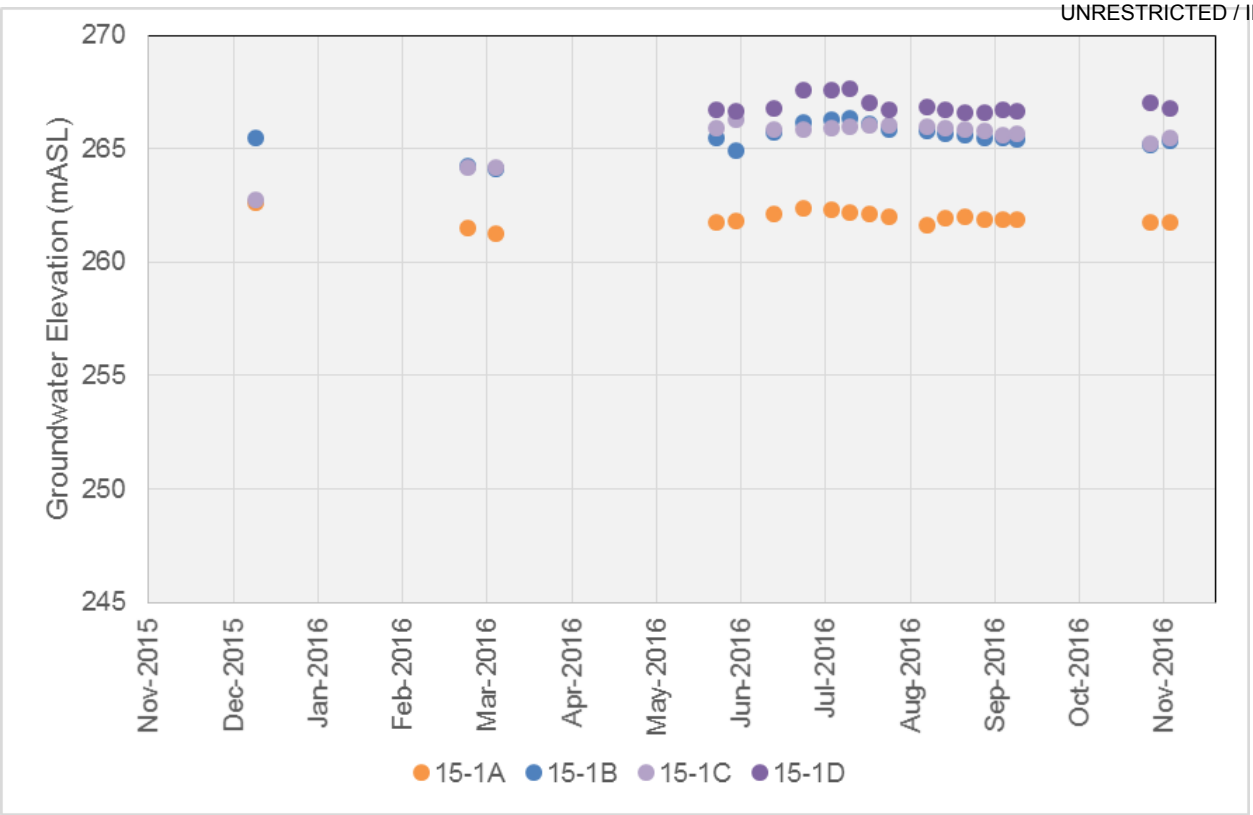
CONSULTANT
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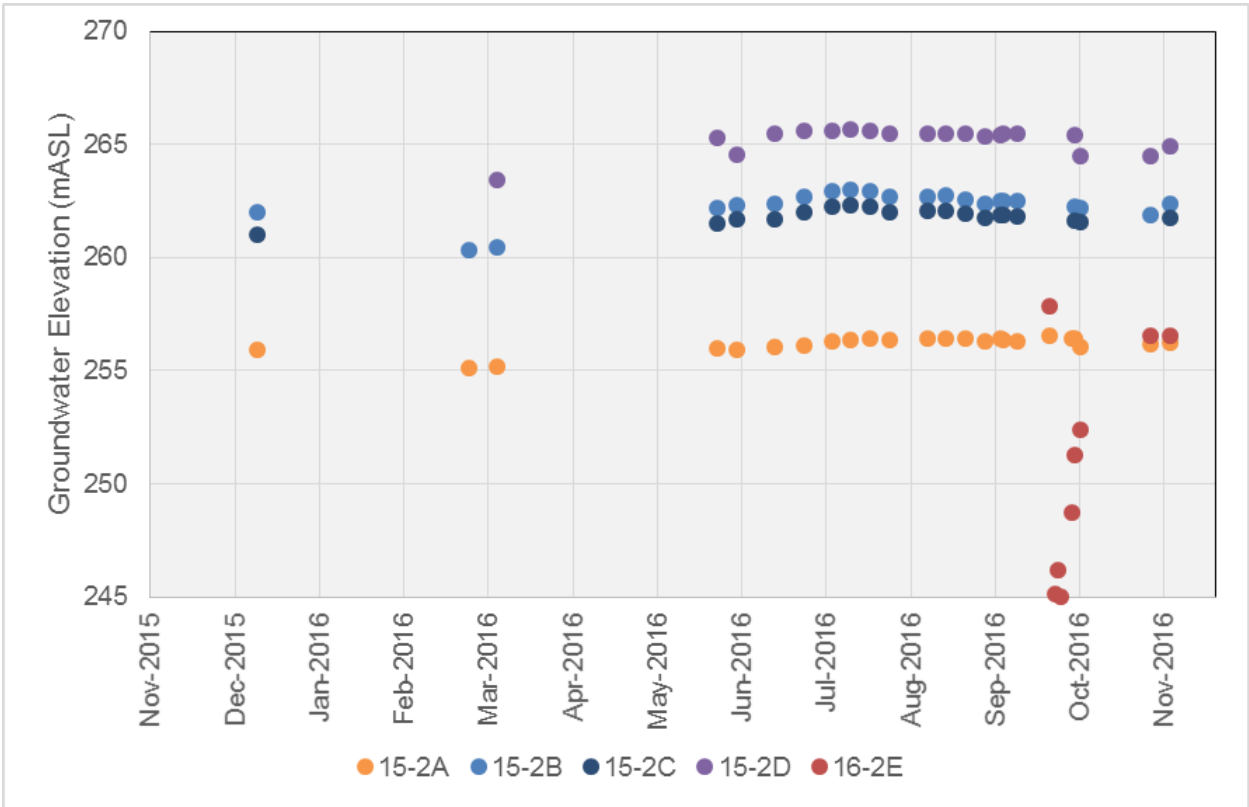
YYYY-MM-DD	2017-09-13
PREPARED	MIB
DESIGN	NFB
REVIEW	MIB
APPROVED	AM

TITLE
GROUNDWATER ELEVATIONS IN COMBINED BASAL-SAND / UPPER BEDROCK UNIT

PROJECT No.	CONTROL	Rev.	FIGURE
1656897		**1**	**6.3.2-4**

S:\Clients\Canadian_Nuclear_Laboratories\Manitoba\69_PRO\1656897_CNL_Whiteshell_EA\0_PRO\0015_Groundwater_Modelling_Report\1656897-0015-G-0017_Figure 6.3.2-4 - Groundwater Elevation in basal sand.pptx





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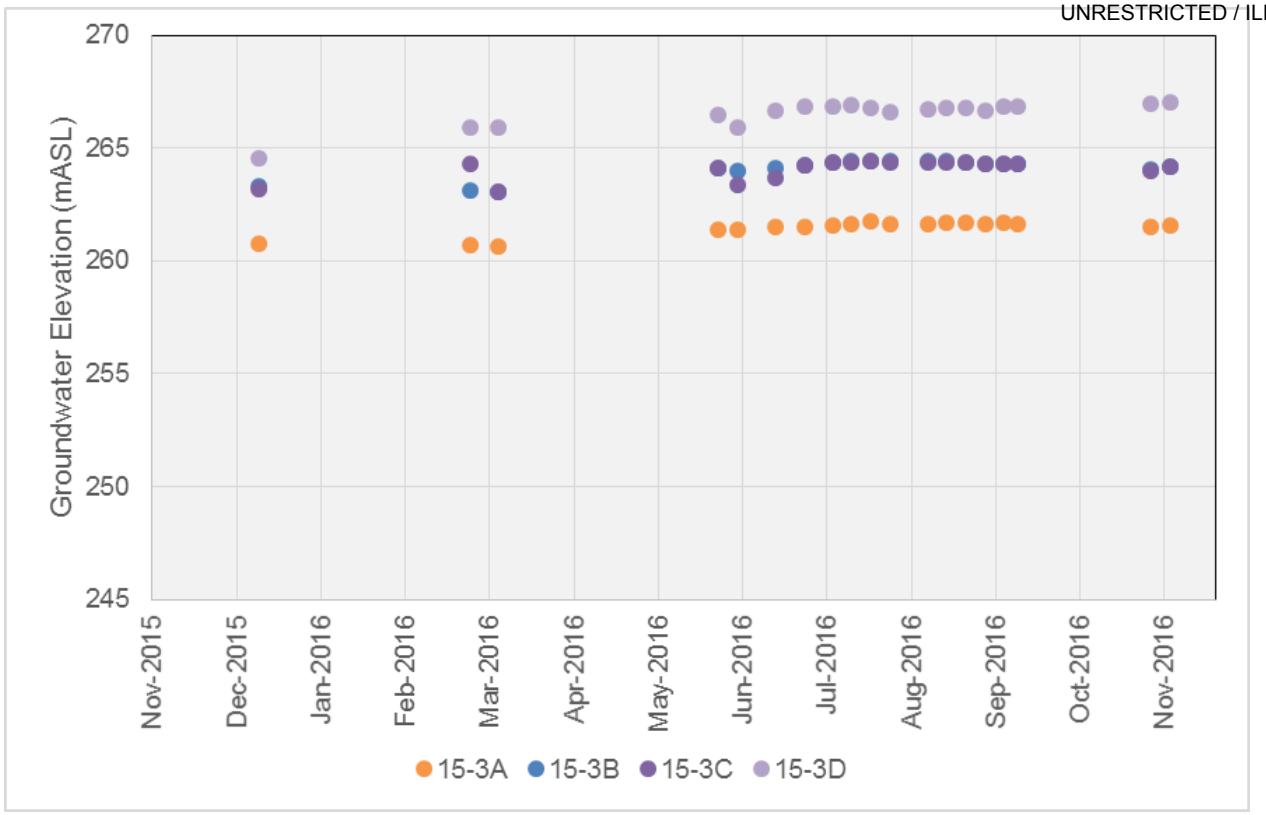
CONSULTANT
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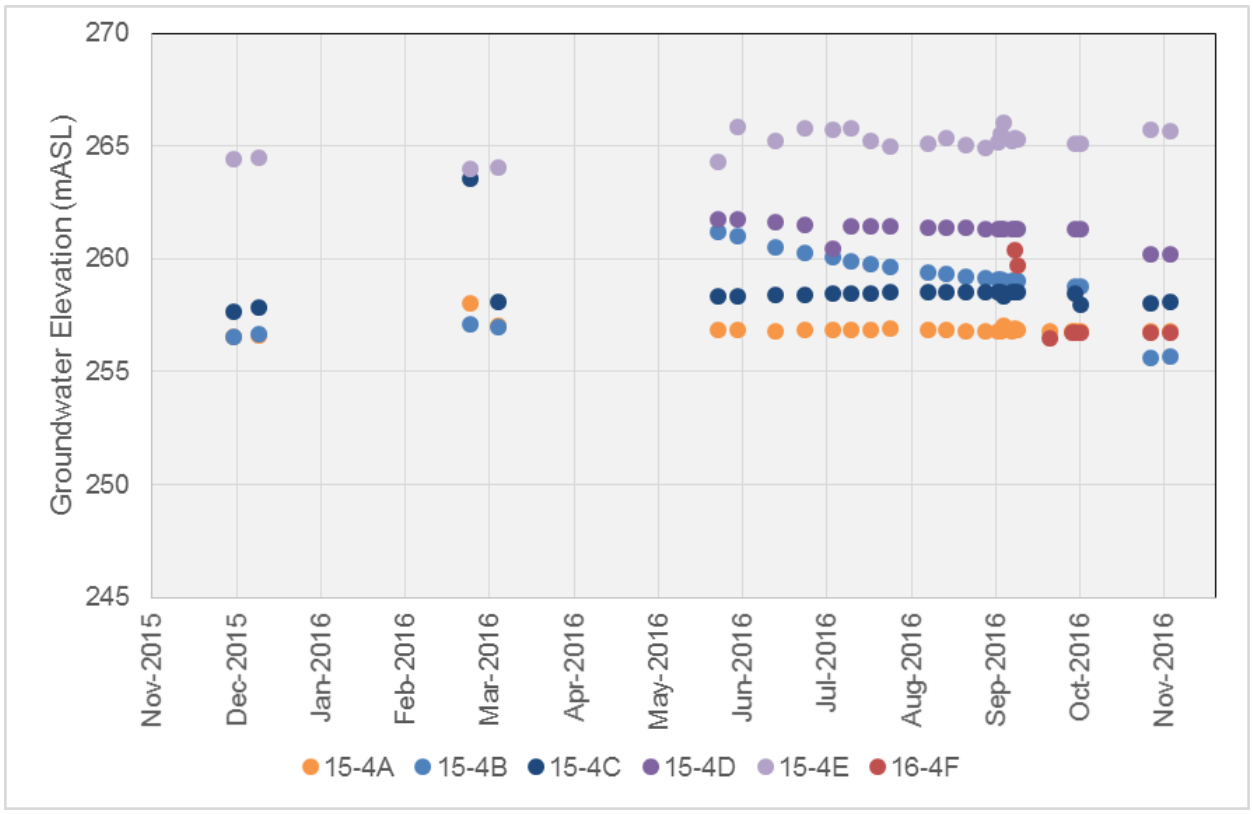
YYYY-MM-DD	2017-09-13
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DESIGN	NFB
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APPROVED	AM

TITLE
GROUNDWATER ELEVATIONS IN MONITORING WELL NESTS 1 AND 2

PROJECT No. **1656897** CONTROL Rev. **1** FIGURE **6.3.2-5A**

S:\Clients\Canadian_Nuclear_Laboratories\Manitoba\99_PROJ\1656897_CNL_Whiteshell_EA\0_PROD\0015_Groundwater_Modelling_Report\1656897-0015-G-0010_Figure 6.3.2-5A- Groundwater Elevation in Nest 1 and Nest 2.pptx





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WR-1 AT THE WHITESHELL LABORATORIES SITE

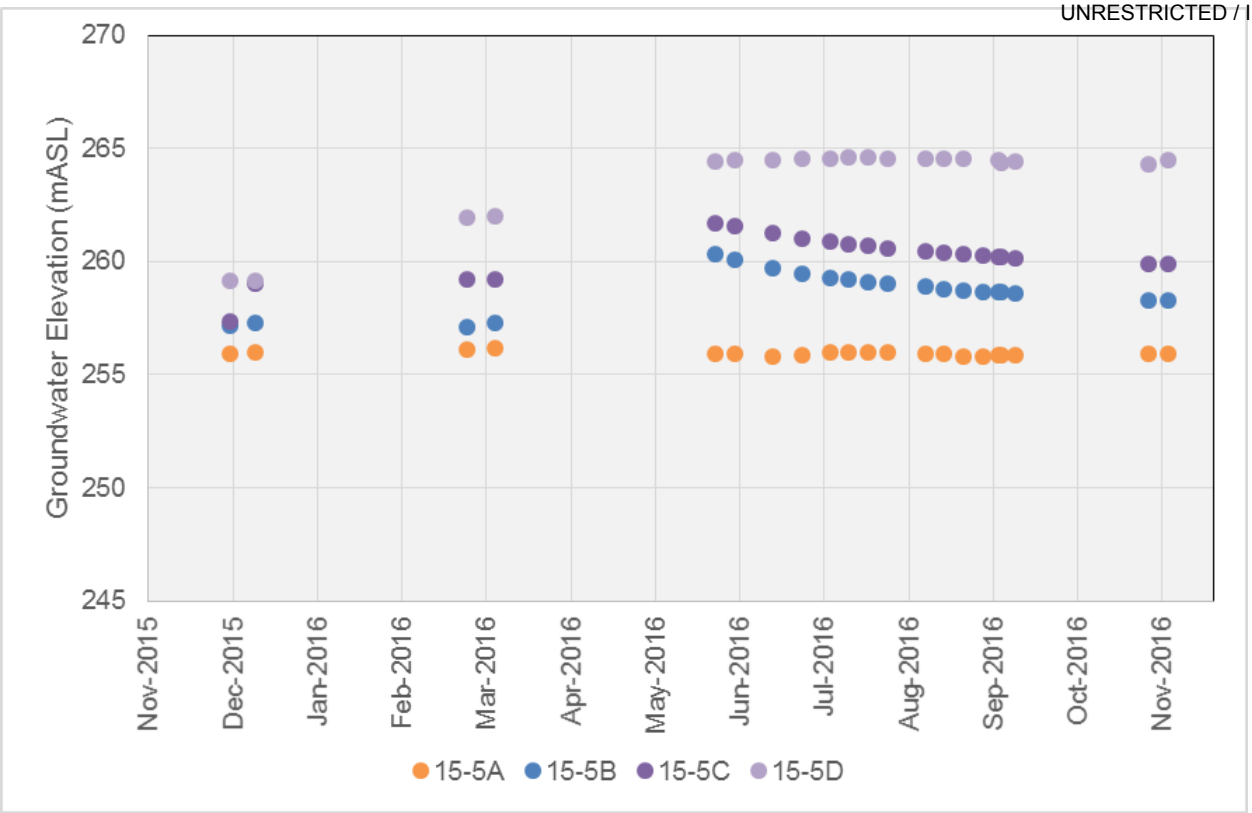
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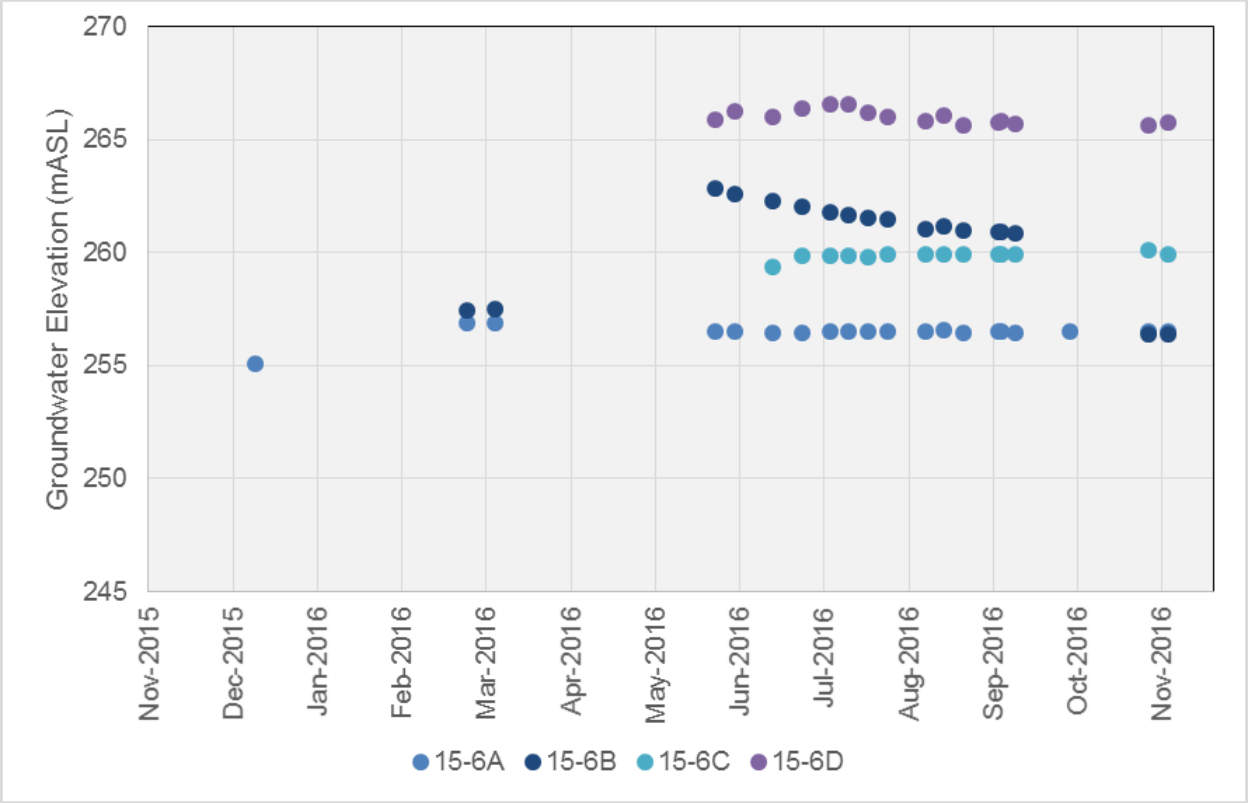
YYYY-MM-DD	2017-09-13
PREPARED	MIB
DESIGN	NFB
REVIEW	MIB
APPROVED	AM

TITLE
GROUNDWATER ELEVATIONS IN MONITORING WELL NESTS 3 AND 4

PROJECT No.	CONTROL	Rev.	FIGURE
1656897		**1**	**6.3.2-5B**

S:\Clients\Canadian_Nuclear_Laboratories\Manitoba\99_PROJ\1656897_CNL_Whiteshell_EA\0_PROD\0015_Groundwater_Modelling_Report\1656897-0015-G-0010_Figure 6.3.2-5B- Groundwater Elevation in Nest 3 and Nest 4.pptx





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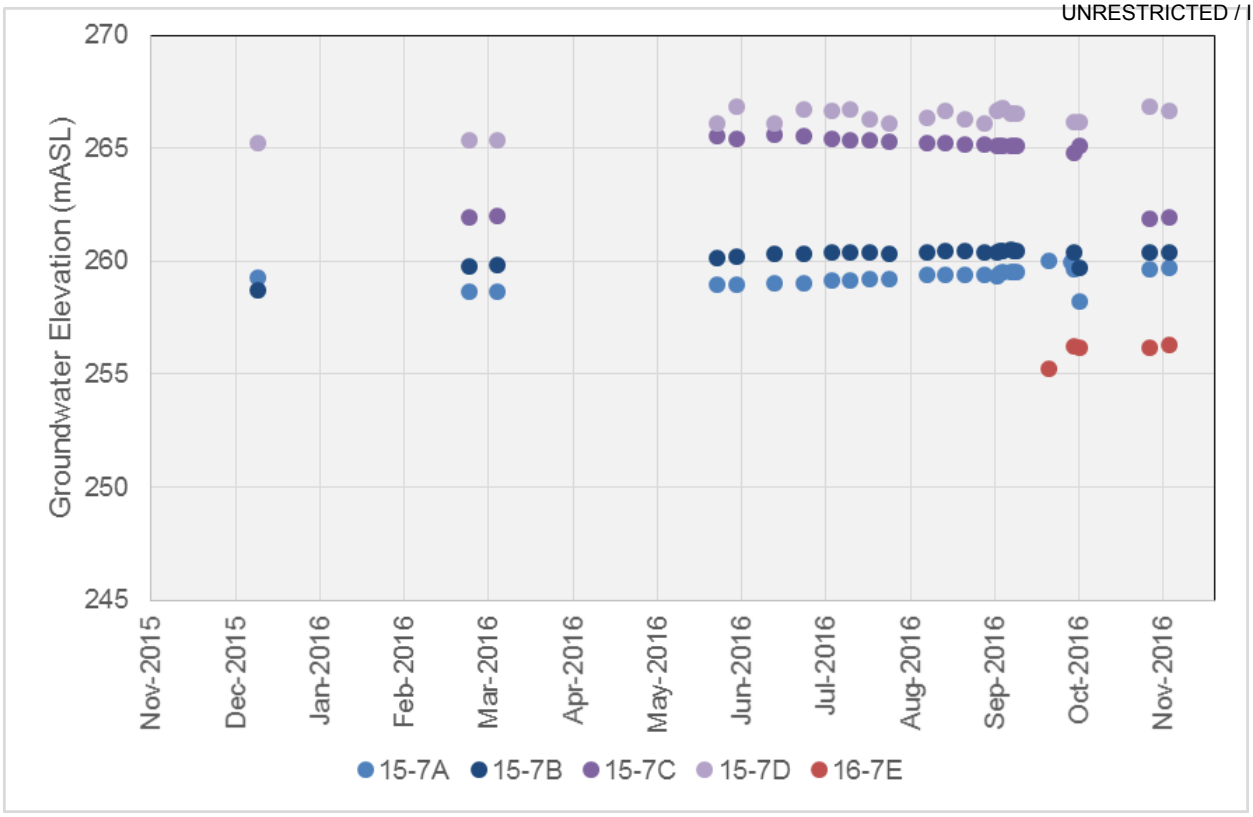
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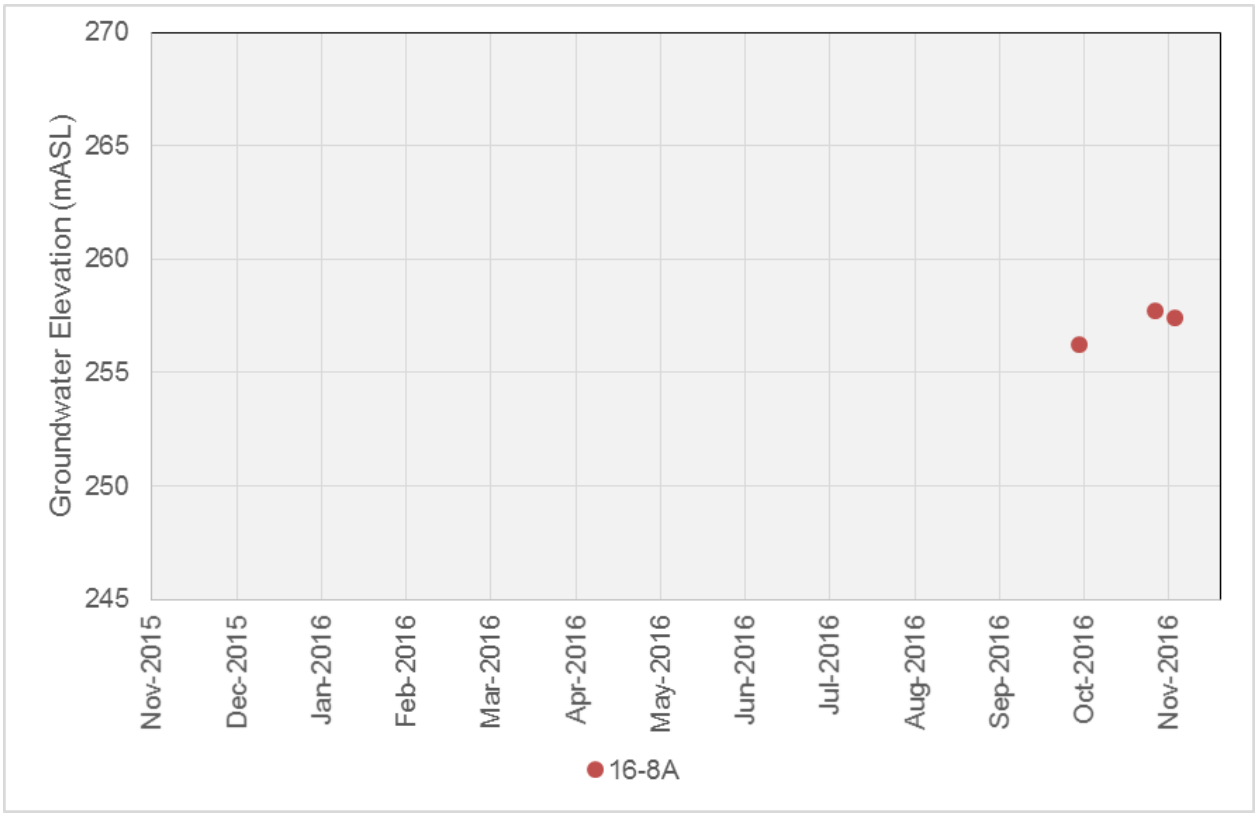
YYYY-MM-DD	2017-09-13
PREPARED	MIB
DESIGN	NFB
REVIEW	MIB
APPROVED	AM

TITLE
GROUNDWATER ELEVATIONS IN MONITORING WELL NESTS 5 AND 6

PROJECT No.	CONTROL	Rev.	FIGURE
1656897		**1**	**6.3.2-5C**

S:\Clients\Canadian_Nuclear_Laboratories\Manitoba\99_PROJ\1656897_CNL_Whiteshell_EA\0_PROD\0015_Groundwater_Modelling_Report\1656897-0015-G-0010_Figure 6.3.2-5C- Groundwater Elevation in Nest 5 and Nest 6.gpk





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PREPARED	MIB
DESIGN	NFB
REVIEW	MIB
APPROVED	AM

TITLE
GROUNDWATER ELEVATIONS IN MONITORING WELL NEST 7 AND MONITORING WELL 16-8A

PROJECT No.	CONTROL	Rev.	FIGURE
1656897		**1**	**6.3.2-5D**

S:\Clients\Canadian_Nuclear_Laboratories\Manitoba\99_PRO\1656897_CNL_Whiteshell_EA\0_PRO\0\0\15_Groundwater_Modelling_Report\1656897-0015-G-0010_Figure 6.3.2-5D- Groundwater Elevation in Nest 7.pptx

Table 6.3.2-5: Groundwater Elevations

	Monitoring Well Nest 1				Monitoring Well Nest 2					Monitoring Well Nest 3				Monitoring Well Nest 4						Monitoring Well Nest 5				Monitoring Well Nest 6				Monitoring Well Nest 7					Monitoring Well 8
Date	15-1A	15-1B	15-1C	15-1D	15-2A	15-2B	15-2C	15-2D	16-2E	15-3A	15-3B	15-3C	15-3D	15-4A	15-4B	15-4C	15-4D	15-4E	16-4F	15-5A	15-5B	15-5C	15-5D	15-6A	15-6B	15-6C	15-6D	15-7A	15-7B	15-7C	15-7D	16-7E	16-8A
12/1/2015	–	–	–	–	–	–	–	–	–	–	–	–	–	256.55	256.55	257.68	–	264.43	–	255.92	257.19	257.37	259.16	–	–	–	–	–	–	–	–	–	–
12/10/2015	262.62	265.47	262.78	–	255.91	262.00	261.01	–	–	260.75	263.32	263.20	264.57	256.60	256.65	257.87	–	264.50	–	255.97	257.27	259.04	259.18	255.07	–	–	–	259.29	258.70	–	265.23	–	–
2/26/2016	261.53	264.25	264.18	–	255.12	260.36	–	–	–	260.68	263.13	264.28	265.94	258.05	257.12	263.58	–	264.01	–	256.11	257.13	259.19	261.95	256.90	257.43	–	–	258.65	259.76	261.93	265.39	–	–
3/7/2016	261.26	264.12	264.17	–	255.17	260.47	–	263.46	–	260.67	263.07	263.08	265.91	257.03	256.99	258.09	–	264.07	–	256.20	257.30	259.24	262.03	256.85	257.51	–	–	258.68	259.85	261.98	265.37	–	–
5/27/2016	261.79	265.48	265.90	266.70	255.99	262.18	261.54	265.30	–	261.41	264.11	264.11	266.45	256.85	261.23	258.34	261.79	264.33	–	255.91	260.33	261.68	264.43	256.53	262.81	–	265.87	258.98	260.13	265.56	266.11	–	–
6/3/2016	261.81	264.91	266.32	266.66	255.95	262.32	261.69	264.58	–	261.42	264.02	263.34	265.95	256.85	261.00	258.37	261.73	265.87	–	255.91	260.08	261.55	264.47	256.53	262.62	–	266.28	258.96	260.23	265.40	266.82	–	–
6/17/2016	262.16	265.76	265.85	266.78	256.08	262.40	261.72	265.49	–	261.49	264.11	263.71	266.65	256.80	260.55	258.39	261.61	265.23	–	255.79	259.74	261.26	264.49	256.45	262.25	259.37	266.02	259.02	260.33	265.59	266.08	–	–
6/28/2016	262.39	266.18	265.87	267.62	256.09	262.70	262.03	265.60	–	261.51	264.22	264.21	266.83	256.83	260.27	258.41	261.52	265.77	–	255.89	259.47	261.04	264.56	256.46	262.02	259.85	266.40	259.04	260.33	265.53	266.70	–	–
7/8/2016	262.31	266.31	265.94	267.62	256.29	262.93	262.28	265.64	–	261.55	264.36	264.34	266.86	256.87	260.07	258.47	260.49	265.71	–	255.97	259.29	260.87	264.58	256.49	261.81	259.83	266.56	259.13	260.38	265.44	266.67	–	–
7/15/2016	262.20	266.36	266.01	267.65	256.35	262.99	262.33	265.67	–	261.61	264.41	264.39	266.92	256.86	259.91	258.49	261.47	265.79	–	255.98	259.20	260.78	264.62	256.52	261.68	259.85	266.59	259.17	260.41	265.39	266.75	–	–
7/22/2016	262.16	266.13	266.06	267.02	256.41	262.93	262.28	265.62	–	261.74	264.46	264.44	266.80	256.87	259.78	258.50	261.44	265.24	–	255.98	259.12	260.68	264.61	256.53	261.56	259.83	266.22	259.21	260.38	265.36	266.30	–	–
7/29/2016	262.03	265.89	266.06	266.71	256.34	262.67	262.03	265.47	–	261.62	264.41	264.39	266.61	256.89	259.64	258.53	261.42	264.99	–	256.01	259.03	260.60	264.58	256.53	261.45	259.95	266.00	259.24	260.35	265.32	266.08	–	–
8/12/2016	261.62	265.81	265.97	266.86	256.43	262.71	262.06	265.48	–	261.65	264.40	264.40	266.73	256.86	259.41	258.53	261.38	265.12	–	255.94	258.88	260.45	264.57	256.52	261.06	259.91	265.83	259.38	260.43	265.24	266.34	–	–
8/19/2016	261.94	265.70	265.92	266.71	256.41	262.74	262.10	265.49	–	261.67	264.40	264.39	266.81	256.87	259.32	258.55	261.37	265.37	–	255.92	258.81	260.38	264.55	256.54	261.15	259.90	266.04	259.41	260.44	265.21	266.66	–	–
8/26/2016	262.02	265.61	265.88	266.59	256.40	262.60	261.96	265.49	–	261.68	264.38	264.37	266.81	256.82	259.23	258.55	261.36	265.05	–	255.83	258.75	260.31	264.53	256.44	260.98	259.91	265.66	259.42	260.44	265.18	266.30	–	–
9/2/2016	261.88	265.47	265.80	266.62	256.33	262.40	261.76	265.35	–	261.65	264.33	264.32	266.66	256.79	259.14	258.54	261.34	264.91	–	255.82	258.69	260.26	–	–	–	–	–	259.40	260.38	265.15	266.13	–	–
9/7/2016	–	–	–	–	–	–	–	–	–	–	–	–	–	256.78	259.07	258.51	261.32	265.17	–	–	–	–	–	–	–	–	–	259.36	260.42	265.12	266.65	–	–
9/8/2016	–	–	–	–	256.40	262.53	261.89	265.44	–	–	–	–	–	256.82	259.07	258.53	261.35	265.54	–	255.84	258.64	260.21	264.47	256.49	260.92	259.92	265.79	259.48	260.46	265.12	266.72	–	–
9/9/2016	261.87	265.46	265.59	266.75	256.39	262.53	261.89	265.48	–	261.67	264.33	264.33	266.86	257.07	259.06	258.35	261.34	266.04	–	255.85	258.63	260.20	264.39	256.49	260.90	259.92	265.82	259.50	260.48	265.11	266.77	–	–
9/12/2016	–	–	–	–	–	–	–	–	–	–	–	–	–	256.82	259.02	258.52	261.34	265.24	–	–	–	–	–	–	–	–	–	259.52	260.49	265.10	266.55	–	–
9/13/2016	–	–	–	–	–	–	–	–	–	–	–	–	–	256.95	259.01	258.52	261.32	265.36	260.37	–	–	–	–	–	–	–	–	259.50	260.47	265.10	266.55	–	–
9/14/2016	261.86	265.45	265.67	266.69	256.33	262.48	261.83	265.49	–	261.63	264.29	264.27	266.87	256.84	259.00	258.51	261.32	265.32	259.70	255.84	258.59	260.16	264.44	256.44	260.84	259.91	265.69	259.50	260.47	265.10	266.55	–	–
9/26/2016	–	–	–	–	256.54	–	–	–	257.84	–	–	–	–	256.82	–	–	–	–	256.46	–	–	–	–	–	–	–	–	260.02	–	–	–	255.22	–
9/28/2016	–	–	–	–	–	–	–	–	245.15	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
9/29/2016	–	–	–	–	–	–	–	–	246.18	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
9/30/2016	–	–	–	–	–	–	–	–	245.02	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
10/4/2016	–	–	–	–	256.40	–	–	–	248.73	–	–	–	–	256.82	–	–	–	–	256.75	–	–	–	–	256.49	–	–	–	259.98	–	–	–	–	–
10/5/2016	–	–	–	–	256.42	262.27	261.63	265.40	251.27	–	–	–	–	256.82	258.79	258.47	261.32	265.12	256.76	–	–	–	–	–	–	–	–	259.67	260.42	264.78	266.14	256.23	256.22
10/7/2016	–	–	–	–	256.06	262.19	261.55	264.51	252.38	–	–	–	–	256.80	258.75	257.99	261.35	265.13	256.74	–	–	–	–	–	–	–	–	258.26	259.69	265.12	266.17	256.19	–
11/2/2016	261.76	265.19	265.26	267.02	256.15	261.88	–	264.48	256.55	261.53	264.03	264.02	266.98	256.79	255.61	258.04	260.19	265.72	256.75	255.90	258.27	259.91	264.33	256.48	256.41	260.08	265.66	259.64	260.40	261.92	266.82	256.19	257.74
11/9/2016	261.77	265.37	265.47	266.79	256.21	262.38	261.77	264.93	256.57	261.55	264.18	264.16	267.03	256.79	255.67	258.11	260.23	265.67	256.73	255.94	258.27	259.90	264.47	256.49	256.37	259.91	265.74	259.71	260.39	261.97	266.69	256.30	257.41

a) Water level data provided in Dillon (2017).
b) "–" indicates no available measurement.

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6.3.2.4.2.2 Hydraulic Gradients

Horizontal hydraulic gradients were estimated based on the groundwater elevations in monitoring wells located parallel to the direction of groundwater flow. Relatively neutral gradients were noted for the clay unit, with a maximum estimated gradient of approximately 0.007 m/m between monitoring well nests 5 and 6. For the clay till unit, the horizontal gradient was approximately 0.012 m/m, as measured between monitoring well nests 3 and 4 and monitoring well nests 1 and 7. Similarly, for the combined basal sand/upper bedrock unit, the horizontal gradient was approximately 0.010 m/m, as measured between monitoring well nests 3 and 4 and monitoring well nests 1 and 7.

Vertical hydraulic gradients were calculated between the various units based on mid-point elevations of monitoring well screens, as summarized in Table 6.3.2-6. At all locations groundwater elevations were highest in the clay unit and lowest in the combined basal sand/upper bedrock unit, indicating a downward direction of groundwater flow through the overburden. Between the clay and clay till units the vertical gradient ranged from 0.22 m/m at monitoring well nest 1 to 1.39 m/m at monitoring well nest 6, with an average vertical gradient of 0.83 m/m across all locations. Between the clay till and combined basal sand/upper bedrock units the vertical gradient ranged from 0.24 m/m at monitoring well nest 2 to 0.86 m/m at monitoring well nest 5, with an average vertical gradient of 0.52 m/m across all locations.

Table 6.3.2-6: Vertical Gradients

Monitoring Well Nest	Groundwater Elevation[a] (masl)					Screen Elevation (masl)			Vertical Gradient[c]	
	Clay	Clay-Till	Basal Till	Bedrock	BT/Br Maximum[b]	Clay	Clay-Till	BT/Br	Clay to Clay-Till	Clay-Till to BT/Br
1	266.69	265.45	261.86	–	261.86	265.81	260.14	254.93	0.22	0.69
2	265.49	261.83	256.33	257.84	257.84	264.92	261.20	244.52	0.98	0.24
3	266.87	264.29	261.63	–	261.63	265.01	260.00	256.00	0.51	0.66
4	265.32	258.51	256.82	256.58	256.82	263.88	257.00	252.21	0.99	0.35
5	264.44	258.59	255.84	–	255.84	261.98	256.40	253.22	1.05	0.86
6	265.69	259.91	–	–	–	264.37	260.21	–	1.39	–
7	266.55	260.02	–	256.27	256.27	264.76	255.44	242.79	0.70	0.30

a) Groundwater elevation measurements taken between September 14, 2016 and September 26, 2016.

b) The maximum groundwater elevation was selected at each monitoring well nest to represent the groundwater elevation for this unit.

c) Vertical gradient calculated based on screen mid-point elevations. Positive values indicate a downward direction of groundwater flow.

"–" indicates no measurement available; masl = metres above sea level; BT/Br = indicates combined basal-till / bedrock unit.

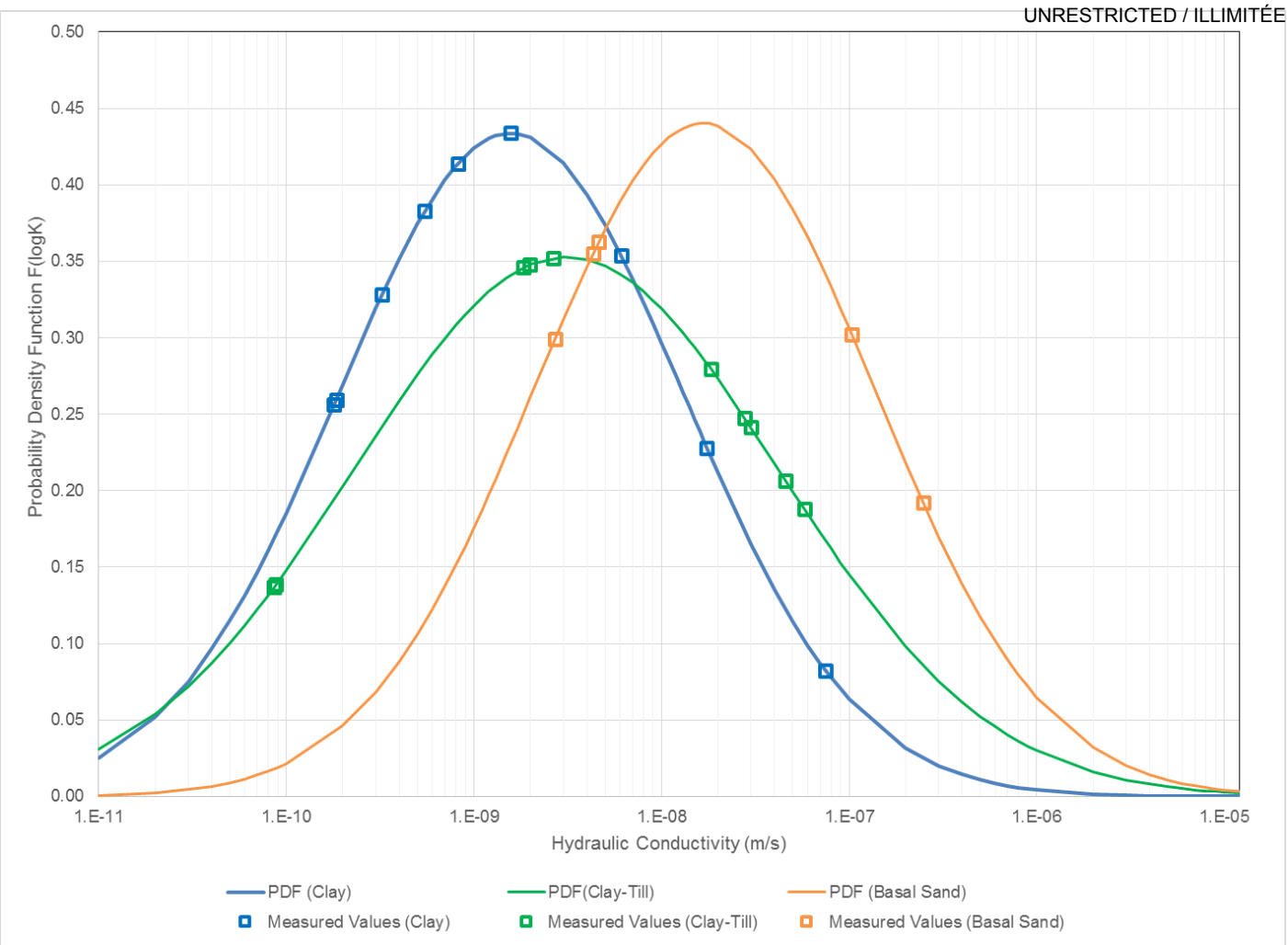
6.3.2.4.2.3 Hydraulic Conductivity

Measurements of hydraulic conductivity of the principal hydrostratigraphic units found within the RSA were available from previous hydrogeological investigations, which focused on the Waste Management Area (WMA). These are summarized below (Dillon 2017).

- Robertson and Cherry (1985) measured the hydraulic conductivity of the overburden in the WMA using both laboratory and field methods (i.e., monitoring well response tests, pumping tests, mass balance methods). The monitoring well response test results suggested that the hydraulic conductivity of the clay (10^{-11} to 10^{-6} m/s), clay till (10^{-10} to 10^{-6} m/s) and basal sand (10^{-11} to 10^{-6} m/s) varied over a wide range of values. Pumping test and mass balance estimates suggested that the average hydraulic conductivity of the clay and clay till units ranged from 10^{-10} to 10^{-9} m/s, and the average hydraulic conductivity of the sand unit ranged from 10^{-6} to 10^{-5} m/s. The wide range of hydraulic conductivity can be attributed to the presence of fine layers of silt/sand and other features such as fractures in the clay which imparts secondary permeability to the soils.
- Singlewell-response tests (AECL 2007) were completed in most of the BHS 500 series groundwater monitoring wells at the WMA. Most of the hydraulic conductivity values in the clay units from the singlewell-response tests were in the range of 10^{-7} to 10^{-9} m/s. Groundwater flow through the clay/silt units is probably controlled, for the most part, by these lower permeability soils. In the clay till, most of the single well response tests (21 of 26) provided hydraulic conductivity values in the range of 10^{-7} to 10^{-9} m/s. Seventeen hydraulic conductivity tests were completed in the basal sand unit (AECL 2007). These tests generally showed a high range of hydraulic conductivity (10^{-5} to 10^{-7} m/s) compared to the clay and clay till units. Fourteen of the 17 single well response tests completed in the basal sand unit had hydraulic conductivity values in the order of 10^{-6} m/s.

Although the primary focus of the above-mentioned studies was the WMA, Robertson and Cherry (1985) indicate that the basal sand demonstrated a fining trend from east to west, resulting in reduction of hydraulic conductivity of this unit in a westerly direction. It is noted that the testing completed by KGS Group (KGS) in the LSA (discussed below), does not indicate a similar fining trend.

Single well response testing was completed at 29 monitoring wells in the LSA by KGS Group (KGS 2016). Data from 25 of the tests were used to define normally-distributed probability density functions of the log hydraulic conductivity estimates for the primary hydrostratigraphic units in the LSA. Data from the remaining wells (15-2C, 15-5D, 15-6D, and 15-7C) were omitted from this analysis due to the anomalous responses observed during testing, as noted in KGS (2016). The probability density functions are plotted on Figure 6.3.2-6, and the data are provided in Table 6.3.2-7.



Hydrostratigraphic Unit	Hydraulic Conductivity (m/s)			
	Minimum	Maximum	Geometric Mean	Standard Deviation
Clay	1.80E-10	7.49E-08	1.58E-09	2.45E-08
Clay Till	8.61E-11	5.76E-08	3.10E-09	2.07E-08
Basal Sand	2.69E-09	2.48E-07	1.69E-08	1.07E-07

CLIENT
CANADIAN NUCLEAR LABORATORIES

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF
WR-1 AT THE WHITESHELL LABORATORIES SITE

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
PREPARED	MIB
DESIGN	NFB
REVIEW	MIB
APPROVED	AM

TITLE
PROBABILITY DENSITY FUNCTIONS FOR HYDRAULIC CONDUCTIVITY MEASUREMENTS

PROJECT No. **1656897** CONTROL Rev. **1** FIGURE **6.3.2-6**

S:\Clients\Canadian_Nuclear_Laboratories\Manitoba89_PROJ\656897_CNL_Whiteshell_EA\6_PROD\0015_Groundwater_Modelling_Report\656897-0015-G-0014_Figure 6.3.2-6 - Hydraulic Conductivity PDFs.pptx

Table 6.3.2-7: Hydraulic Conductivity Estimates

Monitoring Well	Hydrostratigraphic Unit	Hydraulic Conductivity Estimate (m/s)
15-1A	Basal Sand	4.61×10^{-9}
15-1B	Clay Till	2.78×10^{-8}
15-1C	Clay	3.24×10^{-10}
15-1D	Clay	1.57×10^{-9}
15-2A	Basal Sand	4.30×10^{-9}
15-2B	Clay Till	4.59×10^{-8}
15-2D	Clay	5.48×10^{-10}
15-3A	Basal Sand	2.69×10^{-9}
15-3B	Clay Till	1.84×10^{-8}
15-3C	Clay	1.74×10^{-8}
15-3D	Clay	8.23×10^{-10}
15-4A	Basal Sand	1.03×10^{-7}
15-4B	Clay Till	8.63×10^{-11}
15-4C	Clay Till	5.76×10^{-8}
15-4D	Clay	1.80×10^{-10}
15-4E	Clay	7.49×10^{-8}
15-5A	Basal Sand	2.48×10^{-7}
15-5B	Clay Till	8.83×10^{-11}
15-5C	Clay	1.85×10^{-10}
15-6A	Clay Till	2.64×10^{-9}
15-6B	Clay Till	8.61×10^{-11}
15-6C	Clay Till	2.99×10^{-8}
15-7A	Clay Till	1.99×10^{-9}
15-7B	Clay Till	1.84×10^{-9}
15-7D	Clay	6.11×10^{-9}

Key observations from Figure 6.3.2-5 are summarized as follows:

- Consistent with the observations made by others within the RSA, the hydrostratigraphic units exhibited a wide range in estimated hydraulic conductivity values, spanning two to three orders of magnitude.
- Hydraulic conductivity estimates within the LSA were generally within the ranges defined by testing completed at the WMA as noted above, though the basal sand unit was somewhat less permeable.
- Hydraulic conductivity increases with depth on a unit-average basis (i.e., the clay is the least permeable and the basal sand is the most permeable), though this was not always the case at individual monitoring well nests (e.g., the hydraulic conductivity estimate in the basal sand at 15-2A was lower than the estimate in the clay till at 15-2B).

Hydraulic conductivity within the basal sand appears to increase in an east to west direction. Hydraulic conductivity estimates for 15-1A, 15-2A, and 15-3A (located in the eastern portion of the LSA) are approximately one to two orders of magnitude lower than the hydraulic conductivity estimates for 15-4A and 15-5A (located in the eastern portion of the LSA. These results appear to indicate that the east to west fining trend noted by Robertson and Cherry (1985) in the WMA is not present throughout the RSA, and that the opposite trend may occur in the LSA.

6.3.2.4.2.4 Groundwater Quality

Ongoing groundwater sampling within the RSA for both radiological and non-radiological parameters occurs at specific facilities as part of the routine environmental monitoring for the WL site. These facilities include the sewage lagoon, the landfill, and the WMA, which includes unlined trenches used to dispose of low level radioactive and conventional waste. The monitoring programs differ slightly by facility and are documented in CNL (2016a).

Concentrations of metals in groundwater within the RSA are generally low. Slightly elevated concentrations of arsenic (0.017 to 0.025 mg/L) at the landfill, and iron (0.2 to 3.0 mg/L) at the WMA were reported in 2015 (CNL 2016a). These metals are known to be naturally elevated in groundwater elsewhere in Manitoba, and concentrations observed in 2015 were attributed to these natural conditions as opposed to anthropogenic sources (CNL 2016a). Volatile organic compounds (VOCs) including benzene, ethylbenzene, toluene and xylene were detected at low concentrations within the WMA, and are possibly related to gas powered equipment used during sampling (CNL 2016a). HB-40, the primary coolant feedstock for the WR-1, was detected at trace concentrations (less than 0.026 mg/L) at four monitoring wells within the WMA in 2015 (CNL 2016a).

The radiological component of the routine environmental monitoring program includes the analysis of gross beta, gross alpha, tritium, and uranium in groundwater. In the landfill area gross beta, gross alpha, and uranium activities/concentrations are low (less than 1 Bq/L, 0.5 Bq/L, and 0.020 mg/L respectively). Tritium was detected in the shallow groundwater (at 13.6 Bq/L) at one location within the landfill, and is likely related to emissions from the WR-1 Building deposited in nearby ponds (CNL 2016a).

At the lagoon area, gross beta activity in groundwater is elevated, and greater than 1 Bq/L at all monitoring locations within the basal sand unit. Gross alpha activity was also greater than 0.5 Bq/L at half of the lagoon monitoring locations. Uranium concentrations at the lagoon ranged from 0.006 to 0.128 mg/L. Gamma analysis indicated the presence of naturally occurring potassium-40 and uranium progeny, and the elevated gross beta and gross alpha at the lagoon were attributed to natural conditions as opposed to anthropogenic sources (CNL 2016a).

Within the WMA the five year average gross beta activities in groundwater within the clay and basal sand units are below 1 Bq/L, and are slightly above 1 Bq/L within the clay till unit. The five year average gross alpha activities within the clay and basal sand units are below 0.5 Bq/L, and are slightly above 0.5 Bq/L within the clay till unit. Uranium concentrations in groundwater within the WMA ranged from 0.0004 to 0.127 mg/L, with concentrations being highest in the clay unit, lowest in the basal sand. As with the lagoon area, gamma analysis of groundwater within the WMA indicated the presence of naturally occurring potassium-40 and uranium progeny, and the elevated gross beta and gross alpha are likely related to natural sources (CNL 2016a). Tritium was detected at several wells within the clay and clay till units, with activities ranging from 7.2 to 66.4 Bq/L in 2015 (CNL 2016a). Tritium was detected at one location within the basal sand (at 17.3 Bq/L) in an area of the WMA where transient reversals of recharge/discharge conditions have been noted (CNL 2016a). These tritium concentrations in groundwater are attributed to the low level radioactive waste stored in unlined trenches within the WMA (CNL 2016a). Based on the results of the 2015 monitoring program it was concluded at no significant contaminant migration from the WMA with groundwater flow has occurred (CNL 2016b).

Previous studies within the RSA have indicated that the groundwater quality in the overburden and bedrock aquifers is generally considered potable (AECL 2001). Within the LSA, a piper tri-linear plot presented in Dillon (2017) indicates that groundwater within the bedrock and basal sand units was predominately of a calcium-magnesium-sulphate type, while groundwater within the clay unit was predominately of a calcium-magnesium-bicarbonate type.

Dillon (2017) noted that the measured uranium concentration in the initial sample collected from the bedrock at monitoring well nest 2 was approximately 2 mg/L. Following subsequent sampling and further analysis completed in October 2016, Dillon (2017) concluded that the results indicated the presence of naturally occurring uranium. Similar elevated uranium concentrations have been previously noted in the Precambrian bedrock within the RSA. These concentrations were previously attributed to leakage of natural groundwater from the overlying uraniferous clay (AECL 2001).

Analysis of groundwater samples for radiological constituents completed by Dillon (2017) resulted in the presence of the following parameters at activities above their respective detection limits:

- Actinum-228 (at monitoring well 15-4A);
- Bismuth-214 (at monitoring well 16-2E);
- Lead-210 (at monitoring wells 15-2A, 15-2D, 16-2E, 16-4F, and 16-7E);
- Lead-212 (at monitoring wells 15-2A, 15-4A, and 15-7A);
- Lead-214 (at monitoring well 16-2E);
- Radium-226 (at monitoring wells 16-2E, 16-4F, 15-7B, 16-7E); and,
- Thorium-234 (at monitoring well 16-2E).

6.3.2.5 Project Interactions and Mitigation

6.3.2.5.1 Methods

This section describes the process by which interactions between Project components and activities and groundwater quantity and quality were identified and evaluated. Potential effect 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 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 Section 6.3.2.6 Residual Effects Analysis. 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 Project. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. The next step in the analysis was the development of environmental design features and mitigation practices that could be incorporated into the 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 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 pathway –** 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 to groundwater quantity and quality.
- **Secondary pathway –** the pathway could result in a measurable minor environmental change, but would have a negligible residual effect on groundwater quantity and 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 past, present 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 groundwater quantity and quality.

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.

6.3.2.5.2 Results

Pathways through which all phases of the Project may interact with and result in changes to measurement indicators for hydrogeology is provided in Table 6.3.2-8.

Table 6.3.2-8: Pathways Analysis for Hydrogeology Valued Components

WR-1 Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Closure of the entire WL site	Decommissioning and reclamation of the entire WL site, including the Project.	■ The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. ■ The drainage system for the reclaimed WL site will have similar physical characteristics as similar natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. ■ The WL site will be graded to promote drainage from the site to the Winnipeg River.	Secondary

Table 6.3.2-8: Pathways Analysis for Hydrogeology Valued Components

WR-1 Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Long-term performance during the post-closure phase from the Project	Release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time	■ Installation of a multi-component final cover system to mitigate moisture infiltration into the ISD reactor facility and hence limit release of solutes into the groundwater. ■ The planned decommissioning of the WR-1 Building presently involves: ▪ removal the service area and infilling in these areas with compact soil; ▪ sealing of open conduits in the building foundation; and ▪ grouting the interior portion of the building (containing the remaining components of WR-1) to ground surface elevation. ■ Performance monitoring will also be completed throughout the post-closure phase for the Project to confirm that the cover and grout is functioning as intended, and to confirm modelling predictions.	Primary
	Release of chemical and radiological contaminants in the long-term during the post-closure phase from the previous activities completed at the WL site.	■ As part of CNL's licence with the CNSC, environmental monitoring around the WL site will continue for the Project. ■ Follow-up monitoring during the post-closure phase will continue to verify effect predictions and to provide information for use in adaptive management to address potential unforeseen effects.	No Linkage

6.3.2.5.2.1 No Linkage Pathway

The following pathway was assessed as having no measurable environmental change and hence, no linkage to residual effects on groundwater quality.

- **Release of chemical and radiological contaminants in the long-term during the post-closure phase from the previous activities completed at the WL site.**

Results in the Comprehensive Study Report (AECL 2001) indicate that for effects to groundwater quality, the main area of concern was the LLW that may be managed in situ in the WMA. The assessment included a development of a conceptual model of the trench storage/disposal environment, as well as contaminant migration modelling and exposure pathway analysis. The evaluation of contaminant migration from the WMA trenches concluded that the nature of groundwater flow in the area around the WMA limits contaminant migration away from the WMA. There is no downward movement of groundwater flow from the WMA to the underlying permeable sandy zone which has the potential to act as a transmission zone to the Winnipeg River (see Section 6.3.4 and Appendix C of AECL 2001). Generally, the natural hydraulic head at 10 m depth is higher, meaning that the hydraulic head gradient is upward leading to potential water discharge towards the surface (i.e., artesian conditions).

Preliminary investigations undertaken in support of the Comprehensive Study Report found no evidence of significant movement upward of contamination even after over 20 years of contact with the waste in the trenches (AECL 2001). There was some evidence of a very small amount of upward movement of salts and contaminants from the trench into the cap materials in a few samples. Contaminant migration, if it occurred, is less than 10 cm over 20 years. Testing also provided no evidence of a “bathtub effect” (i.e., flooding of the trenches such that they have a higher conductivity than the trench wall), and associated near-surface lateral movement of contaminants, although further testing was recommended to support a future detailed safety analysis (AECL 2001).

Consequently, there is no overlap of effects between WR-1 and previous activities at the WL site (i.e., effects from the WMA) and changes to groundwater quality from the Project. Potential for cumulative effects with surface water quality and human health are considered in Section 6.4.2 Surface Water Quality and Section 6.7 A detailed safety analysis still needs to be completed for the ISD of the WMA trenches. It is expected that this analysis will capture the potential changes to groundwater quality and surface water loadings to the Winnipeg River and site-specific acceptance criteria would be defined in accordance with applicable regulatory requirements.

6.3.2.5.2.2 Secondary Pathways

The following pathways were assessed as potentially having a measurable minor change to hydrogeology relative to Base Case.

- **Decommissioning and reclamation of the entire WL site, including the Project.**

The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe and in keeping with the land use and landscape of the day. Following decommissioning of the building sumps, groundwater levels will rebound to static conditions similar to the local environment. On the main campus of the WL site, groundwater heads indicate downward flow conditions exist. For the Project, as the conditions rebound in during the post-closure phase groundwater will flow downwards through the overburden and westward, ultimately discharging at the Winnipeg River. Consequently, although closure of the WL site and the project may slightly alter the drainage flow patterns to the Winnipeg River for a short period of time; the changes are expected to be within the natural range of variation. Overall, cumulative effects from the Project in combination with the decommissioning of the remaining infrastructure and support facilities, and reclamation of the affected areas at the WL site are anticipated to have a negligible effect on groundwater quantity.

6.3.2.5.2.3 Primary Pathways

The Project is expected to have the following primary pathway effects on groundwater quality that are carried forward to the residual effects analysis:

- **Release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time.**

6.3.2.6 Residual Effects Analysis

The objectives of the groundwater flow and solute transport modelling include estimation of the potential long-term changes to the groundwater flow regime and groundwater quality resulting from the proposed decommissioning of the WR-1 Building The modelling was completed to provide screening level solute mass loadings during the post-closure phase. For the purposes of this assessment, “Screening level” refers to the simplified (conservative) approach that was adopted for that assessment in order to identify potential solutes of concern within the Environmental Risk Assessment (ERA) framework.

6.3.2.6.1 Methods

6.3.2.6.1.1 Flow and Solute Transport Modelling

Groundwater flow and solute transport modelling was completed in support of an assessment of the Project, and is described in detail in the Groundwater Modelling Report (Golder 2017). The conceptual model, upon which the numerical model was founded, was developed based on the available information. Primarily, these data included borehole logs, estimates of hydraulic conductivity, and groundwater elevations collected during recent field investigations of the SSA (Dillon 2017). Groundwater elevations and estimates of inflows to the WR-1 Building sump were used as metrics for calibration of the groundwater flow model. A comparison of the simulated to measured data showed that an acceptable model calibration was achieved.

MODFLOW-2005 (Harbaugh 2005) was used to complete the groundwater flow simulations and Visual MODFLOW® (Version 4.6.0.156) was used as the numeric flow engine for the simulations. MODPATH (Pollock 1989), a companion code to MODFLOW, was used to complete the particle tracking analyses necessary to illustrate the flow paths from the WR-1 Building.

An analytical approach was adopted to complete the solute transport modelling. GoldSim® (Version 11.1), a commercially available, flexible, object-oriented computer program, was selected as the software package to complete the analytical calculations. The GoldSim software is fully documented in the Main Users Guide (GTG 2014a), and the Contaminant Transport Module Users Guide (GTG 2014b). Details of the conceptual model development, modelling approach, and model assumptions are described in the Groundwater Modelling Report (Golder 2017).

6.3.2.6.1.2 Contaminant Release

The planned decommissioning of the WR-1 Building presently involves:

- removal of the service area and infilling in these areas with compact soil;
- sealing of open conduits in the building foundation; and
- grouting the interior portion of the building (containing the remaining components of WR-1) to ground surface elevation.

Following the encapsulation of WR-1 and the cessation of pumping from the sumps, the groundwater elevation will be restored to an equilibrium elevation and the majority of the grout (including the remaining components of the reactor) will be situated below the groundwater table. The calibrated groundwater flow model was reconfigured for representation of these conditions at various states of degradation of the encapsulation with respect to the condition of the cover, grout, and foundation materials. The assumption is that these materials will experience an increase in hydraulic conductivity as they degrade over time. Simulations were completed to estimate the groundwater flow through the components of the decommissioned structure and results of these simulations were used as input to the analytical solute transport model.

The solute transport model was defined as a source area (representing the remaining solute mass contained within the decommissioned structure), a barrier for containment (the building foundation), a transport pathway (the bedrock, which receives flow from the decommissioned building via advection and diffusion through the barrier and into the surrounding fill material), and a receptor (the Winnipeg River). Solute mass originating from the WR-1 and lead-containing materials is released gradually over time to represent corrosion of the reactor components that remain following decommissioning; whereas mass originating from other sources was assumed to be present in a dissolved phase throughout the grout at the start of decommissioning. Retardation from adsorption of the solutes was considered for the bedrock pathway only, as determined through a review of the available information on sorption-partitioning coefficients. Details are provided in the Groundwater Flow and Solute Transport Modelling Report (Golder 2017).

6.3.2.6.2 Application Case

The following provides a summary of the key findings from the groundwater flow and solute transport modelling assessment.

- The post-decommissioning groundwater elevation is expected to recover to the top of (or above) the reactor materials. Groundwater seepage (and mass flux) pathways were estimated to occur downwards to the underlying bedrock, and then laterally to the west towards the Winnipeg River. The Winnipeg River was identified as the eventual discharge location of seepage from the WR-1.
- Mean advective groundwater travel times to the Winnipeg River were estimated to be on the order 100 years.
- The peak total activity level estimated from the simulations (~3×10^9 Bq/yr.) occurs after approximately 70 years. The peak activity is principally related to the migration of tritium from the WR-1. Due to dispersion, the finite amount of tritium in the source (grout) and the half-life associated with tritium (approximately 12 years) its peak arrival occurs earlier than the mean advective groundwater travel time.
- Mass flux rates from 53 radiological parameters, and 29 non-radiological elements were simulated in the groundwater flow and transport model as shown in Golder (2017). These parameters and elements were selected based on the expected mass inventory for the WR-1 Building as discussed in Section 4.1.1 of Golder (2017). Mass flux estimates for a simulation period of 500,000 years were then provided for incorporation in the ERA for an assessment of effects to human and ecological health. Key controls on the magnitude of the peaks and the timing of the peak mass fluxes include adsorption properties for each solute, rates of decay and in-growth for the radiological parameters, and source release mechanism (i.e., distributed initially within the grout matrix versus released slowly through corrosion of WR-1 components).

6.3.2.7 Prediction Confidence and Uncertainty

The groundwater flow and solute transport results presented in Golder (2017) are based on our currently available best-estimates and assumptions of the input parameters and processes affecting solute transport. Uncertainty in both the groundwater flow and solute transport modelling is recognized, and was evaluated through the completion of a sensitivity analysis. The sensitivity analysis included the evaluation of the effect of thirteen various model assumptions on model results as discussed in detail in Golder (2017).

One of the key assumptions of the solute transport modelling that was evaluated through the sensitivity analysis was that the source mass was distributed evenly throughout the grout block and that solute transport occurred through the foundation, which was conceptualized as a 1 m thick concrete material. This assumption is conservative, as the grout itself is anticipated to provide some additional separation between the source mass (most of which is confined within the metal components of the reactor) and the downstream environment.

Results of the sensitivity analysis indicate that inclusion of the grout as a barrier to solute migration generally resulted in considerably (5x for conservative species) lower peak mass loadings and significant increases (5x for conservative species) to the arrival time for peak mass loadings relative to the base case. For solutes with relatively short half-lives (e.g., tritium), the mass loadings were reduced by more than an order of magnitude. These changes reflect the additional time required for solute mass to migrate through the grout prior to reaching the foundation. Exceptions to this can occur for solutes where the advective mass loading was the predominant component of the total mass released from the source area (e.g., for C-14, this scenario resulted in a minor increase [<10%] to peak mass loadings at the bedrock pathway outflow).

6.3.2.8 Monitoring and Follow-up

As part of CNL's licence (NRTEDL-W5-8.04/2018) with the CNSC, CNL will implement an Environmental Assessment Follow-up Program for WR-1 to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. For monitoring requirements arising from the Project appropriate procedures will be developed that will meet or exceed federal and provincial regulatory requirements (Table 6.3.2-9). Monitoring will be coordinated with the Environmental Assessment Follow-up Program for the WL site, where practical. A post-decommissioning monitoring program will also be developed that will provide the sampling and analysis objectives and procedures for sampling and testing the groundwater quality in the vicinity of the WR-1 Building. The program will include details concerning sampling locations and sampling frequencies, analysis, quality assurance/quality control requirements, and will be compliant with CSA N288.7-15.

Table 6.3.2-9: 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	Changes to groundwater quality from the release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time during post-closure phases	■ Verify effects predictions on groundwater from the Project. ■ Verify the effectiveness of mitigation.	■ Water elevation measurements to determine groundwater flow direction and gradients. ■ Sampling to confirm groundwater quality to detect potential releases of constituents from the ISD reactor facility. ■ Initial sampling frequency will likely be twice per year (spring and fall).	Groundwater monitoring will continue through closure and post-closure. The number of parameters and locations may change based on annual review of monitoring data.	Project groundwater monitoring will be integrated into the overall CNL Groundwater Monitoring Program, and will be compliant with CSA N288.7-15.

6.3.2.9 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, scientists, government agencies, First Nation and Métis communities, or the public (the Agency 2014). Hydrogeology is recognized as an important component of the environment that may be affected by the Project and changes to hydrogeology could, in turn, lead to effects on other VCs selected for assessment. Acknowledging that changes to hydrogeology are considered to be important aspects of the natural and human environment, hydrogeology is referred to as an intermediate component. Results of the analysis of changes in measurement indicators for hydrogeology are provided to other disciplines for inclusion in their assessment.

Table 6.3.2-10 provides a summary of the residual adverse effects identified for hydrogeology. Based on the Comprehensive Study Report (AECL 2001), it was determined that the likelihood of contaminant transport beyond the WMA was very low and no effects on groundwater were anticipated from in situ disposal of the trenches; therefore, no overlap with the Project is expected. Changes to groundwater quality from the Project due to the release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time was identified as having a residual effect on the hydrogeological environment. Environmental design features and mitigation implemented to reduce residual effects on groundwater quality include:

- installation of a multi-component final cover system to mitigate moisture infiltration into the ISD reactor facility;
- removal of the service area and infilling in these areas with compact soil;
- sealing of open conduits in the building foundation;
- grouting the interior portion of the building (containing the remaining components of WR-1) to ground surface elevation; and
- performance monitoring will be completed throughout the post-closure phase for the Project to confirm that the cover and grout is functioning as intended, and to confirm modelling predictions.

Groundwater flow and solute transport modelling was completed to provide screening level solute mass loadings during the post-closure phase. The Winnipeg River was identified by the post-decommissioning groundwater flow model as the principal receptor of groundwater discharge from the geological pathway. Results of the groundwater flow modelling indicate that the mean advective groundwater travel times to the Winnipeg River were estimated to be on the order of 100 years. The peak total activity level estimated from the simulations occurs after approximately 70 years and is principally related to the migration of tritium from the WR-1. Due to dispersion, the finite amount of tritium in the source (grout) and the half-life associated with tritium (approximately 12 years) its peak arrival occurs earlier than the mean advective groundwater travel time.

As part of CNL's licence (NRTEDL-W5-8.04/2018) with the CNSC, CNL will continue to implement the Environmental Assessment Follow-up Program for the WL site to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. For monitoring requirements arising from the Project, but not covered in the Environmental Assessment Follow-up Program, appropriate procedures will be developed that will meet or exceed federal and provincial regulatory requirements. A post-decommissioning monitoring program will also be developed that will provide the sampling and analysis objectives and procedures for sampling and testing the groundwater quality in the vicinity of the WR-1 Building.

Table 6.3.2-10: Summary of Predicted Residual Adverse Effects for Hydrogeology

Valued Component	Assessment Endpoint	Residual Effect	Phase Project Effect Occurs in	Contributing Project Activity	Proposed Mitigation	Significance
Groundwater Quality	Intermediate component (i.e., it does not have an assessment endpoint)	Release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time may cause changes in groundwater quality	Post-Closure Phase	Post-Closure Performance – Grout and reactor components gradually deteriorate over time	■ Installation of a multi-component final cover system to mitigate moisture infiltration into the ISD reactor facility and hence limit release of solutes into the groundwater. ■ The planned decommissioning of the WR-1 Building presently involves: ▪ removal the service area and infilling in these areas with compact soil; ▪ sealing of open conduits in the building foundation; and ▪ grouting the interior portion of the building (containing the remaining components of WR-1) to ground surface elevation. ■ Performance monitoring will also be completed throughout the post-closure phase for the Project to confirm that the cover and grout is functioning as intended, and to confirm modelling predictions.	Significance is not determined as VC does not have an assessment endpoint; rather the results provided to other disciplines for inclusion in their assessment.

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6.4 Surface Water Environment

This section of the Environmental Impact Statement (EIS) for the Canadian Nuclear Laboratories (CNL) In Situ Decommissioning of WR-1 at the Whiteshell Laboratories Site (the Project) provides understanding of the potential residual effects of the Project and other past, present, and reasonably foreseeable developments on the physical aspects of the surface water hydrology (Section 6.4.1 Hydrology) and surface water quality (Section 6.4.2 Surface Water Quality).

6.4.1 Hydrology

6.4.1.1 Scope of the Assessment

The hydrology assessment follows the overall environmental assessment approach and methods described in Section 6.1 Environmental Assessment Approach. The assessment is completed in the following steps:

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries, and assessment cases** (refer to Sections 6.4.1.2 Valued Components and Section 6.4.1.3 Assessment Boundaries). The VCs and measurement indicators used to assess Project-related changes to hydrology, 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 6.4.1.4 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).
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 6.4.1.5 Project Interactions and Mitigation). 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 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. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. 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 described.
- **Step 4 – Identifying monitoring and follow-up** (refer to Section 6.4.1.6 Monitoring and Follow-up) required to confirm effects predictions and address uncertainty.
- **Step 5 – Present a consolidated summary of conclusions and outcomes of the assessment** (refer to Section 6.4.1.7 Conclusions) of residual effects on hydrology.

This section also describes how the input from engagement influenced the scope of the hydrology assessment and identifies the sources of information used to support the assessment. Information and concerns raised by the public, communities of interest, regulators and First Nation and Métis communities during engagement that influenced the scope of the hydrology assessment are summarized in Table 6.4.1-1. Other general concerns and questions raised during the engagement are documented in Section 4 Aboriginal Engagement and Section 5 Public Engagement.

Table 6.4.1-1: Summary of Issues Raised During Engagement Activities that Influenced the Scope of the Hydrology Assessment

Issue	How the Issue Was Included in the Assessment
The public and First Nation and Métis communities identified the importance of the Winnipeg River. A number of communities depend on the river for drinking water, recreation, and food.	The Winnipeg River was included in the Regional Study Area for the assessment of hydrology. Changes in hydrology were considered as an input to the water quality, land use and human health assessments.

6.4.1.2 Valued Components

Valued components refer to environmental features identified to be of concern by the proponent, scientists, government agencies, First Nation and Métis communities, or the public (the Agency 2014). Hydrology, which includes surface water flow and drainage direction, is recognized as an important component of the environment that may be affected by the 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 flow rates, direction and riverbed location potentially have an influence on the local and regional biodiversity, contributing to the spatial and temporal distribution of aquatic and terrestrial ecosystems. Subsequently, changes to these characteristics by Project activities could affect fish and wildlife and land and resource use (Table 6.4.1-2).

Table 6.4.1-2: Valued Components for Hydrology Assessment

Valued Component	Rationale for Selection
Hydrology	■ The Project may affect the spatial and temporal distribution of water quantity for aquatic and terrestrial biodiversity, which can subsequently affect land and resource use. ■ Public, First Nation and Métis concerns regarding changes in water quantity in the Winnipeg River are an important consideration in understanding potential effects of the 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 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 6.4.1-3). 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 6.4.1-3).

Table 6.4.1-3: Measurement Indicators for the Hydrology Assessment

Valued Component	Measurement Indicators	Discipline Assessments where Effects on Hydrology are Considered
Hydrology	■ Runoff rates and volumes ■ Drainage patterns	■ Section 6.4.2 Surface Water Quality ■ Section 6.5 Aquatic Biodiversity ■ Section 6.6 Terrestrial Biodiversity ■ Section 6.8 Land and Resource Use

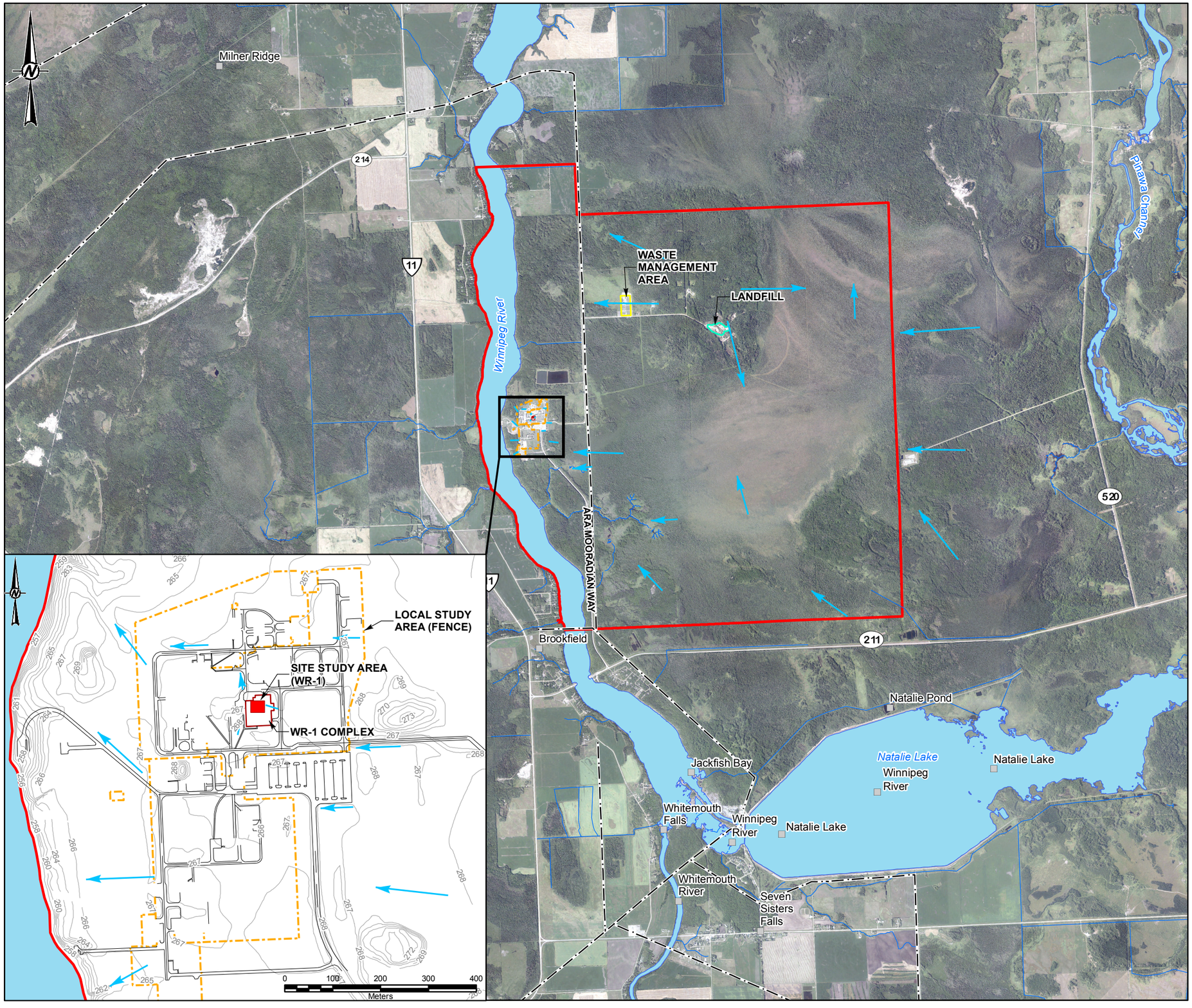
6.4.1.3 Assessment Boundaries

6.4.1.3.1 Spatial Boundaries

The spatial boundaries selected for the hydrology assessment are consistent with the surface water quality and aquatic biodiversity, and are presented on Figure 6.4.1-1 and described below:

- **Site Study Area (SSA)** is the WR-1 Building and represents the Project footprint (i.e., where project activities will be undertaken). The size of the SSA is 0.07 hectares (ha).
- **Local Study Area (LSA)** was selected in consideration of the Project footprint, and the spatial extent of potential direct effects of the Project on hydrology, surface water quality and the aquatic environment. The LSA was selected to represent an area that is likely to be directly affected by the Project, helping to identify Project-specific (rather than cumulative effects of the project in combination with other projects in the region). The LSA is represented by the fenced area of the WL main campus, and includes the SSA. The LSA was based on the area of the WL main campus that is currently drained by roadside ditches and storm sewers. The approximate size of the LSA is 29 ha. The LSA does not include the Winnipeg River as direct effects from the Project on the Winnipeg River are not anticipated. For example, direct effects to Winnipeg River as a result of changes in hydrology are anticipated to be negligible as the drainage area of the LSA is several orders of magnitude smaller than that of the Winnipeg River (15,000,000 ha).
- **Regional Study Area (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 reasonable foreseeable projects. The RSA is delineated by the property boundaries (WL site) including the Winnipeg River reach adjacent to WL site. For example, indirect effects on surface water quality from the Project include potential seepage of groundwater into the Winnipeg River. The plume from the discharged effluent during operation was previously assessed to hug the east bank of the river (AECL 1973) and it is assumed that a groundwater seep in relatively the same area will behave similarly. Therefore, the south boundary of the RSA extends from the west shore of the Winnipeg River to the east fence on the property line about 400 m north of Provincial Highway 211. The eastern boundary of the RSA follows the fence on the property line to the north property line. The north boundary follows the north fence on the property line about 1.6 km and then turns north for about 400 m before turning west and extending to the west side of the Winnipeg River. This is to include the first farm downstream on the east bank because this is the most conservative potential water user. The west boundary follows the west bank of the Winnipeg River. The RSA has an approximate size of 4,000 ha.

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LEGEND

- DRAINAGE FLOW PATTERN
- SITE STUDY AREA (WR-1)
- LOCAL STUDY AREA (WHITESHELL LABORATORIES FENCE)
- REGIONAL STUDY AREA

WHITESHELL LABORATORIES

- WR-1 COMPLEX
- WASTE MANAGEMENT AREA
- LANDFILL

BASE FEATURES

- CITY/TOWN
- TRANSMISSION LINE
- ROAD
- CONTOUR - 1 M INTERVAL
- WATERCOURSE
- WATERBODY

0 1,000 2,000 3,000 4,000
1:60,000 METRES

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

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PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
SPATIAL BOUNDARIES AND DRAINAGE PATTERNS FOR THE SURFACE WATER ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE
REVIEWED	CS
APPROVED	MM

PROJECT NO. 1656897 | CONTROL | REV. 1 | FIGURE **6.4.1-1**

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6.4.1.3.2 Temporal Boundaries

The temporal boundary of the assessment includes effects observed under existing conditions, the timeframe during which Project activities are actively occurring and 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 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 Project:

- **Closure Phase:** Preparation and implementation of In situ Decommissioning (ISD), which includes preparation for ISD, grouting of below-grade structures and systems, removal of above-grade WR-1 structures and systems, installation of the engineered cover and environmental controls and final site restoration. These activities last from 2019 to 2024.
- **Post-closure Phase:** The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. The Institutional Control period includes implementation of both active and passive control throughout 2024 to 2324 (i.e., 300 years). During active Institutional Control, long-term performance monitoring and maintenance activities will continue through to 2124 to demonstrate compliance with the safety case assumptions. The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions) and will continue through 2024 to 2324. Post-institutional Control occurs after year 2324 and continues indefinitely.

6.4.1.3.3 Assessment Cases

The assessment cases considered in the hydrology assessment include the Base Case, Application Case, and the Reasonably Foreseeable Development (RFD) 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, and residential and recreational development. Current effects from the existing WL facilities and operations, for example, are considered part of the Base Case. Seven Sisters Generating Station is approximately 7.5 km upstream of the WL site and McArthur Generating Station is approximately 26 km downstream. In addition, effects from the decommissioning and reclamation activities already completed at the WL site are also considered as part of the Base Case.
- **Application Case:** This scenario represents the effects of the Base Case combined with the predicted effects from the Project. The Application Case includes closure and post-closure activities, and therefore, the associated effects during these phases of the Project represents the bounding case.
- **RFD Case**: this scenario represents the predictions of the cumulative effects of the Application Case, plus projects that are currently under application review or that have officially entered a regulatory application process and which overlap with the surface water environment RSA. Foreseeable developments in the surface water environment RSA that are expected to overlap with residual effects on hydrology from the Project includes the decommissioning of the remaining infrastructure and support facilities at the WL site as per the existing decommissioning licence. A Comprehensive Study Report (AECL 2001) under the *Canadian Environmental Assessment Act (1992)* was completed for the decommissioning of the WL site. The Environmental Assessment decision to approve the project was announced by the Minister of the Environment in March 2002 and a decommissioning licence was issued to AECL and subsequently to CNL. There are no other foreseeable developments in the surface water environment RSA that are expected to overlap with residual effects on hydrology from the Project.

6.4.1.4 Description of the Environment

6.4.1.4.1 Methods

Existing hydrological conditions (e.g., flow rates, volumes, velocities and direction) within and surrounding the RSA, including the Winnipeg River, were obtained through a literature review of available baseline information and public information. Regional and local hydrology described in the Comprehensive Study Report (AECL 2001) and hydrology assessment at the WL site (AECL 2000) are summarized in this section. Daily discharge rates were provided by Manitoba Hydro (2016) at the Seven Sisters Generating Station (approximately 7.5 km upstream) and also taken from the Water Survey of Canada (2016) at McArthur Generating Station (approximately 26 km downstream). Water levels in the Winnipeg River for the intake water were provided by Whiteshell Laboratories (CNL 2016a).

Rainfall data were sourced from Environment Canada Weather Website (Government of Canada 2016). Runoff volumes generated by rainfall events within the SSA were estimated using the rainfall depths and intensities (i.e., Intensity-Duration-Frequency [IDF] data) recorded at the Climate Station 5023233. This is the closest climate station with available rainfall IDF data from Environment Canada is approximately 75 km west of the WL site (i.e., Winnipeg St Boniface CS 5023233). The Rational Method was applied to determine the peak runoff rates generated from the SSA (MOE 2003).

6.4.1.4.2 Results

The following sections present the results of the literature review relating to characterization of the Winnipeg River, local and regional drainage patterns, and estimates of the SSA surface water flows.

6.4.1.4.2.1 General Overview

The dominant hydrological feature of the RSA is the Winnipeg River, which flows on the west side of the RSA (Figure 6.4.1-1). The Winnipeg River flows from the Lake of the Woods and the English River system in Northwestern Ontario and drains to Lake Winnipeg located northwest of the WL site.

The Winnipeg River is classified as a medium-sized low land river. The total drainage basin of the Winnipeg River is approximately 15,000,000 ha. The river flow is determined by hydrologic conditions over the entire upstream drainage area and is not likely affected by localized precipitation events.

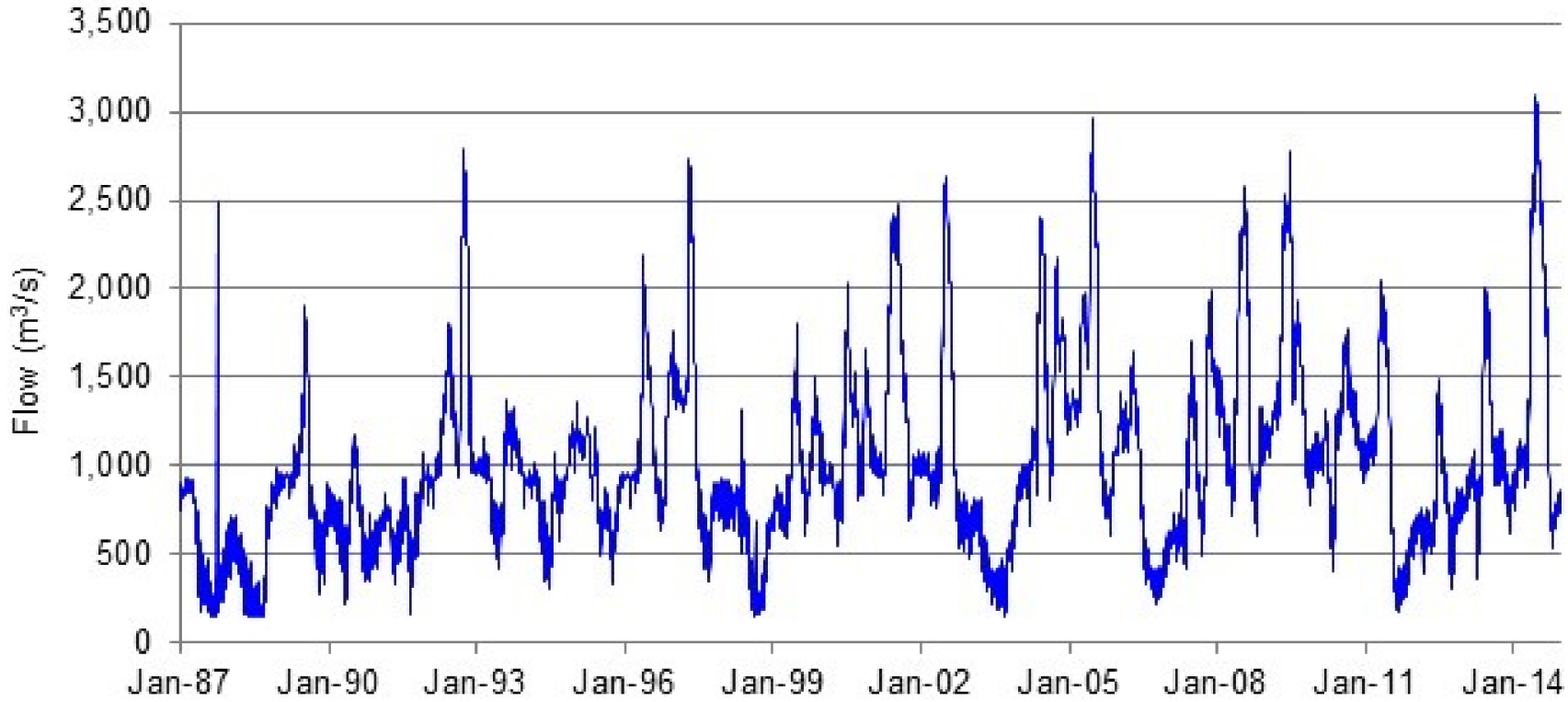
A descent in ground elevation of 83 m from the Manitoba/Ontario border to Lake Winnipeg through a series of falls and rapids has resulted in extensive hydroelectric exploitation of this river. Six electric generating stations are present on the Winnipeg River, whose discharge rate is now largely controlled by these hydroelectric dams, which precludes any short-term correlation between precipitation and river flow. The two most relevant stations are the Seven Sisters Generating Station, which is approximately 7.5 km upstream of the WL site and McArthur Generating Station, which is approximately 26 km downstream.

Near the LSA, the river is approximately 300 m wide, 7 m deep and flows in a northerly direction at a velocity of approximately 0.3 metres per second (m/s). Flow rates measured at the nearby Seven Sisters Falls Hydroelectric Generating Station (approximately 7.5 km upstream of the WL site) typically vary between 600 to 1,800 cubic metres per second (m^3/s) with a record low at 125 m^3/s and as high as 2,800 m^3/s (CNL 2016b).

The flow of the river is usually lowest in late summer/early fall and highest in late spring/early summer (Figure 6.4.2-2). This follows typical temporal river patterns with water levels affected by spring snow melt and large precipitation events in spring and fall. The dams on the Winnipeg River provide some storage capacity, preventing extreme flooding and extreme low water levels.

A stage-discharge graph compares the river level to river flow. For the Winnipeg River, the water levels were taken at the WL pump house (AECL 2016) and the flows were taken approximately 7.5 km upstream at Seven Sisters Generating Station (Manitoba Hydro 2016). The stage-discharge for the Winnipeg River adjacent to the WL site demonstrates that there is a relationship between flow and water level at higher flow and water levels, but this changes when flow is below 1,200 m^3/s and elevation is below 255 m (Figure 6.4.2-3). As there are no extreme low water levels at low flows, it is inferred that the downstream dam, McArthur, is likely influencing water elevation in low flow conditions.

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NOTE(S)

REFERENCE(S)

1. OBTAINED FROM WHITESHELL LABORATORIES 2016, MANITOBA HYDRO 2016

CLIENT
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PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

CONSULTANT
Golder Associates

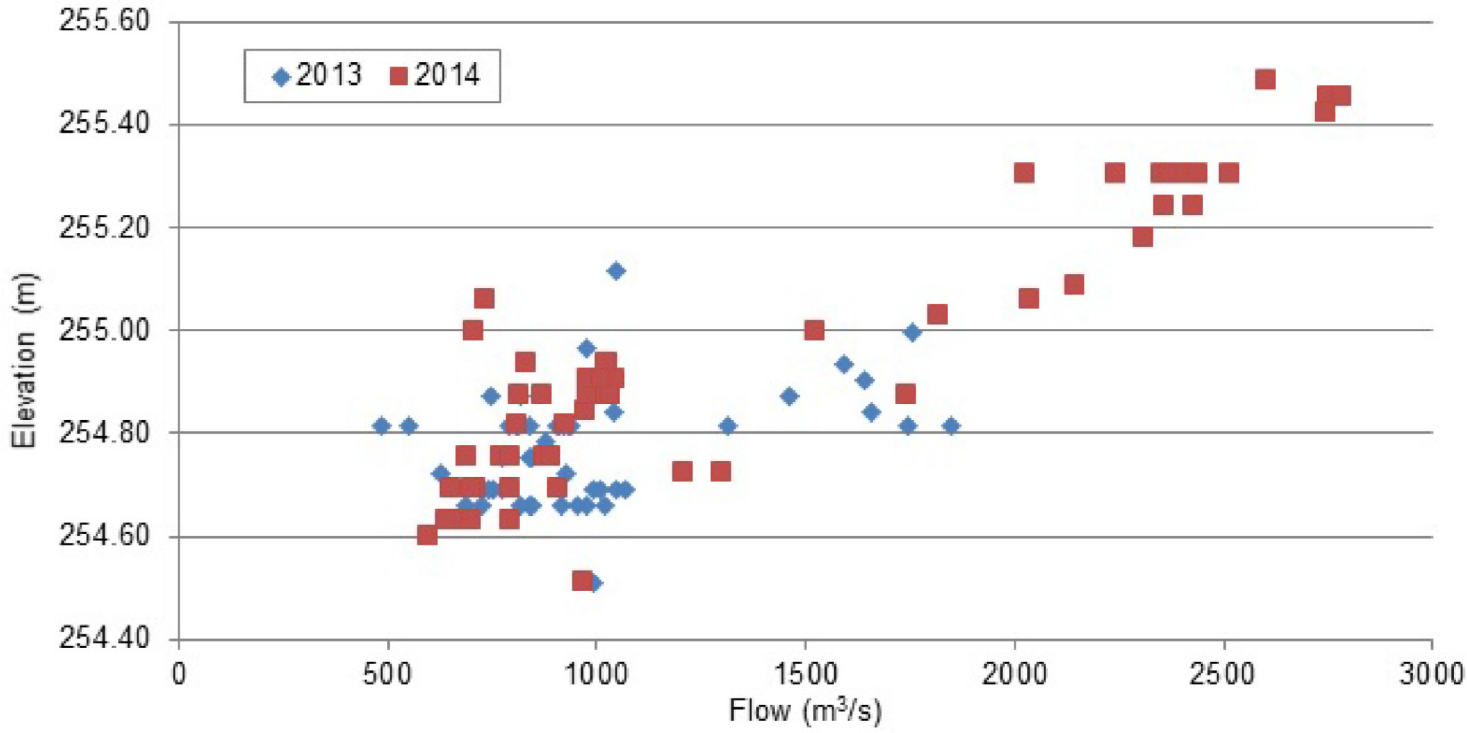
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REVIEWED	NR
APPROVED	NB

TITLE
FLOW OF THE WINNIPEG RIVER AT MCARTHUR GENERATING STATION

PROJECT NO.	CONTROL	REV.	FIGURE
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NOTE(S)

REFERENCE(S)

1. OBTAINED FROM WHITESHELL LABORATORIES 2016, MANITOBA HYDRO 2016

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PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

CONSULTANT
Golder Associates

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REVIEWED	NR
APPROVED	NB

TITLE
WATER ELEVATION OF THE WINNIPEG RIVER AT WHITESHELL LABORATORIES AND THE FLOW AT SEVEN SISTERS GENERATING STATION ON THE SAME DAY IN 2013 AND 2014

PROJECT NO.	CONTROL	REV.	FIGURE
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6.4.1.4.2.2 Drainage Patterns

Surface water runoff generated within the SSA and LSA drains into the Winnipeg River. The SSA area is 0.07 ha and the LSA area is approximately 29 ha. Drainage around the LSA perimeter is accommodated by the use of shallow swales and drainage ditches. The roads, parking pads and roof discharges within the LSA are drained by underground storm drains that flow into the main drainage ditches within the LSA and directed to the Winnipeg River (AECL 2000).

The RSA is a very low-lying area with local elevations of only a few tens of centimetres to a few metres; the elevation difference from the WL main campus to river bank is approximately 0.5 m. Most of the surficial geology consists of glacial lacustrine and glacial till deposits (about 20 m thick). Overlying, are deposits of organic matter (i.e., wetland, swamp areas) most often about 0.5 to a few meters thick. There are also some localized areas that are well-drained, and these drier soils support mixed hardwood stands (AECL 2000). Most of the runoff from the RSA drains directly into Winnipeg River. A small amount of land from the low-lying eastern area within the WL site drains by ditches and small streams that flow into the Pinawa Channel. The Pinawa Channel, a diversion of some of the Winnipeg River discharge, flows in a roughly south to north direction on the eastern side of the RSA. Drainage within the RSA are directed by roadside ditches. The drainage area and quantity of discharge within the various drainage ditches vary, with some ditches and culverts having only measurable flow following spring melt and after sustained wet periods. Two of the drainage ditches (along Provincial Road 211) are considered to be important for reducing surface storage and channel surface runoff directly to the Winnipeg River. One major drainage ditch, potentially diverting surface runoff from eastern boundary of the WL site, crosses Provincial Road 520 and drains into Pinawa Channel.

6.4.1.4.2.3 Surface Water Flow Estimation

The runoff rates and volumes generated by the SSA following activities of the Project are expected to decline slightly from the existing conditions. Therefore, in order to compare Base Case runoff estimates to runoff rates and volumes generated by the SSA after the decommissioning activities, a runoff coefficient of 0.75 was used, which corresponds to concrete covered areas (RTAC 1982). Speciality literature recommends a slightly higher runoff coefficient (0.83) for roofs, which is the current condition for drainage within the SSA.

Runoff volumes generated by rainfall events within the SSA were estimated using the rainfall depths and intensities (i.e., IDF data) recorded at the Climate Station 5023233. The Rational Method was applied to determine the peak runoff rates generated from the SSA that has an area of 0.07 ha (MOE 2003).

The Rational Method equation is: $Q = 0.00278\ C\ i\ A$

Where: Q = peak flow (m^3/s),

- C = runoff coefficient (dimensionless),
- i = rainfall intensity (mm/h), and,
- A = drainage area (ha).

The rainfall intensity used in the Rational Method equation was determined based on the return period at the time of concentration calculated for the SSA drainage area and applying the IDF curves. Rainfall intensities for a range of return periods at the SSA are given in Table 6.4.1-4. Drainage peak flow generated by the SSA for a specific return period and duration of a rainfall event were determined by applying the rainfall intensity values presented in Table 6.4.1-4 to the Rational Method. The resulting runoff volumes generated by the SSA for various return periods and durations are presented in Table 6.4.1-5.

Table 6.4.1-4: Estimated Rainfall Intensities (mm/h) at the Site Study Area for Various Return Periods

Duration	Return Period					
	2 Years	5 Years	10 Years	25 Years	50 Years	100 Years
5 min	99.2	136.9	162.0	193.6	217.0	240.3
10 min	75.9	98.6	113.6	132.5	146.5	160.5
15 min	63.6	80.7	92.1	106.5	117.1	127.7
30 min	45.5	59.9	69.5	81.5	90.5	99.4
1 h	27.2	36.9	43.4	51.6	57.6	63.6
2 h	15.8	21.9	26.0	31.1	34.9	38.7
6 h	6.6	9.2	10.9	13.1	14.7	16.3
12 h	3.8	5.3	6.4	7.6	8.6	9.5
24 h	2.1	2.9	3.4	4.1	4.6	5.0

Note: mm/h = millimetre per hour; min = minute; h = hour.

Table 6.4.1-5: Estimated Runoff Volumes (m^3) Generated by the Site Study Area for Various Return Periods

Duration	Return Period					
	2 Years	5 Years	10 Years	25 Years	50 Years	100 Years
5 min	6	8	9	11	12	13
10 min	7	10	11	13	15	16
15 min	8	11	13	15	17	18
30 min	10	14	16	19	21	23
1 h	12	17	20	23	26	29
2 h	15	21	25	29	32	36
6 h	21	29	35	41	46	51
12 h	26	36	43	52	58	64
24 h	33	45	54	64	72	80

Note: m^3 = cubic metres; min = minute; h = hour.

The peak runoff rate from the SSA for a 1:25-year rainfall event is 0.04 m^3/s and, for a 1:100-year event, it is 0.05 m^3/s. The runoff volume generated by the SSA for a 1:25-year; 24-hour event is approximately 72 m^3 and for a 1:100-year event it is 80 m^3. Flow contribution to the Winnipeg River from the SSA is four or five orders of magnitude smaller than the river average flow.

6.4.1.5 Project Interactions and Mitigation

6.4.1.5.1 Methods

This section describes the process by which interactions between Project components and activities and hydrology were identified and evaluated. Potential effect 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 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 Project. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. The next step in the analysis was the development of environmental design features and mitigation that could be incorporated into the 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 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 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 pathway –** 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 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 Project effects or to the effects of other past, present 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 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 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 Project.

6.4.1.5.2 Results

Pathways through which all phases of the Project may interact with and result in changes to measurement indicators for hydrology are provided in Table 6.4.1-6.

Table 6.4.1-6: Pathways Analysis for Hydrology Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Installation of the engineered cover during closure	Installation of engineered cover at the WR-1 Building may alter drainage rates and flow patterns	The Project site and engineered cover will be graded to promote drainage from the site to the Winnipeg River.	Secondary
Closure of the entire WL site	Decommissioning and reclamation of the entire WL site, including the Project, may alter drainage rates and flow patterns	■ The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. ■ The drainage system for the reclaimed WL site will have the similar physical characteristics as the natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. ■ The WL site will be graded to promote drainage from the site to the Winnipeg River.	Secondary

6.4.1.5.2.1 No Linkage Pathway

There are no pathways identified as having no linkage to effects on hydrology.

6.4.1.5.2.2 Secondary Pathways

■ **Installation of engineered cover at the WR-1 Building.**

Drainage from the LSA is to the Winnipeg River. Following the completion of closure activities, the Project site and engineered cover will be graded to promote drainage from the site to the Winnipeg River. Run-off control for the cover is designed to limit erosion and infiltration of water into the grouted structure. This is achieved by sloping the cover surface to maintain a slope toward the edges, and the collection of water by the surface water management systems at the WL Site. Although the installation of the engineered cover at the WR-1 Building is expected to slightly alter the drainage rates and flow patterns and discharge volume to the Winnipeg River; the changes are expected to be within the natural range of variation. As such, effects to hydrology from the installation of the cover at closure is predicted to have a negligible residual effect on hydrology relative to the Base Case.

- **Decommissioning and reclamation of the entire WL site, including the Project.**

The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. The drainage system for the reclaimed WL site will have similar physical characteristics as similar natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. The contribution to site runoff from the Project is expected to be minor relative to the entire decommissioned WL site. Similar to the decommissioning plan for the Project, the WL site will be graded to promote drainage to the Winnipeg River. Although closure of the WL site may slightly alter the drainage rates and flow patterns and discharge volume to the Winnipeg River; the changes are expected to be within the natural range of variation. As such, effects to hydrology from the closure of the WL site, including the Project, are predicted to have a negligible residual effect on hydrology relative to the Base Case.

6.4.1.5.2.3 Primary Pathways

There are no primary pathways identified as having a residual effect on hydrology. As such, there is no residual effects analysis and determination of significance completed for the hydrology assessment.

6.4.1.6 Monitoring and Follow-up

Monitoring and follow-up programs are not identified as there are no predicted residual effects to hydrology. However, CNL will implement the Environmental Assessment Follow-up Program for WR-1 as identified for other environmental components to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. This monitoring will be coordinated with that for the existing Environmental Assessment Follow-up Program at the WL site, where practical.

6.4.1.7 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, scientists, government agencies, First Nation and Métis communities, or the public (the Agency 2014). Hydrology, which includes surface water quantity, flow and direction, is recognized as an important component of the environment that may be affected by the 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. Results of the analysis of changes in measurement indicators for hydrology are provided to other disciplines for inclusion in their assessment.

The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. Following the completion of closure activities, the WL site and engineered cover will be graded to promote drainage from the site to the Winnipeg River. Run-off control for the cover is designed to limit erosion and infiltration of water into the grouted structure. This is achieved by sloping the cover surface to maintain a slope toward the edges, and the collection of water by the existing surface water management systems at the WL Site. Although the installation of the engineered cover at the WR-1 Building is expected to slightly alter the drainage rates and flow patterns and discharge volume to the Winnipeg River; the changes are expected to be within the natural range of variation. As such, effects to hydrology from the installation of the cover at closure is predicted to have a negligible residual effect on hydrology relative to the Base Case.

The contribution to site runoff from the Project is expected to be minor relative to the entire decommissioned WL site. Similar to the decommissioning plan for the Project, the WL site will be graded to promote drainage to the Winnipeg River. Although installation of the cover and ultimate closure of the WL site may slightly alter the drainage rates and flow patterns and discharge volume to the Winnipeg River, the changes are expected to be within the natural range of variation. As such, effects to hydrology from the closure of the WL site, including the Project, are predicted to have a negligible residual effect on hydrology relative to the Base Case.

6.4.2 Surface Water Quality

6.4.2.1 Scope of the Assessment

Section 6.4.2 focuses on surface water quality within the Winnipeg River. It assesses the potential change in water quality attributed to the Project, including parameters relevant to the health of humans, aquatic biota and terrestrial wildlife.

The surface water quality assessment follows the overall environmental assessment approach and methods described in Section 6.1 Environmental Assessment Approach. The assessment is completed in the following steps.

- **Step 1 – Identifies Valued Components (VCs) and defines the spatial boundaries, temporal boundaries, and assessment cases** (refer to Section 6.4.2.2 Valued Components and Section 6.4.2.3 Assessment Boundaries) for the surface water quality assessment. The VCs, assessment endpoints, and measurement indicators used to assess Project related changes to surface water quality, the spatial and temporal boundaries at which the assessment occurred, and the assessment cases considered are described.
- **Step 2 – Describes the existing conditions** (refer to Section 6.4.2.4 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 – Evaluates Project interactions and mitigation** (refer to Section 6.4.2.5 Project Interactions and Mitigation). 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 effect pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. Where effects are adequately mitigated and are not forwarded to further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are described. 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 – Presents the methods and results of the residual effects analysis** (refer to Section 6.4.2.6 Residual Effects Analysis). This section outlines the methods used to predict and characterize residual effects to surface water quality from primary effect pathways. The analysis results are also presented including the characterization of incremental effects from the 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 surface water parameters in the Winnipeg River that are passed to other disciplines for their assessment.

- **Step 5 – Describes the level of certainty and management of uncertainty** (refer to Section 6.4.2.7 Prediction Confidence and Uncertainty). The purpose of the 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 – Identifies monitoring and follow-up** (refer to Section 6.4.2.8 Monitoring and Follow-up) required to confirm effect predictions and address uncertainty.
- **Step 7 – Presents a consolidated summary of conclusions and outcomes of the assessment** (refer to Section 6.4.2.9 Conclusions) of residual effects on surface water quality.

This section also describes how the input from engagement influenced the scope of the surface water quality assessment. Information and concerns raised by the public, communities of interest, regulators and First Nations and Métis Groups during engagement that influenced the scope of the surface water quality assessment are summarized in Table 6.4.2-1.

Table 6.4.2-1: Summary of Issues Raised During Engagement Activities that Influenced the Scope of the Surface Water Quality Assessment

Issue	How the Issue Was Included in the Assessment
The public and First Nation and Métis communities identified the importance of the Winnipeg River. A number of communities depend on the river for drinking water, recreation, and food.	The Winnipeg River was included in the Regional Study Area for the assessment of water quality. Changes in water quality were considered as an input to the land use and human and ecological health assessments.
Concerns about the long term effects of the WL site and the Project on water quality and fish,	Release of contaminants in the long-term to water quality and aquatic species during the post-closure phase was considered as part of the assessment.

6.4.2.2 Valued Components

Valued components refer to environmental features that may be influenced by the Project and that have been identified to be of importance by the proponent, scientists, government agencies, First Nation and Métis peoples, or the public (the Agency 2014). Surface water quality was selected as a VC since the Project may indirectly discharge to the Winnipeg River (Table 6.4.2-2). Subsequently, changes to surface water quality by Project activities could affect human health, fish and wildlife, and land and resource use (Table 6.4.2-2).

Table 6.4.2-2: Valued Components for Surface Water Quality Assessment

Valued Component	Rationale for Selection
Surface Water Quality	There is potential for interaction with the Project; species of concern live in the river; river has ecological and socio-economic value to communities, government agencies, and the public; and downstream areas have traditional, cultural, and heritage importance to First Nation and Métis people.

Acknowledging that changes to water quality is considered to be an important aspect 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 VCs must be understood to facilitate assessment of project interactions. The surface water assessment, therefore, is analyzed for incremental and cumulative (if applicable) changes in the relevant measurement indicators associated with surface water quality (Table 6.4.2-3).

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 changes are characterized in terms of magnitude, duration and geographic extent, but are not classified using rankings for effects criteria. The surface water quality assessment also does not include the assessment of the significance of these changes; rather, results of the analysis of changes in measurement indicators for surface water quality are provided to other disciplines for inclusion in their assessment (Table 6.4.2-3).

Surface waters interact with other environment features, including humans, aquatic biota and terrestrial wildlife. The results of the surface water quality assessment therefore extend to other disciplines as listed in Table 6.4.2-3.

Table 6.4.2-3: 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	Changes to ambient levels of surface water contaminants (turbidity, radionuclides, metals)	■ Aquatic Environment (Section 6.5) ■ Terrestrial Environment (Section 6.6) ■ Human and Ecological Health (Section 6.7) ■ Land and Resource Use (Section 6.8)

6.4.2.3 Assessment Boundaries

6.4.2.3.1 Spatial Boundaries

The spatial boundaries selected for the surface water quality assessment are consistent with hydrology and aquatic environment, and are presented on Figure 6.4.2-1.

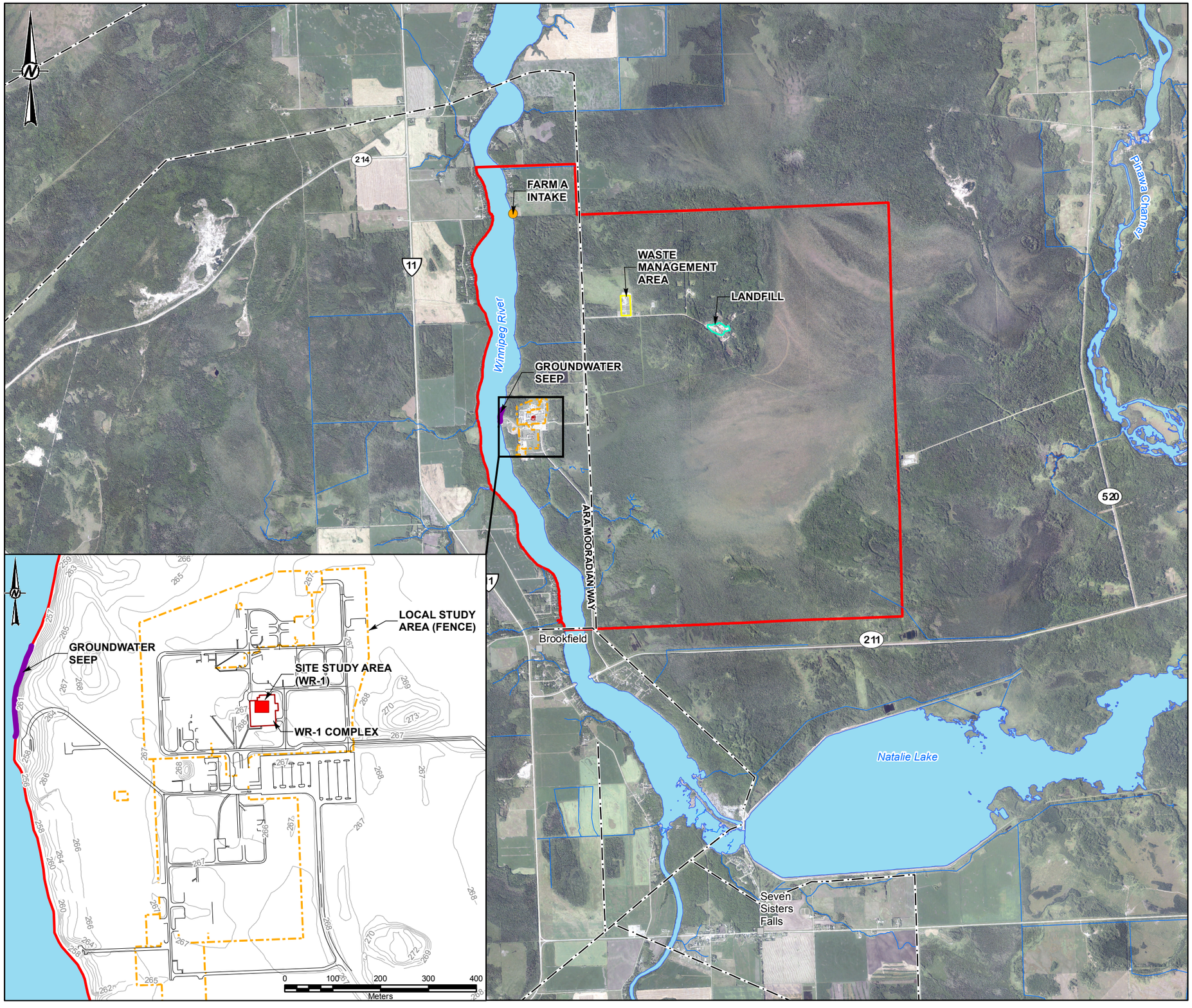
- **Site Study Area (SSA):** is the WR-1 Building and represents the Project footprint (i.e., where project activities will be undertaken). The area size of the SSA is 0.07 hectares (ha).
- **Local Study Area (LSA):** was selected in consideration of the Project footprint and the spatial extent of potential direct effects of the Project on hydrology, surface water quality, and the aquatic environment. The LSA was selected to represent an area that is likely to be directly affected by the Project, helping to identify Project-specific (rather than cumulative effects of the Project in combination with other projects in the region). The LSA is represented by the fenced area of the WL main campus, and includes the SSA. The LSA was based on the area of the WL main campus that is currently drained by roadside ditches and storm sewers. The approximate size of the LSA is 29 ha. The LSA does not include the Winnipeg River as direct effects to surface water quality from the Project on the Winnipeg River are anticipated to be negligible. Conversely, indirect effects to the surface water quality of the Winnipeg River may occur as a result of changes to groundwater quality resulting from the Project. As such, the Winnipeg River is considered as part of the RSA (see description below).

- **The Regional Study Area (RSA)** is defined as the area within which maximum geographical extent of potential indirect effects of the Project may interact with the effects of other existing or reasonably foreseeable projects. For example, indirect effects on surface water quality from the Project include potential seepage of groundwater into the Winnipeg River. The plume from the discharged effluent during operation was previously assessed to hug the east bank of the river (AECL 1973) and it is assumed that a groundwater seep in relatively the same area will behave similarly. Therefore, the south boundary of the RSA extends from the west shore of the Winnipeg River to the east fence on the property line about 400 m north of Provincial Highway 211. The eastern boundary of the RSA follows the fence on the property line to the north property line. The north boundary follows the north fence on the property line about 1.6 km and then turns north for about 400 m before turning west and extending to the west side of the Winnipeg River. This is to include the first farm (Farm A) downstream on the east bank because this is the most conservative potential water user. The west boundary follows the west bank of the Winnipeg River. The RSA has an approximate size of 4,000 ha.

6.4.2.3.2 Temporal Boundaries

The temporal boundary of the assessment includes effects observed under existing conditions, the timeframe during which Project activities are actively occurring, and 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 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 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 Project:

- **Closure Phase:** Preparation and implementation of In Situ Decommissioning (ISD), which includes preparation for ISD, grouting of below-grade structures and systems, removal of above-grade WR-1 structures and systems, installation of the engineered cover and environmental controls and final site restoration. These activities last from 2019 to 2024.
- **Post-closure Phase:** The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. The Institutional Control period includes implementation of both active and passive control throughout 2024 to 2324 (i.e., 300 years). During active Institutional Control, long-term performance monitoring and maintenance activities will continue through to 2124 to demonstrate compliance with the safety case assumptions. The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions) and will continue through 2024 to 2324. Post-institutional Control occurs after year 2324 and continues indefinitely.



LEGEND

- FARM A INTAKE
- GROUNDWATER SEEP
- SITE STUDY AREA (WR-1)
- LOCAL STUDY AREA (WHITESHELL LABORATORIES FENCE)
- REGIONAL STUDY AREA

WHITESHELL LABORATORIES

- WR-1 COMPLEX
- WASTE MANAGEMENT AREA
- LANDFILL

BASE FEATURES

- CITY/TOWN
- TRANSMISSION LINE
- ROAD
- CONTOUR - 1 M INTERVAL
- WATERCOURSE
- WATERBODY

0 1,000 2,000 3,000 4,000
1:60,000 METRES

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
SPATIAL BOUNDARIES FOR THE SURFACE WATER QUALITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE/PR
REVIEWED	CS
APPROVED	MM

PROJECT NO. 1656897 | CONTROL | REV. 1 | FIGURE **6.4.2-1**

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6.4.2.3.3 Assessment Cases

There are three assessment cases considered in this EIS: the base case; application case; and reasonably foreseeable developments (RFD) case.

- **Base Case –** This scenario represents existing conditions and characterized 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 activities. Current effects from the existing WL facilities such as effluent discharged to the Winnipeg River are considered. These include the ditch drainage system of the ~~w~~Waste ~~m~~Management ~~a~~Area (WMA) and sewage lagoon. Sediment near the effluent outfall has elevated levels of radionuclides due to historical discharge and fallout (AECL 2001a), and are is also considered as part of the Base Case. Levels of Cs-137 in soil and sediment are elevated in the WL area (latitude 40 to 60 degrees) due to above average deposition from world-wide nuclear weapon testing during the cold war (AECL 2001a, NRCC 1983). Seven Sisters Generating Station is approximately 7.5 kilometres (km) upstream of the WL site and McArthur Generating Station is approximately 26 km downstream. In addition, effects from the decommissioning and reclamation activities already completed at the WL site are also considered as part of the Base Case.
- **Application Case –** This scenario represents the effects of the Base Case combined with the predicted effects from the Project. The Application Case includes closure and post-closure activities. Surface water runoff during closure and the groundwater seep during post-closure represent the bounding cases.
- **RFD Case –** This scenario represents the predictions of the cumulative effects of the Application Case, plus projects that are currently under application review or that have officially entered a regulatory application process and which overlap with the surface water quality in the RSA. Foreseeable developments in the surface water environment RSA that are expected to overlap with residual effects on surface water quality from the Project includes the decommissioning of the remaining infrastructure and support facilities at the WL site as per the existing decommissioning licence. A Comprehensive Study Report (AECL 2001b) under the *Canadian Environmental Assessment Act* (1992) was completed for the decommissioning of the WL site. The Environmental Assessment decision to approve the project was announced by the Minister of the Environment in March 2002 and a decommissioning licence was issued to AECL and subsequently to CNL. There are no other foreseeable developments in the RSA that are expected to overlap with changes to surface water quality.

6.4.2.4 Description of the Environment

6.4.2.4.1 Methods

This section documents the methods, data, and results that were used to describe the background surface water quality in the SSA, LSA and RSA for surface water parameters. The assessment was carried out by reviewing documents and collecting data from government agencies. Where possible, surface water parameters were compared to federal or provincial standards, objectives, or guidelines. Where guidelines from the federal or provincial jurisdictions were missing, guidelines from other provinces or toxicity tests were used. Acute toxicity tests were divided by 100 and chronic toxicity tests were divided by 10 to adjust the values to a no observable adverse effects level guideline.

Some sediment samples downstream of the outfall had elevated levels of radionuclides so a more detailed investigation was conducted in 2000 (AECL 2001a). The sediment surface was surveyed with a gamma survey probe and gamma spectroscopy probe. Sediment samples were also collected for laboratory analysis of radionuclides. In 2006 sediment cores were taken as part of Work Package #8 of the Environmental Assessment Follow-Up Program (AECL 2008). This program involves sampling in Lake Sylvia, and upstream and downstream of the waterbody Lac du Bonnet every twenty years. The objective is to characterize sediment adjacent to WL by age dating with lead-210 (Pb-210) methods. As part of the routine monitoring at the WL site, water, sediment, and biota are sampled regularly (CNL 2012, 2013, 2014, 2015, and 2016a). Radionuclides measured in liquids are reported as Becquerel per litre (Bq/L) and radionuclides measured in solids are reported as Becquerel per kilogram (Bq/kg).

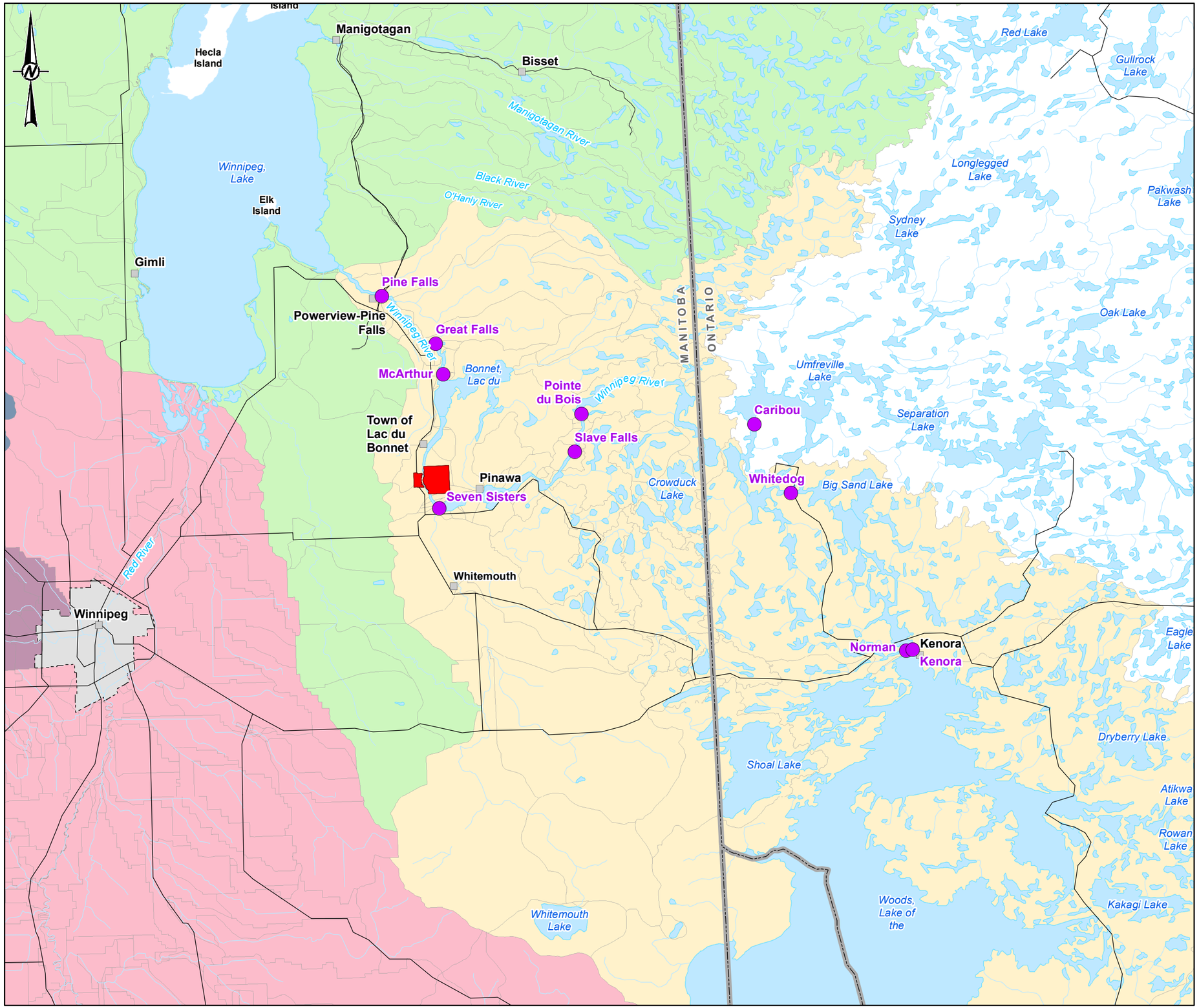
Daily discharge rates were provided by Manitoba Hydro (2016) at the Seven Sisters Generating Station 7.5 km upstream and were also taken from the Water Survey of Canada (2016) at McArthur Generating Station. Water levels in the Winnipeg River and water chemistry for the intake water was provided by Whiteshell Laboratories (CNL 2016d). Water quality was also provided by the Manitoba Water Quality Management Section (2016) from the Pine Falls.

6.4.2.4.2 Results

6.4.2.4.2.1 General Overview

The Winnipeg River is considered to be a medium sized lowland river (AECL 2001b). Its drainage area is approximately 15,000,000 ha, originating in Ontario at Lake of the Woods (Figure 6.4.2-2). There are nine hydroelectric dams within the watershed, the closest approximately 7.5 km upstream of the WL site. These dams have extensively modified flow patterns in the river (AECL 2001b). Dams store water during periods of high precipitation, and release water during periods of low precipitation. This regulates the downstream flow (Section 6.4.1.4.2, Figure 6.4.1-3). Adjacent to the WL site, the river is approximately 0.3 km wide and 7 m deep and flows northerly between 436 and 1,842 cubic metres per second (m^3/s; 2010 to 2015 average at Seven Sisters Generating Station; [Manitoba Hydro 2016]) to Lake Winnipeg.

The flow of the river is usually lowest in late summer/early fall and highest in late spring/early summer (Section 6.4.1.4.2, Figure 6.4.1-2). This follows typical temporal river patterns with water levels affected by spring snow melt and large precipitation events in spring and fall. The dams on the Winnipeg River provide some storage capacity, preventing the extreme flooding and extreme low water levels. For the Winnipeg River, the water levels were taken at the WL pump house (CNL 2016d) and the flows were taken approximately 7.5 km upstream at Seven Sisters Generating Station (Manitoba Hydro 2016). The stage-discharge for the Winnipeg River adjacent to the WL site demonstrates that there is a relationship between flow and water level at higher flow and water levels, but this changes when flow is below 1,200 m^3/s and elevation is below 255 m (Section 6.4.1.4.2, Figure 6.4.1-3).



LEGEND

- HYDROELECTRIC DAM LOCATION
- WHITESHELL LABORATORIES SITE

BASE FEATURES

- CITY/TOWN
- PROVINCIAL BOUNDARY
- MAJOR ROAD
- WATERCOURSE
- WATERBODY
- FIRST NATION RESERVE

WATERSHEDS

- ASSINIBOINE RIVER
- LAKE MANITOBA
- LAKE WINNIPEG
- RED RIVER
- WINNIPEG RIVER

0 20 40 60
KILOMETRES
1:900,000

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. HYDROELECTRIC DAM LOCATION - ECOMETRIX, 2017
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
HYDROELECTRIC DAMS AND WATERSHEDS

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE/PR
REVIEWED	JO/CB
APPROVED	

PROJECT NO. 1656897 | CONTROL | REV. 1 | FIGURE **6.4.2-2**

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6.4.2.4.2.2 Surface Water and Sediment Quality

Liquid effluent from the Active Liquid Waste Treatment Center (ALWTC) is discharged to the Winnipeg River via the Process Sewer at the sewer outfall located about 8 metres (m) offshore in approximately 5 m of water (AECL 2001b). The concentration of the dominant radionuclide associated with the discharge, cesium-137 (Cs-137), in downstream river water was 0.005 Bq/L compared to the Canadian Drinking Water Quality Guideline of 10 Bq/L. The Winnipeg River Task Force (1995) looked at potential sources of Winnipeg River water quality degradation near the community of Sagkeeng. The Task Force found that WL has not had an adverse effect on water quality in the Winnipeg River for downstream communities (AECL 2001b). The task force included members from the Sagkeeng First Nation, Environment Canada, Indian and Northern Affairs Canada, and Health Canada.

The monthly average of water chemistry for 2011 to 2015 for the intake water for WL site had concentrations of copper, iron, and lead exceeding the Manitoba Water Quality Standards, Objectives, and Guidelines (WQSOG) and chromium, copper, and lead exceeded the Canadian Council of Ministers of the Environment Water Quality Guidelines (CCME WQG; Table 6.4.2-4; Figure 6.4.2-2, Figure 6.4.2-3). Phosphorous concentrations in the river also exceed the WQSOG and increased between 2011 and 2015. Recently, the Winnipeg River has been classified as meso-eutrophic (at Pointe du Bois; ECCC 2015). This indicates that nutrient levels are moderate, which may lead to plant growth and reduced water clarity.

The provincial water sampling location at Powerview Dam Forebay (shown as Pine Falls in Figure 6.4.2-2) exceeded the aquatic life guideline for barium. Dissolved oxygen levels (Table 6.4.2-5) were usually around 10 milligrams per litre (mg/L), but were occasionally below 4 mg/L in the morning. Water quality does not comply with the WQSOG if the dissolved oxygen goes below 4 mg/L more than three times per year (MWS 2011). Temperatures varied seasonally, with extremes of 0.8 degrees Celsius (°C) and 29°C. The lowest and highest hardness measured was 43.2 and 58.5 mg/L, respectively, since 2010. Samples collected upstream of the WL site (Pinawa) has consistently had cesium-137 and strontium-90 concentrations below the federal drinking water standard (Table 6.4.2-5).

During the 2000 sediment investigation, the sediment downstream of the outfall was determined to be erosional, with a clay bottom covered in parts with sand, gravel, cobble, and boulders (AECL 2001a). Figure 6.4.2-4 presents the results from the 2000 gamma sediment survey. The y- and x-axis are distance on the bottom of the river in relation to the shore and outfall pipe of WL. The colouring indicates the gamma count rate (Becquerel, equivalent to counts per second; cps), where the redder the peak, the higher the count rate, the higher the disintegration of the radionuclides. The z-axis (up axis) indicates the relation of the disintegration to background, where the very top of the axis is 350-fold above background, which is considered a threshold for environmental exposure (AECL 2001a). AECL (2001a) determined that 350-fold above background or lower was acceptable for the protection of aquatic life. The highest count rate was 54 times background and the area averaged approximately 7 times background. The sediment core samples taken in this area had the highest activity in the top 1 centimetre (cm). A small area adjacent to the outfall had elevated radionuclide levels, but these levels were below the threshold that would cause adverse effects to human or ecological health. Therefore, during the discharge of the 1990s and 2000s, the accumulation of radionuclides in sediment had negligible environmental effects.

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Table 6.4.2-4: Water Quality of the Winnipeg River between Whiteshell Laboratories and Pine Falls, 2011 to 2015, for Parameters that are Stable Metals

Year	Summary Statistic	Unit	Parameter																					
			Boron	Barium	Bismuth	Cadmium	Cobalt	Chromium	Copper	Gadolinium	Iron	Hardness	Lead	Manganese	Mercury	Molybdenum	Nickel	Nitrogen	Palladium	Phosphorous	Potassium	Potassium Hydroxide	Ruthenium	Sulphur	Zinc
WQSOG		µg/L	-	-	-	**0.14***	-	**37.1***	**4.3 ***	-	**300**	**-**	**0.99***	-	**1**	-	**25.5 ***	-	-	**25**	-	-	-	-	**57.8***
CCME WQG		µg/L	**1,500**	-	-	**0.08**	-	**1.0 (VI)**	**2**	-	-	-	**1**	-	**0.026**	**73**	**25**	-	-	-	-	-	-	-	-
CDWG		µg/L	**5,000**	**1,000**	-	**5**	-	**50**	-	-	-	-	**10**	-	**1**	-	-	**1,000**	-	-	-	-	-	-	-
Other Aquatic Life Guideline		µg/L	-	**0.4[1]**	**0.25 [2]**	-	**0.9[3]**	-	-	**1.5[2]**	-	-	-	**794***	-	-	-	**3,000[5]**	**5.7[2]**	-	**5,300[1]**	**5,300[1]**	**10[2]**	-	-
2011	Minimum	µg/L	<10	11	<0.2	<0.01	<0.2	0.5	6.0	NV	400	46	<	10	<	<0.2	<	NV	NV	12	902	NV	NV	NV	<
	Maximum	µg/L	<10	15	<0.2	<0.01	0.31	1.9	39	NV	2,300	51	10	48	0.017	0.23	4.8	NV	NV	30	1,280	NV	NV	NV	20
	Average	µg/L	<10	13	<0.2	<0.01	0.21	1.2	13	NV	821	55	1.5	21	0.01	0.20	2.3	NV	NV	23	1,009	NV	NV	NV	5.1
2012	Minimum	µg/L	<10	11	<0.2	<0.01	<0.2	<	4.0	NV	300	51	<	9.0	<	<0.2	<	NV	NV	18	843	NV	NV	NV	4.0
	Maximum	µg/L	15	15	<0.2	0.02	0.36	2.2	61	NV	2,600	54	7.0	102	0.011	<0.2	4.6	NV	NV	37	1,200	NV	NV	NV	14
	Average	µg/L	11	12	<0.2	0.011	0.21	0.78	14	NV	738	59	1.3	19	0.01	0.20	2.2	NV	NV	27	945	NV	NV	NV	8.9
2013	Minimum	µg/L	<10	11	<0.2	<0.01	<0.2	<	3.0	NV	250	47	<	9.3	<	<0.2	<	NV	NV	20	819	NV	NV	NV	<
	Maximum	µg/L	<10	16	<0.2	0.01; <0.01	0.34	1.0	100	NV	4,000	51	6.0	63	0.01	0.22	3.1	NV	NV	105	1,120	NV	NV	NV	12
	Average	µg/L	<10	12	<0.2	0.01	0.21	0.43	19	NV	853	52	1.5	18	0.004	0.20	1.3	NV	NV	53	961	NV	NV	NV	3.5
2014	Minimum	µg/L	<10	10	<0.2	<0.01	<0.2	<	4.2	NV	300	45	<	10	<	<0.2	<	NV	NV	99	874	NV	NV	NV	<
	Maximum	µg/L	20	14	<0.2	<0.01	0.26	1.9	45	NV	4,801	48	6.3	20	0.030	0.21	3.6	NV	NV	122	1,020	NV	NV	NV	20
	Average	µg/L	12	11	<0.2	<0.01	0.20	0.79	18	NV	1,767	53	1.0	14	0.01	0.20	1.3	NV	NV	108	945	NV	NV	NV	6.5
2015	Minimum	µg/L	<10	9	<0.2	<0.01	<0.2	0.2	3.7	NV	270	44	<	8.5	<	<0.2	<	NV	NV	81	846	NV	NV	NV	<
	Maximum	µg/L	13	12	<0.2	0.01; <0.01	<0.2	4.6	26	NV	771	48	8.0	14	0.048	0.2; <0.2	3.5	NV	NV	290	991	NV	NV	NV	6.2
	Average	µg/L	10	11	<0.2	0.01	0.2	1.7	14	NV	405	54	2.6	11	0.01	0.20	1.8	NV	NV	111	907	NV	NV	NV	2.5
Water Quality Source			WQMS 2016	WQMS 2016	WQMS 2016	WQMS 2016	WQMS 2016	CNL 2016d	CNL 2016d	NA	CNL 2016d	WQMS 2016	CNL 2016d	WQMS 2016	CNL 2016d	WQMS 2016	CNL 2016d	NA	NA	CNL 2016d	WQMS 2016	NA	NA	NA	CNL 2016d

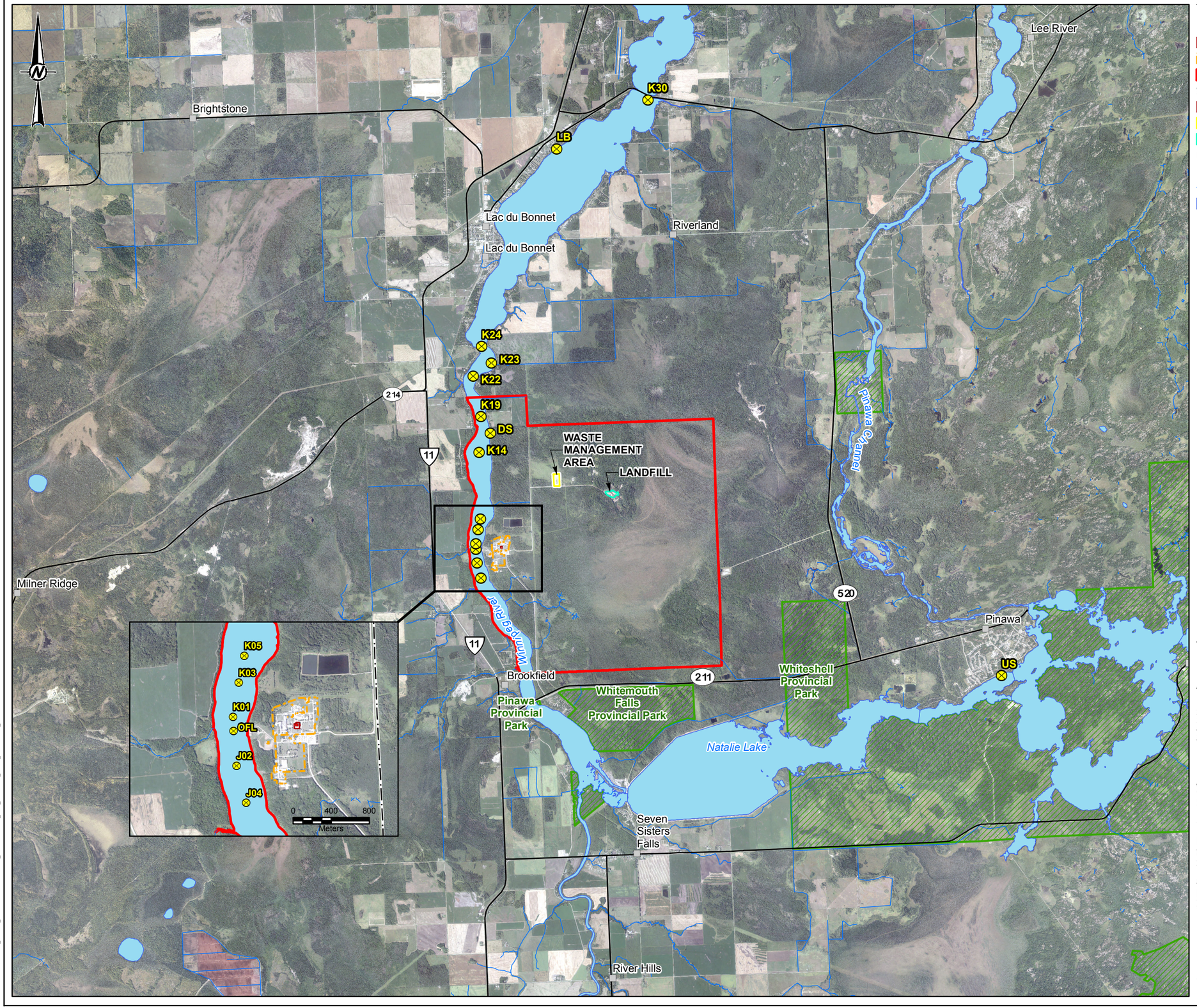
Notes:
WQSOG = Manitoba Water Quality Standards, Objective and Guidelines (MWS 2011). 43 mg/L was used for hardness from Pine Falls (WQMS 2016).
CCME WQG = CCME Water Quality Guidelines for the protection of aquatic life (CCME 1999a).
CDWG = Canadian Drinking Water Guidelines (HC 2009).
Other - Other guidance used where ecological or human health values not provided by sources above.
* Guideline is hardness-dependent.
<Value is less than detection.
1 - Secondary Chronic Value from Suter and Tsao (1996) divided by 10.
2 - LC_{50} from Borgmann et al. (2005) divided by 100.
3 - Ontario Provincial Water Quality Objective (MOEE 1994).
4 - British Columbia Water Quality Guidelines (BC MOE 2009).

WQMS 2016 indicates water quality from the provincial water sampling location at Pine Falls on the Winnipeg River.
CNL 2016d indicates water quality from the Whiteshell Laboratories intake on the Winnipeg River.
µg/L = microgram per litre.
NV – No value

Table 6.4.2-5: Water Quality of the Winnipeg River between Whiteshell Laboratories and Pine Falls, 2011 to 2015, for Parameters that are not Stable Metals

Year	Summary Statistic	Parameter											
		pH	Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Temperature (°C)	Turbidity (NTU)	Total Suspended Solids (mg/L)	Phenol (µg/L)	HB-40	Oil & Grease (mg/L)	Xylene	Cesium-137 (Bq/L)	Stronium-90 (Bq/L)
WQSOG		**6.5-9.0**	-	**‡**	**site-specific**	**10% Change**	-	**4.0**	-	**Free of**	-	-	-
CCME WQG		-	-	-	-	**+8/2 NTU short/long term**	-	**4.0**	-	-	-	-	-
CDWG		**6.5-8.5**	-	-	-	**3.0**	-	-	-	-	**90**	**10**	**5**
Other Aquatic Life Guideline		-	-	-	-	-	-	-	**2[1]**	-	**30[2]**	-	-
2011	Minimum	6.44	101	7.1	1.2	4.0	0.5	<	0	<	NV	0.002	0.004
	Maximum	7.55	114	11	12	48	5.5	2	0	1.9	NV	0.009	0.009
	Average	6.88	107	14	23	11	2.9	1.1	0	1.2	NV	0.004	0.007
2012	Minimum	6.37	98	2.0	4.0	4.2	1.5	<	0	0.7	NV	0.002	0.002
	Maximum	7.55	126	8.8	14	32	9	2	0	2.2	NV	0.007	0.11
	Average	6.81	109	14	24	9.9	4.2	0.79	0	1.4	NV	0.004	0.007
2013	Minimum	6.58	99	3.4	4.0	3.8	0.5	<	0	<	NV	0.003	0.044
	Maximum	7.67	119	9.6	15	8.1	9	2.4	0	3.1	NV	0.016	0.019
	Average	6.93	111	14	25	5.8	3.9	1.1	0	1.4	NV	0.006	0.007
2014	Minimum	6.65	86	1.9	0.8	3.2	0.5	<	0	<	NV	0.002	0.003
	Maximum	7.80	118	9.0	12	20	6	3.4	0	5.1	NV	0.006	0.031
	Average	7.23	102	14	23	5.1	2.9	0.9	0	1.3	NV	0.004	0.009
2015	Minimum	6.86	96	6.7	12	2.6	0.5	<	0	<	NV	0.003	0.005
	Maximum	7.66	113	10	23	7.0	4	7.1	0	3.8	NV	0.009	0.011
	Average	7.30	103	13	6.8	5.2	2.1	1.3	0	1.5	NV	0.005	0.007
Water Quality Source		CNL 2016de	WQMS 2016	WQMS 2016	WQMS 2016	WQMS 2016	CNL 2016d	CNL 2016d	Assumed	CNL 2016d	NA	CNL 2012, 2013, 2014, 2015, 2016a	

Notes:
WQSOG = Manitoba Water Quality Standards, Objective and Guidelines (MWS 2011). 43 mg/L was used for hardness from Pine Falls (WQMS 2016).
CCME WQG = CCME Water Quality Guidelines for the protection of aquatic life (CCME 1999a).
CDWG = Canadian Drinking Water Guidelines (HC 2009).
Other - Other guidance used where ecological or human health values not provided by sources above.
* Standard is hardness-dependent.
<Value is less than detection.
‡ For cool water, not more than once each 3 years below 5.5, 6.0, 4.0, 5.0, and 3.0 mg/L for 30 days, 7 days, 7 day minimum, instantaneous minimum, and instantaneous minimum, respectively. For cold water not more than once each 3 years below 6.5, 9.5, 5, 8, and 4 mg/L for 30 days, 7 days, 7 day minimum, instantaneous minimum, and instantaneous minimum, respectively.
1 - Lowest IC_{25} from HB-40 Toxicity Testing (EcoMetrix 2017a) divided by 10.
2 - British Columbia Water Quality Guidelines (BC MOE 2007).
WQMS 2016 indicates water quality from the provincial water sampling location at Pine Falls on the Winnipeg River.
CNL 2016d indicates water quality from the Whiteshell Laboratories intake on the Winnipeg.
µg/L = microgram per litre; mg/L = milligram per litre; µS/cm = microSiemens per centimetre; °C = degrees Celsius; Bq/L = Becquerel per litre; NTU = Nephelometric Turbidity Units.
NV – No value



LEGEND

- SAMPLING LOCATION
- SITE STUDY AREA (WR-1)
- LOCAL STUDY AREA (WHITESHELL LABORATORIES FENCE)
- REGIONAL STUDY AREA

WHITESHELL LABORATORIES

- BUILDING 100
- WASTE MANAGEMENT AREA
- LANDFILL

BASE FEATURES

- CITY/TOWN
- WATERCOURSE
- WATERBODY

0 1 2 3 4 5
1:100,000 Kilometers

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. SAMPLING LOCATIONS - ECOMETRIX, 2017
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
ANNUAL REPORTING WATER AND SEDIMENT SAMPLING LOCATIONS ON THE WINNIPEG RIVER

CONSULTANT
Golder Associates

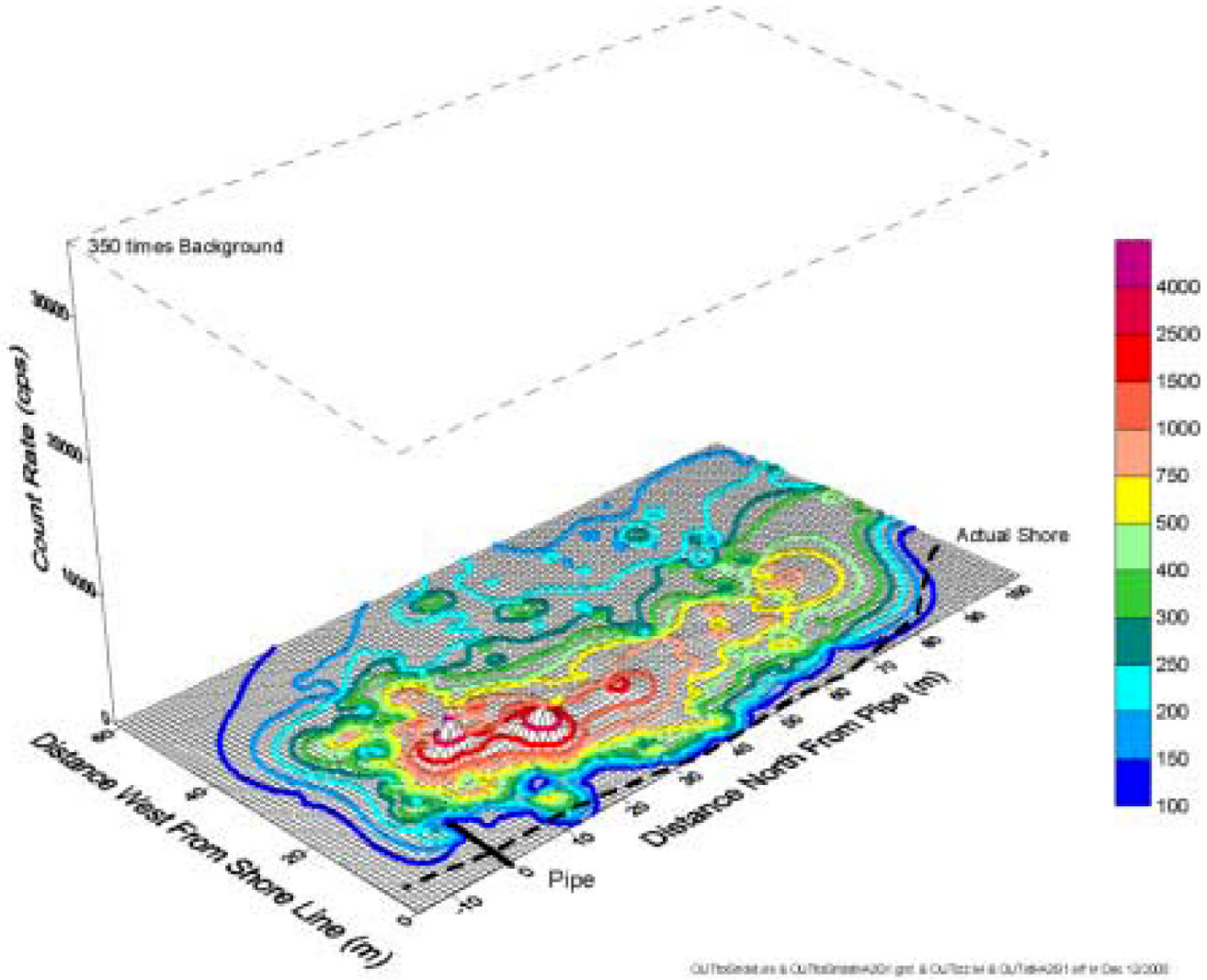
YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE/PR
REVIEWED	CS
APPROVED	MM

PROJECT NO. 1656897 | CONTROL | REV. 1 | FIGURE **6.4.2-3**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm 0

Path: S:\Clients\Canadian_Nuclear_Laboratories\Manitoba\99_PRO\1656897_CNL_Whitshell_EA\40_PRO\0010_SurfaceWater\1656897-0010-CS-0003.mxd

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COUNT RATE FROM OUTFALL STUDY AREA

REFERENCE(S)

AECL. 2001B. EVALUATION OF THE POTENTIAL ECOLOGICAL AND HUMAN HEALTH RISK EFFECTS OF SEDIMENT CONTAMINATED BY THE PROCESS WATER DISCHARGE AT WHITESHELL LABORATORIES. APPENDIX B.1 OF WHITESHELL LABORATORIES DECOMMISSIONING PROJECT COMPREHENSIVE STUDY REPORT. WLDP-03702-041-000. MARCH 2001.

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
GAMMA COUNT RATE OF SEDIMENT DOWNSTREAM OF THE WHITESHELL LABORATORIES EFFLUENT OUTFALL

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	-
PREPARED	PR
REVIEWED	NR
APPROVED	MM

PROJECT NO.	CONTROL	REV.	FIGURE
1656897		1	**6.4.2-4**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
25mm
0

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Sediment core sampling as part of the Environmental Assessment Follow-Up was completed in 2006 and is planned to occur every 20 years following. The top 10 cm in each area was below the Cs-137 Nuclear Substance and Radiation Devices Regulations (NSRDR) Clearance Level of 100 Bq/kg (AECL 2008). Cs-137 activity increased with depth in all cores (AECL 2008). For the upstream cores this was attributed to the preferential fallout in the area during global weapons testing in the 1960s. The downstream cores increase in activity was attributed to a combination of the weapon's testing and WL discharges in the 1970s and 80s. Sediments at depths dating to before 1990 had Cs-137 activities that exceeded the NSRDR Clearance Level (AECL 2008).

As part of the routine monitoring at the WL site, river bottom sediments were collected from twelve locations along the Winnipeg River, ranging from 0.8 km upstream to 13.1 km downstream of the Outfall (Figure 6.4.2-3). In 2015, the gross alpha activity detected in the samples ranged from 214 to 410 Bq/kg (CNL 2016a). In five years prior, average minimums and maximums activities ranged from 268±14 to 520±35 Bq/kg. The alpha activity in these samples is due to naturally occurring isotopes such as uranium-238 (U-238) or thorium-232 (Th-232) and their progeny, as both upstream and downstream samples contain similar levels. Gamma spectrometry of the samples confirmed the presence of uranium and thorium progeny. All samples are below the NSRDR Clearance Level for naturally occurring U-238 and Th-232 of 1,000 Bq/kg (CNL 2016a).

The gross beta activity in sediment ranged from 488 to 781 Bq/kg in 2015 at the twelve sampling locations apart of the routine monitoring (CNL 2016a). The previous five years average minimums and maximums ranged from 390±94 to 2,128±1233 Bq/kg. The variability of the average maximum five year range is large due to extremely high concentrations measured in 2012 at K23 of 7,058 Bq/kg. Beta activity includes contributions from naturally occurring potassium-40 (K-40) and from Cs-137. The majority of the beta activity for all locations continues to be from naturally occurring K-40 (CNL 2016a). The NSRDR Clearance Level for K-40 is 10,000 Bq/kg.

The highest measured Cs-137 level in a sediment sample during the 2000 study was 2,610 Bq/kg (AECL 2001a). This exceeds the NSRDR Clearance Level of 100 Bq/kg for Cs-137. Although the activity level in the sediment at the K03 location is above NSRDR unconditional clearance level, it is well below a human external exposure level of concern of 2.8×10^{6} Bq/kg. It is also well below the Tier 2 ENEV for benthic invertebrates' value of 1.5×10^{5} Bq/kg. The Cs-137 levels detected in the samples collected during routine monitoring at locations OFL, K03, K05, K14 and K23 from 2010 to 2015 were one to two orders of magnitude lower than the highest 2000 sample (Table 6.4.2-6; CNL 2016a). Cesium-137 levels at all locations except OFL and KO5 were below the NSRDR Clearance Level of 100 Bq/kg. The activity at OFL has historically varied from less than 5 Bq/kg to 75,500 Bq/kg (CNL 2016a). Variation of activity is not unexpected for all samples due to the highly localized and spotty nature of the contamination in the river sediments. This variability is the likely reason for the unusually high Cs-137 activity noted in the K05 sample in 2015 (Table 6.4.2-6; CNL 2016a).

Table 6.4.2-6: Sediment Quality Upstream, at Outfall, and Downstream of Whiteshell Laboratories (CNL 2016a)

Location	Distance from Outfall (km)	Cesium-137 (Bq/kg dry weight)					
		2010	2011	2012	2013	2014	2015
J04	-0.76 (US)	9.7	14	18	13	5.7	13
J02	-0.37 (US)	10	13	12	13	4.7	15
OFL	0 (outfall)	240	130	125	75	285	473
K01	0.15 (DS)	23	11	19	13	5.3	11
K03	0.52	49	16	19	11	6.3	59
K05	0.79	21	42	13	68	13	732
K14	2.56	21	33	16	17	12	23
K19	3.48	10	72	14	24	18	10
K22	4.63	15	15	14	29	17	19
K23	4.78	14	18	14	19	15	31
K24	4.93	27	24	28	25	33	24
K30	13.06	25	5.3	13	30	26	15

US – upstream of Whiteshell Laboratories outfall; DS – downstream of Whiteshell Laboratories outfall.
Bq/kg – Becquerels per kilogram

6.4.2.5 Project Interactions and Mitigation

6.4.2.5.1 Methods

This section describes the process by which interactions between Project components and activities and surface water quality were identified and evaluated. Potential effect pathways are identified and mitigation developed to eliminate and/or reduce effect is presented. A pathways analysis is then used to focus the assessment on key interactions between the Project and the environment by evaluating the different effect pathways to assess 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 Section 6.4.2.6 Residual Effects Analysis). As such, this section helps to focus the reminder 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 Project. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. The next step in the analysis was the development of environmental design features and mitigation practices that could be incorporated into the Project to eliminate and/or reduce effects to surface water quality. 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 Pathway –** pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change to concentrations of parameters relative to Base Case values, and therefore would have no residual effects to surface water quality.
- **Secondary Pathway –** the pathway could result in a measurable minor change to concentrations of parameters, but would have a negligible residual effect on surface water quality relative to Base Case and/or guideline values and is not expected to contribute cumulatively to other past, present, or reasonably foreseeable developments to cause a significant effect.
- **Primary Pathway –** the pathway is likely to result in an environmental change to concentrations of parameters relative to the Base Case and/or guideline values that could contribute to residual effects to surface water quality.

Environmental design features and mitigation that have been or could be incorporated into the Project to eliminate and/or reduce adverse effects to the aquatic environment 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 on the aquatic environment through simple qualitative or semi-quantitative 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 Project on the aquatic environment.

6.4.2.5.2 Results

Pathways through which the Project may interact with and result in changes to concentrations of surface water parameters are provided in Table 6.4.2-7.

Table 6.4.2-7: Pathways Analysis for Surface Water Quality Valued Component

WR-1 Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Demolition of the WR-1 Building and ISD of WR-1	Non-radiological air emissions and dust emissions (including sulphur dioxide, nitrogen oxides [NO_X/NO_2], and particulate matter) and subsequent deposition.	■ Implementation of CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring, air verification monitoring and environmental monitoring. ■ Implementation of dust management techniques to control dust generated by the Project, consistent with the current Environmental Assessment Follow-up Program. ■ Road watering and chemical dust suppressant when necessary. ■ Removal of accumulations of particulates (e.g., dirt) on road as soon as possible. ■ On-site vehicles and equipment engines will meet Tier 3 emission standards, where possible, and be maintained in good working order. ■ Limit idling of vehicles on-site and speed on roads. ■ Use of enclosure for raw material handling.	Secondary
	During closure activities, there is the potential for the transport of site runoff to the Winnipeg River.	■ Demolition activities will utilize best management practices for surface water runoff management, such as directing wastewaters to areas with adequate infiltration (i.e., filtration to provide attenuation) or to the existing surface water management system (i.e., storm drains). ■ Existing surface water management systems at the WL Site will remain in place to manage site runoff.	No Linkage
Installation of engineered cover over grouted WR-1 Building and final restoration	Installation of engineered cover at the WR-1 Building may alter drainage rates and flow patterns.	■ The WR-1 site and engineered cover will be graded to promote drainage from the site to the Winnipeg River.	Secondary

Table 6.4.2-7: Pathways Analysis for Surface Water Quality Valued Component

WR-1 Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Closure of the entire WL site	Decommissioning and reclamation of the entire WL site, including the Project, may alter drainage rates and flow patterns as current precipitation management is removed.	■ The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. ■ The drainage system for the reclaimed WL site will have similar physical characteristics as similar natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. ■ The WL site will be graded to promote drainage from the site to the Winnipeg River.	Secondary
Post-closure Performance	Release of chemical and radiological contaminants in the long-term during the post-closure phase from the Project.	■ The planned decommissioning of the WR-1 Complex presently involves: ▪ removal the service area and infilling in these areas with compact soil; ▪ sealing of open conduits in the building foundation; and ▪ grouting the interior portion of the building (containing the remaining components of WR-1) to ground surface elevation. ■ As part of CNL's licence with the CNSC, environmental monitoring around the WL site is required and will continue for the Project. ■ Follow-up monitoring during the post-closure phase will be completed to verify effect predictions and to provide information for use in adaptive management to address potential unforeseen effects.	Primary

Table 6.4.2-7: Pathways Analysis for Surface Water Quality Valued Component

WR-1 Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Post-closure Performance	Release of chemical and radiological contaminants in the long-term during the post-closure phase from the previous activities completed at the WL site.	■ As part of CNL's licence with the CNSC, environmental monitoring around the WL site will continue for the Project. ■ Follow-up monitoring during the post-closure phase will continue to verify effect predictions and to provide information for use in adaptive management to address potential unforeseen effects.	Secondary

6.4.2.5.2.1 No Linkage Pathway

The following pathway was assessed as having no measurable environmental change and hence, no linkage to residual effects on surface water quality.

- **During closure activities, there is the potential for the transport of site runoff to the Winnipeg River.**

The LSA drains to the Winnipeg River. During closure phase activities, specifically those that are demolition-related, there is the potential for the transport of site runoff to the Winnipeg River in the vicinity of the WL site. Site runoff may be compromised by various activities such as the mobile batch plant (increased pH and suspended solids levels), crushing masonry (increased pH and suspended solids levels), and cutting steel (increased metal levels). Wastewater from these activities will be directed to existing surface water management facilities (such as storm drains) or to areas with enough distance from the river to provide adequate infiltration of the wastewater (i.e., attenuation of parameters between the source and river to negligible levels).

During the closure phase, existing surface water management systems at the WL Site will remain in place to manage site runoff. For example, surface water runoff from the site collected by storm sewers and drained via the Process Sewer. In addition, containment barriers will be constructed where necessary to provide for the collection, control of and treatment of contaminated water and to reduce surface water runoff during decommissioning and reclamation activities. Surface water quality is also assessed at locations where surface water leaves the WL site's boundary and in water-bodies affected by discharges. Concentrations of radiological and non-radiological parameters are measured and compared against existing provincial or federal surface water quality guidelines or standards. It is also noted that closure phase activities will occur well away from the river and its riparian zone and therefore no direct changes in surface water quality will result. Consequently, this interaction was determined to have no linkage to effects to surface water quality in the Winnipeg River. Assuming these best management practices are followed and the current surface water management facilities remain in place during building demolition, these mitigation measures are expected to be effective. No residual effects are anticipated.

6.4.2.5.2.2 Secondary Pathways

The following pathways were assessed as potentially having a measurable minor change to surface water quality relative to Base Case.

- **Non-radiological air emissions and dust emissions (including sulphur dioxide, nitrogen oxides [NOx/NO_2], and particulate matter) and subsequent deposition.**

Construction and operation of the Project will generate air and dust emissions such as carbon monoxide (CO), oxides of sulphur (SO_x includes sulphur dioxide [SO_2]), oxides of nitrogen (NO_x includes nitrogen dioxide 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 the largest contributor to particulate matter (SPM, PM_{10}, and $PM_{2.5}$) during both construction and operations phases (Section 6.2.1.6.2).

Examples of mitigation implemented to limit predicted residual effects from Project emissions to air quality (and subsequently surface water quality) include:

- implementation of CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring and air verification monitoring;
- road watering and chemical dust suppressant when necessary; and
- use of enclosure for raw material handling.

The predicted residual effects air quality were estimated to increase because of the Project. Fugitive dust from paved roads is the largest contributor to SPM emissions. Material handling from demolition is the largest contributor to PM_{10} emissions. Non-road equipment exhaust emissions are the largest contributors to $PM_{2.5}$ and NOx (as NO_2) emissions. Finally, the largest contributor to SO_2 and CO emissions is fuel combustion for emergency power generators. Predicted concentrations for the Application Case are below applicable air quality guidelines and/or standards (Section 6.2.1.6.2).

With the implementation of CNL's Management and Monitoring of Emissions Procedure, and through the implementation of dust management techniques for the Project, air and dust emissions and subsequent deposition are expected to result in local, minor changes relative to Base Case conditions. As such, this pathway is determined to result in a negligible effect on surface water quality.

- **Installation of engineered cover at the WR-1 Building may alter drainage rates and flow patterns.**

Installation of engineered cover at the WR-1 Building and alterations of the current precipitation management system may alter drainage rates and flow patterns, and consequently the discharge volume to Winnipeg River. Following the completion of closure activities, the WR-1 site and engineered cover will be graded to promote drainage from the site to the Winnipeg River. Run-off control for the cover is designed to limit erosion and infiltration of water into the grouted structure. This is achieved by sloping the cover surface to maintain a slope toward the edges, and the collection of water by the existing surface water management systems at the WL Site (Section 3.0). Although the installation of the engineered cover at the WR-1 Building is expected to slightly alter the drainage rates and flow patterns and discharge volume to the Winnipeg River; the changes are expected to be within the natural range of variation. As such, changes to the discharge volume from the installation of the cover at closure are predicted to have a negligible effect on surface water quality in the Winnipeg River. Assuming the cover is built to the engineered drawing's specifications, this mitigation measure is expected to be effective. Negligible residual effects are anticipated.

- **Decommissioning and reclamation of the entire WL site, including the Project, may alter drainage rates and flow patterns.**

The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. The drainage system for the reclaimed WL site will have similar physical characteristics as similar natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. The contribution to site runoff from the Project is expected to be minor relative to the entire decommissioned WL site. Although closure of the WL site may slightly alter the drainage rates and flow patterns and discharge volume to the Winnipeg River; the changes are expected to be within the natural range of variation. As such, changes to discharge volume to from the closure of the WL site, including the Project, are predicted to have a negligible effect on the surface water quality in Winnipeg River.

- **Release of chemical and radiological contaminants in the long-term during the post-closure phase from the previous activities completed at the WL site.**

Results of the Comprehensive Study Report indicated residual effects on surface water, particularly the Winnipeg River, are related to discharges from the Active Liquid Waste Treatment Centre and the sewage lagoon. No decrease in water quality is expected and effluent emissions to the Winnipeg River are expected to decline to virtually zero following decommissioning. Re-suspension of contaminated sediments is also not expected to lead to a decrease in water quality (see Section 7.0 of AECL 2001b).

The Comprehensive Study Report (AECL 2001b) also considered the potential for effects via groundwater quality from the LLW that may be managed in situ in the WMA, and their potential to affect the Winnipeg River (see also Section 6.3.2.5.2.1 Hydrogeology). The assessment considered three general exposure pathways: upward migration (with potential contamination of soils and vegetation), near-surface later migration (with potential contamination to local discharge in perimeter and roadside ditches), and downward migration and contamination of the sand and gravel aquifer and subsequently the river). Only the near-surface lateral migration scenario was considered in further detail. With respect to downward migration and release to the river it was determined that the general hydrology of the site limits or eliminates this pathway.

Water concentrations in the ditch were predicted and compared to established guidelines for several of the contaminants in the WMA. Radionuclide modelling in the Comprehensive Study Report (Appendix C of AECL 2001b) indicated that three radionuclides have the potential to exit the WMA through migration over a 200-year period, namely tritium, technetium-99 and carbon-14. Of these three radionuclides only technetium-99 is potentially present in nonzero concentrations in the ditch adjacent to the WMA in as early as 20 years. The carbon-14 and tritium will be lost to the atmosphere, and when this is modelled there is no release of these radionuclides to the perimeter ditch. These predictions were considered further for their potential effect on human health (see Section 6.7.2.5 Human and Ecological Health). With respect to non-radiological contaminants, some exceedances of applicable standards were predicted. Further refinement of the modelling and potential need for selective remediation to remove the hazard was recommended (AECL 2001b).

Consequently, there is no overlap of effects between WR-1 and previous activities at the WL site (i.e., effects from the WMA) and changes to surface water quality in the Winnipeg River. A detailed safety analysis still needs to be completed for the ISD of the WMA trenches. It is expected that this analysis will capture the potential changes to groundwater quality and surface water loadings to the Winnipeg River and site-specific acceptance criteria would be defined in accordance with applicable regulatory requirements.

As part of CNL's licence with the CNSC, environmental monitoring around the WL site will continue for the Project. Follow-up monitoring during the post-closure phase will continue to verify effect predictions and to provide information for use in adaptive management to address potential unforeseen effects. Consequently, changes to surface water quality from the closure of the WL site, are predicted to be negligible.

6.4.2.5.2.3 Primary Pathways

The Project is expected to have the following primary pathway effects on surface water quality that are carried forward to the residual effects analysis:

- **Release of chemical and radiological contaminants in the long-term during the post-closure phase from the Project.**

6.4.2.6 Residual Effects Analysis

6.4.2.6.1 Methods

Residual effects of the Project are those effects that remain after implementation of all mitigation. During the post-closure phase groundwater will come into contact with materials from the reactor and migrate to the Winnipeg River. As such, the potential for groundwater seepage to the Winnipeg River is considered a primary pathway and carried forward to the residual effects analysis. The assessment of effects of the Project on surface water quality involves two steps, namely the calculation of groundwater release rates and use of a dispersion model to predict concentrations of surface water parameters. These steps are described below.

6.4.2.6.1.1 Groundwater Release Rates

When groundwater enters the WR-1 Building it will come in contact with radioactive and non-radioactive materials from the reactor. In Section 6.3.2 on Hydrogeology, the groundwater plume from the WR-1 Building was modeled and loadings reaching the Winnipeg River were determined from the start of post-closure, when pumping groundwater away from the WR-1 Building foundation ceases, spanning 500,000 years. The various materials in the reactor building were modeled considering flow of the groundwater through the cover, grout, building foundation, and geological pathways. Only radionuclides with half-lives longer than one day were included in the modelling. GoldSim® (Version 11.1) was used to model transportation and is described further in Section 6.3.2.

The majority of the potentially contaminated groundwater was predicted to reach the Winnipeg River approximately 100 years after groundwater infiltrates the WR-1 Building. Parameters not within the WR-1 core had an instantaneous mass release. The groundwater plume was estimated to move west-northwest from the WR-1 Building and seep into the river over 95 m of bank.

The groundwater release rates (A_{Bq}) for radionuclides were calculated by using the groundwater loadings in the equation below.

$$A_{Bq} = \frac{m}{m_a} N_A \frac{ln(2)}{t_{1/2}}$$

where,

- m = mass of radionuclide (g)
- m_a = atomic mass (g/mol)
- N_A = Avogadro's number (6.022×10^{23}/mol)
- $t_{1/2}$ = half-life of the radionuclide (s)
- ln(2) = natural log of 2

Atomic masses and the half-lives used in this calculation can be found in Appendix 6.4.2-1.

To calculate the groundwater concentrations, the release rates were divided by the groundwater flow used in the groundwater model (Section 6.3.2), which ranged from 2.0×10^{-6} to 2.2×10^{-6} metre cubed per second (m^3/s), depending on the year (Appendix 6.4.2-1). The maximum mass loadings, the year the maximum loading occurs, the release rates to surface water, and the concentration of the groundwater are provided in Table 6.4.2-8 for radionuclides and Table 6.4.2-9 for non-radionuclides.

Mass loadings from the groundwater model of argon, helium, radon-222 and xenon were provided but aquatic dispersion of these parameters was excluded as they are expected to volatilize rapidly to air. Samarium-148 (Sm-148) also had mass loadings provided from the groundwater model but was determined to have no radiological concern due to its very long half-life and no toxicological concern based on its low groundwater concentration (2.71E-21 µg/L versus an aquatic life benchmark of 0.74 µg/L (Borgmann et al., 2005)). Therefore, Sm-148 was also excluded from aquatic dispersion modelling. Americium-241 (Am-241), americium-243 (Am-243), curium-244 (Cm-244), cobalt-60 (Co-60), Cs-137, europium-152 (Eu-152), europium-154 (Eu-154), europium-155 (Eu-155), iron-55 (Fe-55), neodymium-144 (Nd-144), nickel-63 (Ni-63), neptunium-239 (Np-239), plutonium-238 (Pu-238), plutonium-241 (Pu-241), strontium-90 (Sr-90), uranium-237 (U-237), and yttrium-90 (Y-90) were also included in the groundwater model but did not reach the river (mass loadings equal zero). Therefore, these parameters are not included in the analysis.

Table 6.4.2-8: Mass Loadings and Radiological Release Rates to the Winnipeg River during Post-Closure

Radionuclide	Maximum Groundwater Mass Loading (g/a)	Time of Maximum (yr.)	Maximum Groundwater Release Rate (Bq/s)	Maximum Groundwater Concentration (Bq/L)
Actinium-225	1.78E-17	124,500	1.21E-09	5.50E-07
Actinium-227	1.63E-15	192,500	1.38E-10	6.29E-08
Bismuth-210	3.22E-15	204,000	4.69E-07	2.13E-04
Carbon-14	5.55E-04	1,020	2.90E+00	1.47E+03
Calcium-41	1.55E-06	20,400	1.56E-04	7.10E-02
Chloride-36	1.15E-08	172	4.48E-07	2.28E-04
Gadolinium-152	1.71E-07	214	4.38E-15	2.22E-12
Tritium	8.75E-06	68	7.40E+01	3.76E+04
Iodine-129	1.50E-06	1,451	3.10E-07	1.58E-04
Niobium-94	1.54E-21	500,000	3.40E-19	1.55E-16
Nickel-59	5.48E-05	493,000	3.86E-03	1.76E+00
Neptunium-237	3.48E-06	57,300	2.88E-06	1.31E-03
Protactinium-231	2.49E-12	192,500	1.38E-10	6.29E-08
Protactinium-233	1.57E-16	57,300	3.84E-09	1.74E-06
Lead-210	1.31E-13	204,000	1.17E-08	5.33E-06
Polonium-210	2.33E-11	203,200	1.23E-04	5.60E-02
Plutonium-239	1.41E-07	123,100	1.02E-05	4.66E-03
Plutonium-240	4.34E-11	74,400	1.16E-08	5.26E-06
Radium-223	3.89E-17	192,500	2.34E-09	1.06E-06
Radium-224	6.68E-22	500,000	1.26E-13	5.72E-11
Radium-225	2.27E-16	124,500	1.04E-08	4.71E-06
Radium-226	2.32E-12	204,000	2.69E-09	1.22E-06

Table 6.4.2-8: Mass Loadings and Radiological Release Rates to the Winnipeg River during Post-Closure

Radionuclide	Maximum Groundwater Mass Loading (g/a)	Time of Maximum (yr.)	Maximum Groundwater Release Rate (Bq/s)	Maximum Groundwater Concentration (Bq/L)
Radium-228	3.90E-19	500,000	1.26E-13	5.73E-11
Technetium-99	5.86E-06	23,000	1.18E-04	5.36E-02
Thorium-227	7.07E-18	192,500	2.56E-10	1.16E-07
Thorium-228	2.84E-20	500,000	2.73E-14	1.24E-11
Thorium-229	9.09E-12	124,500	2.28E-09	1.04E-06
Thorium-230	2.43E-11	201,800	5.89E-10	2.68E-07
Thorium-231	5.20E-19	150,100	3.24E-10	1.47E-07
Thorium-232	2.12E-10	500,000	2.72E-14	1.24E-11
Uranium-233	2.87E-08	113,500	3.25E-07	1.48E-04
Uranium-234	2.02E-08	134,400	1.48E-07	6.71E-05
Uranium-235	1.79E-05	149,900	4.55E-08	2.07E-05
Uranium-236	6.76E-06	142,900	5.12E-07	2.33E-04

Radon-222 and samarium-148 in groundwater were excluded from the surface water assessment as they will not emit radiation to potential receptors.

Multiple radionuclides in WR-1 had mass loadings of 0 (i.e., did not reach the Winnipeg River), and are excluded from the assessment (e.g., Cs-137 and Sr-90).

g/a = grams per year; Bq/s = Becquerel per second; Bq/L = Becquerel per litre.

Table 6.4.2-9: Mass Loadings and Non-Radiological Release Rates to the Winnipeg River during Post-closure

Non-Radionuclide	Maximum Groundwater Mass Loading (g/a)	Time of Maximum (yr.)	Maximum Groundwater Release Rate (µg/s)	Maximum Groundwater Concentration (µg/L)
Boron	1.87E-04	4,240	5.92E-06	2.84E-03
Barium	1.76E-23	500,000	5.57E-25	2.53E-22
Bismuth	1.59E-08	98,400	5.04E-10	2.29E-07
Cadmium	3.71E-01	204,800	1.18E-02	5.35E+00
Cobalt	2.12E-02	94,500	6.71E-04	3.05E-01
Chromium	4.95E-27	500,000	1.57E-28	7.14E-26
Copper	1.96E-04	500,000	6.23E-06	2.83E-03
Gadolinium	2.30E-07	1,565	7.29E-09	3.70E-06
HB-40[(a)]	4.05E+01	10,700	1.28E+00	5.84E+02
Mercury	1.37E-18	500,000	4.34E-20	1.97E-17
Potassium	3.27E-07	13,600	1.04E-08	4.72E-06
Potassium Hydroxide	4.76E-02	142	1.51E-03	5.37E-01
Manganese	8.33E-05	361,300	2.64E-06	1.20E-03
Molybdenum	1.17E-02	17,900	3.72E-04	1.69E-01
Nitrogen	5.44E-04	17,900	1.73E-05	7.85E-03
Nickel	2.01E-05	500,000	6.38E-07	2.90E-04
Lead	7.57E-02	500,000	2.40E-03	1.09E+00
Palladium	1.05E-01	123,200	3.32E-03	1.51E+00
Ruthenium	6.72E-09	500,000	2.13E-10	9.70E-08
Sulphur	2.37E-12	198	7.51E-14	1.14E-10
Xylene	4.32E+00	203	1.37E-01	6.96E+01

g/a = grams per year; µg/s = microgram per second; µg/L = microgram per litre.

a) HB-40 was used in WR-1 as a cooling agent. It consists mainly of hydrogenated terphenyl (74-87%), with smaller fractions of partially hydrogenated terphenyls and terphenyl.

6.4.2.6.1.2 Dispersion Modelling

The Winnipeg River flows approximately 1,014 m^3/s near the WL site, in comparison to a predicted groundwater flow rate at the WL site of 2.0E-06 to 2.2E-06 m^3/s. This results in a dilution factor of 460,000,000:1 to 515,000,000:1 once the groundwater seepage fully mixes with the river. Even if the groundwater seepage mixes with a fraction of the river flow, the attenuation renders it indistinguishable from ambient river water.

Surface water concentrations were estimated using the EcoMetrix Incorporated software IMPACT™ DRL Version 5.5.1 (IMPACT™). IMPACT™ is consistent with the equations outlined in CSA N288.1 (2014). The equations for surface waters represent the advection, dispersion, and radioactive decay and ingrowth of radionuclides from the point of release through the receiving water to the receptor. It also represents the advection and dispersion of trace metals and other parameters. It is applicable to the WL site by representing the groundwater release as an area source within the Winnipeg River. The concentrations of parameters in water is determined by the release rate and the transfer parameter (P_{02} in seconds per litre (s/L) for non-radiological parameters and seconds per Becquerel (s/Bq) for radiological parameters) from the source to the Winnipeg River.

$$P_{02}\,(x,y) = \frac{1}{2\pi d\sqrt{k_x k_y}} e^{\left(\frac{U_x x}{2k_x} - \lambda_s \frac{x}{U_x}\right)} e^{\left(-\lambda_r \frac{x}{U_x}\right)} K_o\left(\frac{U_x}{2k_x}\sqrt{x^2\frac{k_x}{k_y}(y-y_o)^2}\right)$$

where,

- d = average water depth between the release point and the receptor (m)
- k_x = longitudinal dispersion coefficient (m^2/s)
- k_y = lateral dispersion coefficient (m^2/s)
- U_x = current velocity (m/s)
- x = downstream distance between the source and the point (x,y) (m)
- λ_s = removal constant for sedimentation (s^{-1})
- λ_r = radioactive decay constant (s^{-1})
- K_o = modified Bessel function of the second kind
- y = offshore distance coordinate for the point (x,y) (m)
- y_o = offshore distance to the plume centreline (m)

The transfer parameter (P_{02}) is multiplied by the release rate (x_o (w)) to give the concentration (X_2) at point (x,y). For non-radionuclides, the decay constant was set to zero. This equation above works if there are no riverbanks, as it assumes infinite spread of parameters downstream of the source. To account for the restriction of riverbanks, a mirroring effect was applied as follows:

$$X_2{}' = X_2 + \sum_{n=1}^{\infty} (X_2[x, y_n] + X_2[x, y'_n])$$

where,

- X_2' = concentration modified to account for the effects of the riverbanks (Bq/L)
- X_2 = P_{02} X_0 (w) in accordance with Equation above (Bq/L)
- x = downstream distance between the source and the point (x,y) (m)
- $y = n \bullet B - \left(y_0 - \frac{B}{2}\right) + (-1)^n \bullet \left(y - \frac{B}{2}\right)$
- $y'_n = -n \bullet B - \left(y_0 - \frac{B}{2}\right) + (-1)^n \bullet \left(y - \frac{B}{2}\right)$

  where,

  - n = number of reflection cycles
  - B = average width of the river between the release point and the receptor (m)
  - y_0 = offshore distance to the plume centreline (m)
  - y = offshore distance coordinator for the point (x,y) (m)

The input parameters for the model are shown in Table 6.4.2-10. The concentration of surface water parameters was determined at 50 m and 3,150 m downstream from the upstream edge of the groundwater seep. These locations correspond to the Nearfield and Farm A receptors (Figure 6.4.2-1), which are used in the Environmental Risk Assessment (EcoMetrix 2017b).

Table 6.4.2-10: Input Parameters for Surface Water Modelling

Parameter	Value	Unit	Source
River Depth	0.1 and 7.7	m	Nearfield and Farm in DRL (CNL 2016c)
River Width	470	m	DRL (CNL 2016c)
Longitudinal Dispersion Coefficient	150	m^2/s	DRL (CSA value for Deep River; CNL 2016c)
Lateral Dispersion Coefficient	0.129	m^2/s	Calculated (CSA N288.1-14)
Flow Rate	1,014	m^3/s	WSC (2016)
Current Velocity	0.3	m/s	Calculated
Distance between Upstream Edge of Seep and Nearfield Area	145	m	Calculated
Distance between Downstream Edge of Seep and Nearfield	50	m	Nearfield Assessment
Distance between Upstream Edge of Seep and Farm A Water Intake	3,150	m	Measured on Google Earth
Distance between Downstream Edge of Seep and Farm A Water Intake	3,055	m	Calculated

m = metre; m^3/s = cubic metres per second; m^2/s = square metres per second; m/s = metres per second; DRL = derived release limit.

Table 6.4.2-11 presents the predicted dilution at the Nearfield located 50 m downstream and at the Farm A Intake located 3,055 m downstream. The dilution at the Nearfield location exceed 1,000,000:1, which would result in concentrations difficult to detect *in situ*. Dilution at the Farm A location was 69,000,000:1

Table 6.4.2-11: Calculated Dilution

Location	Calculated Dilution
Nearfield	1,300,000:1
Farm A Intake	69,000,000:1
Fully mixed condition	460,000,000:1 to 515,000,000:1

Where available, the concentration of the river (Table 6.4.2-4 and Table 6.4.2-5) was added to the concentration derived from the dispersion model to estimate surface water concentrations.

6.4.2.6.2 Application Case Results

The assessment considered maximum surface water concentrations in accordance with CNSC (2013) REGDOC-2.9.1. Table 6.4.2-8 and Table 6.4.2-9 presented the estimated loadings from the groundwater seep to the Winnipeg River, and Table 6.4.2-12 and Table 6.4.2-13 presents the corresponding predicted surface water quality associated with radionuclide and non-radionuclide loadings, respectively. The surface water quality is predicted from the river dispersion model in CSA N288.1 (2014) and corresponds to two locations: 1) the Winnipeg River immediately at the point of groundwater release to the river (Nearfield); and 2) the Winnipeg River at the freshwater intake for the nearest downstream farm (Farm A Intake).

Table 6.4.2-12 and Table 6.4.2-13 compares the predicted surface water quality to the available guidelines and to available background concentrations. For radionuclides predicted to reach the Winnipeg River from WR-1 or decay products of those materials, no water guidelines or background concentrations were available. Surface water concentrations in the Nearfield and Farm A intake are six and eight orders of magnitude lower than the groundwater concentration, respectively.

Table 6.4.2-12: Predicted Radionuclide Concentrations in the Winnipeg River at the Nearfield and Farm A Intake

Radionuclide	Time of Maximum (yr.)	Maximum Groundwater Concentration (Bq/L)	Surface Water Concentration Nearfield (Bq/L)	Surface Water Concentration Farm A Intake (Bq/L)
Actinium-225	124,500	5.50E-07	4.27E-13	7.95E-15
Actinium-227	192,500	6.29E-08	4.88E-14	9.17E-16
Bismuth-210	204,000	2.13E-04	1.65E-10	3.06E-12
Carbon-14	1,020	1.47E+03	1.02E-03	1.93E-05
Calcium-41	20,400	7.10E-02	5.51E-08	1.04E-09
Chloride-36	172	2.28E-04	1.58E-10	2.97E-12
Gadolinium-152	214	2.22E-12	1.54E-18	2.90E-20
Tritium	68	3.76E+04	2.61E-02	4.91E-04
Iodine-129	1,451	1.58E-04	1.09E-10	2.06E-12
Niobium-94	500,000	1.55E-16	1.20E-22	2.26E-24
Nickel-59	493,000	1.76E+00	1.36E-06	2.56E-08
Neptunium-237	57,300	1.31E-03	1.02E-09	1.91E-11
Protactinium-231	192,500	6.29E-08	4.88E-14	9.17E-16
Protactinium-233	57,300	1.74E-06	1.35E-12	2.54E-14
Lead-210	204,000	5.33E-06	4.14E-12	7.78E-14
Polonium-210	203,200	5.60E-02	4.34E-08	8.16E-10
Plutonium-239	123,100	4.66E-03	3.61E-09	6.80E-11
Plutonium-240	74,400	5.26E-06	4.08E-12	7.68E-14
Radium-223	192,500	1.06E-06	8.24E-13	1.54E-14
Radium-224	500,000	5.72E-11	4.44E-17	8.14E-19
Radium-225	124,500	4.71E-06	3.66E-12	6.84E-14
Radium-226	204,000	1.22E-06	9.49E-13	1.78E-14

Table 6.4.2-12: Predicted Radionuclide Concentrations in the Winnipeg River at the Nearfield and Farm A Intake

Radionuclide	Time of Maximum (yr.)	Maximum Groundwater Concentration (Bq/L)	Surface Water Concentration Nearfield (Bq/L)	Surface Water Concentration Farm A Intake (Bq/L)
Radium-228	500,000	5.73E-11	4.45E-17	8.36E-19
Technetium-99	23,000	5.36E-02	4.16E-08	7.82E-10
Thorium-227	192,500	1.16E-07	9.01E-14	1.69E-15
Thorium-228	500,000	1.24E-11	9.63E-18	1.81E-19
Thorium-229	124,500	1.04E-06	8.04E-13	1.51E-14
Thorium-230	201,800	2.68E-07	2.08E-13	3.91E-15
Thorium-231	150,100	1.47E-07	1.14E-13	1.98E-15
Thorium-232	500,000	1.24E-11	9.61E-18	1.81E-19
Uranium-233	113,500	1.48E-04	1.15E-10	2.16E-12
Uranium-234	134,400	6.71E-05	5.20E-11	9.79E-13
Uranium-235	149,900	2.07E-05	1.60E-11	3.02E-13
Uranium-236	142,900	2.33E-04	1.81E-10	3.40E-12

Bq/L = Becquerel per litre.

Non-radionuclide concentrations estimate in the Nearfield and at Farm A surface water intake were compared to the lowest available guideline, which are presented in Table 6.4.2-4 and Table 6.4.2-5. There was no guideline available for sulphur and guidelines were not applicable for the Noble gasses, such as argon, helium, and xenon, because they volatilize out of the surface water immediately. Background concentrations are from Table 6.4.2-4 and Table 6.4.2-5, available from the WL site (CNL 2016d) and Pine Falls (WQMS 2016).

For non-radionuclides without background concentrations, the groundwater concentrations were diluted six and eight orders of magnitude lower at the Nearfield and Farm A intake, respectively. The river concentrations for parameters with background concentrations were equal to background. Surface water concentrations of barium, chromium, copper, and lead exceed the lowest available guideline. These exceedances are due to background concentrations, measured from the Winnipeg River, and not the potential groundwater seep from WR-1 Building.

Table 6.4.2-13: Predicted Non-Radionuclide Concentrations in the Winnipeg River at the Nearfield and Farm A Intake

Non-Radionuclide	Lowest Guideline (µg/L)	Background (µg/L)	Time of Maximum (yr.)	Maximum Groundwater Concentration (µg/L)	Surface Water Concentration Nearfield (µg/L)	Surface Water Concentration Farm A Intake (µg/L)
Boron	1.50E+03	1.00E+01	4,240	2.84E-03	1.00E+01	1.00E+01
Barium	4.00E-01	1.10E+01	500,000	2.53E-22	1.10E+01	1.10E+01
Bismuth	2.50E-01	<2.00E-01	98,400	2.29E-07	<2.00E-01	<2.00E-01
Cadmium	7.87E-02	1.00E-02	204,800	5.35E+00	1.00E-02	1.00E-02
Cobalt	9.00E-01	2.00E-01	94,500	3.05E-01	2.00E-01	2.00E-01
Chromium	1.00E+00	1.70E+00	500,000	7.14E-26	1.70E+00	1.70E+00
Copper	2.00E+00	1.40E+01	500,000	2.83E-03	1.40E+01	1.40E+01
Gadolinium	1.50E+00	NV	1,565	3.70E-06	2.57E-12	4.83E-14
HB-40	2.00E+00	0.00E+00	10,700	5.84E+02	4.53E-04	8.52E-06
Mercury	2.60E-02	1.00E-02	500,000	1.97E-17	1.00E-02	1.00E-02
Potassium	5.30E+03	9.07E+02	13,600	4.72E-06	9.07E+02	9.07E+02
Potassium Hydroxide	5.30E+03	NV	142	5.37E-01	5.32E-07	1.00E-08
Manganese	7.94E+02	1.10E+01	361,300	1.20E-03	1.10E+01	1.10E+01
Molybdenum	7.30E+01	2.00E-01	17,900	1.69E-01	2.00E-01	2.00E-01
Nitrogen	1.00E+03	NV	17,900	7.85E-03	6.09E-09	1.14E-10
Nickel	2.50E+01	1.78E+00	500,000	2.90E-04	1.78E+00	1.78E+00
Lead	9.93E-01	2.60E+00	500,000	1.09E+00	2.60E+00	2.60E+00
Palladium	5.70E+00	NV	123,200	1.51E+00	1.17E-06	2.21E-08
Ruthenium	1.00E+01	NV	500,000	9.70E-08	7.52E-14	1.41E-15
Sulphur	NV	NV	198	1.14E-10	2.65E-17	4.98E-19
Xylene	3.00E+01	NV	203	6.96E+01	4.83E-05	9.08E-07

µg/L = microgram per litre.

Available guidelines and background values are from Table 6.4.2-4 and Table 6.4.2-5.

NV – No value

The CSA N288.1 (2014) provides a model for sediment concentrations based on surface water concentrations. The surface water concentration is multiplied by the partition coefficient of the specific parameter (Clause 7.8.1). This approach assumes sediments and water are in equilibrium, and that sediments are fine grain, remain stationary or accumulate. As the Winnipeg River is erosional, with a hard clay bottom strewn with sand, gravel, cobble, and boulders (AECL 2001a), it is likely that this model overestimates the contribution of groundwater to concentrations in sediment.

Predicted radionuclide concentrations are presented in Table 6.4.2-14 with NSRDR Clearance Levels (NSCA 2000). The maximum concentrations in sediment were calculated by running the model with the maximum release rates presented in Table 6.4.2-8. Predicted sediment concentrations are lower than their respective Clearance Levels.

Table 6.4.2-14: Predicted Maximum Radionuclide Concentrations in Sediment at the Nearfield and Farm A Intake

Radionuclide	NSRDR Clearance Level (Bq/kg)	Maximum Sediment Concentration Nearfield (Bq/kg (dw))	Maximum Sediment Concentration Farm A Intake (Bq/kg (dw))
Actinium-225	NV	7.25E-10	1.35E-11
Actinium-227	1.00E+03	8.29E-11	1.56E-12
Bismuth-210	NV	8.27E-07	1.53E-08
Carbon-14	1.00E+03	5.12E-02	9.63E-04
Calcium-41	NV	1.05E-05	1.97E-07
Chloride-36	1.00E+03	3.16E-09	5.95E-11
Gadolinium-152	NV	1.53E-15	2.87E-17
Iodine-129	1.00E+01	4.81E-07	9.05E-09
Niobium-94	1.00E+02	2.04E-19	3.84E-21
Nickel-59	1.00E+05	1.91E-03	3.59E-05
Neptunium-237	1.00E+03	1.02E-08	1.91E-10
Protactinium-231	1.00E+03	2.63E-10	4.95E-12
Protactinium-233	1.00E+04	7.31E-09	1.37E-10
Lead-210	1.00E+03	5.38E-09	1.01E-10
Polonium-210	1.00E+03	5.65E-08	1.06E-09
Plutonium-239	1.00E+02	8.67E-04	1.63E-05
Plutonium-240	1.00E+02	9.80E-07	1.84E-08
Radium-223	1.00E+03	6.10E-09	1.14E-10
Radium-224	1.00E+03	3.28E-13	6.03E-15
Radium-225	1.00E+04	2.71E-08	5.06E-10
Radium-226	1.00E+03	7.02E-09	1.32E-10
Radium-228	1.00E+05	3.29E-13	6.19E-15
Technetium-99	1.00E+03	2.08E-07	3.91E-09
Thorium-227	1.00E+03	1.71E-08	3.21E-10
Thorium-228	1.00E+03	1.83E-12	3.44E-14

Table 6.4.2-14: Predicted Maximum Radionuclide Concentrations in Sediment at the Nearfield and Farm A Intake

Radionuclide	NSRDR Clearance Level (Bq/kg)	Maximum Sediment Concentration Nearfield (Bq/kg (dw))	Maximum Sediment Concentration Farm A Intake (Bq/kg (dw))
Thorium-229	1.00E+02	1.53E-07	2.87E-09
Thorium-230	1.00E+03	3.95E-08	7.42E-10
Thorium-231	NV	2.17E-08	3.76E-10
Thorium-232	1.00E+03	1.82E-12	3.43E-14
Uranium-233	1.00E+03	5.73E-09	1.08E-10
Uranium-234	1.00E+03	2.60E-09	4.89E-11
Uranium-235	1.00E+03	8.02E-10	1.51E-11
Uranium-236	1.00E+04	9.03E-09	1.70E-10

NSRDR Clearance Level = Nuclear Substance and Radiation Devices Regulations Unconditional Clearance Levels (NSCA 2000)
Bq/kg – Becquerels per kilogram; dw = dry weight.
NV – No value

Table 6.4.2-15 presents the predicted non-radionuclide sediment concentrations with federal sediment quality guidelines. The surface water background and maximum surface water concentrations from Table 6.4.2-9 were used to calculate sediment concentrations.

Where background concentrations of surface water were available, predicted sediment concentrations at the Nearfield and Farm A Intake were the same as sediment concentrations derived from background. Predicted sediment concentrations at Farm A Intake were two orders of magnitude lower than concentrations predicted in the Nearfield, for parameters without background available. Predicted sediment concentrations from background surface water concentrations exceeded available guidelines as background surface water concentrations are high and lead to high predicted background sediment concentrations.

Table 6.4.2-15: Predicted Non-Radionuclide Concentrations in Sediment at the Nearfield and Farm A Intake

Non-Radionuclide	CCME Sediment Quality Guidelines (mg/kg)	Sediment Concentration From Background Surface Water (mg/kg)	Maximum Sediment Concentration Nearfield (mg/kg)	Maximum Sediment Concentration Farm A Intake (mg/kg)
	Probable Effect Level			
Boron	—	5.00E+05	5.00E+05	5.00E+05
Barium	—	2.20E+07	2.20E+07	2.20E+07
Bismuth	—	1.00E+06	1.00E+06	1.00E+06
Cadmium	3.50E+00	5.00E+03	5.00E+03	5.00E+03
Cobalt	—-	8.60E+06	8.60E+06	8.60E+06
Chromium	9.00E+01	2.21E+08	2.21E+08	2.21E+08

Table 6.4.2-15: Predicted Non-Radionuclide Concentrations in Sediment at the Nearfield and Farm A Intake

Non-Radionuclide	CCME Sediment Quality Guidelines (mg/kg)	Sediment Concentration From Background	Maximum Sediment Concentration Nearfield	Maximum Sediment Concentration Farm A Intake
Copper	1.97E+02	7.00E+06	7.00E+06	7.00E+06
Gadolinium	—	NV	2.55E-06	4.79E-08
HB-40	—	0.00E+00	5.01E+03	9.43E+01
Mercury	4.86E-01	1.60E+03	1.60E+03	1.60E+03
Potassium	—	0.00E+00 †	0.00E+00 †	0.00E+00 †
Potassium Hydroxide	—	0.00E+00 †	0.00E+00 †	0.00E+00 †
Manganese	1.10E+03 ‡	1.43E+09	1.43E+09	1.43E+09
Molybdenum	—	2.00E+04	2.00E+04	2.00E+04
Nitrogen	—	NV	0.00E+00	0.00E+00
Nickel	7.50E+01 ‡	2.49E+06	2.49E+06	2.49E+06
Lead	9.13E+01	3.38E+06	3.38E+06	3.38E+06
Palladium	—	NV	6.33E+00	1.19E-01
Ruthenium	—	NV	2.41E-06	4.53E-08
Sulphur	—	NV	2.91E-12	5.48E-14
Xylene	—	NV	7.49E-01	1.41E-02

CCME Sediment Quality Guidelines = Canadian Council of Ministers of the Environment Sediment Quality Guidelines (CCME 1999b).

† Assumed potassium and potassium hydroxide are extremely soluble and would not be found in sediment.

‡ Values are the severe effect level from the Ontario Sediment Quality Guidelines (MOE 2008).

mg/kg – milligrams per kilogram.

NV – No value

Potential groundwater seepage into the Winnipeg River from the WR-1 Building was predicted to produce surface water concentrations of radionuclide six orders of magnitude lower than groundwater concentrations in the Nearfield. Non-radionuclides in the potential groundwater seep were predicted to have no effect on existing elevated surface water concentrations for all parameters with available background concentrations. Similarly, predicted sediment concentrations from radionuclides were below NSRDR Clearance Levels and non-radionuclides predicted sediment concentrations were dominated by background surface water contributions. The potential groundwater seep is predicted to have no effect on the Winnipeg River surface water quality.

6.4.2.7 Prediction Confidence and Uncertainty

Potential sources of uncertainty in the assessment of surface water quality include:

- the accuracy and representativeness of the groundwater loadings;
- the accuracy and representativeness of the inputs used in the dispersion model; and
- the accuracy of formulations within the river dispersion model.

Uncertainty related to the groundwater loadings is discussed in Section 6.3.2 (Hydrogeology). In summary, the bedrock was considered to be a single hydrostatic unit and no discrete features (fractures) present in any material. The cover, grout, and foundation were assumed to degrade at rates comparable to other projects (i.e., Savannah River), which increased groundwater flow through time, resulting in total failure (degradation) of grout by year 10,000. Parameters outside the reactor were assumed to be instantly released. Partition coefficients to bedrock were applied to parameters where available and solubility was only applied to HB-40. From these inputs, groundwater loadings are likely overestimated, since all parameters were instantly soluble when in contact with groundwater. The exception, HB-40, had a solubility applied from recent toxicity testing (EcoMetrix 2017a) that was only achieve through extreme agitation (emulsified). The degradation of the cover, grout, and building foundation may occur at different rates than those used in the model, which may mean the peak loadings would occur sooner than predicted. The model was run for 500,000 years to ensure most parameters achieved groundwater loading peaks (past maximum load).

Uncertainty in both the groundwater flow and solute transport modelling is recognized, and was evaluated through the completion of a sensitivity analysis. The sensitivity analysis included the evaluation of the effect of 13 various model assumptions on model results as discussed in detail in Golder (2017). One of the key assumptions of the solute transport modelling that was evaluated through the sensitivity analysis was that the source mass was distributed evenly throughout the grout block and that solute transport occurred through the foundation, which was conceptualized as a 1 m thick concrete material, or equivalent barrier. This assumption is conservative, as the grout itself is anticipated to provide some additional separation between the source mass (most of which is confined within the metal components of the reactor) and the downstream environment. Results of the sensitivity analysis indicate that inclusion of the grout as a barrier to solute migration resulted in considerably (5x for conservative species) lower peak mass loadings and significant increases (5x for conservative species) to the arrival time for peak mass loadings relative to the base case. For solutes with relatively short half-lives (e.g., tritium), the mass loadings were reduced by more than an order of magnitude. These changes reflect the additional time required for solute mass to migrate through the grout prior to reaching the foundation.

Dispersion models employ assumptions that simplify the random processes associated with water flow and turbulence. Values for the parameters input into the model were selected to represent the Winnipeg River in the vicinity of the WL site. Historical data collected in the WL site area was used for modelling. To determine if a significant difference of model inputs would change the surface water concentration, the model using the maximum predicted groundwater concentrations was run multiple times varying flow and river depth in a sensitivity analysis. The lowest and highest average daily flows from 1987 and 2014 were used, 458 m^3/s and 1,538 m^3/s, respectively (WSC 2016). Elevations above sea level of the river taken at the WL site varied approximately 1 m. From another source the Winnipeg River in the vicinity of the WL site was reported as 7.7 m deep. The relationship between the river elevation and the reported depth is unknown. Therefore, the water level at the farm was varied 1 m above and below 7.7 m, with water levels of 6.7 and 8.7 m to test sensitivity. This is a conservative approach, as water levels do not vary more than one metre currently. For the Nearfield,

water levels were varied 0.05 m, with 0.15 m and 0.05 m used to test sensitivity. Model runs included: 1) low flow and low water level; 2) high flow and low water level; 3) high flow and low water level; and 4) high flow and high water level.

The groundwater seepage enters the river over a broad area extending into the river. If the groundwater intercepts the full depth of the river, the spatial extent of the influx could extend over 200 m width across the river by 95 m length along the river. This conceptual model differs from the model assumed in CSA N288.1 (2014), which assumes an influx over a 95 m length along the river bank. Assuming an area source, the estimated dilution could be in the order of 283,000:1 if the plume rises 1 cm from the bottom and 1,400,000:1 if the plume rises 5 cm from the bottom. In either case, the available dilution is sufficient to render the plume indistinguishable from ambient river water.

6.4.2.8 Monitoring and Follow-up

As part of CNL's licence (NRTEDL-W5-8.04/2018) with the CNSC, CNL will implement an Environmental Assessment Follow-up Program for WR-1 to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. The current Environmental Assessment Follow-up Program for the WL site includes collecting water samples at collecting water samples at one location 17 km upstream near Pinawa (US in Figure 6.4.2-3), 2 km downstream at the site boundary (DS in Figure 6.4.2-3), 10 km downstream at the town of Lac du Bonnet water intake (LB in Figure 6.4.2-3), and 28 km downstream at the Great Falls generating station (CNL 2016b; Figure 6.4.2-2). Surficial sediment is also collected at two locations upstream, at the outfall, and nine locations downstream (CNL 2016a; Figure 6.4.2-3). In addition, CNSC has committed to collecting cores in depositional areas in 2026, 2046, and 2066 at Sylvia Lake and upstream and downstream of the waterbody at Lac du Bonnet, which are part of the Winnipeg River system. It is proposed that these same monitoring locations be used to support the WR-1 Environmental Assessment Follow-up Program, coordinating with the existing program, where practical. Follow-up monitoring during the post-closure phase is necessary to confirm predicted concentrations in surface water and sediment and provide information for use in adaptive management to address potential unforeseen effects (Table 6.4.2-16).

Table 6.4.2-16: 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	Changes to surface water quality from the release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time during the post-closure phases.	Environmental monitoring – Verify effects predictions related to surface water quality.	Monitor the quality of water in the Winnipeg River to evaluate whether the quality of the water is affected by the ISD reactor facility Monitor the quality of water in on-site ditches to verify the hydrogeological model	Water quality monitoring will continue through closure and post-closure phase (i.e., during the active Institutional Control period). The number of parameters and locations may change based on annual review of monitoring data.	Surface water monitoring in the receiving environment is integrated into the CNL Environmental Monitoring Program, and will be compliant with CSA N288.4-10.

6.4.2.9 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, scientists, government agencies, First Nation and Métis peoples, or the public (the Agency 2014). Surface water quality was selected as a VC as humans and the environment depend on the quality. Measurement indicators include estimated concentrations of surface water parameters in the Winnipeg River.

A summary of predicted residual effects for surface water quality are provided in Table 6.4.2-17. Residual effects during the Post-closure phase have been identified as the primary linkage to potentially affect surface water quality. Groundwater may come into contact with the WR-1 Building and then flow to the Winnipeg River, resulting in changes to surface water and sediment quality. The predicted maximum radionuclide concentrations in surface water at both the Nearfield and the Farm A Intake on the Winnipeg River are orders of magnitude lower than groundwater concentrations. Predicted maximum non-radionuclide concentrations in surface water are driven by current river concentrations and some parameters exceed surface water guidelines.

Predicted sediment concentrations of radionuclides are lower than their respective Clearance Levels. Predicted sediment concentrations of non-radionuclides are driven by current river concentrations and exceed available sediment guidelines.

CNL will implement an Environmental Assessment Follow-up Program for WR-1 to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. CNL's current environmental monitoring program includes collecting water samples at one location upstream and three locations at varying distances downstream of the WL site. Surficial sediment is also collected at two locations upstream, at the outfall, and nine locations downstream. In addition, CNL has committed to collecting cores in depositional areas in 2026, 2046, and 2066 at Sylvia Lake and upstream and downstream of the waterbody Lac du Bonnet. Follow-up monitoring during the post-closure phase is necessary to confirm predicted concentrations in surface water and sediment in the Winnipeg River and to provide information for use in adaptive management to address potential unforeseen effects.

Table 6.4.2-17: Summary of Predicted Residual Adverse Effects for Surface Water Quality

Valued Component	Assessment Endpoint	Residual Effect	Phase Project Effect Occurs in	Contributing Project Activity	Proposed Mitigation	Significance
Surface Water Quality	Intermediate component (i.e., it does not have an assessment endpoint)	Release of chemical and radiological contaminants in the long-term during the post-closure phase from the Project, which can alter surface water and sediment quality.	Post-Closure	Post-Closure Performance - Grout and reactor components gradually deteriorate over time	■ As part of CNL's licence with the CNSC, environmental monitoring around the WL site is required and will continue for the Project. ■ Follow-up monitoring during the post-closure phase will be completed to verify effects predictions and to provide information for use in adaptive management to address potential unforeseen effects.	Significance is not determined as VC does not have an assessment endpoint; rather the results provided to other disciplines for inclusion in their assessment.

6.5 Aquatic Environment

This section of the Environmental Impact Statement (EIS) for the Canadian Nuclear Laboratories (CNL) In Situ Decommissioning of WR-1 at the Whiteshell Laboratories Site (the Project) provides understanding of the potential residual effects of the Project and other past, present, and reasonably foreseeable developments on the physical aspects of the aquatic environment.

6.5.1 Scope of the Assessment

The scope of the assessment focuses on the evaluation of potential changes in the aquatic environment (the Winnipeg River) that may result from activities associated with the Project. Hydrology, surface water quality and sediment quality are discussed in detail in Section 6.4 Surface Water Environment and risks to ecological health as the result of chemical and radiological exposures are discussed in Section 6.7 Human and Ecological Health. Results of these assessments are used to support the assessment of effects on the aquatic environment.

The aquatic environment assessment follows the overall environmental assessment approach and methods described in Section 6.1 Environmental Assessment Approach. The assessment is completed in the following steps:

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries, and assessment cases** (refer to Section 6.5.2 Valued Components and Section 6.5.3 Assessment Boundaries) for the aquatic environment assessment. The VCs, assessment endpoints, and measurement indicators used to assess Project related changes to the aquatic environment, 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 6.5.4 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).
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 6.5.5 Project Interactions and Mitigation). Project components and/or activities with the potential to affect the aquatic environment (biota) 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 effect pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. Where effects are adequately mitigated and are not forwarded to further analysis (i.e., secondary pathways, or where mitigation will remove the pathway altogether), the reasons for concluding the assessment at this stage are described.
- **Step 4 – Identify monitoring and follow-up** (refer to Section 6.5.6 Monitoring and Follow-up) required to confirm effect predictions and address uncertainty.
- **Step 5 – Present a consolidated summary of conclusions and outcomes of the assessment** (refer to Section 6.5.7 Conclusions) of residual effects on the aquatic environment.

This section also describes how the input from engagement influenced the scope of the aquatic environment assessment. Information and concerns raised by the public, communities of interest, regulators, and First Nations and Métis communities during engagement that influenced the scope of the aquatic environment assessment are summarized in Table 6.5.1-1.

Table 6.5.1-1: Summary of Issues Raised During Engagement Activities that Influenced the Scope of the Aquatic Environment Assessment

Issue	How the Issue Was Included in the Assessment
The public and First Nation and Métis communities identified the importance of the Winnipeg River. A number of communities depend on the river for drinking water, recreation, and food.	The Winnipeg River was included in the Regional Study Area for the assessment of water quality. Changes in water quality were considered as an input to the land use and human and ecological health assessments. The public and First Nations and Métis communities identified the importance of the Winnipeg River. A number of communities depend on the river for drinking water, recreation, and food.
Concerns about the long term effects of the WL site and the Project on water quality and fish, including accumulation of contaminants over time.	Release of contaminants in the long-term to water quality and aquatic species during the post-closure phase was considered as part of the assessment.
An interest in fish monitoring at locations in proximity to the community.	Fish monitoring within the aquatic study area is described as part of the baseline environment.

6.5.2 Valued Components

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, First Nations and Métis, or the public (the Agency 2014). For the aquatic environment, fish and fish habitat was selected as a VC as there is a potential for the Project activities to affect aquatic biota in the Winnipeg River (Table 6.5.2-1).

Table 6.5.2-1: Valued Components for Aquatic Environment Assessment

Valued Component	Rationale for Selection
Fish and Fish Habitat	The Winnipeg River supports a diverse fish community, including species-at-risk, and species that support recreational fisheries. The migration of radionuclides to the Winnipeg River via groundwater may potentially affect fish and fish habitat.

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 the aquatic environment is the maintenance of self-sustaining and ecologically effective fish populations. Self-sustaining populations are healthy and viable and, by definition, robust and capable of withstanding environmental change and accommodating stochastic processes (Reed et al. 2003). Maintaining viable fish 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).

Measurement indicators represent the specific properties of the aquatic environment assessment endpoints and VCs that, when changed, could represent 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 measures for study in follow-up and monitoring programs. The measurement indicators for the aquatic environment include measurable attributes that broadly represent various facets of the aquatic environment. These include fish habitat (quality and quantity), benthic invertebrate community structure, and fish community structure (Table 6.5.2-2).

Table 6.5.2-2: Assessment Endpoints and Measurement Indicators for the Aquatic Environment Assessment

Valued Component	Assessment Endpoint	Measurement Indicators
Fish and Fish Habitat	Maintenance of self-sustaining and ecologically effective fish populations	Changes to quality and/or quantity of fish habitat
		Changes in benthic macroinvertebrate community structure (diversity, abundance)
		Changes in fish community structure (diversity, abundance)
		Changes in fish flesh radiochemistry

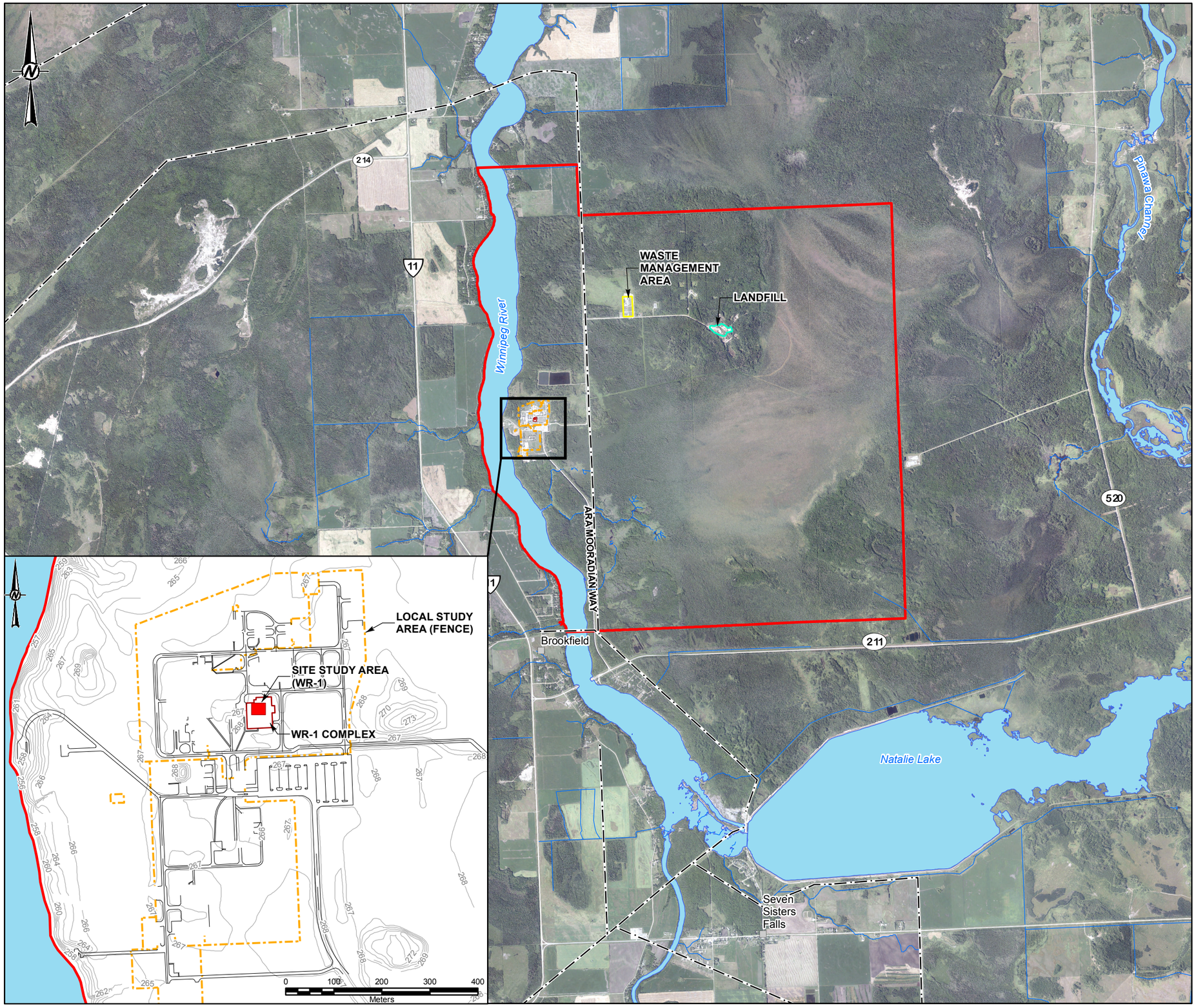
6.5.3 Assessment Boundaries

6.5.3.1 Spatial Boundaries

The spatial boundaries selected for the aquatic environmental assessment are consistent with hydrology and surface water quality, and are presented on Figure 6.5.3-1 and are described below:

- **Site Study Area (SSA):** is the WR-1 Building and represents the Project footprint (i.e., where project activities will be undertaken). The area size of the SSA is 0.07 hectares (ha).
- **Local Study Area (LSA):** was selected in consideration of the Project footprint, and the spatial extent of potential direct effects of the Project on hydrology, surface water quality and the aquatic environment. The LSA was selected to represent an area that is likely to be directly affected by the Project, helping to identify Project-specific (rather than cumulative effects of the project in combination with other projects in the region). The LSA is represented by the fenced area of the WL main campus, and includes the SSA. The LSA was based on the area of the WL main campus that is currently drained by roadside ditches and storm sewers. The approximate size of the LSA is 29 ha. The LSA does not include the Winnipeg River as direct effects to the aquatic environment from the Project on the Winnipeg River are anticipated to be negligible (i.e., the drainage area of the LSA is several orders of magnitude smaller than that of the Winnipeg River). Conversely, indirect residual effects to the surface water quality of the Winnipeg River may occur as a result of changes to groundwater quality resulting from the Project. As such, the Winnipeg River is considered as part of the Regional Study Area (RSA).

- **Regional Study Area:** is defined as the area within which maximum geographical extent of potential indirect effects of the Project may interact with the effects of other existing or reasonably foreseeable projects. For example, indirect effects on surface water quality from the Project include potential seepage of groundwater into the Winnipeg River. The plume from the discharged effluent during operation was previously assessed to hug the east bank of the river (AECL 1973) and it is assumed that a groundwater seep entering the river in generally the same area will behave similarly. Therefore, the south boundary of the RSA extends from the west shore of the Winnipeg River to the east fence on the property line about 400 m north of Provincial Highway 211. The eastern boundary of the RSA follows the fence on the property line to the north property line. The north boundary follows the north fence on the property line about 1.6 km and then turns north for about 400 m before turning west and extending to the west side of the Winnipeg River. This is to include the first farm downstream on the east bank because this is the most conservative potential water user. The west boundary follows the west bank of the Winnipeg River. The RSA has an approximate size of 4,000 ha.



LEGEND

- SITE STUDY AREA (WR-1)
- LOCAL STUDY AREA (WHITESHELL LABORATORIES FENCE)
- REGIONAL STUDY AREA

WHITESHELL LABORATORIES

- WR-1 COMPLEX
- WASTE MANAGEMENT AREA
- LANDFILL

BASE FEATURES

- CITY/TOWN
- TRANSMISSION LINE
- ROAD
- CONTOUR - 1 M INTERVAL
- WATERCOURSE
- WATERBODY

0 1,000 2,000 3,000 4,000
1:60,000 METRES

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
SPATIAL BOUNDARIES FOR THE AQUATIC ENVIRONMENT ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE
REVIEWED	CS
APPROVED	MM

PROJECT NO.	CONTROL	REV.	FIGURE
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6.5.3.2 Temporal Boundaries

Temporal boundaries (i.e., project phases) represent the time period during which project activities are actively occurring and considers the duration of predicted residual effects and establishes the timeframe during which Project effects are assessed. 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 length of 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 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 Project:

- **Closure Phase**: Preparation and implementation of In Situ Decommissioning (ISD), which includes preparation for ISD, grouting of below-grade structures and systems, removal of above-grade WR-1 structures and systems, installation of the engineered cap and environmental controls and final site restoration. These activities last from 2019 to 2024.
- **Post-closure Phase:** The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. The Institutional Control period includes implementation of both active and passive control throughout 2024 to 2324 (i.e., 300 years). During active Institutional Control, long-term performance monitoring and maintenance activities will continue through to 2124 to demonstrate compliance with the safety case assumptions. The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions) and will continue through 2024 to 2324. Post-institutional Control occurs after year 2324 and continues indefinitely.

Project activities associated with the closure and post-closure phases are described in more detail in Section 3.5 Project Components.

6.5.3.3 Assessment Cases

The assessment cases considered in the aquatic environment assessment include the Base Case, Application Case, and the Reasonably Foreseeable Development (RFD) 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, hydroelectric, and residential and recreational development. Current effects to surface water and sediment quality from the existing WL facilities and operations are considered part of the Base Case (i.e., existing conditions). In addition, effects from the decommissioning and reclamation activities already completed at the WL site are also considered as part of the Base Case.
- **Application Case** – This scenario represents the effects of the Base Case combined with the predicted effects from the Project. The Application Case includes closure and post-closure activities, and therefore, the associated effects during these phases of the Project represents the bounding case.
- **RFD Case –** This scenario represents the predictions of the cumulative effects of the Application Case, plus projects that are currently under application review or that have officially entered a regulatory application process and which overlap with the aquatic environment RSA. Foreseeable developments in the air quality RSA that are expected to overlap with residual effects on air quality from the Project includes the decommissioning of the remaining infrastructure and support facilities at the WL site as per the existing decommissioning licence. A Comprehensive Study Report (AECL 2001a) under the *Canadian Environmental Assessment Act* (1992) was completed for the decommissioning of the WL site. The Environmental Assessment decision to approve the project was announced by the Minister of the Environment in March 2002 and a decommissioning licence was issued to AECL and subsequently to CNL.

6.5.4 Description of the Environment

6.5.4.1 Methods

Baseline aquatic environment data were compiled from existing information. Sources included the *Whiteshell Laboratories Decommissioning Project Comprehensive Study Report* (AECL 2001a, b), as well as annual environmental monitoring reports (AECL 2012, 2013, 2014; CNL 2015, 2016). Internet searches were also performed to locate additional or more recent relevant information. Where applicable, radionuclide concentrations and dose rates were compared to international, federal or provincial standards, objectives, or guidelines.

6.5.4.2 Results

6.5.4.2.1 General Overview

The principal aquatic habitat occurring within the RSA is the Winnipeg River. The Winnipeg River flows through the WL site, approximately 500 m the west of the WR-1 Building. In addition, there are several small isolated ponds on the WL site that are fed by local runoff and intermittent streams that flow primarily during the spring (AECL 2001a). The streams are associated with gullies that dissect the clay plains along the banks of the Winnipeg River. Beaver ponds are a common feature on the WL site; however, ponds rarely persist for more than a few years, affording limited quality aquatic habitat. There is also a sewage lagoon, situated north of the main plant site that harbours a number of aquatic plants and animals, as well as man-made ditches that convey water during spring runoff, but are generally dry in summer.

Liquid effluent from the Active Liquid Waste Treatment Center (ALWTC), as well as stormwater is discharged to the Winnipeg River at an outfall located about 8 m offshore in approximately 5 m of water (AECL 2001a). In 2015, the concentration of the dominant radionuclide associated with the discharge, Cesium-137 (Cs-137), in downstream river water was 0.005 Becquerel per litre (Bq/L) (CNL 2016), which for example is considerably lower than the current maximum acceptable concentration guideline for Canadian Drinking Water Quality of 10 Bq/L (Health Canada 2014) (see Section 6.7 Human Health). In 2000, elevated radionuclide concentrations were measured in sediments in the immediate vicinity of the outfall (in an area approximately 20 m wide by 80 m downstream); however the total radionuclide inventory was very low, approximately 1.3 Gigabecquerel (GBq). This level of activity was substantially less than the annual releases of Cs-137 prior to 1985 when the reactor was operating (AECL 2001a). Measured concentrations of Cs-137 were as high as 1,345 Bq/kg in sediments collected near the outfall in 2008 (AECL 2012). Subsequently (2009-2015), concentrations measured during annual environmental monitoring have ranged from 14 to 473 Bq/kg. Sediment concentrations 150 m downstream of the outfall were measured at 118 Bq/kg in 2009 and subsequently ranged from 5.3 to 49 Bq/kg between 2010 to 2015 (AECL 2013, 2014; CNL 2015, 2016). Variation of activity is not unexpected for all samples due to the highly localized and spotty nature of the contamination in the river sediments at the outfall. Sample collection is difficult as the sediment is largely impenetrable at the sampling locations due to the erosion created by the river current.

The Winnipeg River supports a diverse fish community and affords spawning, rearing and foraging habitats. A total of 61 native species are reported for the river (Stewart and Watkinson 2004) and two species-at-risk are known to be present within the vicinity of the WL site: Lake Sturgeon (*Acipenser fulvescens*) and Carmine Shiner (*Notropis percobromus*) (COSEWIC 2016). Fish occurring within the study reach include species that are primarily resident (present year-round), as well as migratory (passing through). Fish habitat is generally similar throughout the RSA.

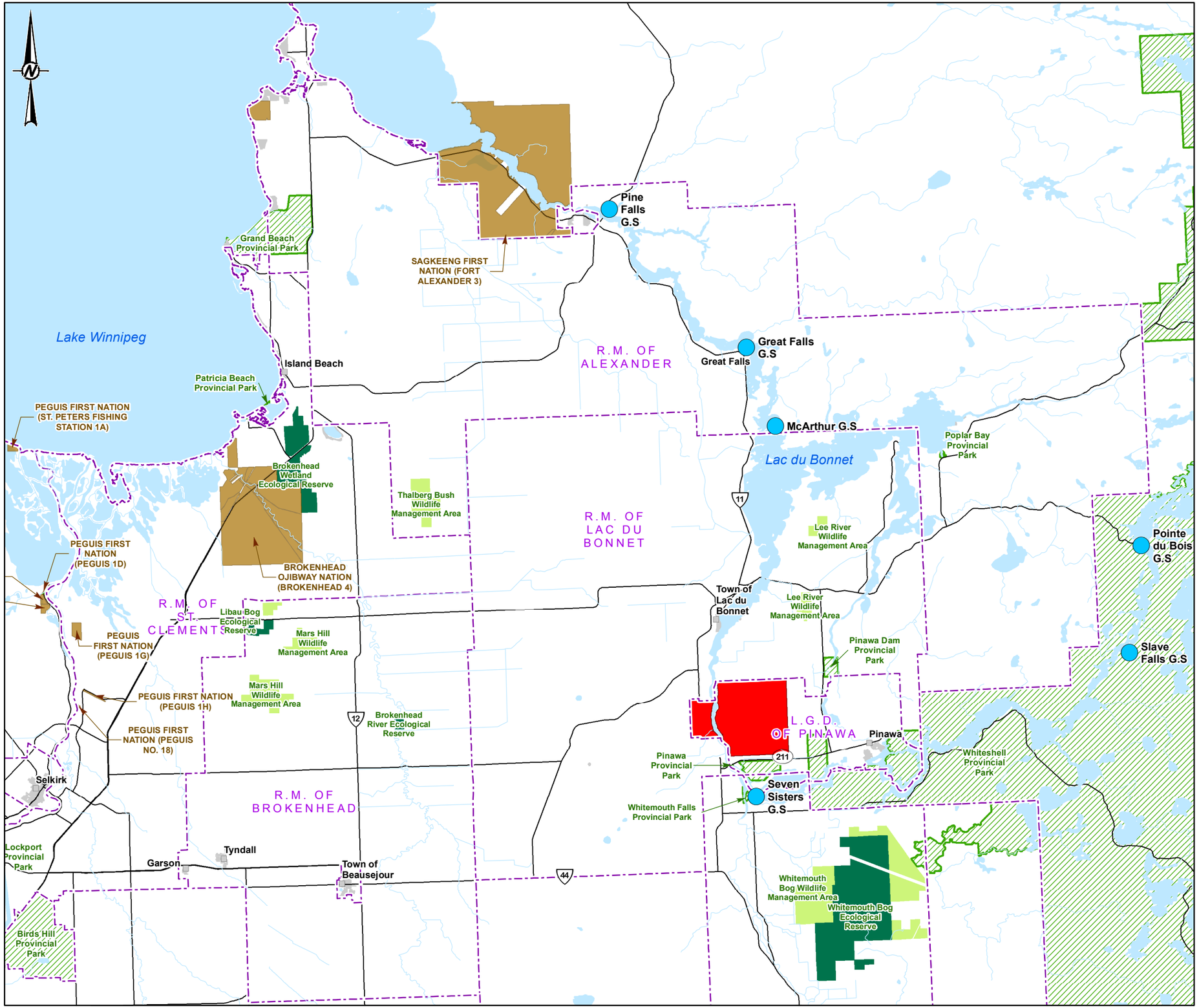
6.5.4.2.2 Fish Community

Of the 177 native freshwater fish species present in Canada, 94 species occur in the Hudson Bay drainage, which includes the Winnipeg River (Scott and Crossman 1973). A total of 79 native species are reported for Manitoba including 61 species for the Winnipeg River (Stewart and Watkinson 2004).

Many of the fish species occurring in the Winnipeg River within the vicinity of the WL site are forage fish including minnows (*Cyprinidae*), suckers (*Catostomidae*), sculpins (*Cottidae*) and darters (*Percidae*). Predatory fish species reported in the area include Walleye (*Sander vitreus*), Northern Pike (*Esox lucius*) and Smallmouth Bass (*Micropterus dolomieu*) (AECL 2001a). Walleye, Northern Pike, Lake Whitefish (*Coregonus clupeaformis*), White Sucker (*Catostomus commersonii*) and Shorthead Redhorse (*Moxostoma macrolepidotum*), are routinely captured upstream and downstream of the WL site, during annual environmental monitoring (CNL 2016).

Thirty-six species of fish were reported from the Winnipeg River near Pointe du Bois Generating Station (situated approximately 55 km upstream of the WL site, see Figure 6.5.4-1) during fish community studies conducted between 2006 and 2010 (Manitoba Hydro 2011). The principal large-bodied species captured included Walleye, Sauger (*Sander canadensis*), Northern Pike, Yellow Perch (*Perca flavescens*), Burbot (*Lota lota*), Lake Whitefish, Cisco (*Coregonus artedi*), Longnose Sucker (*Catostomus catostomus*), White Sucker and Lake Sturgeon. Small-bodied species included Spottail Shiner (*Notropis hudsonius*), Emerald Shiner (*Notropis atherinoides*), Trout-perch (*Percopsis omiscomaycus*) and Logperch (*Percina caprodes*). The larvae of three families, *Salmonidae* (Cisco, Lake Whitefish), *Percidae* (Yellow Perch, Logperch, Walleye, Sauger), and *Cottidae* (sculpin) were captured in drift nets throughout the study area. Lake Sturgeon and Northern Pike larvae were collected in low abundance.

Two species at risk occur within the Winnipeg River in the vicinity of the WL site: Lake Sturgeon and Carmine Shiner. Lake Sturgeon (Winnipeg River-English River populations) is designated as Endangered by COSEWIC (2016). Historically, populations supported a commercial fishery and prior to construction of the Seven Sisters GS (situated approximately 8 km upstream of the WL site; see Figure 6.5.4-1) there was an important Lake Sturgeon spawning and nursery area located below the GS site (COSEWIC 2006). Currently, Lake Sturgeon remain relatively common within several kilometres downstream of the Seven Sisters GS. Spawning occurs below the GS and recruitment is occurring (Cleator et al. 2010). The current status of Lake Sturgeon in this reach of the Winnipeg River is thought to be cautious, although a population trend is unknown (DFO 2010). The Carmine Shiner is designated as Threatened by COSEWIC (2016) and is listed on Schedule 1 of the *Species at Risk Act* (SARA). The known distribution of the Carmine Shiner is limited to the Winnipeg River, at the base of Whitemouth Falls (located approximately 7 km upstream of the WL site; see Figure 6.5.4-1), and its tributaries (Whitemouth, Birch, Bird, and Lee Rivers; DFO 2013).



LEGEND

- GENERATING STATIONS
- WHITESHELL LABORATORIES SITE

BASE FEATURES

- CITY/TOWN
- MAJOR ROAD
- WATERCOURSE
- WATERBODY
- MUNICIPAL BOUNDARY
- FIRST NATION RESERVE

PROTECTED AREAS

- PROVINCIAL PARK
- ECOLOGICAL RESERVE
- WILDLIFE MANAGEMENT AREA

0 10 20
1:330,000 KILOMETRES

NOTE(S)

REFERENCE(S)
1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
WHITESHELL LABORATORIES SITE AND REGIONAL HYDROELECTRIC GENERATING STATIONS ON THE WINNIPEG

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE
REVIEWED	CS
APPROVED	AB

PROJECT NO. 1656897 | CONTROL | REV. 1 | FIGURE **6.5.4-1**

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6.5.4.2.3 Radioactivity in Fish

Fish consumption is the dominant exposure pathway of Cs-137 for people in the local area. CNL undertakes annual monitoring of radioactivity in fish flesh (muscle and tissue) collected from the Winnipeg River upstream and downstream of the WL site (CNL 2016). Walleye, Northern Pike, Shorthead Redhorse, White Sucker and Lake Whitefish are usually captured and analyzed. It is important to note the Seven Sisters GS hydroelectric dam, located approximately 8 km upstream from WL, acts as an effective barrier, separating fish populations downstream of WL from the upstream (control) populations. Between 1962 and 1972, fallout from nuclear weapons testing contributed 99% or more of the total Cs-137 in the river and levels were not statistically different between the fish upstream and downstream of the WL site. From 1976 to 1982, downstream fish flesh concentrations of Cs-137 were greater than upstream concentrations for all fish species. However, the estimated dose from fish consumption (<0.005 mSv/a) remained far below (0.01%) the occupational dose limit, so the fish remained safe to eat (AECL 1983). Concentrations in water decreased subsequent to improvements to effluent treatment at the ALWTC in 1982, similar to levels observed between 1962 and 1972 (AECL 1983).

Data collected between 1992 and 1999 indicated that fish from the downstream area generally contained higher concentrations of Cs-137 than upstream. Walleye, White Sucker and Northern Pike showed elevated concentrations in 1996 at 0.5 km downstream of the outfall. Otherwise, concentrations were fairly uniform among areas over the eight years (AECL 1999, 2000).

Table 6.5.4-1 provides a summary of the Cs-137, K-40 and gross beta activity found in fish flesh at three locations on the Winnipeg River, from 2010 to 2015. Average concentrations of all three radionuclides were slightly greater for Walleye at downstream locations compared to upstream (CNL 2016). However, for the other species, on average radionuclide levels were slightly lower downstream of the WL site compared to upstream. Overall, no significant differences or trends in radionuclide concentrations were apparent among areas over the last five years.

In 2015, the total incremental dose due to fish ingestion was 1.14×10^{-4} mSv/a for adults (CNL 2015). This was equivalent to about 0.0114% of the annual regulatory limit of 1 mSv/a for members of the public. Table 6.5.4-2 shows the dose estimates for 2010 to 2015 along with the five-year average. The 2015 dose was slightly lower than 2014 and higher than the five-year average.

Table 6.5.4-1: Average Radioactivity in Flesh of Winnipeg River Fish, 2010 to 2015

Location and Year	Radioactivity (Bq/kg fresh weight)											
	White and Redhorse Sucker			Walleye			Northern Pike			Lake Whitefish		
	Cs-137	K-40	Gross Beta	Cs-137	K-40	Gross Beta	Cs-137	K-40	Gross Beta	Cs-137	K-40	Gross Beta
Upstream of WL Site												
2010	0.30	134	150	0.34	123	145	0.37	113	133	0.58	125	161
2011	<1.4	139	171	1.90	126	148	<1.9	107	137	—	—	—
2012	<0.5	155	163	0.40	160	149	0.30	130	164	0.40	185	148
2013	0.40	139	135	0.40	104	107	0.40	137	130	—	—	—
2014	1.40	141	138	0.50	135	131	0.60	143	138	0.30	140	146
2015	<0.44	143	119	0.46	147	121	0.30	124	120	—	—	—
Average	**0.74**	**142**	**146**	**0.67**	**133**	**134**	**0.65**	**126**	**137**	**0.43**	**150**	**152**
0 to 2 km Downstream of WL Site												
2010	0.57	131	136	0.86	128	130	—	—	—	—	—	—
2011	0.30	130	156	1.80	130	153	<1.1	101	119	0.40	169	169
2012	0.40	130	152	0.70	123	148	0.20	139	156	0.40	155	156
2013	0.40	165	151	0.8	164	163	0.50	119	107	0.50	142	129
2014	0.30	147	145	1.00	143	144	0.40	105	112	0.40	140	146
2015	0.31	134	116	0.73	120	111	0.49	112	111	<0.29	127	120
Average	**0.38**	**140**	**143**	**0.98**	**135**	**142**	**0.54**	**115**	**121**	**0.40**	**147**	**144**
5 km Downstream of WL Site												
2010	0.29	141	152	0.92	155	149	0.53	119	131	0.40	151	177
2011	0.27	130	156	1.32	124	140	0.79	107	138	0.50	141	161
2012	0.35	126	136	0.67	185	154	0.50	131	162	0.59	204	172
2013	0.47	134	151	0.86	136	137	0.65	128	116	0.40	138	128
2014	0.34	127	124	0.73	141	143	—	—	—	0.39	142	134
2015	<0.29	131	116	0.90	119	111	<0.52	106	103	<0.31	121	115
Average	**0.36**	**130**	**134**	**0.81**	**146**	**138**	**0.57**	**122**	**130**	**0.43**	**152**	**141**

— No data available; <= less than; Bq/kg = Becquerel per kilogram; km = kilometre; Cs-137 = Cesium-137; K-40 = Potassium-40.

Source: WL-509243-ASR-2015 Table 6 (CNL 2016).

Table 6.5.4-2: Estimated Adult Dose from WL Effluents due to Fish Ingestion, 2010 to 2015

Dose (mSv/a)						
2010	**2011**	**2012**	**2013**	**2014**	**2015**	**Five-Year Average**
5×10^{-5}	3×10^{-5}	2×10^{-5}	3.1×10^{-5}	1.3×10^{-4}	1.14×10^{-4}	5.2×10^{-5}

Source: WL-509243-ASR-2015 Table 18 (CNL 2016).

6.5.4.2.4 Benthic Macroinvertebrates

Benthic invertebrate studies were undertaken on the Winnipeg River in the vicinity of the WL site by AECL (1973). Additional studies have been undertaken downstream near Pine Falls by Wong et al. (1996) and upstream in Whiteshell Provincial Park (McKillop 1996). Most recently, Manitoba Hydro (2011) undertook studies associated with the Pointe du Bois GS (see Figure 6.5.4-1).

The benthic macroinvertebrate community within a riverine system is often comprised of both sediment-dwelling and drifting organisms. Sediment-dwelling invertebrates inhabit areas with slow flow velocities and soft substrate materials, whereas drifting organisms inhabit areas of higher flow velocity and coarser substrates. Both types of macroinvertebrates are important food sources for fish. Diversity and production of benthos is generally greater in littoral (shallow) areas than in profundal (deep water) areas.

Benthic fauna include protozoa, ostracods, nematodes, oligochaetes, leeches, mysids (opossum shrimp), crayfish, amphipods, mollusks (snails), bivalve clams (e.g., mussels) and aquatic insects. The latter include Diptera larvae including Chironomid and Chaoborus, dragonflies, mayflies (e.g., *Hexagenia*) caddisflies, true bugs and aquatic beetles. Chironomidae and tubificids were particularly numerous in the early operational survey carried out by AECL (1973). This study compared benthic communities in the Winnipeg River upstream and downstream of the WL liquid effluent outfall.

At Pointe du Bois (situated approximately 55 km upstream of the WL site; see Figure 6.5.4-1), 42 sediment-dwelling macroinvertebrate taxa were collected; the majority from the shallow habitats where sediments predominantly consisted of clay (sediments in deeper habitats generally consisted of sand). For the most part, non-biting midges (*Chironomidae*) dominated the benthic community. Worms (*Olichochaeta*), amphipods (*Amphipoda*), mayflies (*Ephemeroptera*), and pea clams (*Sphaeriidae*) also were also common in sediments (Manitoba Hydro 2011). Macroinvertebrates collected in drift traps consisted of 64 identified taxa, 44 of which were from the Class Insecta. During all years and within all study reaches, amphipods (*Hyalellidae*) and mites (*Hydrachnidae*) dominated the non-insect group of the macroinvertebrates; whereas mayflies (*Ephemeridae*), stoneflies (*Perlodidae*), caddisflies (*Hydropsychidae*), and non-biting midges (*Chironomidae*) dominated the insect group.

A 2000 study found Cs-137 levels in clam shells and tissues collected downstream of the WL outfall to be slightly elevated (AECL 2001b). There was considerable variation in levels with slight trends to higher tissue concentrations nearer to the outfall and higher concentrations in larger (older) clams. The effect of exposure from radionuclides in sediments on aquatic biota was estimated in 2000 using clams (AECL 2001b). The doses for the 99th and 99.9th percentile scenarios were 0.0106 milligray per day (mGy/d) and 0.0465 mGy/d (AECL 2001a), a small fraction of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR 2011) benchmark of 9.6 mGy/d and the limit at which no effect on aquatic populations would be expected.

Among the many species of zooplankton in Winnipeg River, rotifers, cladocera and copepod are usually dominant (AECL 2001a). Near Pointe du Bois GS, total mean density (individuals/m^3) of zooplankton was relatively similar among years and Cyclopoida and Cladocera were the most abundant taxa, with Calanoida accounting for only 10% to 12% of the mean total collected (Manitoba Hydro 2011).

6.5.4.2.5 Fish Habitat

General physical habitat attributes of the river in the vicinity of the WL site include a width of approximately 0.3 km, a depth of 7 m, and a flow velocity of approximately 0.3 m/s (AECL 2001a). Additional data on currents and velocities in the vicinity of the WL outfall are presented in AECL (1973). Typical baseflow at Seven Sisters GS ranges seasonally between 600 and 1,200 m^3/s, but discharge rates in the order of 2,400 m^3/s and 220 m^3/s have been measured during flood and drought conditions, respectively (LWCB 2017). Downstream, channel width within the RSA reaches about 0.6 km. The shoreline consists of a steep clay till bank with frequent cobbles and some large boulders. The substrates are similar to the exposed stream banks, and typical of an erosional habitat, largely comprised of gravel, cobbles and boulders, overlying dense clay (AECL 2001a).

Spawning habitat for several species, including Lake Sturgeon, Walleye, Smallmouth Bass, and suckers, likely occurs 7 to 8 km upstream of the WL site, associated with the rapids downstream of the Seven Sisters GS and Whitemouth falls (see Figure 6.5.4-1), whereas Northern Pike spawning habitat would be more likely to occur downstream in Lac du Bonnet, although suitable spawning habitats may be present within the RSA, associated with the confluence of smaller tributaries. Optimal spawning habitat for Northern Pike is flooded vegetation in shallow, sheltered areas (Casselman and Lewis 1996), which is more often associated with lacustrine environments. Habitat use by fishes with the RSA would also include nursery, foraging and migration for species that spawn upstream.

Emergent macrophytes such as bulrushes (*Scirpus* spp.), cattails (*Typha* spp.) and wild rice (*Zizania palustris*) are found to a depth of about 1 m along the shores of the Winnipeg River. There are no major aquatic macrophyte beds on the WL site (AECL 2001a); however, in riverine environments, a relatively large amount of vascular plant and algal biomass is transported downstream by flowing water. A recent study undertaken upstream of the RSA, in the vicinity of Pointe du Bois GS (see Figure 6.5.4 1), recorded at least 18 aquatic macrophyte taxa, collected from drift traps deployed in the main stem of the Winnipeg River (Manitoba Hydro 2011). Algae, mainly filamentous, were the most abundant type of vegetation collected in drift traps. Dominant macrophytes collected include pondweeds (*Potamogeton* spp.), grasses (Poaceae), sedges (Cyperaceae), rushes (Juncaceae), water milfoil (*Myriophyllum* spp.), wild celery (*Vallisneria americana)*, bladderworts (*Utricularia* spp.), spikerush (*Eleocharis acicularis*) and duckweed (*Lemna trisulca*). These aquatic plants would also be expected to occur within the RSA.

Phytoplankton (algae) of the Winnipeg River is comprised of a diverse assemblage of nearly all major algal taxonomic groups (AECL 2001a). Studies in upstream reaches have indicated the phytoplankton abundance and composition varies between years and among sites (Manitoba Hydro 2011). The overall mean phytoplankton biomass was 84,410 mg/m^3 and phytoplankton biomass peaked in August. Phytoplankton community composition dominance varied seasonally among chlorophytes, cyanophytes, and diatoms.

6.5.5 Project Interactions and Mitigation

6.5.5.1 Methods

This section describes the process by which interactions between Project components/activities and the aquatic environment were evaluated. Potential effect pathways were identified and mitigation developed, where possible, to eliminate and/or reduce effects. A pathways analysis was then used to focus the assessment on key interactions between the Project and the environment by evaluating the different effect pathways to assess if, after incorporating mitigation, there remained a potential to cause residual effects. Where effects were adequately mitigated and were not forwarded for further analysis (i.e., secondary pathways, or where mitigation removed the pathway altogether), the rationale for concluding the assessment at this stage were articulated. Primary pathways that may lead to residual effects after incorporation of mitigation are further characterized. 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 Project. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. The next step in the analysis was the development of environmental design features and mitigation practices that could be incorporated into the Project to eliminate and/or reduce effects to the aquatic environment. Environmental design features included design elements, environmental best practices, and management policies and procedures.

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 pathway** – 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 the Base Case, and therefore would have no residual effects on the aquatic environment.
- **Secondary pathway** – the pathway could result in a measurable minor change to features of the aquatic environment, but these changes would represent a negligible residual effect relative to the Base Case and are not expected to contribute cumulatively to other Project effects or to the effects of other past, present 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 to the aquatic environment.

Environmental design features and mitigation that have been or could be incorporated into the Project to eliminate and/or reduce adverse effects to the aquatic environment 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 on the aquatic environment through simple qualitative or semi-quantitative 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 Project on the aquatic environment.

6.5.5.2 Results

Pathways through which the Project may interact with the aquatic environment and result in changes to the fish and fish habitat VC are summarized in Table 6.5.5-1. Project activities are described in more detail in Section 3.5 Project Components.

Table 6.5.5-1: Pathways Analysis for Aquatic Environment Valued Components

WR-1 Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Activities associated with ISD of the WR-1 and demolition of above-ground structures of the WR-1 Building	During closure activities, there is the potential for the transport of site runoff to the Winnipeg River.	■ Existing surface water management systems at the WL Site will remain in place to manage site runoff. ■ The Project site and engineered cover will be graded to promote drainage from the site to the Winnipeg River.	No Linkage
	Non-radiological air emissions and dust emissions (including sulphur dioxide, nitrogen oxides [NOx/NO2], and particulate matter) and subsequent deposition.	■ Implementation of CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring, air verification monitoring and environmental monitoring. ■ Implementation of dust management techniques to control dust generated by the Project, consistent with the current Environmental Assessment Follow-up Program. ■ Road watering and chemical dust suppressant when necessary. ■ Removal of accumulations of particulates (e.g., dirt) on road as soon as possible. ■ On-site vehicles and equipment engines will meet Tier 3 emission standards, where possible, and be maintained in good working order. ■ Limit idling of vehicles on-site and speed on roads. ■ Use of enclosure for raw material handling.	Secondary
Installation of engineered cover over during closure	Installation of engineered cover at the WR-1 Building may alter drainage rates and flow patterns.	The Project site and engineered cover will be graded to promote drainage from the site to the Winnipeg River.	Secondary

Table 6.5.5-1: Pathways Analysis for Aquatic Environment Valued Components

WR-1 Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Closure of the entire WL site	Decommissioning and reclamation of the entire WL site, including the Project, may alter drainage rates and flow patterns	■ The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. ■ The drainage system for the reclaimed WL site will have same physical characteristics as similar natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity.	Secondary
Post-closure Performance	Release of chemical and radiological contaminants in the long-term during the post-closure phase from the Project.	■ The planned decommissioning of the WR-1 Complex presently involves: ▪ removal the service area and infilling in these areas with compact soil; ▪ sealing of open conduits in the building foundation; and ▪ grouting the interior portion of the building (containing the remaining components of WR-1) to ground surface elevation. ■ As part of CNL's licence with the CNSC, environmental monitoring around the WL site is required and will continue for the Project. ■ Follow-up monitoring during the post-closure phase will be completed to verify effects predictions and to provide information for use in adaptive management to address potential unforeseen effects.	Secondary
	Release of chemical and radiological contaminants in the long-term from the closure of the entire WL site, in combination with the Project.		Secondary

Table 6.5.5-1: Pathways Analysis for Aquatic Environment Valued Components

WR-1 Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Post-closure Performance	Release of chemical and radiological contaminants in the long-term during the post-closure phase from the previous activities completed at the WL site.	■ As part of CNL's licence with the CNSC, environmental monitoring around the WL site will continue for the Project. ■ Follow-up monitoring during the post-closure phase will continue to verify effect predictions and to provide information for use in adaptive management to address potential unforeseen effects.	Secondary

6.5.5.2.1 No Linkage Pathway

The following pathway was assessed as having no measurable environmental change and hence, no linkage to residual effects on VCs for the aquatic environment.

- **During closure activities, there is the potential for the transport of site runoff to the Winnipeg River.**

Drainage from the LSA is to the Winnipeg River. During Closure Phase activities, specifically those that are demolition-related, there is the potential for the transport of site runoff to the aquatic environment in the Winnipeg River in the vicinity of the WL site. Unabated, this runoff could negatively affect the aquatic environment through indirect habitat degradation (e.g., increase in suspended solids levels in water, increase in metal concentrations in water, swamping of the benthic environment through the settling of solids) that could result in reductions in diversity and abundance of aquatic biota in the nearshore area. During the closure phase, existing surface water management systems at the WL Site will remain in place to manage site runoff. It is also noted that Closure Phase activities will occur well away from the river and its riparian zone and therefore no direct habitat loss, either in terms of quality or quantity, will result. Consequently, this interaction was determined to have no effect on the maintenance of self-sustaining and ecologically effective fish populations, including species-at-risk.

6.5.5.2.2 Secondary Pathways

The following pathways were assessed as potentially having a measurable minor environmental change, but negligible residual effect on the aquatic environment relative to Base Case.

- **Installation of engineered cover at the WR-1 Building may alter drainage rates and flow patterns.**

Installation of engineered cover at the WR-1 Building may alter drainage rates and flow patterns, and consequently the discharge volume to Winnipeg River. Following the completion of closure activities, the Project site and engineered cover will be graded to promote drainage from the site to the Winnipeg River. Run-off control for the cover is designed to limit erosion and infiltration of water into the grouted structure. This is achieved by sloping the cover surface to maintain slope toward the edges, and the collection of water by the existing surface water management systems at the WL Site. Although the installation of the engineered cover at the WR-1 Building is expected to slightly alter the drainage rates and flow patterns and discharge volume to the Winnipeg River; the changes are expected to be within the natural range of variation. As such, changes to the hydrology from the installation of the cover at closure is predicted to have a negligible effect on the maintenance of self-sustaining and ecologically effective fish populations, including species-at-risk.

- **Decommissioning and reclamation of the entire WL site, including the Project, may alter drainage rates and flow patterns.**

The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. The drainage system for the reclaimed WL site will have similar physical characteristics as similar natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. The contribution to site runoff from the Project is expected to be minor relative to the entire decommissioned WL site. Similar to the decommissioning plan for the Project, the WL site will be graded to promote drainage to the Winnipeg River. Although closure of the WL site may slightly alter the drainage rates and flow patterns and discharge volume to the Winnipeg River; the changes are expected to be within the natural range of variation. As such, changes to hydrology from the closure of the WL site, including the Project, are predicted to have a negligible effect on the maintenance of self-sustaining and ecologically effective fish populations, including species-at-risk.

- **Release of chemical and radiological contaminants in the long-term during the post-closure phase from the previous activities completed at the WL site.**

Results of the Comprehensive Study Report indicated residual effects on surface water, particularly the Winnipeg River, are related to discharges from the Active Liquid Waste Treatment Centre and the sewage lagoon. No decrease in water quality is expected and effluent emissions to the Winnipeg River are expected to decline to virtually zero following decommissioning. Re-suspension of contaminated sediments is also not expected to lead to a decrease in water quality. As part of CNL's licence with the CNSC, environmental monitoring around the WL site will continue for the Project. Follow-up monitoring during the post-closure phase will continue to verify effect predictions and to provide information for use in adaptive management to address potential unforeseen effects. Consequently, changes to surface water quality from the closure of the WL site, are predicted to have a negligible effect on the maintenance of self-sustaining and ecologically effective fish populations, including species-at-risk.

- **Non-radiological air emissions and dust emissions (including sulphur dioxide, nitrogen oxides (NOx/NO_2), and particulate matter) and subsequent deposition.**

Construction and operation of the Project will generate air and dust emissions such as carbon monoxide (CO), oxides of sulphur (SO_x includes sulphur dioxide [SO_2]), oxides of nitrogen (NO_x includes nitrogen dioxide 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 the largest contributor to particulate matter (SPM, PM_{10}, and $PM_{2.5}$) during both construction and operations phases (Section 6.2.1.6.2).

Examples of mitigation implemented to limit predicted residual effects from Project emissions to air quality (and subsequently surface water quality) include:

- implementation of CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring and air verification monitoring;
- road watering and chemical dust suppressant when necessary; and
- use of enclosure for raw material handling.

The predicted residual effects air quality were estimated to increase because of the Project. Fugitive dust from paved roads is the largest contributor to SPM emissions. Material handling from demolition is the largest contributor to PM_{10} emissions. Non-road equipment exhaust emissions are the largest contributors to $PM_{2.5}$ and NOx (as NO_2) emissions. Finally, the largest contributor to SO_2 and CO emissions is fuel combustion for emergency power generators. Predicted concentrations for the Application Case are below applicable air quality guidelines and/or standards (Section 6.2.1.6.2).

With the implementation of CNL's Management and Monitoring of Emissions Procedure, and through the implementation of the Dust Management Plan for the Project, air and dust emissions and subsequent deposition are expected to result in local, minor changes to soil quality relative to Base Case conditions. As such, this pathway is determined to result in a negligible effect on the maintenance of self-sustaining and ecologically effective aquatic populations, including species-at-risk.

- **Release of chemical and radiological contaminants in the long-term during the post-closure phase from the Project.**

Successful closure of the WR-1 Building will require that the dose limit is not exceeded for the protection of aquatic health. The planned decommissioning of the WR-1 Complex presently involves removal the service area and infilling in these areas with compact soil, sealing of open conduits in the building foundation, and grouting the interior portion of the building (containing the remaining components of WR-1) to ground surface elevation.

An Ecological Risk Assessment was completed to evaluate the potential for adverse effects on aquatic health associated with exposure to chemical and radiological contaminants from the Project (Section 6.7.2) in the long-term. For the post-closure phase, the relevant chemical and radiological contaminants may be released over time by a combination of diffusion and advection through the grout and concrete barriers to groundwater and subsequent migration of groundwater to surface water at the Winnipeg River. The Ecological Risk Assessment utilized groundwater release rates (see Section 6.3 Geology and Hydrogeology) and dispersion modelling to estimate radionuclide concentrations in surface water (see Section 6.4.2 Surface Water quality), to calculate dose rates to aquatic biota. These dose rates were compared to international standards (UNSCEAR 2011) and used as a surrogate to assess effects to resident fish and benthos.

The incremental change in radionuclide levels in the Winnipeg River as the result of the transport of radionuclides from the WR-1 Building to the Winnipeg River via groundwater in the post-closure phase is predicted to be not practically distinguishable from background levels (see Section 6.4 Surface Water) and, therefore, no negative effects on the quality or quantity of available fish habitat in the RSA are anticipated as the result of decommissioning.

Similarly, as no practically measurable change in radionuclides levels in water post-closure is expected no radiological effects that would affect benthic community and fish community diversity and density are anticipated. This no effect characterization is supported by the results of the Ecological Risk Assessment (Section 6.7.2) that considered radiological dose to select aquatic biota, including fish, and benthic organisms, as well as aquatic macrophytes, in the Winnipeg River. Post-closure maximum total radionuclide doses, as a result of groundwater seepage, were estimated (Table 6.5.5-2). Radio-sensitivity of aquatic organisms was reviewed by UNSCEAR, which concluded that the reproductive viability of aquatic populations would not be affected at dose rates less than 9.6 mGy/d (UNSCEAR 2011). In all cases the calculated total maximum doses were considerably less than this value.

Table 6.5.5-2: Post-closure Maximum Total Radionuclide Dose to Aquatic Biota in the Winnipeg River

Aquatic Biota	Maximum Total Dose (mGy/d)
Carmine Shiner	4.03×10^{-6}
Lake Sturgeon	4.03×10^{-6}
Walleye	4.03×10^{-6}
Aquatic Macrophytes	4.12×10^{-6}
Benthic Invertebrates	3.59×10^{-6}
Benchmark (UNSCEAR 2011)	**9.6**

The largest contributor to dose post-closure is C-14. Baseline data for C-14 in fish flesh were not available. It is expected that the predicted incremental change in C-14 in fish flesh (5.8 Bq/kg fw) is not a measurable change from baseline, because C-14 global background levels are high, supported by natural production due to cosmic irradiation in the upper atmosphere. C-14 is readily exchanged between atmospheric $^{14}CO_2$ and stable carbon in surface water and fish flesh. A typical background level measured in Great Lakes fish is 240 Bq/kg-C (OPG 2013; BP 2013), which is equivalent to approximately 29,000 Bq/kg fw, much higher than the predicted change. Pu-239 and tritium (HTO and OBT) are minor contributors to dose (1% or less). Tritium is also unlikely to be detectable against the natural background in fish flesh.

In consideration of these results, decommissioning of the WR-1 Building is not expected to adversely affect radionuclide levels in aquatic biota flesh during the Post-closure phase. As part of CNL's licence with the CNSC, environmental monitoring around the WL site is required. The current program includes collecting fish flesh at one location upstream and 2 locations downstream of the WL site (CNL 2016). Follow-up monitoring might include both C-14 and tritium in the radiochemical analyses of fish, to confirm that there is no measureable upstream-downstream difference, as expected. Monitoring of both surface water quality and fish flesh will continue into the post-closure period. Overall, changes to surface water quality from the Project, are predicted to have a negligible effect on the maintenance of self-sustaining and ecologically effective fish populations, including species-at-risk.

- **Release of chemical and radiological contaminants in the long-term from the closure of the entire WL site, in combination with the Project.**

Historically, liquid effluent from the ALWTC was discharged to the Winnipeg River and elevated radionuclide concentrations were measured in sediments in the local outfall area (AECL 2001a). Exposure pathways to aquatic biota include radiation from nuclides in the water and sediment. An immeasurable increase in radionuclide concentrations in water and sediments are anticipated once groundwater from the WL site reaches the river (during the post-closure period). The effect of exposure from radionuclides in sediments on aquatic biota was estimated in 2000 using clams (AECL 2001b). The study found Cs-137 concentration in shells and tissues collected downstream of the WL outfall to be slightly elevated (AECL 2001b). Given the erosional nature of the Winnipeg River in the vicinity of WL site, it would be highly unlikely that residual sediment contamination would persist for a century. Regardless, cumulative (residual plus incremental groundwater concentrations from the Project during the post-closure period) doses to aquatic biota would remain a small fraction of the UNSCEAR (2011) benchmark of 9.6 mGy/d and the limit at which no effect on aquatic populations would be expected. Follow-up monitoring during the post-closure phase will be completed to confirm radionuclide concentrations in both surface water quality and fish flesh will verify the anticipated low effects (or lack thereof) and provide information for use in adaptive management to address potential unforeseen effects. Overall, changes to surface water quality from the closure of the WL site, including the Project, are predicted to have a negligible effect on the maintenance of self-sustaining and ecologically effective fish populations, including species-at-risk.

6.5.5.2.3 Primary Pathways

No primary pathways were identified between the Project and the aquatic environment. As such, a residual effects analysis and determination of significance has not been completed for the aquatic environment assessment.

6.5.6 Monitoring and Follow-up

Monitoring and follow-up programs for WR-1 are not identified as there are no predicted residual effects to fish and fish habitat. CNL will implement an Environmental Assessment Follow-up Program for WR-1 to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. As part of CNL's current licence (NRTEDL-W5-8.04/2018), the current Environmental Monitoring Program includes water monitoring and collecting fish flesh at one location upstream and two locations downstream of the WL site (CNL 2016). Follow-up monitoring during the post-closure phase to confirm radionuclide concentrations in surface water quality (see Section 6.4.2.8) will also verify the accuracy of environmental effects for the aquatic environment.

6.5.7 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, scientists, government agencies, First Nations and Métis, or the public (the Agency 2014). For the aquatic environment, fish and fish habitat was selected as a VC, as there is a potential for the Project activities to affect aquatic biota in the Winnipeg River. The assessment endpoint for the aquatic environment is the maintenance of self-sustaining and ecologically effective fish populations. Fish habitat, benthic macroinvertebrate community structure, fish community structure, and fish flesh radiochemistry were selected as the measurement indicators for the aquatic environment VCs. The assessment of potential pathways of effects determined there are no primary pathways that would lead to residual effects on aquatic environment VCs. CNL will continue to implement the Environmental Assessment Follow-up Program for the WL site to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented.

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6.6 Terrestrial Environment

This section of the Environmental Impact Statement (EIS) for the Canadian Nuclear Laboratories (CNL) In Situ Decommissioning of WR-1 at the Whiteshell Laboratories Site (the Project) provides understanding of the potential residual effects of the Project and other past, present and reasonably foreseeable developments on the terrestrial environment, including potential effects on the ecological and biological processes that connect species with each other and their physical environment.

6.6.1 Scope of the Assessment

The scope of the assessment focuses on the evaluation of potential changes in the terrestrial environment that may result from activities associated with the Project. Risks to ecological health as the result of chemical and radiological exposures are discussed in detail in Section 6.7 Human and Ecological Health. Results of this assessments are used to support the assessment of effects on the terrestrial environment.

The terrestrial environment assessment follows the overall environmental assessment approach and methods described in Section 6.1 Environmental Assessment Approach. The assessment is completed in the following steps:

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries and assessment cases** (refer to Sections 6.6.2 Valued Components and Section 6.6.3 Assessment Boundaries) for the terrestrial environment assessment. The VCs and measurement indicators used to assess project-related changes to the terrestrial environment, 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 6.6.4 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).
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 6.6.5 Project Interactions and Mitigation). Project components and/or activities with the potential to affect the terrestrial environment 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 effect pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. 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 described.
- **Step 4 – Identify monitoring and follow-up** (refer to Section 6.6.9 Monitoring and Follow-up) required to confirm effects predictions and address uncertainty.
- **Step 5 – Present a consolidated summary of conclusions and outcomes of the assessment** (refer to Section 6.4.1.7 Conclusion) of residual effects on the terrestrial environment.

This section also describes how the input from engagement influenced the scope of the terrestrial environment assessment. Information and concerns raised by the public, communities of interest, regulators, First Nations and Métis communities during engagement activities that influenced the scope of the terrestrial environment assessment are summarized in Table 6.6.1-1.

Table 6.6.1-1: Summary of Issues Raised During Engagement Activities that Influenced the Scope of the Terrestrial Environment Assessment

Issue	How the Issue Was Included in the Assessment
Consideration of migratory birds	Barn swallow and Golden-winged warbler are migratory birds selected valued components included in the terrestrial assessment.
Concerns about potential impacts to wildlife	Multiple wildlife species were considered as valued components in the assessment of effects.
Concerns regarding potential effects to animals in the long-term (as they do not obey the same sorts of boundaries as humans)	Changes in radiation and radioactivity levels during the post-closure phase were predicted for terrestrial and riparian biota living on or near the WL site.

6.6.2 Valued Components

Valued components refer to environmental features identified to be of concern by the proponent, scientists, government agencies, First Nations and Métis people, or the public (the Agency 2014). They are elements of the environment that are considered to have economic, social, biological, conservation, aesthetic and/or ethical value. 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 Project. This section describes how VCs were selected for the terrestrial environment assessment and identifies the assessment endpoints and measurement indicators that were used to assess the effects of the 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 Policy, 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).

Based on the nature of this project and limited pathway of effects on natural terrestrial ecosystems, the focus of this assessment is at a species-level and primarily focuses on wildlife species identified on Schedule 1 of the federal *Species at Risk Act* (SARA 2002). 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, as well as damage or destroy the residence of a species listed as Extirpated, Endangered or Threatened (SARA 2002). Furthermore, species that are included on Schedule 1 as Extirpated, Endangered or Threatened are afforded protection of species-specific critical habitat on federal lands (such as the WL property), once critical habitat is defined in a recovery strategy.

Baseline wildlife data have been compiled for the WL property through incidental observations by staff and some targeted surveys for species at risk in 2015 (i.e., bats and barn swallow). There has also been a spatial query conducted by Manitoba Conservation Data Centre (CDC) to determine the potential for 33 species at risk (animals

and plants), to occur within the RSA (CNL 2016a). Staff observation records and surveys have confirmed the presence of five terrestrial wildlife species at risk listed on Schedule 1 of SARA within the WL property (Appendix 6.6-1).

All SARA-listed species identified in Appendix 6.6-1 with confirmed observation records within the WL property (the Regional Study Area: RSA), as well as all species returned from the CDC query with the potential to occur within the WL property, were considered as potential VCs at the species level. Each species was evaluated to determine whether or not its presence was likely within the Project footprint (Site Study Area: SSA) or the Local Study Area (LSA) defined for the terrestrial environment assessment (Section 6.6.3.1 Spatial Boundaries). Species with a very low likelihood of occurrence, for which habitat was not present in the LSA, or for which measurable effects from the Project were unlikely, were excluded as VCs. Rationale for inclusion or exclusion species at risk with confirmed or potential presence within the WL property is presented in Appendix 6.6-1.

Species at risk identified as VCs for the terrestrial environment assessment are presented in Table 6.6.2-1. Individual species for which the potential effects of the Project are similar were grouped into a single VC (e.g., bats; Table 6.6.2-1). Both of the avian VC species are also protected by additional federal legislation (*Migratory Birds Convention Act, 1994* [MBCA 1994}). 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. The Project has the potential to affect migratory birds, and adherence to the MBCA is required as part of the Project works. Because the RSA is a federally-owned site, the applicable legislation for wildlife species protection is the federal *Species at Risk Act*. However, CNL also recognizes the importance of protecting species designated under provincial legislation (i.e., the provincial *Endangered Species and Ecosystems Act, C.C.S.M. c. E111*; ESEA).

Most of the VCs identified for the terrestrial assessment can also be used as indicators for broader groups of species. For example, golden-winged warbler represents migratory bird species that may breed in the edge habitat within adjacent forested areas and could be affected by decommissioning-related noise. Snapping turtle represents herpetile species vulnerable to mortality on roadways. Consequently, understanding the potential effects of the Project on the selected VCs provides inferences about effects on other wildlife species or guilds with similar life history traits and habitat requirements (Appendix 6.6-1).

Table 6.6.2-1: Valued Components for Terrestrial Environment Assessment

Valued Component	Rationale for Selection
Barn Swallow	■ Barn swallow (*Hirundo rustica*) is currently listed as Threatened by COSEWIC, but not currently listed under SARA. On March 11, 2017, the federal Department of Environment submitted a proposed order to amend Schedule 1 of SARA to include additional species, one of which is barn swallow (Government of Canada 2017). As proposed, barn swallow would be up-listed to Threatened in Canada. As a migratory bird, barn swallow currently has legal individual and nest protection under the MBCA. If up-listed on SARA, barn swallow would also gain legal individual and habitat protection provisions under SARA. Because the RSA is federally-owned, critical habitat of the species would also be afforded protection, once defined in a federal recovery strategy. ■ There is the potential for barn swallow to be indirectly and directly affected by the Project through sensory disturbance, habitat loss, and mortality. Barn swallows have been observed nesting within the LSA.

Table 6.6.2-1: Valued Components for Terrestrial Environment Assessment

Valued Component	Rationale for Selection
Golden-winged warbler	■ Golden-winged warbler (*Vermivora chrysoptera*) is federally listed as Threatened under SARA and listed under the MBCA. It has legal individual and habitat protection provisions under SARA and individual and nest protection under MBCA. ■ As the RSA is federally-owned, 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 affected by the Project through sensory disturbance (i.e., noise created by decommissioning activities). ■ Avian species with the potential to occur within the RSA (no confirmed observation records to-date), that represents a guild of edge habitat specialists.
Bats ■ Little brown myotis ■ Northern myotis	■ Little brown myotis (*Myotis lucifugus*) and northern myotis (*M. septentrionalis*) have observation records within the LSA. Both bat species are federally listed as Endangered and have legal individual protection provisions under the federal SARA. ■ As the RSA is federally-owned, these bat species are afforded protection of critical habitat because they are listed as Endangered on Schedule 1 of SARA. ■ Critical habitat has only been “partially identified”, for one life history requirement and habitat type (overwintering habitat), as the largest threat to these species is associated with that habitat type. No active hibernacula have been identified in the RSA and the geological conditions make the presence of caves or exposed bedrock highly unlikely (See Section 6.3.1.4 Description of the Existing Environment). ■ Other critical habitat types that are identified, but not yet legally defined and protected as “critical habitat”, include: roosting, foraging, and swarming habitat. ■ Maternity roost habitat for little brown myotis and northern myotis is potentially present in the treed areas of the RSA surrounding the LSA. There is the potential for both species to be indirectly affected by the Project through sensory disturbance and related habitat avoidance (caused by noise associated with decommissioning activities and potential roost abandonment). ■ Maternity roost habitat for little brown myotis is also potentially present in the WR-1 Building, and little brown myotis have the potential to be indirectly and directly affected by the through disturbance, habitat loss, and mortality. ■ Represents small mammal species recorded in the LSA that may utilize buildings for part of their life history (maternity roosting, diurnal roosting, and evening roosting).
Snapping Turtle	■ Snapping turtle (*Chelydra serpentina*) have been observed within the RSA. They are federally listed as Special Concern under SARA, but they do not have legal individual protection provisions under the Act, nor do they receive protection of critical habitat. ■ There is the potential for snapping turtle to be indirectly and directly affected by the Project through sensory disturbance (noise) and mortality (i.e., vehicle strike on roads). All snapping turtle observations to-date within the RSA have been on roads. ■ Represents herpetile species that are vulnerable to mortality on roadways.

Each VC was assessed using the assessment endpoints and measurement indicators listed in Table 6.6.2-2.

Table 6.6.2-2: Assessment Endpoints and Measurement Indicators for the Terrestrial Environment Assessment

Valued Component	Assessment Endpoints	Measurement Indicators
Barn Swallow	Maintenance of self-sustaining and ecologically effective populations	■ Habitat availability ■ Habitat distribution ■ Survival and reproduction
Golden-winged warbler		
Bats		
Snapping Turtle		

Assessment endpoints represent the key properties of each VC that should be protected. The assessment endpoint for the terrestrial environment is the maintenance of self-sustaining and ecologically effective wildlife populations. Self-sustaining populations are healthy and viable and, by definition, robust and capable of withstanding environmental change and accommodating stochastic processes (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).

Changes in 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. Habitat availability, habitat distribution, and survival and reproduction were selected as the measurement indicators for the terrestrial environment species VCs. The measurement indicators are defined as follows:

- **Habitat availability**: changes to the amount (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; and,
- **Survival and reproduction:** changes to abundance caused by altering survival and/or recruitment.

6.6.3 Assessment Boundaries

6.6.3.1 Spatial Boundaries

The spatial boundaries selected for the terrestrial environment assessment were chosen because they permit description of Base Case 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 Project to cumulative effects.

The spatial boundaries selected for the terrestrial environment assessment are presented on Figure 6.6.3-1 and are described below:

- **Site Study Area**: the SSA is the Project footprint, which accounts for the direct physical disturbance and alteration of potential wildlife habitat caused by demolition and reclamation of the WR-1 Building (0.07 ha).
- **Local Study Area**: was selected in consideration of the Project footprint, and the spatial extent of potential direct effects of the Project on the terrestrial environment. The LSA was selected to represent an area that is likely to be directly affected by the Project, helping to identify Project-specific (rather than cumulative effects of the project in combination with other projects in the region). The LSA includes the fenced area of the WL main campus, which includes the SSA. This spatial area was chosen as it represents an area under the highest anthropogenic activity levels that is distinct from, and also separated from, the surrounding area by a physical barrier (i.e., a six-foot high chain-link fence). Ground-based VC species (i.e., snapping turtle) have restricted access to, or from, the LSA, although movement of aerial VC species (i.e., birds, bats) is less constrained by the presence of the fence. The spatial extent of project-related physical disturbances to wildlife VCs (through noise) is also highest within this defined area. The approximate size of the LSA is 29 ha.
- **Regional Study Area**: 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 reasonable foreseeable projects. The RSA is the 3,710 ha portion of the WL property on the east side of the Winnipeg River (Figure 6.6.3-1). This federally-owned property is not fenced around the perimeter, which means there is no physical barrier restricting access to or from the area by ground-based wildlife from the north, east, or south. The Winnipeg River itself represents a partial barrier to (primarily ground-based) wildlife access from the west. The RSA is relevant to the evaluation of effects on wildlife VCs because it is under distinct management and ownership relative to the surrounding landscape. The entire area is under ownership by CNL, and because there are nuclear facilities within the area, it is managed differently from the surrounding landscape (i.e., with respect to active fire suppression and prevention). The RSA also represents a suitable scale to assess potential cumulative effects on wildlife VCs. Cumulative effects of beyond regional disturbance factors (e.g., forestry and climate change) are considered if they are likely to affect populations of wildlife VCs with ranges that are much larger than, but overlap the RSA.



LEGEND

- SITE STUDY AREA (WR-1 COMPLEX)
- LOCAL STUDY AREA (WHITESHELL LABORATORIES FENCE)
- REGIONAL STUDY AREA (WHITESHELL LABORATORIES SITE - EXCLUDING PORTION ON WEST SIDE OF WINNIPEG RIVER)

WHITESHELL LABORATORIES

- WASTE MANAGEMENT
- LANDFILL

BASE FEATURES

- CITY/TOWN
- TRANSMISSION LINE
- PROVINCIAL PARK

0 1,000 2,000
1:30,000 METRES

NOTE(S)

1. SPATIAL EXTENT OF SSA FOR TERRESTRIAL ECOLOGY WILL BE BROADENED TO INCLUDE THE DIMENSIONS OF ADDITIONAL GROUND DISTURBING PROJECT COMPONENTS INCLUDING A GROUT BATCH PLANT, CONSTRUCTION TRAILERS AND LAYDOWN AREAS

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. ORTHO IMAGERY - CNL, 2016 (ACQUIRED 2014)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
SPATIAL BOUNDARIES FOR TERRESTRIAL ENVIRONMENT ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE
REVIEWED	LH
APPROVED	HM

PROJECT NO. 1656897 | CONTROL | REV. 1 | FIGURE **6.6.3-1**

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6.6.3.2 Temporal Boundaries

The temporal boundaries of the assessment include effects observed under existing (Base Case) conditions, the timeframe during which Project activities are actively occurring, and 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 if the effect is predicted to last so far into the future that the duration cannot be predicted with any level of certainty (e.g., residual effect lasts for thousands of years). The following phases were identified for the Project:

- **Closure Phase:** Preparation and implementation of In Situ Decommissioning (ISD), which includes preparation for ISD, grouting of below-grade structures and systems, removal of above-grade WR-1 structures and systems, installation of the engineered cover and environmental controls and final site restoration. These activities last from 2019 to 2024.
- **Post-closure Phase:** The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. The Institutional Control period includes implementation of both active and passive control throughout 2024 to 2324 (i.e., 300 years). During active Institutional Control, long-term performance monitoring and maintenance activities will continue through to 2124 to demonstrate compliance with the safety case assumptions. The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions) and will continue through 2024 to 2324. Post-institutional Control occurs after year 2324 and continues indefinitely.

6.6.3.3 Assessment Cases

The assessment cases considered in the terrestrial environment assessment include the Base Case, Application Case, and the Reasonably Foreseeable Development (RFD) 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 WL facilities and operations, for example, are considered part of the Base Case. In addition, effects from the decommissioning and reclamation activities already completed at the WL site are also considered as part of the Base Case.
- **Application Case**: The Application Case represents predictions of the effects that may results from the Project combined with the existing effects of the Base Case.
- **RFD Case**: This scenario represents the effects of the Base Case combined with the predicted incremental effects from the Project, as well as effects from other RFDs within the RSA that are currently under application review or that have officially entered a regulatory application process. There are no RFDs expected in the RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. Results of the Comprehensive Study Report indicated that no effects were identified for terrestrial biota, as natural vegetation will re-establish following completion of decommissioning and reclamation activities. Airborne emissions from decommissioning activities are likely to be less than in the past and no effect from this exposure pathway is expected (AECL 2001). Overall, decommissioning of these structures is anticipated to positively affect the terrestrial environment. Effects of RFDs in the RSA are expected to be primarily positive, because activities will focus on decommissioning existing infrastructure. Once existing infrastructure is removed and the RSA is reclaimed the level of anthropogenic disturbance within RSA will be reduced, benefiting the terrestrial environment of the RSA. Because RFD identified in the RSA is expected to positively affect the terrestrial environment, an RFD Case is not presented as part of this assessment.

6.6.4 Description of the Environment

6.6.4.1 General Overview

The RSA is located within the larger Boreal Shield Ecozone, Lake of the Woods Ecoregion, and Stead Ecodistrict (Smith et al. 2001). In general, this ecoregion has a large number of forest types characterized by tall, closed stands of jack pine (*Pinus banksiana*), trembling aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), white spruce (*Picea glauca*), eastern white cedar (*Thuja occidentalis*), black ash (*Fraxinus nigra*), and American elm (*Ulmus americana*) (Smith et al. 2001). The English, Winnipeg, and Rainy rivers are the dominant waterways, with small to large bedrock-shore lakes in the northern portion of the ecoregion. Wildlife are diverse and abundant and characteristic regional species include: gray wolf (*Canis lupus*), American black bear (*Ursus americanus*), moose (*Alces americanus*), snowshoe hare (*Lepus americanus*), hooded merganser (*Lophodytes cuculata*), turkey vulture (*Cathartes aura*), and ruffed grouse (*Bonasa umbellus*) (Smith et al. 2001). This description of the characteristic habitat types and wildlife species of the Lake of the Woods Ecoregion has been provided as context for the RSA, which is described below.

The RSA is located on the east bank of the Winnipeg River (Figure 6.6.4-1), at an elevation of approximately 267 metres above sea level (masl). It lies within a broader zone at the convergence of prairie grassland to the southwest and boreal forest to the northeast and is also on the edge of the Precambrian Shield (AECL 2001). The surrounding area consists of cleared lands with areas of peat bog. Whiteshell Provincial Park, the largest provincial park in Manitoba, is located on the east side of the RSA; Pinawa and Whitemouth Falls Provincial Parks are both immediately south of the RSA.

There is a relatively high degree of diversity in terrestrial habitat within the RSA (Figure 6.6.4-1). The RSA is primarily under treed cover (83% of total area), consisting of a mixture of wetlands and forests of broadleaf, mixed and coniferous stand types. A large area (1,946 ha, or 52% of the total area) contains a complex of bog, fen and swamp wetlands spanning the center and east portions of the RSA, from north to south. Black spruce dominates large portions of this wetland habitat and it is reported that stands may be over 100 years old (AECL 2001). Black spruce dominated bog wetlands have understories of tamarack (*Larix* sp.), willow sp. (*Salix* sp.), blueberry (*Vaccinium* sp.), common Labrador tea (*Rhododendron groenlandicum*), horsetail sp. (*Equisetum* sp.) and mosses. The herbaceous wetland types contain mannagrass sp. (*Glyceria* sp.), cattail sp. (*Typha* sp.), sedge sp. (*Carex* sp.) and bulrush sp. (*Schoenoplectus sp.*). A ridge of well-drained sandy soil within the wetland area contains jack pine dominated forest stands. To the west of the wetland area, forests dominated by black ash and poplar sp., are present on poorly drained clay plains (AECL 2001). There are also areas of abandoned farm fields and areas where vegetation height is controlled, that contain a mixture of regenerating grasses and shrub species such as bluegrass (*Poa* sp.), sedge sp., strawberry (*Fragaria* sp.), clover sp. (*Trifolium* sp.) and aster sp. (*Aster* sp.). The area near the Field Irradiator Gamma (FIG) site contains upland mixed forests with jack pine and trembling aspen dominant stands, as well as spruce sp., fir sp. (*Abies* sp.), birch and an understory of common Labrador tea, hazelnut (*Corylus* sp.), wild plum (*Prunus americana*) and blueberry. There is a broadleaf forest dominated by trembling aspen with an understory of willow sp., rose (*Rosa* sp.), alder sp. (*Alnus* sp.), currant (*Ribes* sp.) and dogwood (*Cornus* sp.) on the west half of the RSA, with gullies and ravines adjacent to the Winnipeg River.

There have been few formal wildlife inventories within the RSA. The focus of this terrestrial environment assessment is therefore based on known ranges of wildlife species, habitat suitability, and incidental observations by WL staff. White-tailed deer (*Odocoileus virginianus*) are reportedly common, with established wintering areas on site, and beaver (*Castor canadensis*) activity is common within the gullies adjacent to the Winnipeg River (AECL 2001). Permits have been obtained by WL staff for dam removal on numerous occasions. Other commonly observed mammal species within the RSA include black bear, red fox, and groundhog (a.k.a., woodchuck; *Marmota monax*). Commonly observed amphibian and reptile species include northern leopard frog (*Lithobates pipiens*) and gartersnake (*Thamnophis* sp.), and there have also been observations of snapping turtle and western painted turtle (*Chrysemys picta bellii*). According to the Comprehensive Study Report (AECL 2001), there are important bird migration staging areas on, or near the RSA, centering on the Winnipeg River. The Winnipeg River is an important migratory corridor for many species including common loon (*Gavia immer*), red-necked grebe (*Podiceps grisegena*), horned grebe (*P. auritus*), double-crested cormorant (*Phalacrocorax auritus*), American white pelican (*Pelecanus erythrorhynchos*), Bonaparte's gull (*Chroicocephalus philadelphia*), common tern (*Sterna hirundo*), Caspian tern (*Hydroprogne caspia*), lesser scaup (*Aythya affinis*), greater scaup (*A. marila*), and bald eagle (*Haliaeetus leucocephalus*) (AECL 2001). Bird species recorded within the RSA by WL staff since 2014 have included many federally secure (i.e., not at risk) species. There have been observations of passerines such as cliff swallow (*Petrochelidon pyrrhonota*) and American robin (*Turdus migratorius*), woodpeckers such as pileated woodpecker (*Dryocopus pileatus*), and northern flicker (*Colaptes auratus*), owls including great gray owl (*Strix nebulosa*) and great horned owl (*Bubo virginianus*), as well as sandhill crane (*Grus canadensis*) and bald eagle. Observations of federal species at risk have included trumpeter swan (*Cygnus buccinator*), barn swallow, loggerhead shrike (*Lanius ludovicianus*), and red-headed woodpecker (*Melanerpes erythrocephalus*) and are described in Appendix 6.6-1.

The Base Case for each wildlife VC represents the outcome of past and present effects of natural disturbances and anthropogenic activities on the environment. Wildfire was likely the primary disturbance factor in the RSA before the 1890s and remains the primary disturbance and stand determining agent in forested areas of the Boreal Shield Ecozone (Smith et al. 2001). Human development in the area around Lac du Bonnet began in 1898 when a large number of mining claims were staked in the area (Lac du Bonnet Pioneer Club 1980). The road from Molson to Lac du Bonnet was finished in the fall of 1899 as far as Milner Ridge, and wood and lumber operations were started soon after (Lac du Bonnet Pioneer Club 1980). The construction of the Pinawa power plant began in 1903 and was completed in 1906 (Manitoba Historical Society 2017). Most roads in the Lac du Bonnet area were built after 1917, when the rural municipality of Lac du Bonnet was formed (Lac du Bonnet Pioneer Club 1980). The WL property was established by AECL in the early 1960s as a nuclear research facility. Since the 1960s, land uses within the RSA have been limited to operations and activities undertaken at the WL site (AECL 2001).

As part of the Comprehensive Study Report, the RSA (WL property – including the portion of the west side of the Winnipeg River) was divided into "affected" and "unaffected" land. Affected land was defined as areas where nuclear development, operations or supporting activities are conducted and includes land potentially affected by such activities (AECL 2001). This area includes the LSA derived for the terrestrial environment assessment, plus some surrounding areas with supporting infrastructure. Outside of this area, the majority of the WL Property consists of unaffected land. These broad categories are also applicable to the likely extent of noise-related effects on wildlife; with the areas beyond the affected land having low likelihood of being subject to noise levels that would have effects on wildlife.

Anthropogenic disturbance of the RSA and current activity (e.g., the WL main campus area, access roads, and waste management areas) is largely concentrated in the northwest quarter of the RSA. Disturbance in the form of roads is primarily within the far western portion of the RSA, with the main access road for employees (Ara Mooradian Way) aligned north-south, with a few secondary roads branching off the main Plant Road to various locations (i.e., landfill, sewage lagoons, and waste management area). There is one cleared and maintained hydroelectric corridor for a 115 KV transmission line through the WL property. The transmission line corridor spans the north-south length of the property and is in the western portion of the RSA.

The LSA (main campus area) comprises a small proportion of the RSA (less than 1% of the RSA), and is located on the west side of the RSA, on the east bank of the Winnipeg River (See Figure 6.6.4-2). It contains 10 major buildings and support facilities (a total of 61 structures) within a chainlink fenced perimeter. Infrastructure and paved areas comprise 25% of the total area and the remaining 74% is primarily landscaped and maintained turfgrass lawn (Figure 6.6.4-2). A small proportion of the area contains broadleaf forest (less than 1%).

Overall, the operation of WL and federal ownership of the RSA have likely allowed for conditions of the terrestrial environment to improve over time, as the majority of the lands owned have not been disturbed from WL related development and activity for the last 50 years. Consequently, much of the RSA, with the exception of the LSA itself, sustains a high value terrestrial environment in the Base Case, including habitat for the VCs identified for this assessment.

6.6.4.2 Methods

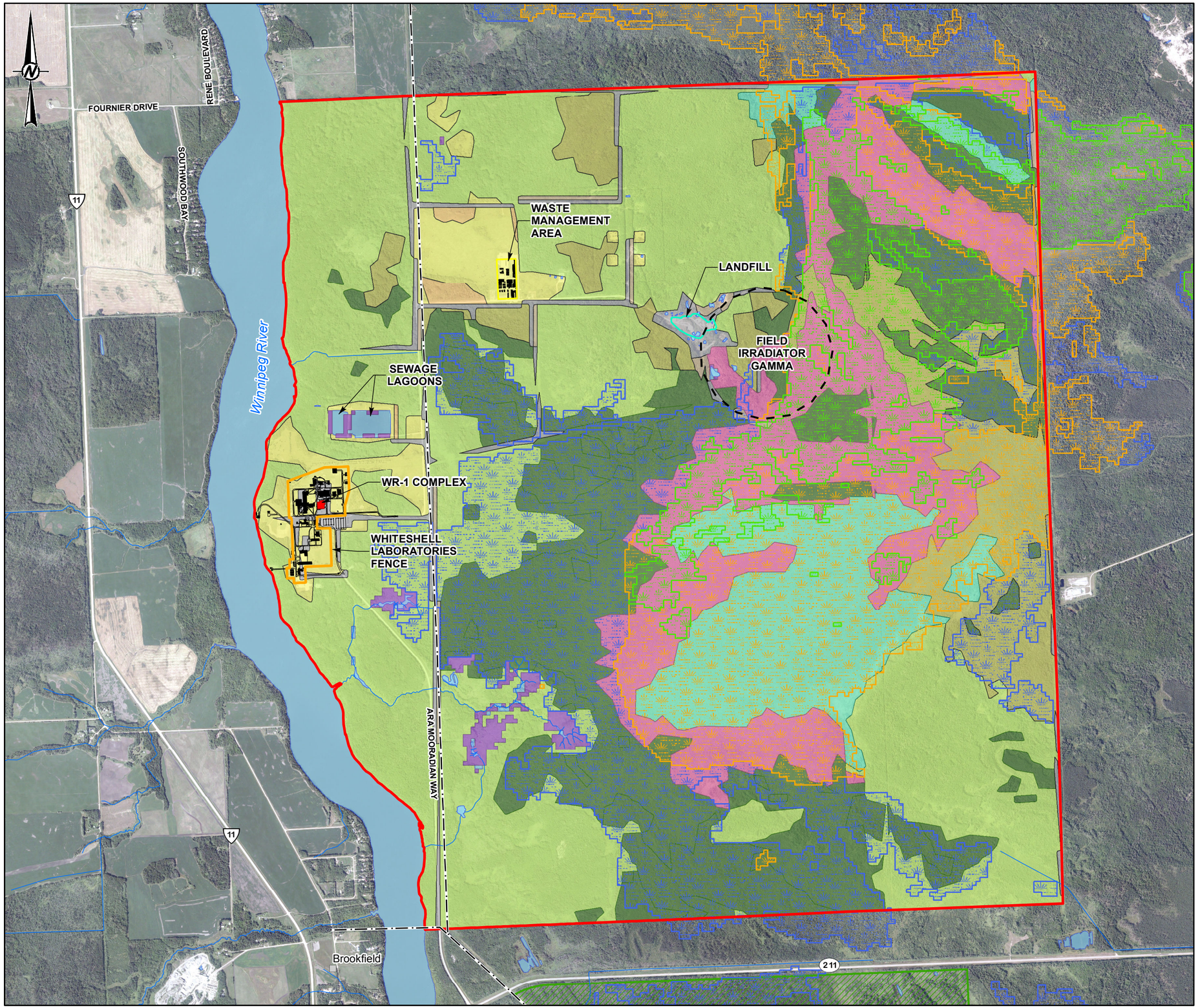
The following information sources were used to describe Base Case conditions for terrestrial environment VCs:

- species at risk file data file, assumed to be compiled through a spatial query by the Manitoba Conservation Data Centre (CNL 2016a);
- incidental wildlife species observations recorded by WL staff (CNL 2016c);
- results of bat acoustic monitoring surveys conducted from June to August, 2015 (22 acoustic monitoring sites) (Murrant 2016);
- studies published in scientific journals and reports providing information on VC habitat preferences, current stressors and threats to populations, and documented effects caused by anthropogenic disturbances;
- previous environmental assessments conducted for the WL property (primarily the Comprehensive Study Report, AECL 2001);
- federal recovery strategies for VCs available in Environment and Climate Change Canada's (ECCC) Species at Risk database (Government of Canada 2016);
- Manitoba Breeding Bird Atlas 2010-2014 (Manitoba Breeding Bird Atlas 2016);
- eBird web-based bird observation database hosted by the Cornell Lab of Ornithology and National Audubon Society (2016; 2017);
- Manitoba Herps Atlas (Manitoba Herps Atlas 2016);
- landcover and buildings spatial data (CNL 2016d); and
- wetlands spatial data (Manitoba Land Initiative 2013).

A description of the Base Case conditions is provided for each terrestrial environment VC in the following sections. Base Case conditions are described according to the measurement indicators selected for each VC (Table 6.6.2-1).

For each wildlife VC, landcover and wetlands spatial data were used to provide 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 its abundance in the RSA. The limiting habitat was selected as the focus of the assessment.

UNRESTRICTED / ILLIMITÉE



LEGEND

- SITE STUDY AREA (WR-1 COMPLEX)
- LOCAL STUDY AREA (WHITESHELL LABORATORIES FENCE)
- REGIONAL STUDY AREA (WHITESHELL LABORATORIES SITE - EXCLUDING PORTION ON WEST SIDE OF WINNIPEG RIVER)

WHITESHELL LABORATORIES

- WASTE MANAGEMENT AREA
- LANDFILL
- FIELD IRRADIATOR GAMMA
- BUILDINGS
- SITE ROADS

BASE FEATURES

- CITY/TOWN
- TRANSMISSION LINE
- WATERCOURSE
- WATERBODY
- PROVINCIAL PARK

VEGETATION COMMUNITIES (SOURCE: CNL 2016 LANDCOVER)

- BROADLEAF DENSE
- CONIFEROUS (DENSE AND OPEN)
- MIXEDWOOD DENSE
- GRASS
- HERBACEOUS
- DEVELOPED
- EXPOSED LAND
- WETLAND - SHRUB
- WETLAND - TREED

WETLAND TYPE (SOURCE: MLI 2013 WETLAND INVENTORY)

- BOG
- FEN
- MARSH
- SWAMP

0 1,000 2,000

1:30,000 METRES

NOTE(S)

1. SPATIAL EXTENT OF SSA FOR TERRESTRIAL ECOLOGY WILL BE BROADENED TO INCLUDE THE DIMENSIONS OF ADDITIONAL GROUND DISTURBING PROJECT COMPONENTS INCLUDING A GROUT BATCH PLANT, CONSTRUCTION TRAILERS AND LAYDOWN AREAS

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. ORTHO IMAGERY - CNL, 2016 (ACQUIRED 2014)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE

TERRESTRIAL ENVIRONMENT EXISTING CONDITIONS IN THE RSA - BASE CASE

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE
REVIEWED	LH
APPROVED	HM

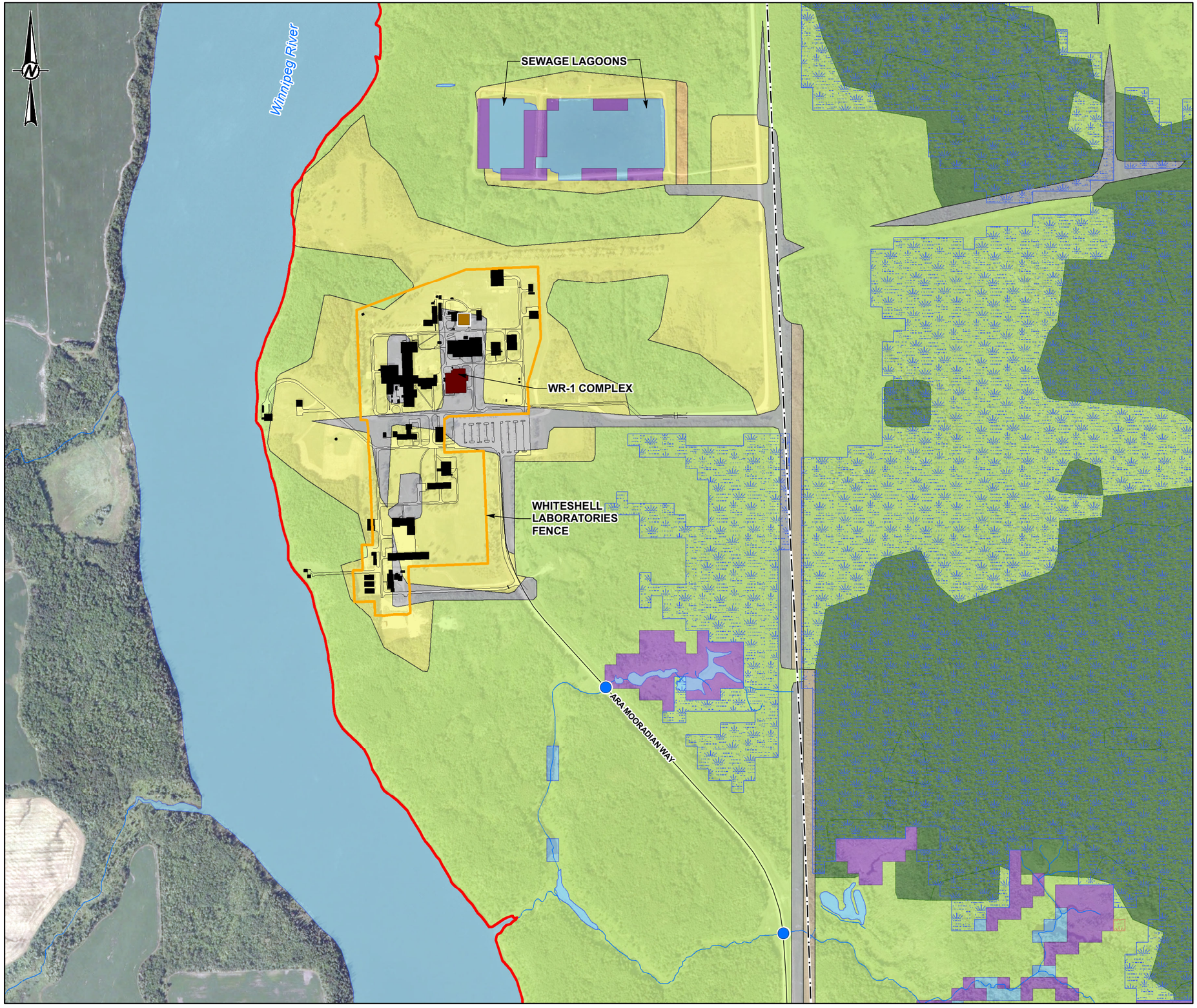
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UNRESTRICTED / ILLIMITÉE



LEGEND

- LOCATION OF BARN SWALLOW NESTING ACTIVITY - JUNE 2016[2]
- LIKELY SNAPPING TURTLE ROAD CROSSING LOCATIONS AND SUITABLE AQUATIC HABITAT FEATURES
- SITE STUDY AREA (WR-1 COMPLEX)
- LOCAL STUDY AREA (WHITESHELL LABORATORIES FENCE)
- REGIONAL STUDY AREA (WHITESHELL LABORATORIES SITE - EXCLUDING PORTION ON WEST SIDE OF WINNIPEG RIVER)

WHITESHELL LABORATORIES

- WASTE MANAGEMENT AREA
- LANDFILL
- BUILDINGS
- SITE ROADS

BASE FEATURES

- CITY/TOWN
- TRANSMISSION LINE
- WATERCOURSE
- WATERBODY

VEGETATION COMMUNITIES (SOURCE: CNL 2016 LANDCOVER)

- BROADLEAF DENSE
- CONIFEROUS (DENSE AND OPEN)
- MIXEDWOOD DENSE
- GRASS
- HERBACEOUS
- DEVELOPED
- EXPOSED LAND
- WETLAND - SHRUB
- WETLAND - TREED

WETLAND TYPE (SOURCE: MLI 2013 WETLAND INVENTORY)

- BOG
- FEN
- MARSH
- SWAMP

0 250 500 750

1:10,000 METRES

NOTE(S)

1. SPATIAL EXTENT OF SSA FOR TERRESTRIAL ECOLOGY WILL BE BROADENED TO INCLUDE THE DIMENSIONS OF ADDITIONAL GROUND DISTURBING PROJECT COMPONENTS INCLUDING A GROUT BATCH PLANT, CONSTRUCTION TRAILERS AND LAYDOWN AREAS
2. PRECISE LOCATION OF MARINE CONTAINER WHERE BARN SWALLOW NESTING OCCURRED TO BE VERIFIED BY CNL STAFF.

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. ORTHO IMAGERY - CNL, 2016 (ACQUIRED 2014)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT

CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT

EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE

TERRESTRIAL ENVIRONMENT EXISTING CONDITIONS IN THE LSA - BASE CASE

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE
REVIEWED	LH
APPROVED	HM

PROJECT NO.	CONTROL	REV.	FIGURE
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6.6.4.3 Barn Swallow

6.6.4.3.1 Habitat Availability

The breeding range of barn swallow overlaps the RSA. Breeding habitat for barn swallow typically includes three components: a vertical or horizontal substrate (often enclosed) for the nest site itself, open habitat (e.g., fields, meadows) for foraging, and a body of water that provides mud for nest building (Brown and Brown 1999). Barn swallow nests are typically found inside or outside of buildings, under bridges, and in road culverts. There are a total of 128 buildings and permanent structures of various sizes within the RSA, and 61 buildings and permanent structures within the LSA. Common foraging habitat includes open riparian areas, road rights-of-way, urban and residential areas, and clearings in wooded areas (Brown and Brown 1999; Heagy et al. 2014).

This species is not currently listed under SARA and therefore does not have legally defined critical habitat. A pair of nesting barn swallows was observed with eggs in a nest within the LSA, in a temporary storage facility housed in a marine container (see approximate location of marine container on Figure 6.6.4-2). Although a nest survey completed in the summer of 2015 found no nesting activity observed on the outside of the WR-1 Building (CNL 2016b), the 2015 survey did confirm 13 barn swallow nests on other WL main campus buildings (CNL 2017).

For the purposes of this assessment, a conservative approach has been taken, and all mapped buildings in the RSA and LSA were considered suitable nesting habitat for barn swallow. There are a total of 128 buildings of various sizes in the RSA and 61 buildings in the LSA. A total of 4 ha (0.1%) and 3 ha (11%) of suitable nesting habitat for barn swallow is estimated to be present in the RSA and LSA, respectively, in the Base Case (Table 6.6.4-1). There is also likely additional nesting habitat located in the culverts at any watercourse crossings, particularly at the three watercourse crossings at Ara Mooradian Way, south of the LSA (two of which are visible in Figure 6.6.4-2). Although not quantified, the other two required habitat components are most likely met within the RSA: the sewage lagoons and Winnipeg River represent likely locations of potential mud sources and there is open foraging habitat within the LSA and non-treed portions of the RSA.

Table 6.6.4-1: Nesting Habitat Availability for Barn Swallow in the Base Case

Habitat Suitability	Regional Study Area		Local Study Area	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Suitable	4	0.1	3	11.0
Unsuitable	3,706	99.9	26	89.0
Total	**3,710**	**100.0**	**29**	**100.0**

ha = hectare; % = percent.

Disturbances can have both positive and negative effects on barn swallow breeding habitat availability. Past and present anthropogenic development has most likely increased the amount of nesting habitat in the LSA for barn swallow by providing suitable substrate for nest building (e.g., buildings and culverts). Vegetation clearing can also improve breeding habitat by creating open areas for foraging (Brown and Brown 1999; Heagy et al. 2014). Utility and road corridors and the open turfgrass lawn areas of the campus likely provide suitable foraging habitat for barn swallow in the Base Case. Fire suppression activities have likely had negative effects on barn swallow foraging habitat availability relative to what was historically available for this species in the RSA, as barn swallow require open areas for foraging.

6.6.4.3.2 Habitat Distribution

The range of barn swallow in Manitoba is largely unknown; this species is considered widespread in southern Manitoba, but is considered to be a very local breeder in northern Manitoba (Brown and Brown 1999). At Base Case, suitable barn swallow nesting habitat (i.e., buildings) is patchily distributed throughout the RSA (Figure 6.6.4-1) and LSA (Figure 6.6.4-2). Habitat may be a limiting factor for barn swallow in the Base Case because this species relies heavily on buildings for nest sites; however, this species is highly mobile and can establish territories in new areas.

Narrow linear disturbances, such as road corridors in the LSA and RSA, generally do not represent barriers to bird movement (Desrochers and Hannon 1997). Existing disturbances in the RSA do not likely function as dispersal barriers for this species in the Base Case. Habitat fragmentation is not thought to be a limiting factor for barn swallow (Gaines et al. 2003), likely because of their high mobility and use of open areas for foraging.

6.6.4.3.3 Survival and Reproduction

Canada is thought to support approximately 22% of the North American population of barn swallow (10.9 million individuals), and 6% of the global population (COSEWIC 2011). As of 1999, Manitoba supported approximately 1.5 million individuals of the species (COSEWIC 2011). Long-term Breeding Bird Survey (BBS) data show a decline of barn swallow abundance in Manitoba of 2.78% per year from 1970 to 2012 (overall 69% decline; EC 2014).

Because the barn swallow population in Canada has declined by 69% from 1970 to 2012, it is considered a priority species under the Bird Conservation Strategy for the region, which has the objective of doubling current abundance (EC 2014). The barn swallow was designated as threatened by COSEWIC in 2011, but has yet to be listed under SARA; however, it is acknowledged that The Department of Environment has submitted a proposed order to amend Schedule 1 of the *Species at Risk Act* to include additional migratory birds, one of which is the barn swallow (Canada Gazette, website).

Barn swallow is recorded as a confirmed breeder in the Manitoba Breeding Bird Atlas squares that overlap the RSA (squares 14QA06 and 14QA16). Breeding activity was confirmed within the LSA in June 2016 in a marine container located west of Building 411 (see approximate location of the marine container with documented nesting activity on Figure 6.6.4-2).

The main threats to barn swallow populations in Canada are not well understood. Habitat loss and degradation of breeding grounds, large scale changes in insect prey abundance, climate change, interspecific competition for nest sites from invasive species, nest parasitism, and human-caused nest destruction and removal are all threats that may be affecting barn swallow populations (COSEWIC 2011).

Barn swallow primarily feed on flying insects. Insect populations are declining worldwide and this may be contributing to barn swallow declines (COSEWIC 2011). Many aerial-foraging insectivorous birds, such as barn swallow, 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 at Base Case.

6.6.4.4 Golden-winged Warbler

6.6.4.4.1 Habitat Availability

The breeding range for golden-winged warbler overlaps the RSA. Golden-winged warbler is a habitat specialist that relies on early successional habitat (10 to 30 years after disturbance) (COSEWIC 2006). Forest type appears to be less important for this species than habitat structure (Confer et al. 2011), with most individuals found in shrubby, deciduous habitats (Beaudry et al. 2010). Golden-winged warblers prefer habitats with low to moderate tree canopy cover and moderate shrub and herb cover (Confer et al. 2011). Critical habitat has been partially identified in the federal recovery strategy for this species to be a combination of habitat suitability and habitat occupancy, where suitable breeding and foraging habitat has been identified as the interface (shared edge) between young forest and open habitat within an appropriately sized and specific type of forest landscape (ECCC 2016a). Forest cover must be at least 50-75% within a 5 by 5 km area with primarily deciduous or mixed tree composition (greater than 50%), and no more than 30% coniferous forest composition (ECCC 2016a). The edges of wetland habitat including bogs and fens with greater than 15% sapling and shrub cover is also considered breeding and foraging habitat for this species (ECCC 2016a). Nests are often located within 200 m on either side of a forest edge (ECCC 2016a). Edges can also be located along cutblocks, transmission line rights-of-way and other anthropogenic disturbances if there is sufficient cover of tall grass (i.e., not mown turf-grass lawn), herb and shrub species (ECCC 2016a).

The available land cover and wetlands spatial data were used to map suitable breeding and foraging habitat for golden-winged warbler in the LSA and RSA as follows:

- confirmation of suitable forest cover on the local landscape (minimum 50% to 75% forest cover with some openings of shrub / herbaceous habitat, no more than 30% coniferous forest type) that spans a minimum of 5 km by 5 km area overlapping the RSA;
- if the above criterion is met, broadleaf dense forest stands within 200 m of the forest polygon edge where it abuts open habitat (wetland – all [i.e., bog, fen, marsh, swamp], waterbody, herbaceous);
- if the above criterion is met, mixedwood dense forest stands within 200 m of the forest polygon edge where it abuts open habitat (wetland – all, waterbody, herbaceous); and
- 200 m buffer into the following polygon types where they abut broadleaf dense or mixedwood dense forest stands:
  - Wetland – all; and
  - Herbaceous.

Suitable breeding and foraging habitat for Golden-winged Warbler consists of early successional habitat at the interface of forest and open habitat (i.e., edge habitat). Availability of breeding and foraging habitat for golden-winged warbler was predicted at Base Case using the available land cover and wetlands spatial data.

The dimensions of the RSA are approximately 5 km by 6.5 km, with a total of 83% tree cover (meeting the minimum size criterion and exceeding the minimum total forest cover criterion of 50%). There is 23% coniferous forest cover, which meets the criterion of less than 30% coniferous forest cover. Within the edge habitats between mixedwood and broadleaf forest and open / shrubby habitat, there is no suitable habitat for golden-winged warbler in the LSA in the Base Case, but 986 ha (27%) of suitable habitat estimated in the RSA (Table 6.6.4-2). The federal recovery strategy identifies 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 GL3, and within a grid square identified to contain critical habitat for this species (ECCC 2016a). The breeding bird survey (BBS) for Manitoba found no breeding evidence of Golden-winged Warbler within MBBA squares 14QA06 or 14QA16 that overlap the RSA; however, there is possible breeding evidence for this species in the areas surrounding these two squares. No eBird sightings of Golden-winged Warbler have been reported in the LSA or RSA; however, there has been a recent sighting of a male individual approximately 11 km to the southeast of the RSA in August 2016, near Pinawa (eBird 2017).

Table 6.6.4-2: 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	986	26.6	0	0.0
Unsuitable	2,723	73.4	29	100.0
Total	**3,710**	**100.0**	**29**	**100.0**

ha = hectare; % = percent.

Disturbances can have both positive and negative effects on Golden-winged Warbler habitat availability. Fire suppression activities within the RSA since the 1960s 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). Stand ages for the RSA were not provided with the land cover dataset; therefore, the age of forests in the RSA is not known precisely. It can be assumed they are at least 60 years old, as there has not been active tree harvesting activity throughout the majority of the WL site since opening in the 1960s.

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 (e.g., long and narrow disturbance area as opposed to circular) are more likely to have positive effects on golden-winged warbler habitat availability.

6.6.4.4.2 Habitat Distribution

At Base Case, suitable breeding and foraging habitat for golden-winged warbler is distributed throughout the RSA, primarily along the edges of the wetland complex that spans north-south through the centre of the WL property (Figure 6.6.4-1), and is absent within the LSA (Figure 6.6.4-2). There are many areas where broadleaf and mixedwood forest stands are adjacent to open / shrub habitat in the RSA. Golden-winged warblers are edge habitat specialists, and edge habitat suitable for this species is increased with some types of linear development (i.e., transmission line rights-of-way that maintain some level of natural ground cover in the form of grasses, herbaceous and shrub species). Therefore, past anthropogenic activities within the RSA have likely positively affected the distribution of habitat for golden-winged warbler, due to the increased level of habitat fragmentation from linear disturbances present in the RSA. There is a maximum amount of potential benefit that linear development can have for golden-winged warbler, as extensive habitat fragmentation resulting in small forest patches may negatively affect this species. One study found golden-winged warblers do not use forest patches smaller than 10 ha (Confer and Knapp 1981). Although some forms of linear disturbance can create suitable

habitat for golden-winged warbler, gaps in forest cover can also create barriers to the movement of songbirds, if they become too large. Narrow linear disturbances generally do not represent barriers to bird movement (Desrochers and Hannon 1997) and are less likely to be perceived as movement barriers by edge species such as golden-winged warblers, compared to other species of songbirds that are interior-forest specialists. There is potentially a maximum width for linear disturbances beyond which they become a barrier to bird movement; it has been shown that songbirds often avoid crossing gaps in forest cover greater than 45 m wide (Tremblay and St. Clair 2009).

Within the RSA, the availability of breeding and foraging habitat does not appear to be a limiting factor for golden-winged warbler. 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. The linear disturbances in the RSA do not likely function as dispersal or movement barriers for this species. However, the LSA itself, which contains the WL campus, is a larger gap in forest cover that is approximately 800 m wide at the widest point. It contains a dense cluster of buildings, parking lot areas, and mown / maintained turf-grass lawn. The landfill is also approximately 500 m wide at the widest point. Both areas likely serve as local barriers to golden-winged warbler movement, as they contain ground cover that is unsuitable for their nesting and foraging needs.

6.6.4.4.3 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 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 (EC 2014). Golden-winged warbler was designated as threatened by COSEWIC in 2006 and was listed under Schedule 1 of SARA as threatened 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 for this species are not available for the RSA; however, the RSA is located within one of the three focal areas in Manitoba (GL3) identified in the federal recovery strategy (ECCC 2016a). These focal areas are known to contain core populations that sustain the current breeding distribution and are important for expanding the population into adjacent areas (ECCC 2016a). Golden-winged warblers have not been recorded in the RSA; however, there is possible breeding evidence for this species in the areas surrounding the two MBBA squares that overlap the RSA. No eBird sightings of golden-winged warbler have been reported in the RSA; however, there has been a recent sighting of a male approximately 11 km to the southeast, in August 2016 near Pinawa (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.

6.6.4.5 Bats

6.6.4.5.1 Habitat Availability

All bat species in Canada have four primary habitat requirements: overwintering sites (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 and northern myotis within their ranges (COSEWIC 2013). Critical habitat for these SARA-listed bat species has only been "partially identified" for a portion of their over-all critical habitat requirements (i.e., hibernacula). It is acknowledged that protection of hibernacula alone is insufficient to meet the population and distribution objectives for the three endangered bat species (EC 2015a). Critical habitat requirements for maternity roosts and summering habitat for roosting and foraging have not yet been formally identified, and are the focus of future research effort (EC 2015a).

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. Based on Figure 6.3.1-1, which describes regional geology in the RSA, the potential for bat hibernacula is low across the RSA, because these mineral types are not present. There is also no exposed bedrock within the RSA. There have been no 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 very low based on geological conditions. Although little brown myotis occasionally hibernate in anthropogenic structures (like houses), it is unlikely that this is occurring within the WR-1 building, as there are likely few gaps between the outer walls and below-grade floors that would permit entry, as there was significant shielding and barrier installation of the below-grade floors to limit the release of radioactivity during the time when the reactor was functional. The report on the results of acoustic monitoring conducted in 2015 also reported there have been no hibernacula identified within any buildings in the RSA to-date (Murrant 2016). As a final confirmation to ensure their absence, pre-demolition visual surveys will be conducted in all below-grade floors of the WR-1 building (See Section 6.6.6). Foraging habitat requirements are varied between the two species representing this VC and not likely limiting in the local 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 two species represented by this VC, likely because of higher snag availability (COSEWIC 2013). Snags contain cavities and loose bark required for sheltering roosting females and pups (EC 2015a). Little brown myotis and northern myotis show a preference for large-diameter (i.e., older) trees and little brown myotis females show evidence of philopatry in roost selection (the tendency to return to the same home area following hibernation; COSEWIC 2013; EC 2015a).

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, but also in white spruce and red spruce. Olson and Barclay (2013) found the majority of roosts located in trembling aspen or balsam poplar. 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). Poplar-leading deciduous and mixed forest stands are common within the RSA. However, preferred roost tree species may vary by region and availability in the forest community.

The available landcover and wetlands spatial data were used to determine a conservative, coarse-scale estimation of the availability of forests or swamp wetland types representing maternity roost habitat preferences for little brown myotis and northern myotis as follows:

- forest stands (all types); and
- treed wetlands (swamps).

A total of 3,091 ha and 0.2 ha of suitable natural maternity roost habitat for little brown myotis and northern myotis is estimated to occur in the RSA and LSA, respectively, in the Base Case, comprising 83% of total land cover in the RSA, and 0.6% of total land cover in the LSA (Table 6.6.4-3).

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). For the purposes of this assessment, as part of a conservative approach, all mapped buildings in the RSA and LSA were considered potential suitable maternity roost habitat for little brown myotis. There are a total of 128 buildings of various sizes in the RSA and 61 buildings in the LSA. A total of 4 ha and 3 ha of suitable anthropogenic maternity roost habitat for bats (primarily little brown myotis) is estimated to occur in the RSA and LSA, respectively, in the Base Case, comprising 0.1% of total land cover in the RSA, and 11% of total land cover in the LSA (Table 6.6.4-3).

Table 6.6.4-3: 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 – Natural (both species)	3,091	83.3	<1	0.6
Suitable – Buildings (primarily little brown myotis)	4	0.1	3	11.0
Unsuitable	615	16.6	26	88.4
Total	**3,710**	**100.0**	**29**	**100.0**

ha = hectare; % = percent.

In 2015, a single season of acoustic monitoring surveys were completed to determine the composition of the bat community at specific areas within the RSA. The surveys focused on the area of the main campus, (i.e., LSA). The presence of both SARA-listed species, little brown myotis, and northern myotis, was confirmed within the LSA. A summary memo from the 2015 acoustic monitoring bat surveys reported that the initial recordings of bats occurred well after sunset. The conclusion was made that this indicates bats are likely travelling to the site from farther away, and not roosting within the LSA, because an initial burst of bat activity, typically observed when bats emerge en masse from their communal roosts at sunset, was not recorded. There is uncertainty in this conclusion, as it is possible that some locations within the LSA that have roosting bats were not within the detection range of the acoustic monitoring devices, and the emergence of bats from some buildings or structures was not captured. There has been no physical evidence of roosting activity recorded to-date within the WR-1 Building or any buildings within the LSA (i.e., piles of bat feces/guano, or observations of bats in buildings) (Murrant 2016). Within the LSA, any building with suitable access for bat entry could potentially provide suitable maternity roosting habitat, and for the purposes of this assessment, all mapped buildings are considered potential anthropogenic roosting habitat (for little brown myotis) as part of the conservative approach.

The acoustic monitoring conducted to-date supports a conservative assumption that little brown myotis and northern myotis could be roosting within treed areas of the RSA. The nature of acoustic monitoring (which only detects individual bats moving past the detector while in flight) cannot identify the location of individual roosts in buildings or trees. Only visual roost emergence surveys can definitively confirm where bats are roosting, by observing bat emergence from the roost. Although it does not confirm individual roost locations, the use of passive acoustic detectors in habitats that contain candidate roosts can provide evidence of roosting activity within an area, as the peak in bat activity immediately following sunset indicates that bats are roosting in an area and are emerging to forage. Because the forest types present in the RSA are consistent with roosting habitat preferences and because SARA-listed bats have been recorded flying within the LSA, this assessment applies the precautionary assumption that the small treed area within the LSA and treed areas within the outer RSA could provide suitable natural habitat and likely contains maternity roosts for both bat species.

The RSA contains abundant areas of potential maternity roosting habitat for bats. The majority of the RSA has been undisturbed for the last 50 years as a result of WL activities focused primarily within the main campus area. 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 of these species are more commonly found roosting in large diameter trees that are present in mature forest stands. In addition, suitable foraging habitat in the form of wetlands and riparian areas around the Winnipeg River is also abundant in close proximity to potential roosting habitats.

The clearing, building construction, and maintenance of large turfgrass covered lawns within the LSA, and the presence of roads and associated infrastructure have likely reduced natural maternity roosting habitat availability within the LSA. However, as described above, these changes do not represent a complete reduction of potential roosting habitat availability for one of the two bat species. Little brown myotis are well adapted to human disturbance and use buildings, bat houses and bridges for maternity roosts. Considering the natural and anthropogenic roosting habitat within the RSA, the availability of maternity roosting habitat is not likely a limiting factor for bats in the Base Case.

6.6.4.5.2 Habitat Distribution

In the Base Case, potential maternity roost habitat for little brown myotis and northern myotis is common, and well-distributed across the RSA in the form of tree covered habitat (Figure 6.6.4-1). Required foraging habitat features (wetlands, open water features such as the sewage lagoons and east bank of the Winnipeg River) are also well distributed and commonly intersperse the potential maternity roosting habitat of the RSA. Throughout the RSA, linear features in the form of roads, the hydroelectric corridor, and other gaps in forest cover create gaps and potential commuting corridors, if they are not too wide. Both species generally avoid large clearcuts in forested areas, as well as open areas (COSEWIC 2013; EC 2015a). Studies in Alberta found the center of clearcuts greater than 30 m from the forest edge were completely avoided by northern myotis and that little brown myotis traveled 2 to 2.5 times less in the center than through the forest edges or along retained stands of trees within the clearcut block (COSEWIC 2013).

The effects of edges and corridors around mature forest stands on little brown myotis and northern myotis 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 in the Base Case, they are also well connected.

Within the LSA, although potential maternity roosting habitat for little brown myotis in the form of buildings is dispersed throughout the area, with the much larger area of undisturbed forest surrounding the main campus, it does not appear to represent an area with a high likelihood of containing significant maternity roost numbers (Figure 6.6.4-2).

6.6.4.5.3 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. These two 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 hibernating.

White-nose syndrome 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 (i.e., the source of the name; EC 2015a). The physical damage causes bats to arouse from their state of torpor and expend energy that is typically reserved until spring emergence. The change in activity levels and physical damage combined are what eventually causes death (EC 2015a). Canada is currently divided into WNS-affected and non WNS-affected areas. The provinces of Ontario, Quebec, New Brunswick, Nova Scotia and PEI are considered WNS-affected and all other provinces and territories (including Manitoba) 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. Populations of both species might have exceeded one million individuals (COSEWIC 2013). 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.

White-nose syndrome 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 impacted 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) in Canada and the United States by 2026 (COSEWIC 2013); 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 (EC 2015a). Little brown myotis and northern myotis populations that overlap the RSA are within the non WNS-affected area of Canada. Consequently, these populations are not likely as susceptible to any additional pressures as those in WNS-affected areas.

Beyond the devastating effects of WNS, other threats to little brown myotis and northern myotis 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 or scientific disturbances and industrial disturbance), pollution, and climate change (EC 2015a). Little brown myotis in particular are vulnerable to persecution and extermination efforts because of their tendency to roost in anthropogenic structures such as attics (EC 2015a). Extermination of large

colonies can affect local populations, particularly in WNS-affected areas, but also potentially in non-affected areas, depending on local densities.

Regarding reproduction and life span, both 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 life span is thought to be shorter (COSEWIC 2013). The life span of northern myotis is at least 15 years (COSEWIC 2013).

Survivorship of both 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 (COSEWIC 2013). Survival rates are lowest in the first year of life because juveniles often lack sufficient fat reserves needed for hibernation (COSEWIC 2013). Females of both species start breeding after their first year and continue breeding annually. Females give birth to one pup per year after 44-60 days of gestation. 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 33-74% in the Yukon (COSEWIC 2013). In summary, because the RSA is within a non WNS-affected area, survival and reproduction of bat populations overlapping the RSA are not likely impaired at the Base Case, assuming WNS has not yet passed from Ontario into Manitoba.

6.6.4.6 Snapping Turtle

6.6.4.6.1 Habitat Availability

Snapping turtle are considered one of the most aquatic freshwater turtle species in Canada (i.e., they are primarily located in wetted habitats), and their preferred aquatic habitat consists of shallow, slow-flowing, permanent streams, lakes and ponds with soft mud substrate and dense aquatic vegetation (Preston 1982; COSEWIC 2008; ECCC 2016b). Based on records from established snapping turtle populations in Canada, natural habitat types typically include wetland habitats such as marshes, swamps, peat bogs; lentic habitats including ponds and lake edges and shallow bays, as well as lotic habitat, including river edges and slow-moving streams (ECCC 2016b). Overwintering habitat is also aquatic, as snapping turtle also typically hibernate in lentic or lotic habitat, beneath a thick layer of mud (ECCC 2016b).

Upland (terrestrial) habitat is also required by snapping turtle, for nesting and overland migration to/from nesting and aquatic habitats. Nesting habitat consists of exposed sand or gravel substrate adjacent to water, and can be located on road shoulders (which are present within the RSA and LSA). Movement corridors to and from bodies of water are also required habitat components and this type of terrestrial habitat is particularly important if local aquatic habitat conditions become unfavourable and overland migration to areas with better conditions is undertaken (ECCC 2016b). Although terrestrial habitat is important, the focus of this spatial habitat assessment is on aquatic habitat, with particular focus on aquatic habitat near roadways. Road crossings of streams represent one of the largest threats to the species (road mortality during overland migration), and also a primary pathway of effects for this project. The chain link fencing surrounding the LSA greatly limits the potential for snapping turtle access and habitat use within the LSA.

The land cover and wetlands spatial data were used to determine a conservative, coarse-scale estimation of the availability of aquatic habitat for snapping turtle as follows:

- waterbodies; and
- marsh wetlands.

The highest quality potentially suitable aquatic habitats for snapping turtle in the RSA are wetlands and watercourses that are located 500 m, and 2 km, and 2.5 km southeast of the LSA, near Ara Mooradian Way, and connected to the Winnipeg River. There is no suitable aquatic habitat within the LSA (Table 6.6.4-4).

Table 6.6.4-4: Aquatic Habitat Availability for Snapping Turtle in the Base Case

Habitat Suitability	Regional Study Area		Local Study Area	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Suitable	43	1.1	0	0.0
Unsuitable	3,667	98.9	29	100.0
Total	**3,710**	**100.0**	**29**	**100.0**

ha = hectare; % = percent.

6.6.4.6.2 Habitat Distribution

Approximately 10% of the snapping turtle range is contained within Canada. Snapping turtle have been recorded in the Winnipeg River near the Project location (Preston 1982) and within the RSA, by the Manitoba Herps Atlas (Manitoba Herps Atlas 2016) and CNL staff (CNL 2016c). The highest likelihood areas of suitable habitat for snapping turtle in the RSA is limited to wetlands and streams that are connected to the Winnipeg River (Figure 6.6.4-1). Potential aquatic habitat is located from 500 m to 2.5 km southeast of the LSA, but there is no suitable habitat within the LSA itself (Figure 6.6.4-2). No other wetlands in the RSA appear to be connected to the Winnipeg River. The Winnipeg River shoreline is expected to provide higher quality habitat than wetlands in the RSA. Although there have been no habitat assessments or turtle nesting surveys completed in the RSA, there is potential for snapping turtle to use roads such as Ara Mooradian Way as travel corridors and possibly the gravel shoulders of the roads as nesting areas. Snapping turtle have been incidentally observed and recorded by staff on the WL property on site roads (CNL 2016c).

6.6.4.6.3 Survival and Reproduction

Snapping turtle populations are primarily limited by this species' late age of maturity, long lifespan, high adult survival, and slow recruitment (COSEWIC 2008). Females in southern populations reach sexual maturity at 12 years of age, while individuals in more northern populations (e.g., in Manitoba) reach sexual maturity between 15 and 20 years of age (COSEWIC 2008). Lifespan in the wild is largely unknown but is has been suggested that individuals can live over 100 years (COSEWIC 2008). Females lay approximately 40 eggs in late May to June (COSEWIC 2008).

Snapping turtle populations are particularly vulnerable to increases in adult mortality and do not recover quickly from declines. It has been suggested that a 0.1% increase in annual adult mortality rate will cause a population to be halved in under 20 years (COSEWIC 2008). A primary cause of adult mortality is from traffic, especially on roads located through or adjacent to wetlands (COSEWIC 2008). Female turtles are most vulnerable to mortality from vehicle collisions during the reproductive season because females frequently cross roads in search of nesting sites and soft gravel road shoulders are attractive nesting sites (Aresco 2005; COSEWIC 2008). In populations with high mortality of females from road mortality, the sex ratio of the population can become highly skewed towards males. In an area of New York State with high road density, a population of snapping turtles was found to be made up of 95% males (Steen and Gibbs 2004). Other causes of adult mortality include fishing (swallowing hooks or being hooked by anglers), human persecution, and legal and illegal hunting.

Eggs and juveniles are susceptible to nest predation (particularly in road rights-of-way and areas with high road densities; Browne 2003), contaminants (Bishop et al. 1998), and short, cool summers in the northern portion of this species range, which affect hatching success as embryo development is temperature dependent (COSEWIC 2008).

6.6.5 Project Interactions and Mitigation

6.6.5.1 Methods

This section describes the process by which interactions between Project components and activities and the terrestrial environment were identified and evaluated. Potential effect 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 Project and the terrestrial 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 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 Project. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. The next step in the analysis was the development of environmental design features and mitigation that could be incorporated into the Project to eliminate and/or reduce adverse effects on the terrestrial environment. 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 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 pathway –** 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 the terrestrial environment.
- **Secondary pathway –** the pathway could result in a measurable minor environmental change, but would have a negligible residual effect on the terrestrial environment 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 past, present 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 terrestrial environment.

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 on terrestrial environment through simple qualitative or semi-quantitative 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 Project.

6.6.5.2 Results

Potential interactions between the Project and terrestrial environment VCs are presented in Table 6.6.5-1. Mitigations identified to address and, if possible, remove potential interactions between the Project and terrestrial environment are also integrated into the pathway analysis presented in Table 6.6.5-1.

Table 6.6.5-1: Pathways Analysis for Terrestrial Environment Valued Components

WR-1 Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Construction of temporary supporting infrastructure during decommissioning (e.g., batch mixing plant for preparation of grout)	Potential loss or alteration of wildlife habitat from demolition of the WR-1 Building and construction of temporary supporting infrastructure.	■ The Project footprint is located in an already disturbed area. ■ Temporary supporting infrastructure will be located within the LSA (i.e., previously disturbed and developed area). ■ Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the RSA will be used during decommissioning activities around disturbed areas, where appropriate. This will reduce the potential for effects on adjacent natural areas that provide suitable wildlife habitat.	No Linkage
Activities associated with ISD of the WR-1 and demolition of above-ground structures of the WR-1 Building	■ Potential mortality or injury to wildlife (particularly snapping turtle) from movement of decommissioning-related heavy equipment and other vehicles on roads. ■ Sensory disturbance from increased noise levels created by ISD of the WR-1 demolition of above-ground structures of the WR-1 Building ■ Potential loss of nest/roost substrate for barn swallow and little brown myotis within WR-1 Building	■ Wildlife have the right of way. ■ Drivers have standard safety training and are provided with environmental awareness training. ■ Enforcement of existing CNL property speed limits on access roads. ■ Post turtle crossing warning signage at the watercourse crossings on Ara Mooradian Way approximately 300 m south of the LSA fenceline and at 2 km and 2.5 km south of the LSA fenceline, where snapping turtle are likely to cross. Installation of silt fencing would also be completed at these thee potential crossing locations. ■ As per CNL's Management of Land, Habitat, and Wildlife Procedure (CNL 2015), dead or wounded animals on roads must be reported to the Environmental Protection (EnvP) department. ■ Wildlife collisions with vehicles will be monitored, which provides feedback for adaptive management (and the potential need for more signage, or other fencing to restrict wildlife access to road surfaces). ■ Decommissioning activity will be primarily limited to daytime hours and noise will be short-term and sporadic. Decommissioning of the WR-1 Building will be completed in a controlled manner, and no blasting will be required. The loudest decommissioning activity will be jack hammering to remove deeply embedded contaminants in concrete – this activity will be limited to the interior of the building envelope, which will serve to reduce the level of noise outside the building, and in the surrounding RSA where there may be wildlife present. ■ Pre-disturbance surveys by suitably trained and experienced biologists or environmental specialists will be conducted to confirm presence/absence of little brown myotis roosts and active barn swallow nests inside the WR-1 Building prior to removal of suitable nesting areas (assumed to be limited to above-grade building structures). Surveys to be conducted the year prior to initiation of decommissioning, during the appropriate season, over multiple visits, if necessary.	Secondary

Table 6.6.5-1: Pathways Analysis for Terrestrial Environment Valued Components

WR-1 Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Activities associated with ISD of the WR-1 and demolition of above-ground structures of the WR-1 Building	■ Potential mortality or injury to wildlife (particularly snapping turtle) from movement of decommissioning-related heavy equipment and other vehicles on roads. ■ Sensory disturbance from increased noise levels created by ISD of the WR-1 demolition of above-ground structures of the WR-1 Building ■ Potential loss of nest/roost substrate for barn swallow and little brown myotis within WR-1 Building	■ As a precaution, pre-disturbance searches for hibernating little brown myotis will also be conducted during the winter prior to the initiation of decommissioning to confirm the absence of hibernating individuals inside the below-grade floors of the WR-1 Building, taking ALARA into consideration. ■ If active bat maternity roosts or barn swallow nests are identified in any structure to be affected by decommissioning, initiate erection of species-appropriate barriers once individuals have left the structure and roosts/nests are no longer active.	Secondary
	Release of chemical and radiological contaminants during the closure phase.	■ As part of CNL's licence with the CNSC, environmental monitoring around the WL site is required and will continue for the Project. ■ Follow-up monitoring during the closure phase will be completed to verify effects predictions and to provide information for use in adaptive management to address potential unforeseen effects.	Secondary
	Air and dust emissions (including sulphur dioxide, nitrogen oxides, and particulate matter) and subsequent deposition.	■ Implementation of CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring, air verification monitoring and environmental monitoring. ■ Implementation of dust management techniques to control dust generated by the Project, consistent with the current Environmental Assessment Follow-up Program. ■ Road watering and chemical dust suppressant when necessary. ■ Removal of accumulations of particulates (e.g., dirt) on road as soon as possible. ■ On-site vehicles and equipment engines will meet Tier 3 emission standards, where possible, and be maintained in good working order. ■ Limit idling of vehicles on-site and speed on roads. ■ Use of enclosure for raw material handling.	Secondary

Table 6.6.5-1: Pathways Analysis for Terrestrial Environment Valued Components

WR-1 Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Installation of engineered cover over grouted WR-1 Building and final restoration	Potential introduction and spread of noxious weed species during decommissioning and reclamation.	■ Locally-appropriate grass seed mixtures that are certified weed-free will be applied to any cleared and reclaimed areas as soon as practical following decommissioning. ■ Upon completion of the installation of the engineered cover over the grouted WR-1 Building, turf grass will be established and maintained. Turf grass establishment methods will include selective herbicide application to remove weeds prior to grass seeding and watering of newly seeded areas until grass has established. Maintenance of the engineered cover during the Institutional Control period includes restricting weed establishment and preventing surface erosion and abrasion. ■ The former WR-1 Building location will be fenced around the perimeter with six foot-high chain link fence. This will serve to reduce access to ground-based wildlife species. The engineered cover will be maintained during the Institutional Control period to deter wildlife and avoid the disruption of roots to the WR-1 ISD structure.	No Linkage
Post-closure Performance	Release of chemical and radiological contaminants in the long-term during the post-closure phase.	■ As part of CNL's licence with the CNSC, environmental monitoring around the WL site is required and will continue for the Project. ■ Follow-up monitoring during the post-closure phase will be completed to verify effects predictions and to provide information for use in adaptive management to address potential unforeseen effects.	Secondary

6.6.5.2.1 No Linkage Pathways

The following pathways were assessed as having no measurable environmental change and hence, no linkage to residual effects on VCs for the terrestrial environment.

- **Potential loss or alteration of wildlife habitat from demolition of the WR-1 Building and construction of temporary supporting infrastructure.**

The Project footprint (i.e., SSA) is 0.07 ha; and it is located in an area that has been previously disturbed, where wildlife habitat value is considered to be negligible to low. In addition, temporary supporting infrastructure will be located within the LSA on previously disturbed and developed areas. Therefore, the Project is not expected to result in an incremental loss of wildlife habitat from current conditions at the WL site. Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the RSA will be used during decommissioning activities around disturbed areas, where appropriate. This will reduce the potential for effects on adjacent natural areas that provide suitable wildlife habitat. Consequently, this interaction was determined to have no residual effect on the maintenance of self-sustaining and ecologically effective wildlife populations in the RSA.

- **Potential introduction and spread of noxious weed species during reclamation can affect vegetation community species composition.**

Reclamation of temporarily disturbed areas and the former WR-1 Building site has potential to introduce noxious weed species listed under *The Noxious Weeds Act* of Manitoba (The Noxious Weeds Act2010). There is also potential to introduce invasive plant species into new areas, which can disrupt adjacent natural vegetation communities and decrease habitat quality (Mack et al. 2000; Carlson and Shepherd 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). Ara Mooradian Way is the primary access route to the site and provides 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 become 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). Locally-appropriate grass seed mixtures that are certified weed-free will be applied to any cleared and reclaimed areas as soon as practical following decommissioning. This will reduce the potential for the establishment and spread of invasive plant and weed species. Upon completion of the installation of the engineered cover, turf-grass will be established and maintained. Turf-grass establishment methods will include selective herbicide application to remove weeds prior to grass seeding and watering of newly seeded areas until grass has established. Maintenance of the engineered cover during the Institutional Control period includes restricting weed establishment and preventing surface erosion and abrasion.

The implementation of these mitigation measures will reduce the potential for introduction of weed species during decommissioning activities. Some localized introduction of weed and invasive species may occur, but mitigation measures to address these identified in Table 6.6.5-1 would result in no measurable changes to the abundance and distribution of natural wildlife habitat relative to Base Case conditions. Therefore, this interaction was determined to have no residual effect on the maintenance of self-sustaining and ecologically effective wildlife populations in the RSA.

6.6.5.2.2 Secondary Pathways

The following pathways were assessed as potentially having a measurable minor environmental change, but negligible residual effect on the terrestrial environment relative to Base Case.

- **Sensory disturbance from increased noise levels created by ISD of WR-1 and demolition of above-ground structures of the WR-1 Building.**

Short-term sensory effects of noise from ISD of WR-1 and demolition of above-ground structures of the WR-1 Building has the potential to affect golden-winged warbler. Noise levels greater than 50 dB can negatively affect local birds, including golden-winged warbler, and may lead to temporary displacement if birds avoid otherwise suitable habitat in areas of the RSA adjacent to the LSA where decommissioning activities create noise levels greater than 50 dB. It should be noted that this displacement would only occur if noise at that level is propagated to the required distance to suitable habitat. If experienced at sufficient levels, noise can also potentially reduce reproductive success and survival by raising stress levels and interfering with communications (e.g., reducing ability to hear approaching predators or intraspecific vocalizations; Ortega 2012).

Short-term sensory effects of noise from decommissioning activities also has the potential to affect bat survival by altering their ability to effectively carry out echolocation (Mackay and Barclay 1989; Schaub et al. 2008; Siemer and Schaub 2011). Available research has not resulted in definition of measurable thresholds that may negatively affect bat activity (e.g., dB levels). The pathway of this potential effect is limited by the primary work period (during daylight hours, when bats are inactive), and because bats are highly mobile, they are also able to avoid areas with elevated noise. Noise could also result in adverse changes to the availability of potential bat maternity roosting habitat in the RSA area outside of the LSA, 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).

The creation of noise likely represents more of a potential effect on habitat availability for both golden-winged warbler and bats, and any wildlife species in proximity to the LSA, if the noise causes individuals to avoid previously occupied breeding or maternity roost habitat that is in or around areas with high noise levels. However, this potential effect is reduced by a number of factors. The closest potential natural bat maternity roosting habitat (forested land) is approximately 250 m away from the SSA, and there is already anthropogenic activity on-going within the LSA that bats would have become habituated to since the inception of WL in the 1960s. Similarly, for golden-winged warbler, there is mapped suitable habitat present in the area surrounding the LSA; however, the ongoing anthropogenic activity has likely habituated songbirds to ongoing noise levels and disturbance. In addition, the predicted level and nature of noise associated with decommissioning activities (with the loudest activity occurring inside the building), and the attenuation of noise that occurs with distance and tree cover. As a result, noise is expected to have a negligible effect on golden-winged warbler and bat survival and reproduction or habitat availability.

- **Potential mortality or injury to wildlife (particularly snapping turtle) from movement of decommissioning-related heavy equipment and other vehicles on roads.**

The ISD of WR-1 Building will have project-associated vehicular traffic, primarily along Ara Mooradian Way. This could result in increased injury and mortality to wildlife VCs, particularly snapping turtle. The risk of vehicle-wildlife collisions is not uniform in regards to species, as species with small size and slow movement speeds (e.g., amphibians and turtles) have a higher mortality risk from crossing roads than larger and/or more mobile species (e.g., birds; 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 are clearly posted on the main access road (Ara Mooradian Way) and enforced to mitigate against potential wildlife mortalities during decommissioning as well as all other WL site activity. In addition, CNL staff have standard safety training and are provided with environmental and wildlife awareness training. It is expected that this will serve to reduce the risk for vehicular collision with avian and bat VC species, as well as other large mammals that frequent the RSA such as deer. In addition, new signs with the text: “CAUTION - turtle crossing area” will be installed on Ara Mooradian Way at the three highest potential snapping turtle crossing locations (the closest two locations shown on Figure 6.6.4-2), at the stream crossings located approximately 500 m, 2 km, and also 2.5 km south of the LSA. Installation of silt fencing would also be completed at these thee potential crossing locations. Installation of silt fencing provides additional protection to crossing turtles by blocking them from the road surface and directing them through culverts instead.

Because of the mitigation measures that have already been applied (i.e., speed limits and staff awareness training for wildlife), and the addition of signage and silt fencing as access barriers at high potential crossing locations, increases in vehicle traffic during decommissioning activities is expected to result in a minor increase in mortality risk to wildlife populations as compared to Base Case conditions. It should be noted that there have been no reported road mortalities of snapping turtles to this point, but there has been reported road mortality of painted turtles near the sewage lagoons (CNL 2016c). Overall, collisions with vehicles are expected to have negligible residual effect on wildlife populations (and snapping turtle in particular) and are not predicted to affect the maintenance of self-sustaining and ecologically effective wildlife populations that overlap the RSA. A follow-up monitoring program to address the uncertainty regarding the effectiveness of this mitigation for protecting snapping turtle populations is described in Section 6.6.6 Monitoring and Follow-up.

- **Potential loss of nest/roost substrate for barn swallow and little brown myotis within WR-1 Building.**

The MBCA (1994) prohibits the destruction of migratory bird nests during the breeding season. In the RSA (Zone C4), the migratory bird breeding season for all habitat types (forested, open and wetlands) extends from April 14 to August 27 (ECCC 2016c). The only VC bird species likely to nest in an area to be directly affected by decommissioning of the WR-1 Building is barn swallow. A nest survey was completed in the summer of 2015 and no barn swallow nesting activity was found on the outside of the WR-1 Building (CNL 2016b); however, CNL staff have reported barn swallow do nest in many other buildings within the LSA (CNL 2017). Barn swallows commonly reuse nests from previous years (Brown and Brown 1999). Because there has been no nesting activity to-date, it is less likely that new nests will be established on, or in, the WR-1 Building before demolition. However, the potential remains for new nests to be created on the building exterior.

A detailed pre-disturbance survey for nesting barn swallow will be conducted in the summer preceding the initiation of decommissioning activities in the WR-1 Building. A suitably trained biologist or environmental specialist will conduct a minimum of two visual surveys during the appropriate nesting season and weather conditions to confirm the presence/absence of barn swallow nesting activity on all external structures of the WR-1 Building. If there are no barn swallow nests observed, no further exclusion methods will be required, if the building will be demolished before the start of the breeding season in the following year. If demolition activities are not initiated prior to the start of the breeding season, deterrents will be installed at any potential barn swallow nesting areas (e.g., overhanging rooflines). This will serve to reduce the likelihood that new barn swallow nests will be created on the building exterior.

If barn swallow nesting activity is observed on the WR-1 Building, the locations of any nests will be recorded and nest activity monitored until the young have fledged. This can occur as late as September, as there can be two broods per season in Manitoba (COSEWIC 2011). Additionally, if barn swallow become listed on SARA, their residences (nests), which are re-used from year to year will become protected. If they are found nesting on the WR-1 Building, appropriate mitigation measures would then be put into place in consultation with Environment and Climate Change Canada (ECCC) and in accordance with habitat protection provisions and permitting requirements under SARA. In order to avoid new nests from being built on the WR-1 Building the next year (when demolition is to commence), species-specific and appropriate deterrents will be installed the year before demolition activities commence. This could include installation of netting to block the area used as nest substrate, and any other similar areas where nests may be built (e.g., overhanging roofs).

Little brown myotis and northern myotis are SARA listed species. There are prohibitions against killing or harming individuals or destroying a residence, including actively used maternity roosting habitat. This risk is highest for little brown myotis, which are commonly known to roost in buildings, and much less so for northern myotis, as they are less frequently documented to roost in anthropogenic structures, and typically only resort to them if natural tree roosting habitat is fragmented and less available (EC 2015a). Little brown myotis show a high degree of philopatry (tendency to return to the same home area each year), and site fidelity (individuals will tend to roost in the same sites and buildings once established; EC 2015a). They also are highly loyal to roost locations in anthropogenic structures (like buildings), with some sites used continually for 50 years or more (EC 2015a). This site fidelity behaviour would mean that because there has been no roost activity identified within the WR-1 Building to-date (survey conducted in 2015), there is lower likelihood that a new roost would be established in the building, prior to the initiation of decommissioning activity. Pre-disturbance surveys to confirm the absence of roosting bats will be conducted in the following phased approach.

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, the bat roosting period is assumed to be from May 1 to August 31. A survey for roosting bats will be conducted in the summer preceding the initiation of decommissioning activities in the WR-1 Building. Visual surveys for evidence of roosting bats and roost emergence surveys will be conducted, using hand-held acoustic bat monitoring detectors (to determine species identification), on all four sides of the building. The objective of these surveys is to visualise and confirm bats exiting from any potential roosting locations within the building. This monitoring will be conducted in the summer – from June to July – during the expected period of highest bat activity in the RSA. Monitoring will be conducted for a minimum of two nights, during suitable conditions (i.e., not on nights with rainfall events or high winds). If there are no bats detected leaving the WR-1 Building, it can be concluded that bats are not likely roosting in the building and no further survey or exclusion effort is required.

If the visual roost emergence survey of the WR-1 Building determines there is active bat maternity roosting occurring in the building, any potential access point to the roost location will be blocked from the outside, once the maternity roosting period is completed (i.e., mid-August). Exclusion tubes (following Bat Conservation International designs; BCI 2014) will be installed at all observed and potential bat access points on the building envelope. These tubes will allow any remaining bats to exit the building, but will not permit re-entry. At the end of October, permanent exclusion materials can be installed on these above-ground, exterior portions of the building, as per the BCI guidelines (BCI 2014), if necessary.

Pre-disturbance searches for hibernating little brown myotis will be conducted during the winter prior to the initiation of decommissioning to confirm the absence of hibernating individuals inside the below-grade floors of the WR-1 Building. Starting in November of the calendar year prior to decommissioning activities, searches will be conducted for hibernating bats. An appropriate survey method will be used, which may include the use of a laser thermometer or thermal imaging camera. The laser thermometer survey method is described as follows: a surveyor will use a laser thermometer to measure the ambient temperature of the walls and ceilings on each sub-surface floor of the WR-1 building, along perimeter walls. If the temperature on the ceiling and/or walls on a particular floor is above 15°C (the suitable temperature for hibernacula described in the recovery strategy is 2°C to 10°C), no further surveys will be performed, as the temperature on that floor is too high for hibernation. On any floor where there are ambient ceiling and/or wall temperatures between 2°C to 10°C, all available lights will be turned on, and a suitably trained biologist or environmental specialist will use a high-powered spotlight to search all surfaces of the walls and ceiling for individual hibernating little brown myotis. Searches for guano (to be distinguished from mouse feces) will also be conducted. If there are no bats detected within the below-grade floors of the WR-1 Building, it can be concluded that bats are not hibernating in the building and no further survey or exclusion effort is required.

The guidance document for federal land managers regarding the emergency listing order for little brown myotis, northern myotis and tri-colored bat (EC 2015b) suggests if active bat roosts are found in a building on a federal site, managers should consider installation of alternate roosting habitat in the form of bat boxes. Offsetting the removal of unoccupied bat maternity roost substrate (buildings) is not required under SARA. Bat boxes can be highly effective at providing habitat for roosting little brown myotis and possibly northern myotis, both of which are currently listed as endangered across Canada due to the effects of WNS.

As a proactive approach, and in consideration of all future decommissioning and building demolition activities that will occur on the WL property, eight bat boxes and one barn swallow nesting structure with nest cups (design examples from Bird Studies Canada [BSC] 2017), may be installed to compensate for potential future loss of anthropogenic maternity roosting habitat for little brown myotis and barn swallow nesting habitat. CNL has made

a corporate commitment to sustainable development and responsible environmental stewardship at all of their sites, and installation of these compensatory habitat structures will demonstrate visible and measurable commitments to improving habitat availability for these species at risk that occur on the WL site (i.e., RSA). Installation of the habitat structures should occur the year preceding demolition of the building. This is in keeping with guidance that recommends replacement of roost/nest habitat to be lost prior to the removal of habitat, to allow for individuals to recognize and potentially colonize the new structures before old ones are removed (BSC 2017).

Overall, potential loss of nest/roost substrate for barn swallow and little brown myotis within WR-1 Building are expected to have negligible residual effect on the maintenance of self-sustaining and ecologically effective wildlife populations that overlap the RSA. The follow-up monitoring program regarding the effectiveness of the bat boxes and barn swallow nesting structure, if required, is further described in Section 6.6.6 Monitoring and Follow-up.

- **Non-radiological air emissions and dust emissions (including sulphur dioxide, nitrogen oxides [NOx/NO_2], and particulate matter) and subsequent deposition.**

The Project will generate air and dust emissions such as carbon monoxide (CO), oxides of sulphur (SO_x includes sulphur dioxide [SO_2]), oxides of nitrogen (NO_x includes nitrogen dioxide 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. The LSA is characterized as an anthropogenically altered landscape, with limited habitat quality in the form of native tree and shrub species. As described above, infrastructure and paved areas comprise 25% of the total area and the remaining 74% is primarily landscaped and maintained turfgrass lawn (Figure 6.6.4-2). A small proportion of the area contains broadleaf forest (less than 1%).

Examples of mitigation implemented to limit predicted residual effects from Project emissions to air quality and subsequently the terrestrial environment include:

- implementation of CNL's Environmental Protection Program (CNL 2017) and Procedure for Management and Monitoring of Emissions (CNL 2013), which includes operational control monitoring, air verification monitoring and environmental monitoring;
- on-site vehicles and equipment engines will meet a minimum of Tier 3 emission standards, where possible, and be maintained in good working order;
- limit idling of vehicles on-site and limit speed on roads; and,
- use of enclosure for raw material handling.

The predicted residual effects on air quality were estimated to increase because of the Project. Fugitive dust from paved roads is the largest contributor to suspended particulate matter emissions. Material handling from demolition is the largest contributor to PM_{10} emissions. Non-road equipment exhaust emissions are the largest contributors to $PM_{2.5}$ and NOx (as NO_2) emissions. Finally, the largest contributor to SO_2 and CO emissions is fuel combustion for emergency power generators. Predicted concentrations for the Application Case are below applicable air quality guidelines and/or standards (Section 6.2.1.6.2).

With the implementation of CNL's Management and Monitoring of Emissions Procedure, and through the implementation of the dust management techniques for the Project, air and dust emissions and subsequent deposition are expected to result in minor changes to soil quality relative to Base Case conditions. As such, this pathway is determined to result in a negligible residual effect on the maintenance of self-sustaining and ecologically effective wildlife populations in the RSA.

- **Release of chemical and radiological contaminants during the closure phase.**
- **Release of chemical and radiological contaminants in the long-term during the post-closure phase.**

An ecological risk assessment was completed to evaluate the potential for adverse effects on terrestrial biota health associated with exposure to chemical and radiological contaminants from the Project (Section 6.7.2) during the closure and post-closure phases.

For the closure phase, sources of the relevant chemical and radiological contaminants include release via atmospheric releases from the WR-1 Building during grouting and demolition (Section 6.7.2). Exposure pathways include the routes of contaminant dispersion from the source to the receptor location, and the routes of contaminant transport through the food chain or other media to the receptor organism.

During the closure phase, there are predicted to be no exceedances of the 2.4 mGy/d radiation benchmark for terrestrial and riparian biota on or near the WL site (Section 6.7.2). All predicted doses are well below this level. Therefore, it is unlikely that there would be significant adverse effects on terrestrial wildlife populations or communities as a result of chemical and radionuclide releases from closure activities (Section 6.7.2).

Following the completion of closure activities, the Project site and engineered cover will be graded to promote drainage from the site to the Winnipeg River. Run-off control for the engineered cover is designed to limit erosion and infiltration of water into the grouted structure. This is achieved by sloping the engineered cover surface to maintain a slope toward the edges, and the collection of water by the existing surface water management systems at the WL Site. Turfgrass will be established over the engineered cover and a six foot high chain link perimeter fence installed and maintained for perpetuity. The engineered cover will be actively maintained during the Institutional Control period to deter wildlife and avoid the disruption of roots to the WR-1 ISD structure. Consequently, the post-reclamation state of the SSA will be highly modified and unlikely to support a diverse community of terrestrial wildlife VCs. The expansive remaining portions of RSA will provide much higher wildlife habitat value. Avian species (i.e., birds and bat) that could potentially access the SSA will have much larger areas of natural habitat in which to forage and the addition of the relatively small turf grass covered mound on the landscape is unlikely to cause an increase in level of attraction.

For the post-closure phase, the relevant chemical and radiological contaminants may be released via leakage through the grouting to groundwater and subsequent migration of groundwater to surface water at the Winnipeg River. The ecological risk assessment (Section 6.7.2) used groundwater release rates and dispersion modelling to estimate radionuclide concentrations in surface water, to calculate dose rates to terrestrial biota.

During post-closure, the incremental change in radionuclide levels in the Winnipeg River resulting from the transport of radionuclides from the WR-1 Building to the Winnipeg River via groundwater is predicted to be not practically distinguishable from background levels (see Section 6.4 Surface Water). Similar to the closure phase, there are predicted to be no exceedances of the 2.4 mGy/d radiation benchmark for terrestrial and riparian biota on or near the WL site (Section 6.7.2) during the post-closure phase. All predicted doses are well below this level. Therefore, it is unlikely that there would be significant adverse effects on terrestrial wildlife populations or communities as a result of chemical and radionuclide releases from post-closure activities (Section 6.7.2).

6.6.5.2.3 Primary Pathways

No primary pathways were identified between the Project and the terrestrial environment. As such, a residual effects analysis and determination of significance has not been completed for the terrestrial environment assessment.

6.6.6 Monitoring and Follow-up

The conceptual outline for monitoring and follow-up programs recommended to confirm the predictions made in the terrestrial environment assessment during the closure phase are presented in Table 6.6.6-1. Although no residual effects to terrestrial VCs are predicted, the following Environmental Assessment Follow-up Monitoring Program is provided as proactive mitigation by CNL, and includes consideration of all future decommissioning and building demolition activities that will occur on the WL property. In addition, CNL will implement an Environmental Assessment Follow-up Program for WR-1 as outlined for other environmental components to verify the accuracy of indirect environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented.

Table 6.6.6-1: Monitoring and Follow-up Programs for the Terrestrial Environment

Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Barn swallow	Closure and Post-Closure: If barn swallow are confirmed to be using WR-1 as habitat through pre-disturbance surveys, there will be incremental contribution of the Project and all future decommissioning activity to the loss of potential nesting habitat in the RSA. There is predicted to be negligible effects on barn swallow, if determined to be nesting in the WR-1 building, through the implementation of habitat compensation.	■ Offset the incremental contribution of the Project and all future decommissioning activity to the loss of potential nesting habitat in the RSA using compensatory nesting habitat ■ Determine number of individuals using compensatory nesting habitat on an annual basis	■ If barn swallow are confirmed to be using WR-1 as nesting habitat, installation of a compensatory barn swallow nest structure, including nest cups for nest placement, is recommended as an alternative habitat for nesting barn swallow. Installation of barn swallow nest habitat in a suitable location in the RSA will offset the incremental contribution of all decommissioning activities to be undertaken at the WL site to the loss of potential nesting habitat in the RSA. ■ Suitable locations include areas within 1 km of any currently used nesting habitat, but far enough away from other buildings that will be demolished in the future (to avoid colonization on those structures), and adjacent to open foraging areas and aquatic habitat with mud for nest building. Final site selection will be at the discretion of CNL biologists. ■ Effectiveness monitoring will be conducted to determine if the compensatory nest habitat is being used. ■ This compensation model and follow-up monitoring duration is consistent with what has been designed by the Ontario Ministry of Natural Resources and Forestry (OMNRF 2015). Barn swallow are designated as “Threatened” on the Ontario *Endangered Species Act*’s Species at Risk in Ontario list. An equivalent protocol has not been developed for Manitoba (barn swallow are not currently designated on the provincial ESEA).	Annually for three years following installation.	Integrated into CNL’s Environmental Protection Program

Table 6.6.6-1: Monitoring and Follow-up Programs for the Terrestrial Environment

Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Bats	Closure and Post-Closure: If bats are confirmed to be using WR-1 as habitat through pre-disturbance surveys, incremental contribution of the Project and all future decommissioning activity to the loss of potential anthropogenic maternity roosting habitat in the RSA. There is predicted to be negligible effects on bats, if determined to be roosting in the WR-1 building, through the implementation of habitat compensation.	■ Offset the incremental contribution of the Project and all future decommissioning activity to the loss of potential anthropogenic maternity roosting habitat across the RSA. ■ Install bat boxes and determine number of individuals and species using bat boxes on an annual basis.	■ Inherent uncertainty on the current status of bat populations overlapping the RSA and uncertainty regarding the amount and relative importance of anthropogenic maternity roost habitat that will be lost as a result of the Project and future removal of remaining anthropogenic structures is the main rationale for installing bat boxes. ■ In consultation with CNL biologists on other CNL sites to be decommissioned in the future, and in consideration of future losses of anthropogenic structures that may provide roosting habitat at the WL site, offsetting in the form of eight bat boxes is recommended. ■ Criteria for appropriate siting will include: 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 waterbodies (i.e., Winnipeg River) and wetlands are high priority locations, because these forest types do not currently provide high quality tree 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. ■ Effectiveness monitoring will be conducted to determine if boxes are being used.	Bat boxes should remain in place throughout the Closure Phase at minimum. Monitoring should take place annually for three years.	Integrated into CNL's Environmental Protection Program

Table 6.6.6-1: Monitoring and Follow-up Programs for the Terrestrial Environment

Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Snapping turtle	Closure: Negligible effect on snapping turtles regarding vehicle collisions was identified. However, CNL will implement a follow-up monitoring program to address the uncertainty regarding the effectiveness of proposed mitigation for protecting snapping turtle populations	Track turtle mortality and use information for adaptive management.	■ Despite the current mitigation in place (speed limits and wildlife awareness training of staff), the additional protection to turtles provided by installation of new turtle crossing signs and silt fencing as access barriers at the three most likely turtle crossings on Ara Mooradian Way, and the lack of road mortality recorded for snapping turtle to-date, there is the potential for project-related mortality of turtles to occur in the future. Any road mortality or injury of snapping turtle (or other reptile species) will be reported and data will be compiled in a database that can be used to inform adaptive management for the site. ■ If, after mitigation and operational measures are shown to be ineffective (i.e., driver awareness training and speed limits, installation of signage at the three stream crossing locations on Ara Mooradian Way with the highest likelihood of turtle crossings), and any mortality of snapping turtle occurs, further mitigation in the form of comprehensive assessments of high-risk road crossing locations, potential upgrade of existing crossing culverts to turtle passage enabled design, and the potential need to install permanent fencing on either side of the roadway to funnel turtles into the passage culvert and prevent road access will be considered.	On-going reporting and monitoring should take place annually over the active decommissioning period (until the start of Institutional Control).	■ Integrated into CNL's Environmental Protection Program ■ Continuation of WL staff reporting of incidental wildlife observations

6.6.7 Conclusions

Valued components (VCs) refer to environmental features that may be affected by a project. VCs have been identified to be of concern by the proponent, scientists, government agencies, First Nations and Métis peoples, or the public (the Agency 2014). All SARA-listed wildlife species with the potential to occur within the WL property (or with confirmed occurrence records) were considered as potential VCs at the species level, and the chosen species are also useful as indicators for broader species guilds with similar life history traits. Barn swallow were also included despite the lack of SARA-listing, based on their COSEWIC ranking and more significant potential pathway for effects through nest destruction associated with the Project. Species with a very low likelihood of occurrence in the LSA, for which habitat was not present in the RSA, or for which effects of the Project were unlikely, were excluded as VCs. The VCs assessed for the terrestrial environment included barn swallow, golden-winged warbler, bats, and snapping turtle.

The assessment endpoint for the terrestrial environment is the maintenance of self-sustaining and ecologically effective populations. Habitat availability, habitat distribution, and survival and reproduction were selected as the measurement indicators for the terrestrial environment VCs. The assessment of potential pathways of effects determined there are no primary pathways that would lead to residual effects on VCs. Surveys during the appropriate season, to be undertaken the year prior to initiation of decommissioning activities, will confirm whether nesting and/or roosting activity is occurring in the WR-1 Building. If evidence of nesting or roosting activity is found, appropriate mitigation measures in the form of deterrents will be implemented, under consultation with ECCC, and in accordance with habitat protection provisions and the required permitting process under SARA. The objective of the selected mitigation measures will be to prevent birds and bats from accessing the building during the period when it will be demolished. Compensatory habitat features (i.e., bat boxes and barn swallow nesting structures) may be installed depending on the outcome of the above surveys, and to demonstrate CNL's commitment to environmental stewardship. The potential for road mortality of snapping turtle will be addressed through adaptive management and on-going monitoring and documentation of road mortalities. If road mortality of snapping turtle occurs, additional mitigation will be enacted, as required. Following implementation of mitigation and monitoring in an adaptive management framework, there is predicted to be negligible effects on the terrestrial environment as a result of the Project.

During the closure and post-closure phases, there are predicted to be no exceedances of the 2.4 mGy/d radiation benchmark for terrestrial and riparian biota on or near the WL site. All predicted doses are well below these levels. Therefore, based on the assessment completed in Section 6.7.2, it is unlikely there would be significant adverse effects on either aquatic or terrestrial populations or communities as a result of radionuclide releases from closure activities or in the long-term during the post-closure phase.

Although no residual effects on terrestrial VCs are predicted, monitoring programs are described as possible proactive mitigation by CNL, and includes consideration of all future decommissioning and building demolition activities that will occur on the WL property. In addition, CNL will implement an Environmental Assessment Follow-up Program for WR-1 as outlined for other environmental components to verify the accuracy of indirect environmental effects and determine the effectiveness of mitigation measures that have been, or are to be, implemented.

6.7 Human and Ecological Health

This section of the Environmental Impact Statement (EIS) for the Canadian Nuclear Laboratories (CNL) In Situ Decommissioning of WR-1 at the Whiteshell Laboratories Site (the Project) summarizes the results of the Environmental Risk Assessment (ERA) completed for the Project (EcoMetrix 2017). The purpose of the ERA is to evaluate effects to human health (Section 6.7.1 Human Health) and ecological health (Section 6.7.2 Ecological Health) from changes in ambient levels of radioactivity and non-radiological substances. The assessment considers potential effects on human and ecological health during the closure phase and the post-closure phase, which includes a Normal Evolution Scenario. The Normal Evolution Scenario represents a reasonable extrapolation of present day site features and receptor lifestyles, and it includes the expected evolution of the WR-1 site after closure and degradation of engineered controls. Disruptive Events are identified in the Decommissioning Safety Assessment Report (DSAR; CNL 2017a) for the Project and represent the occurrence of very unlikely events that could lead to higher risk conditions. Disruptive Events are summarized in Section 7.0 Accidents and Malfunctions of the EIS.

6.7.1 Human Health

6.7.1.1 Scope of the Assessment

The scope of the assessment focuses on summarizing the potential health effects to humans from Project activities. The general approach to In Situ Decommissioning (ISD) for the WR-1 Building involves preparing systems and structures for grouting, then the below-grade structure will be filled with grout to encapsulate and immobilize radiological sources and hazardous materials for a defined period of Institutional Control. The decommissioning activities proposed as part of the Project include:

- preparation for ISD;
- grouting of below-grade structures and systems;
- removal of above-grade WR-1 Building;
- installation of an engineered cover over the WR-1 ISD structure;
- final site restoration;
- preparation of Institutional Control; and
- Institutional Control.

The above-grade uncontaminated structures will be demolished and removed. Some above-grade structures (e.g., part of the primary heat transport system) will be dismantled and placed within the WR-1 Building prior to ISD. An engineered cover will then be constructed over the below-grade structure (refer to Section 3.5 for more detail) and the Project site will be regraded and reclaimed. Environmental and performance monitoring will be completed to confirm that the ISD of WR-1 is functioning as intended in the long-term.

The human health environment assessment follows the overall environmental assessment approach and methods described in Section 6.1 Environmental Assessment Approach. The assessment is completed in the following steps:

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries, and assessment cases** (refer to Section 6.7.1.2 Valued Components and Section 6.7.1.3. Assessment Boundaries) for the human health assessment. The VCs, assessment endpoints, and measurement indicators used to assess Project related changes 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 6.7.1.4 Description of the Existing 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 6.7.1.5 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 is presented. A pathways analysis is then used to focus further assessment on key interactions between the Project and human health by evaluating the different effect pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. Where effects are adequately mitigated and are not forwarded to 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 4 for further analysis and residual effects characterization.
- **Step 4 – Present the methods and results of the residual effects analysis** (refer to Section 6.7.1.6 Residual Effects Analysis). This section outlines the methods used to predict and characterize residual effects to human health from primary effect pathways. The analysis results are also presented including the characterization of: (i) residual incremental effects of the Project and the effects of the Project in combination with past and present developments on human health (Application Case); and (ii) residual effects of the Project in combination with past and present developments, as well as other reasonably foreseeable developments (Reasonably Foreseeable Development Case). A key outcome of this section is the predicted effects to human health 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 6.7.1.7 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** (refer to Section 6.7.1.8 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 of the 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** (refer to Section 6.7.1.9 Monitoring and Follow-up) required to confirm effect predictions and address uncertainty.
- **Step 8 – Present a consolidated summary of conclusions and outcomes of the assessment** (refer to Section 6.7.1.10 Conclusions) of residual effects on human health.

This section also describes how the input from engagement influenced the scope of the human health risk assessment (HHRA; EcoMetrix 2017). Information and concerns raised by the public, communities of interest, regulators, and Aboriginal Groups during engagement that influenced the scope of the assessment are summarized in Table 6.7.1-1.

Table 6.7.1-1: Summary of Issues Raised During Engagement Activities that Influenced the Scope of the Human Health Risk Assessment

Issue	How the Issue Was Included in the Assessment
Concerns about the water quality in various waterbodies, including the Winnipeg River, the Lee River and Lac du Bonnet, as a result of In Situ Decommissioning.	The spatial boundaries of the assessment were selected to include consideration of potential effects to the Winnipeg River. The human health risk assessment considered potential changes in surface water quality relative to relevant guidelines.
Releases of contaminants on the WL site and how they are handled.	Potential changes in emissions during both closure and post-closure were considered as part of the human health risk assessment.
Concerns about fish, and how contaminants can accumulate in fish over time. Concerns about potential impacts to wildlife and to human health.	Potential changes in human health considered the consumption of fish and wildlife potentially affected by the Project. Specifically, farm residents are assumed to fish in the Winnipeg River, and harvesters are assumed to ingest country foods such as fish and waterfowl, as well as deer that drink from the Winnipeg River.
It was noted from engagement with Sagkeeng First Nation that members in the Whiteshell area harvest wild rice and medicinal plants.	Consumption of local plants and foods was considered as a pathway in the assessment. Wild rice does not grow in close proximity to WR-1. Within the assessment, it was considered that any medicinal plant intakes would be bounded by the assumed consumption of local berries.

6.7.1.2 Valued Components

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, First Nation and Métis communities, or the public (the Agency 2014). The HHRA focused on worker and public health. The assessment for public health considered locations where people are known to be present. During post-closure, there is no exposure pathway for workers (i.e., surveillance and monitoring personnel during period of institutional control) as airborne emissions will be limited by the Project and workers will not be exposure to liquid emissions. Valued components and rationale for their selection for the HHRA are provided in Table 6.7.1-2.

Table 6.7.1-2: Valued Components for the Human Health Risk Assessment

Valued Component	Rationale for Selection
Public Health	Potential exposure to airborne and waterborne radiological and non-radiological emissions
Worker Health	Potential exposure radiological and non-radiological hazards (e.g., asbestos)

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 endpoints represent properties of the environment, that when changed, could result in or contribute to an effect on an assessment endpoint. The measurement endpoints for the HHRA are outlined in Table 6.7.1-3.

Table 6.7.1-3: Assessment Endpoints and Measurement Indicators for the Human Health Risk Assessment

Valued Component	Assessment Endpoints	Measurement Indicators
Public Health	Protection of human health	■ Changes to air quality ■ Changes to surface water quality ■ Changes to groundwater quality
Worker Health		

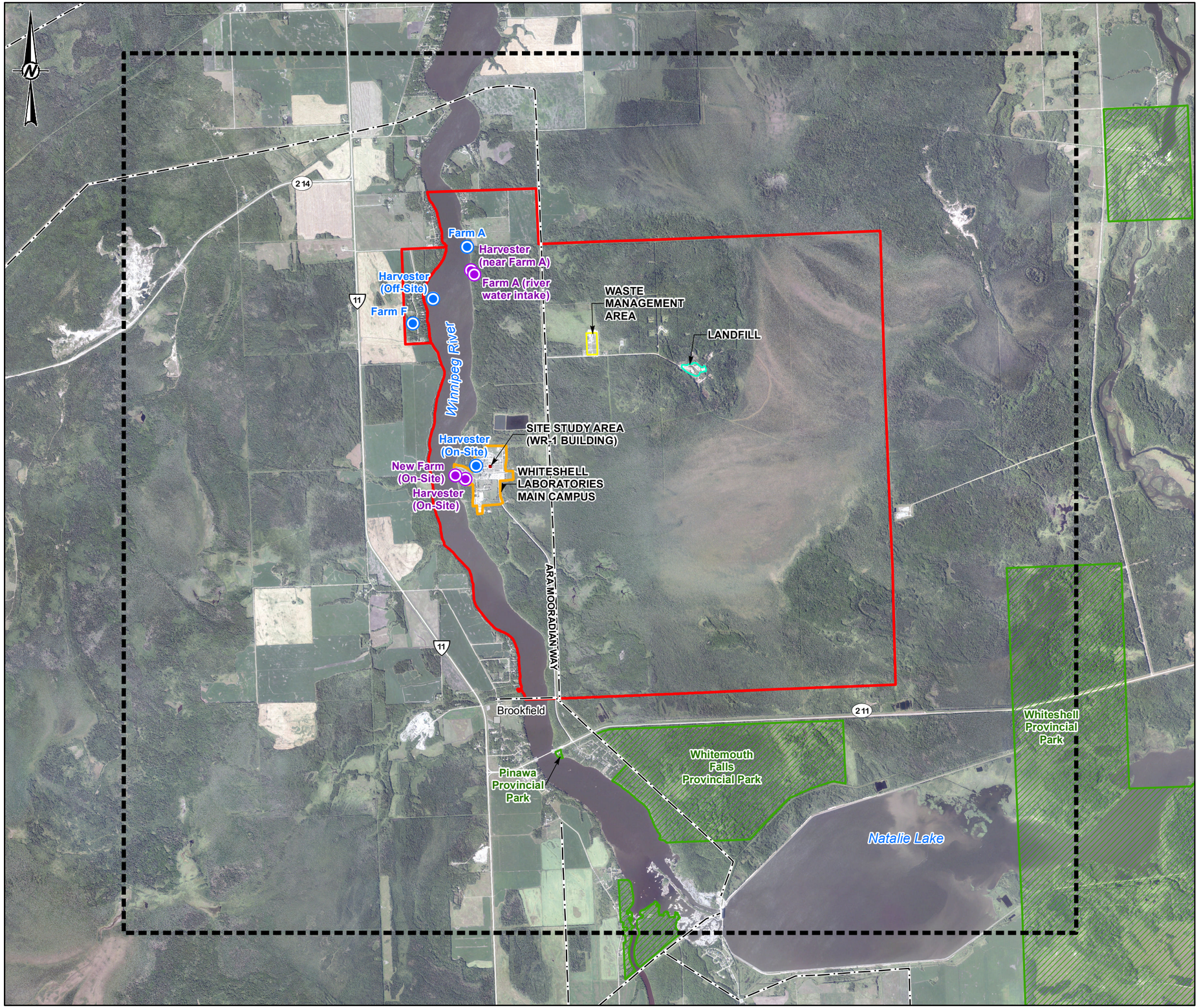
6.7.1.3 Assessment Boundaries

6.7.1.3.1 Spatial Boundaries

In order to assess the potential effects of the Project on human health, an appropriate spatial boundary was defined, with consideration given to locations where people could be affected by Project activities directly or where they could be indirectly affect by interacting with aquatic and terrestrial resources affected by Project activities (Figure 6.7.1-1).

- **Site Study Area (SSA):** is the WR-1 Building and represents the Project footprint (i.e., where project activities will be undertaken). The area size of the SSA is 0.07 hectares (ha).
- **Local Study Area (LSA):** is defined as the area within which there is potential for measurable changes to measurement indicators resulting from the proposed Project activities. The LSA was adapted from the surface water RSA and is designed to include receptors from both the HHRA and ecological risk assessment (EcoRA). Therefore, the southern boundary of the LSA extends from the west shore of the Winnipeg River to the east fence on the property line about 400 m north of Provincial Highway 211. The eastern boundary of the LSA follows the fence on the property line to the north property line. The northern boundary follows the north fence on the property line about 1.6 km and then turns north for about 400 m before turning west and extending to the west side of the Winnipeg River. This is to include the closest existing farm (Farm A) downstream on the east bank because this is the most conservative potential water user. The western boundary follows the west bank of the Winnipeg River for about 1.5 km and then turns west for 370 m, north for 1.4 km and then turns east for 630 m to the west side of the Winnipeg River. This is to include the closest farm (Farm F) and harvester that could be affected by air emissions from the Project. The LSA has an approximate size of 4,174 ha.
- **Regional Study Area:** is defined as the area within which the potential effects of the Project may interact with the effects of other existing or reasonably foreseeable projects. The RSA was adapted from the air quality study area and is defined as a 12 kilometre (km) by 12 km rectangle surrounding the LSA.

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LEGEND

- LOCATION OF HUMAN RECEPTORS FOR CLOSURE PERIOD
- LOCATION OF HUMAN RECEPTORS FOR POST-CLOSURE PERIOD
- SITE STUDY AREA (WR-1 BUILDING)
- WASTE MANAGEMENT AREA
- WHITESHELL LABORATORIES MAIN CAMPUS
- LANDFILL
- LOCAL STUDY AREA
- REGIONAL STUDY AREA

BASE FEATURES

- CITY/TOWN
- TRANSMISSION LINE
- PROVINCIAL PARK

0 1 2 3

1:55,000 Kilometers

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
SPATIAL BOUNDARIES FOR THE HUMAN HEALTH AND ECOLOGICAL HEALTH ASSESSMENTS

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE/PR
REVIEWED	CS
APPROVED	AB

PROJECT NO. 1656897 | CONTROL | REV. 1 | FIGURE **6.7.1-1**

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6.7.1.3.2 Temporal Boundaries

The temporal boundaries of the assessment include effects observed under existing (Base Case) conditions, the timeframe during which Project activities are actively occurring, and 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 if the effect is predicted to last so far into the future that the duration cannot be predicted with any level of certainty (e.g., residual effect lasts for thousands of years). The following phases were identified for the Project:

- **Closure Phase:** Preparation and implementation of ISD, which includes preparation for ISD, grouting of below-grade structures and systems, removal of above-grade WR-1 structures and systems, installation of the engineered cover and environmental controls and final site restoration. These activities last from 2019 to 2024.
- **Post-closure Phase:** The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. The Institutional Control period includes implementation of both active and passive control throughout 2024 to 2324 (i.e., 300 years). During active Institutional Control, long-term performance monitoring and maintenance activities will continue through to 2124 to demonstrate compliance with the safety case assumptions. The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions) and is assumed to continue through 2024 to 2324. Post-institutional Control occurs after year 2324 and continues indefinitely.

6.7.1.3.3 Assessment Cases

The assessment cases considered for human health include the Base Case, the Application Case, and the Reasonably Foreseeable Development (RFD) 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 WL facilities and operations, for example, are considered part of the Base Case. In addition, effects from the decommissioning and reclamation activities already completed at the WL site are also considered as part of the Base Case. The base case is represented in the assessment by baseline air quality (Section 6.2.4) and surface water quality (Section 6.4.1.4), and used in the assessment as required by the relevant human health guideline for each contaminant of potential concern (COPC).
- **Application Case**: The scenario represents the effects of the Base Case combined with predicted effects from the Project. The Application Case includes post-closure activities, and therefore, the associated effects during the post-closure phase of the Project represent the bounding case.
- **RFD Case**: This scenario represents the predictions of the cumulative effects of the Application Case, plus projects that are currently under application review or that have officially entered a regulatory application process and which overlap with the human health RSA. Effects from the future decommissioning and reclamation activities to be completed at the WL site, as described in the Comprehensive Study Report (AECL 2001), are considered as part of the RFD Case. There are no other foreseeable developments in the human health environment RSA that are expected to overlap with residual effects on human health.

Results of the Comprehensive Study Report (AECL 2001) indicated that no public health threats were predicted from the decommissioning and reclamation activities for the WL site. Releases are well within regulatory limits for the protection of human health and regular monitoring provides that any aberrations are detected immediately (AECL 2001). Current effects from the existing WL facilities and operations are considered part of the Base Case (i.e., existing conditions). Consequently, cumulative effects of the Base Case and the potential effects from the Project are evaluated in the Application Case. A detailed safety analysis still needs to be completed for the ISD of the Waste Management Area (WMA) trenches. Specific cleanup criteria and defined end-states would be defined as part of the detailed safety analysis of the ISD of the (WMA) trenches. It is expected that this analysis will capture the potential loadings to the Winnipeg River from not remediating the trenches in combination with the predictions for the Project. Therefore, a RFD Case is not applicable to the human health assessment and is not further discussed.

6.7.1.4 Description of the Existing Environment

Background radiation dose from natural and anthropogenic sources and historical radiation dose from WL operations is used to establish a baseline characterization of radiation dose for the HHRA prior to the Project. Section 6.9.4.2.6 outlines a variety of factors that contribute to the communities' overall sense of well-being, including their relationship to the WL site.

6.7.1.4.1 Background Sources of Radiation and Radioactivity

This section describes the background radiation and radioactivity (i.e., ambient radioactivity) that is present in the environment due to natural and anthropogenic sources independent of WL operations, including air, soil, food, water, aquatic sediments and plant or animal tissue. 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 2017a).

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 also incorporate 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 background radiation doses in Canada are shown on Figure 6.7.1-2; the total average annual dose is about 1.8 millisieverts (mSv), worldwide the average is 2.4 mSv. The average dose reported for Winnipeg is 4.1 mSv/a (CNSC 2017a).

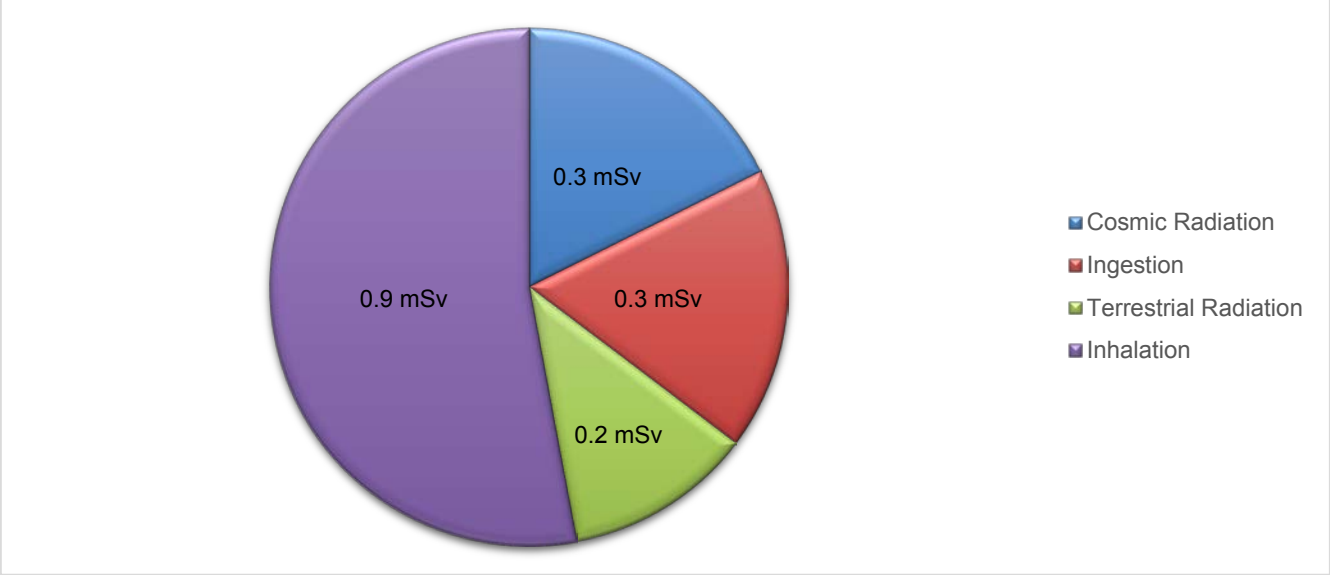


Figure 6.7.1-2: Average Background Radiation Doses in Canada (mSv/a) (CNSC 2017a)

6.7.1.4.2 Radiation Dose from Whiteshell Operations

Canadian Nuclear Laboratories reports the results of the Environmental Monitoring Program (EMP) for the WL site each year to the Canadian Nuclear Safety Commission (CNSC). The EMP data is collected to verify that radiation doses to members of the public as a result of the operations of the WL site remain as low as reasonably achievable (ALARA). The calculated radiation dose to members of the public from WL operations is shown in Table 6.7.1-4, and represents the baseline radiation dose from WL prior to the Project. The 2015 dose assessment showed the radiation dose to the public from WL operations was 0.000006 millisieverts per year (mSv/a.) for airborne effluent and 0.00011 mSv/a for liquid effluent, totalling 0.00012 mSv/a, which represents 0.01 percent (%) of the effective dose limit of 1 mSv/a for members of the public. The 6-year average adult dose from 2010 to 2015 is 0.000006 mSv/a for airborne effluent and 0.0007 mSv/a for liquid effluent (CNL 2016c), totalling 0.00071 mSv/a, which represents 0.07% of the effective dose limit. The dose to members of the public is predominantly from liquid effluents.

Table 6.7.1-4: Total Dose to Critical Groups outside the Whiteshell Laboratories Boundary Based on Environmental Monitoring Results – 2010-2015

Year	Airborne Effluent Pathway – Adult Dose (mSv/a)	Liquid Effluent Pathway – Adult Dose (mSv/a)
2015	0.000006	0.00011
2014	0.000004	0.0015
2013	0.000004	0.00010
2012	0.000008	0.00013
2011	0.000005	0.00062
2010	0.000006	0.0018
6-year Average (2010-2015)	**0.000006**	**0.0007**

Source: CNL 2016c.
mSv/a. = millisieverts per year.

6.7.1.5 Project Interactions and Mitigation

6.7.1.5.1 Methods

This section describes the process by which interactions between Project components and activities and human health were identified and evaluated. Potential effect 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 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 assessment is concluded at this stage and the reasons are articulated. Primary pathways that may lead to residual effects after incorporation of mitigation are further characterized in Section 6.7.1.6 Residual Effects Analysis. 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 Project. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. The next step in the analysis was the development of environmental design features and mitigation practices that could be incorporated into the 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 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 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 pathway –** 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 to human health.
- **Secondary pathway –** the pathway could result in a measurable minor environmental change, but would have a negligible residual effect on human health 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 past, present 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 human health.

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 human health 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.

6.7.1.5.2 Results

Pathways through which the Project may interact with the human health environment are summarized in Table 6.7.1-5.

Table 6.7.1-5: Pathways Analysis for the Human Health Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
General Project activities during the closure phase	Closure activities will result in the release of air contaminants (CACs) and fugitive dust emissions which could affect human health.	■ Implementation of CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring, air verification monitoring and environmental monitoring. ■ Implementation of CNL's Occupational Safety and Health Program, including work permit system and Personnel Protection Equipment and Clothing (PPE&C). ■ Implementation of dust management techniques. ■ Radiation monitoring of vehicles leaving the project site and, if needed, implementation of decontamination. ■ All vehicles will pass through a vehicle monitoring station. ■ On-site vehicles and equipment engines will meet Tier 3 emission standards, where possible, and be maintained in good working order. ■ Limit idling of vehicles on-site and speed on roads. ■ Use of enclosure for raw material handling.	Secondary
	Closure activities will result in the atmospheric release of radiological and non-radiological compounds from the WR-1 Building	■ Implementation of CNL's Radiation Protection Program and Procedure, which includes Radiation Safety Zones, detailed work planning to limit doses to as low as reasonably achievable (ALARA), dose monitoring, and contamination control procedures (e.g., stabilizing and immobilizing agents). ■ Implementation of CNL's Occupational Safety and Health Program, including work permit system and training requirements. ■ Implementation of CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring, air verification monitoring and environmental monitoring.	Primary

Table 6.7.1-5: Pathways Analysis for the Human Health Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Long-term performance during the post-closure phase	Release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time may cause changes in groundwater quality which could migrate towards the Winnipeg River	■ Implementation of silt control measures and protection of drains and storm water collection points. ■ Encapsulation of the reactor by a multi-component WR-1 ISD structure (i.e., geosphere, concrete foundation, grout, and facility systems and components) to mitigate groundwater flow into the ISD waste. ■ Installation of a multi-component final cover system to mitigate moisture infiltration into the WR-1 ISD structure and hence limit release of solutes into the groundwater. ■ Environmental/performance monitoring will be completed throughout the post-closure phase for the Project to confirm that the cover and grout is functioning as intended, and to confirm modelling predictions.	Primary
Long-term performance during the post-closure phase	Release of chemical and radiological contaminants in the long-term during the post-closure phase from the previous activities completed at the WL site.	■ As part of CNL's licence with the CNSC, environmental monitoring around the WL site will continue for the Project. ■ Follow-up monitoring during the post-closure phase will continue to verify effect predictions and to provide information for use in adaptive management to address potential unforeseen effects.	Secondary

6.7.1.5.2.1 No Linkage Pathway

There are no pathways identified as having no linkages to effects to the human health VCs.

6.7.1.5.2.2 Secondary Pathways

In some cases, a Project source of effect and an interaction with an assessment endpoint exists but mitigation is expected to cause minor changes to human health relative to the existing Base Case and/or guidelines. The following pathway is expected to result in negligible effects on the human health VCs and will not be evaluated further in the EIS.

- **Closure activities will result in the release criteria air contaminants (CACs) and fugitive dust emissions.**

Closure activities will result in the release of CACs and fugitive dust emissions. Sources of dust deposition and air emissions include stack emissions, fuel use, aggregate material handling, on-site batch mixing plant, and road dust. Environmental design features and mitigation have been incorporated into the Project to reduce potential adverse effects from dust deposition and air emissions. CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions (CNL 2013) includes operational control monitoring, air verification monitoring and implementation of dust management techniques.

The release of CACs (particulate matter, nitrogen oxides, sulphur dioxide, and carbon monoxide) and fugitive dust were assessed as part of the air quality VC in Section 6.2 Air Quality. Predicted concentrations for the Application Case (Section 6.2.1.8) are below applicable air quality guidelines and/or standards. Therefore, the release of CACs and fugitive dust are not expected to result in effects to human health.

- **Release of chemical and radiological contaminants in the long-term during the post-closure phase from the previous activities completed at the WL site.**

Results of the Comprehensive Study Report indicated no residual effects on public health are expected as a result of the closure of the WL site. The assessment considered potential effects on the Winnipeg River and management of releases to ensure no residual effect. No decrease in water quality is expected and effluent emissions to the Winnipeg River are expected to decline to virtually zero following decommissioning. Re-suspension of contaminated sediments is also not expected to lead to a decrease in water quality (see Section 7.0 of AECL 2001).

The Comprehensive Study Report (AECL 2001) also considered the potential for effects via groundwater quality from the LLW that may be managed in situ in the WMA, and their potential to affect the Winnipeg River and human health (see also Section 6.4.2.5.2.2 Surface Water Quality). The assessment considered three general exposure pathways: upward migration (with potential contamination of soils and vegetation), near-surface later migration (with potential contamination to local discharge in perimeter and roadside ditches), and downward migration and contamination of the sand and gravel aquifer and subsequently the river). Only the near-surface lateral migration scenario was considered in further detail. With respect to downward migration and release to the river it was determined that the general hydrology of the site limits or eliminates this pathway.

Water concentrations in the ditch were predicted and compared to established guidelines for several of the contaminants in the WMA. Radionuclide modelling in the Comprehensive Study Report (Appendix C of AECL 2001) indicated that three radionuclides have the potential to exit the WMA through migration over a 200-year period, namely tritium, technetium-99 and carbon-14. Of these three radionuclides only technetium-99 is

potentially present in nonzero concentrations in the ditch adjacent to the WMA in as early as 20 years. The carbon-14 and tritium will be lost to the atmosphere, and when this is modelled there is no release of these radionuclides to the perimeter ditch. The preliminary exposure assessment for radiological contamination of the ditch resulted in a dose of 0.16 mSv/a at the predicted peak concentration of technetium-99.

With respect to non-radiological contaminants, some exceedances of applicable standards were predicted. Further refinement of the modelling and potential need for selective remediation to remove the hazard was recommended (AECL 2001). Organic contaminants were also considered; it was concluded that the remaining concentrations of the solvents and DDT are very small and unlikely to present a residual hazard.

Consequently, there is no overlap of effects between WR-1 and previous activities at the WL site (i.e., effects from the WMA) and changes to surface water quality in the Winnipeg River. A detailed safety analysis still needs to be completed for the ISD of the WMA trenches. It is expected that this analysis will capture the potential changes to groundwater quality and surface water loadings to the Winnipeg River and site-specific acceptance criteria would be defined in accordance with applicable regulatory requirements. CNL would be required to meet the applicable regulatory requirements at that time.

As part of CNL's licence with the CNSC, environmental monitoring around the WL site will continue for the Project. Follow-up monitoring during the post-closure phase will continue to verify effect predictions and to provide information for use in adaptive management to address potential unforeseen effects. Consequently, changes to surface water quality from the closure of the WL site, are predicted to be negligible.

6.7.1.5.2.3 Primary Pathways

The following primary pathways were identified between the Project and human health and therefore, are carried forward to the residual effects analysis for their potential to affect human health:

- **Closure activities will result in the atmospheric release of radiological and non-radiological compounds from the WR-1 Building.**
- **Release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time may cause changes in groundwater quality which could migrate towards the Winnipeg River.**

6.7.1.6 Residual Effects Analysis

An Environmental Risk Assessment (ERA; EcoMetrix 2017) was completed for the Project to assess potential adverse effects of the Project on human health during the closure and post-closure phases of the Project. A summary of the methods and results of this assessment during the closure and post-closure phases of the Project is provided in Section 6.7.1.6.1 (Application Case – Closure Phase) and Section 6.7.1.6.2 (Application Case – Post-closure Phase), respectively.

6.7.1.6.1 Application Case - Closure Phase

6.7.1.6.1.1 Methods

This section summarizes the methods used to assess the residual effects on human health, during the closure phase, for the Project activities and pathways identified as primary in Table 6.7.1-5. Policies, guidelines and standards considered in the analysis, as well as the model used to predict residual effects are described.

Receptor Selection and Characterization

The receptors for the HHRA were selected to be appropriate for assessment of both radiological and non-radiological stressors on human health. Off-site members of the public will potentially be exposed to low levels of airborne contaminants from decommissioning of the WR-1 Building. The most-affected off-site members of the public are defined as the "critical group" which include:

- Farm A and F (year-round occupants, with livestock); and
- Harvesters (additional receptor not identified in the derivation of derived release limits [DRL] for the WL site [CNL 2016b]).

Radiological dose to workers at WR-1 during closure may result from external exposure to radiation emitted from WR-1. Doses to workers will be monitored and managed as part of CNL's Radiation Protection Program and Occupational Safety and Health Program. The application of the Radiation Protection Program provides that exposures will be kept As Low As Reasonable Achievable (ALARA) and below the effective dose limit of 100 mSv over 5 years, and below 50 mSv in any single year, with human factors taken into account. Worker dose and protection from occupational exposures is further considered in the Decommissioning Safety Assessment Report (CNL 2017a) and the ERA (EcoMetrix 2017).

Within the ERA (EcoMetrix 2017), consistent with direction in CSA N288.6-12, Nuclear Energy Workers and workers who lease businesses on-site are not addressed for the radiological assessment because their radiation exposure is monitored and their doses during closure are controlled through CNL's Radiation Protection Program as outlined above. However, on-site workers are assessed for radiological exposures. Decommissioning work will be conducted in accordance with requirements of the CNL Occupational Safety and Health Program Manual and CNL Work Permit System. The foundation of the safeguards against industrial hazards is qualified staffing and the implementation of proven and approved procedures through a system that requires continual improvement.

Farms A and F are the highest likely exposure group (i.e., critical groups) and are shown on Figure 6.7.1-1. Farms A and F are both livestock farms with the same characteristics as each other except for the location. Farm F being north-northeast of the WL site and Farm A being north of the WL site. Doses presented for Farm F are considered bounding for Farm A, as modelling indicated that doses to residents at Farm F would be higher than at Farm A (EcoMetrix 2017); therefore, radiological doses are presented only for Farm F. Members of Farms A and F are considered to:

- reside at the farm 100% of the time;
- obtain the majority of their fruit and vegetables from their on-site garden;
- supply all of their own milk, poultry and eggs from their farm;
- supply some of their beef and pork from their farm;
- acquire honey from another local farm;
- obtain game (deer) (i.e., meat requirement) from hunting on their own property; and
- use a backyard swimming pool filled with well water 3 months out of the year.

Harvesters represent traditional users of the area who may be exposed through harvesting of country foods. It is assumed that the harvesters would spend part of their time on-site, part near Farm F, and part at an unexposed location. Recreational users such as swimmers, anglers, and boaters that occasionally carry out recreational activities along the Winnipeg River at locations close to the WL site, as compared to the most critical group locations (Farm A and Farm F), are not directly considered for the assessment because these activities are not representative of population groups in the area. Exposure to these individuals are anticipated to be well encompassed by those to the critical group.

Contaminants of Potential Concern

As part of normal operation, nuclear facilities release, in a controlled manner, small quantities of radioactive substances into the atmosphere and geosphere. These releases are regulated and carefully monitored by the CNSC. Doses received by members of the public from routine releases at nuclear facilities are too low to be measured directly; therefore, a quantity known as a DRL is established for the site. Operating DRLs for the WL site were established in accordance with CSA N299.1-08: Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities. The DRLs have been calculated for 30 radionuclides that have been found or may reasonably expected to be present in airborne and liquid effluent streams at the WL site (CNL 2016b).

For the closure phase, the relevant contaminants of potential concern (COPCs) are expected to be released via airborne effluents from the WR-1 Building as reactor systems are dismantled, transported off-site or encapsulated within the WR-1 ISD structure. It has been assumed that the WR-1 Building stack will be dismantled during the closure phase, after grouting has been completed; therefore, airborne effluents are assumed to occur at ground level. Airborne emission estimates have been provided for demolition activities prior to grouting (referred to as demolition) and during grouting activities (refer to Section 6.2.1, Tables 6.2.1-9 and 6.2.1-10) as emissions are anticipated to be elevated during grouting (6 months). For both stages (demolition and grouting) airborne emission estimates have been provided for the average scenario or anticipated activities and activity level, as well as for the potential maximum scenario or accelerated activities and/or activity level. For example, in the average grouting scenario it was assumed that 125 m^3 of grout would be produced per day, but for the maximum grouting scenario the throughput of grout was assumed to be 200 m^3/day. For more detail refer to Section 5.1, Table 11 and 12, which summarize the maximum and average scenario daily emission rates, respectively.

Selection of Radiological COPCs

The radionuclides that are considered in the HHRA for the closure phase are those radionuclides that have been found in WL's airborne effluent or are reasonably expected to be found in the airborne effluent. Radionuclides are considered of public and regulatory interest and therefore all radionuclides identified through the source-term characterization process were carried forward quantitatively in the HHRA and did not undergo a formal screening assessment.

During closure, operational controls and procedures in place to prevent or limit the release of airborne effluents will be in effect (e.g., during demolition the above-grade building will be in place, the waste collection system and proven emergency response plans and personnel will all be operational, and adequate ventilation and infiltration will be established). As well, decontamination, and the use of stabilizing and immobilizing agents prior to dismantling the WR-1 Building will be used to control the release of airborne radionuclides. Release of radionuclides to the atmosphere during closure are not anticipated to be above those observed during the operation phase of the facility. During demolition of above-grade structures, radionuclides may be released from the Primary Heat Transport (PHT) system, and some existing surface contamination may become airborne

(Table 6.7.1-6). During grouting, remaining radionuclides may be released from the reactor core and biological shield (Table 6.7.1-6). Tritium may also be released, for example, when disruptive activities on the helium and heavy water system are executed during closure.

Table 6.7.1-6: Potential Radionuclide Release during the Closure Phase

Reactor Core	Biological Shield	Primary Heat Transport System
■ C-14 ■ Fe-55 ■ Co-60 ■ Ni-59 ■ Ni-63 ■ Nb-94 ■ H-3	■ Cl-36 ■ Ca-41 ■ Ni-63 ■ C-14 ■ Co-60 ■ Eu-152	■ Sr-90 ■ Cs-137 ■ Eu-154 ■ Eu-155 ■ Tc-99 ■ I-129 ■ Np-237 ■ Np-239 ■ Pu-238 ■ Pu-239 ■ Pu-240 ■ Pu-241 ■ Am-241 ■ Am-243 ■ Cm-244 ■ Co-60

Selection of Non-Radiological COPCs

A select number of non-radiological airborne COPCs have been identified as potentially being released during the closure phase from the WL site. These include:

- asbestos (friable [contains more than 1% asbestos by weight or area and can be crumbled by the human hand] and non-friable [material that contains more than 1% asbestos and cannot be crumbled under hand pressure] asbestos containing materials);
- organic coolant (HB-40 used as reactor coolant, also known as OS-84, primarily hydrogenated terphenyl) in the primary heat transport system;
- lead based paint and lead shielding;
- polychlorinated biphenyls (PCBs) in fluorescent light fixture ballasts;
- small quantities of mercury in thermostats and switches; and
- mould.

With the exception of HB-40, the identified hazardous substances are routinely addressed in construction projects. HB-40 consists mainly of hydrogenated terphenyl (74% to 87%), with smaller fractions of partially hydrogenated terphenyls and terphenyl. Since HB-40 is an oil, or a tar if irradiated, its release to air with dust should be limited. However, volatilization could be a release pathway.

Exposure Pathways

During the closure phase, releases to surface water are not expected, because any release from the grouted reactor would occur after closure, and contaminant transport via groundwater to surface water would take additional time. Pathways relevant to exposure to airborne effluents are presented for the human receptors in Table 6.7.1-7 and Table 6.7.1-8 and illustrated in Figure 6.7.1-3 and Figure 6.7.1-4. During the closure phase, human receptors on Farm A and F could potentially be exposed via air (inhalation, immersion), soil (incidental ingestion, groundshine), well water (ingestion, bathing), and ingestion of home-grown vegetables, fruits, and livestock, and ingestion from locally hunted deer. Harvesters will ingest country foods such as deer, hare and berries. Exposure pathways for on-site workers include inhalation of air on-site, and soil contact pathways for outdoor workers for non-radiological exposures.

Table 6.7.1-7: Exposure Pathways for Receptors for Exposure to Radiological COPCs during Closure

Receptor	Exposure Pathway	Environmental Media
Farm F	Inhalation	■ Air
	Ingestion	■ Water (well water) ■ Soil (incidental) ■ Terrestrial plants (homegrown) ■ Terrestrial animals (beef, pork, poultry, eggs, milk, game, honey)
	External	■ Air ■ Water (well water) ■ Soil
Harvester	Inhalation	■ Air
	Ingestion	■ Terrestrial animals (hare, deer) ■ Terrestrial plants (berries)
	External	■ Air ■ Soil

Table 6.7.1-8: Exposure Pathways for Receptors for Exposure to Non-Radiological COPCs during Closure

Receptor	Exposure Pathway	Environmental Media
On-site Worker	Inhalation	■ Air
	Dermal	■ Soil

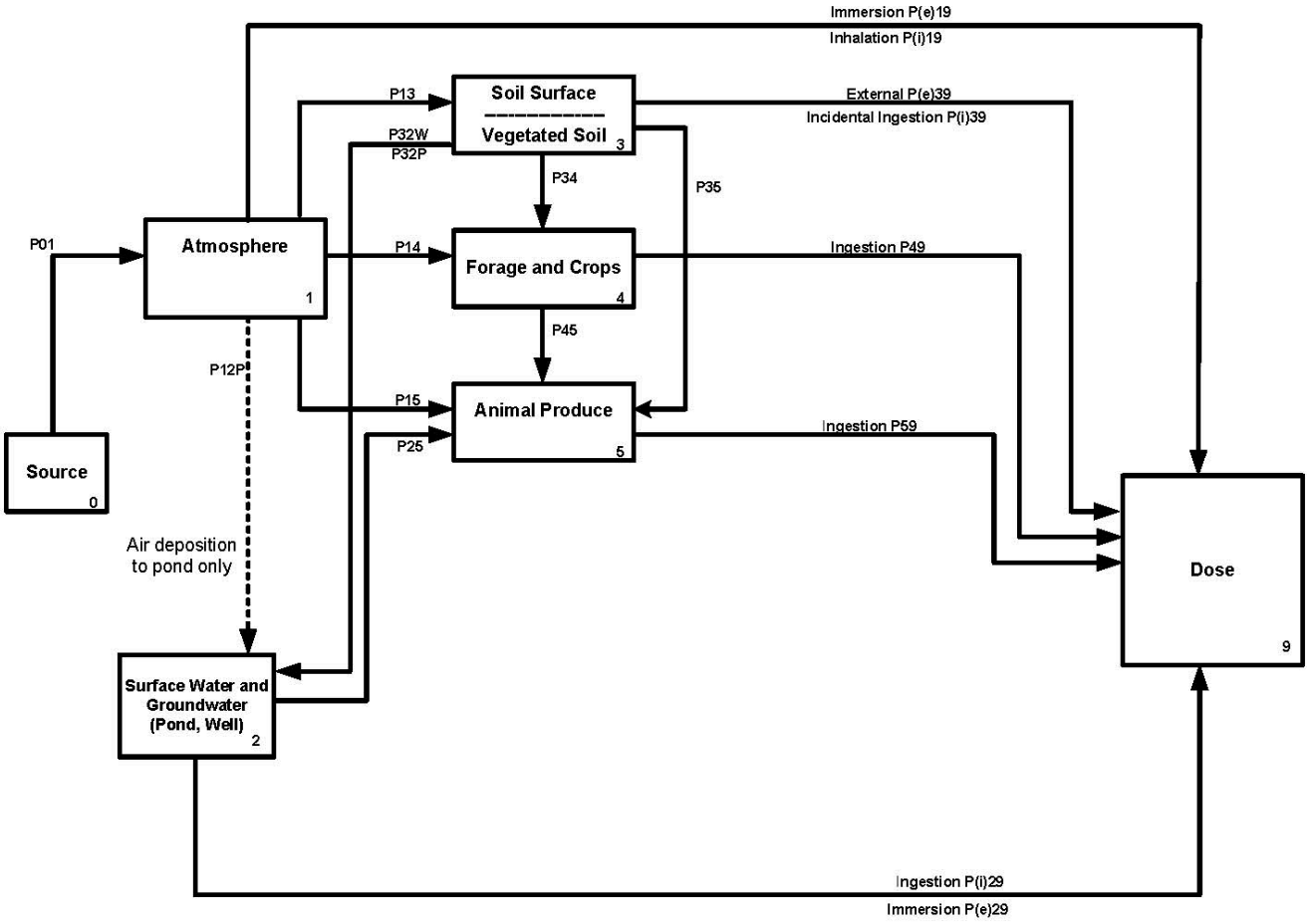


Figure 6.7.1-3: Conceptual Model for Human Receptors during the Closure Phase for Farm F

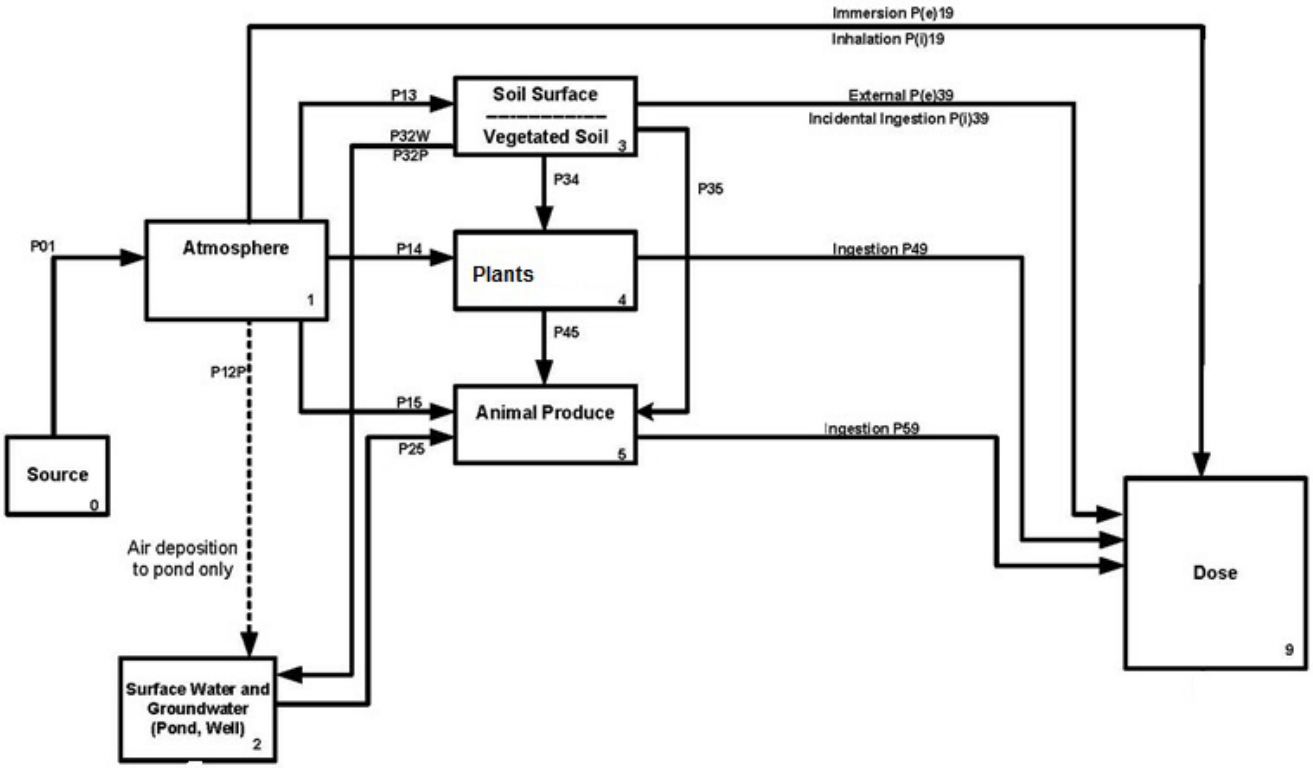


Figure 6.7.1-4: Conceptual Model for Human Receptors during the Closure Phase Harvester

6.7.1.6.1.2 Results

An environmental transport and pathways model was used to evaluate the transport and effects of contaminants on the local environment including human and ecological receptors. A more detailed description of the model is provided in the ERA (EcoMetrix 2017).

The public dose limit for radiation protection is 1 mSv/a, as described in the Radiation Protection Regulations under the *Nuclear Safety and Control Act*. This limit is defined as an incremental dose, and is set at a fraction of natural background exposure to radiation. For the Project an established dose constraint to the public from all nuclides and all pathways for the long-term expected evolution of 0.25 mSv/a is applied for the Project (CNL 2016a).

For radionuclides, the total doses are compared to the public dose limit of 1 mSv/a and the dose constraint for the Project of 0.25 mSv/a. A summary of the total dose for each receptor and age group is provided in Table 6.7.1-9 along with a comparison to the public dose limit and dose constraint. In Table 6.7.1-9, shaded cells indicate exceedance of the public dose limit of 1 mSv/a and bold cells indicate exceedance of the dose constraint of 0.25 mSv/a. The calculated radiological doses are all below this limit, for all human receptors in the candidate critical groups. Since the dose estimates are a small fraction of the public dose limit, no discernable health effects are anticipated due to exposure to radioactive releases from Project activities. Individual dose results for each radionuclide is provided in the ERA completed for the Project, in Tables 4-9 through 4-24 (EcoMetrix 2017).

Table 6.7.1-9: Summary of Total Dose during the Closure Phase Human Health Valued Components

Age Group / Exposure Scenario	Dose (mSv/a)	Dose% of Dose Constraint	Dose% of Public Dose Limit
Demolition			
Adult Harvester			
Demolition - Maximum	4.38E-02	18%	4.4%
Demolition - Average	1.15E-02	4.6%	1.2%
Child Harvester			
Demolition - Maximum	1.75E-02	7.0%	1.8%
Demolition - Average	4.60E-03	1.8%	0.46%
Infant Harvester			
Demolition - Maximum	1.45E-02	5.8%	1.50%
Demolition - Average	3.82E-03	1.5%	0.38%
Adult Farm F Resident			
Demolition - Maximum	3.45E-03	1.4%	0.35%
Demolition - Average	9.07E-04	0.36%	0.09%
Child (10-years old) Farm F Resident			
Demolition - Maximum	3.37E-03	1.3%	0.34%
Demolition - Average	8.86E-04	0.35%	0.09%
Infant (1-year old) Farm F Resident Cow's Milk			
Demolition - Maximum	2.60E-03	1.0%	0.26%
Demolition - Average	6.84E-04	0.27%	0.07%

Table 6.7.1-9: Summary of Total Dose during the Closure Phase Human Health Valued Components

Age Group / Exposure Scenario	Dose (mSv/a)	Dose% of Dose Constraint	Dose% of Public Dose Limit
Infant (1-year old) Farm F Resident Formula Fed			
Demolition - Maximum	1.16E-03	0.46%	0.12%
Demolition - Average	3.05E-04	0.12%	0.03%
3-month Old Farm F Resident Nursing			
Demolition - Maximum	1.23E-03	0.49%	0.12%
Demolition - Average	3.23E-04	0.13%	0.03%
3-month Old Farm F Resident Formula Fed			
Demolition - Maximum	3.95E-04	0.16%	0.04%
Demolition - Average	1.04E-04	0.04%	0.01%
Grouting			
Adult Harvester			
Grouting - Maximum	7.24E-06	0.0029%	0.0007%
Grouting – Average	7.20E-06	0.0029%	0.0007%
Child Harvester			
Grouting - Maximum	7.12E-06	0.0028%	0.0007%
Grouting – Average	7.08E-06	0.0028%	0.0007%
Infant Harvester			
Grouting - Maximum	9.67E-06	0.0039%	0.0010%
Grouting – Average	9.62E-06	0.0038%	0.0010%
Adult Farm F Resident			
Grouting - Maximum	1.08E-05	0.0043%	0.0011%
Grouting – Average	1.08E-05	0.0043%	0.0011%
Child (10-years old) Farm F Resident			
Grouting - Maximum	1.13E-05	0.0045%	0.0011%
Grouting – Average	1.12E-05	0.0045%	0.0011%
Infant (1-year old) Farm F Resident Cow's Milk			
Grouting - Maximum	1.42E-05	0.0057%	0.0014%
Grouting – Average	1.41E-05	0.0056%	0.0014%
Infant (1-year old) Farm F Resident Formula Fed			
Grouting - Maximum	8.23E-06	0.0033%	0.0008%
Grouting – Average	8.17E-06	0.0033%	0.0008%
3-month Old Farm F Resident Nursing			
Grouting - Maximum	1.46E-05	0.0058%	0.0015%
Grouting – Average	1.45E-05	0.0058%	0.0015%

Table 6.7.1-9: Summary of Total Dose during the Closure Phase Human Health Valued Components

Age Group / Exposure Scenario	Dose (mSv/a)	Dose% of Dose Constraint	Dose% of Public Dose Limit
3-month Old Farm F Resident Formula Fed			
Grouting - Maximum	6.96E-06	0.0028%	0.0007%
Grouting – Average	6.91E-06	0.0028%	0.0007%

Notes:

Bold cells indicate exceedance of the dose constraint of 0.25 mSv/a; **bold and shaded** cells indicate exceedance of the public dose limit of 1 mSv/a.
A dose of 0.0025 mSv/a is equivalent to 1% of the dose constraint and a dose of 0.01 mSv/a is equivalent to 1% of the public dose limit.

The predicted maximum doses to an on-site worker during the closure phase were 6.03×10^{-3} mSv/a during demolition and 1.21×10^{-5} mSv/a during grouting, which are well below regulatory limits and dose constraints.

Unlike with radionuclides, which are all COPCs, non-radiological COPCs are identified through the completion of a formal screening process. For the closure phase, all predicted air concentration for non-radiological COPCs were below their relevant ambient air quality criteria (Section 6.2.1.6); therefore, no non-radiological COPCs were identified for the closure phase and no health effects are anticipated as a result of airborne effluent from the Project.

6.7.1.6.2 Application Case – Post-closure Phase

6.7.1.6.2.1 Methods

This section describes the specific methods used to assess the residual effects on human health, during the post-closure phase, for the Project activities and pathways identified as primary in Table 6.7.1-5. Policies, guidelines and standards considered in the analysis, as well as the model used to predict residual effects are described.

Receptor Selection and Characterization

The receptors for the HHRA were selected to be appropriate for assessment of both radiological and non-radiological stressors on human health. On-site workers are not assessed during post-closure for exposures since there is no aquatic pathway. Off-site members of the public will potentially be exposed to low levels of waterborne contaminants. During the post-Institutional Control period (after 300 years), the WR-1 site will likely be designated for industrial land use; however, to account for the possibility of a farm becoming established closer to the Project site, an On-site Farm receptor was considered. These on-site receptors are considered bounding for any other potential land users (e.g., industrial personnel) or farms established closer to the site than the existing farms. The most-affected off-site members of the public are defined as the “critical group”. Human receptors evaluated for both the radiological and non-radiological assessment for the post-closure scenario include:

- Farm A (year-round occupants, with livestock) (located near the east bank of the Winnipeg River);
- On-site Farm (located on the Project site); and
- Harvesters.

Farm A is the highest likely exposure group, critical group, for releases to the Winnipeg River because liquid releases from the Site travel downstream along the east bank (CNL 2016a). Harvesters represent traditional users of the area who may be exposed through harvesting of country foods. It is assumed that the harvesters spend part of their time on-site, part near Farm A, and part at an unexposed location. Human receptors during the post-closure phase are shown on Figure 6.7.1-1.

An On-site Farm was not considered reasonable for the normal evolution scenario during the Institutional Control period. The WL site will be under institutional control for the first 300 years of post-closure, which will physically restrict residential use of the WL site, including any farming activities. However, the establishment of a farm (On-site Farm) was considered following post-Institutional Control once the site is no longer being actively managed. The assumption is made that at some time in the distant future, government failure leads to government controls (e.g., zoning designations, land use restrictions, or orders) becoming ineffective and people will be present on-site and make some use of local resource. The On-site Farm has the same characteristics as Farm A; however, residents obtain water from drinking, irrigation, and bathing from the Winnipeg River directly downstream of the WR-1 groundwater seep into the River.

Contaminants of Potential Concern

For the post-closure phase, no atmospheric releases are expected as the grouting will be completed and the above-grade building and components will have been removed. An engineered cover will have been installed on top of the buried material. During the post-closure phase the site will be under institutional control. The main potential release mechanism during post-closure is via leakage through the WR-1 ISD structure to groundwater and subsequent migration of groundwater to surface water at the Winnipeg River.

Selection of Radiological COPCs

The radionuclides that are considered in the HHRA for the post-closure phase include those that have been historically been found in WL's liquid effluent or are reasonably expected to be found in the grout and have the potential to migrate from groundwater to surface water during the post-closure phase (CNL 2016b). Radionuclides are considered of public and regulatory interest and therefore all radionuclides identified were carried forward quantitatively in the HHRA. The radionuclides included for the post-closure scenario include:

- Am-241;
- Am-243;
- C-14;
- Ca-41;
- Cl-36;
- Cm-244;
- Co-60;
- Cs-137;
- Eu-152;
- Eu-154;
- Eu-155;
- Fe-55;
- I-129;
- Nb-94;
- Ni-59;
- Ni-63;
- Pu-238;
- Pu-239;
- Pu-240;
- Pu-241;
- Sr-90; and
- Tc-99.

Selection of Non-Radiological COPCs

CNL has determined that a select number of non-radiological waterborne COPCs have been identified as potentially being released from the WL site during the post-closure phase (CNL 2017b). These include:

- Boron;
- Cadmium;
- Chromium;
- HB-40;
- Mercury;
- Palladium;
- Potassium hydroxide; and
- Xylene.

Non-radiological parameters with maximum concentrations exceeding the most conservative of these benchmarks according to the hierarchy shown in Figure 6.7.1-5 were carried forward as non-radiological COPCs in this assessment. Based on the screening process, cadmium and lead are carried forward for further quantitative assessment in the HHRA for the post-closure phase.

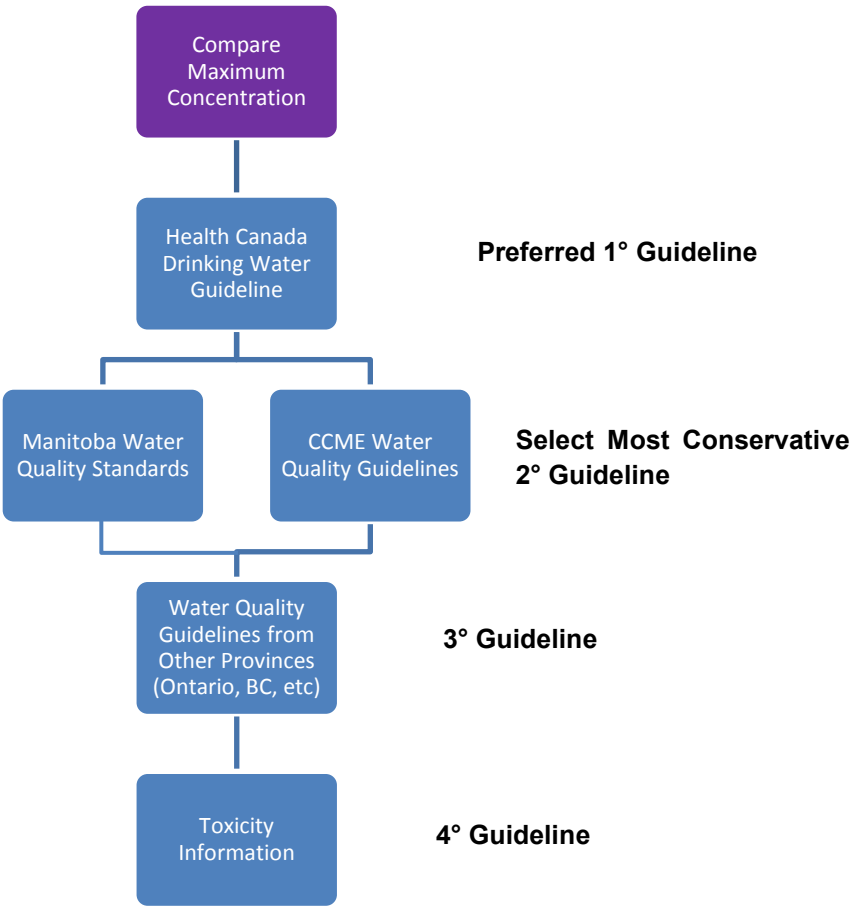


Figure 6.7.1-5: Selection Process for Human Health Screening of Non-Radiological COPCs

Exposure Pathways

The post-closure phase is not expected to result in airborne effluent, as the grouting will have been completed, the above-grade building will have been completely decommissioned, and an engineered cover will have been installed over the WR-1 ISD structure. During the post-closure phase groundwater releases to surface water may occur. Aquatic dispersion will carry contaminants to downstream locations on the Winnipeg River. Waterborne contaminants can partition to sediment. River water and sediment will be the primary exposure media. River water will also be used for irrigation.

Pathways relevant to exposure to releases to surface water are presented for the human receptors in Table 6.7.1-10 and illustrated in Figure 6.7.1-6 and Figure 6.7.1-7. For non-radiological COPCs only the ingestion pathway has been considered, since the dermal pathway is considered negligible for inorganics (i.e., cadmium and lead). During post-closure, human receptors on Farm A and the On-site Farm could potentially be exposed via use of water from the Winnipeg River for drinking, bathing, livestock watering, and irrigation (lawns and gardens), and by ingestion of home-grown vegetables, fruit, and livestock. Farm residents are also assumed to fish in the Winnipeg River. Harvesters will ingest country foods such as fish and waterfowl, as well as deer that drink from the Winnipeg River. There is no direct release to air as the groundwater flow is strongly downward limiting atmospheric environment exposure; however, receptors could potentially be exposed via the air pathway (inhalation and immersion) through volatilization from irrigated soil.

Table 6.7.1-10: Exposure Pathways for Receptors Potentially Exposure to Radiological COPCs during Post-closure

Receptor	Exposure Pathway	Environmental Media
Farm A and On-site Farm	Inhalation	■ Air
	Ingestion	■ Water (Winnipeg River) ■ Soil/Sediment (incidental) ■ Terrestrial plants (homegrown) ■ Aquatic animals (fish) ■ Terrestrial animals (beef, pork, poultry, eggs, milk, game, honey)
	External	■ Air ■ Water (Winnipeg River) ■ Soil/Sediment
Harvester	Inhalation	■ Air
	Ingestion	■ Aquatic animals (fish) ■ Terrestrial animals (waterfowl, deer)
	External	■ Air ■ Soil

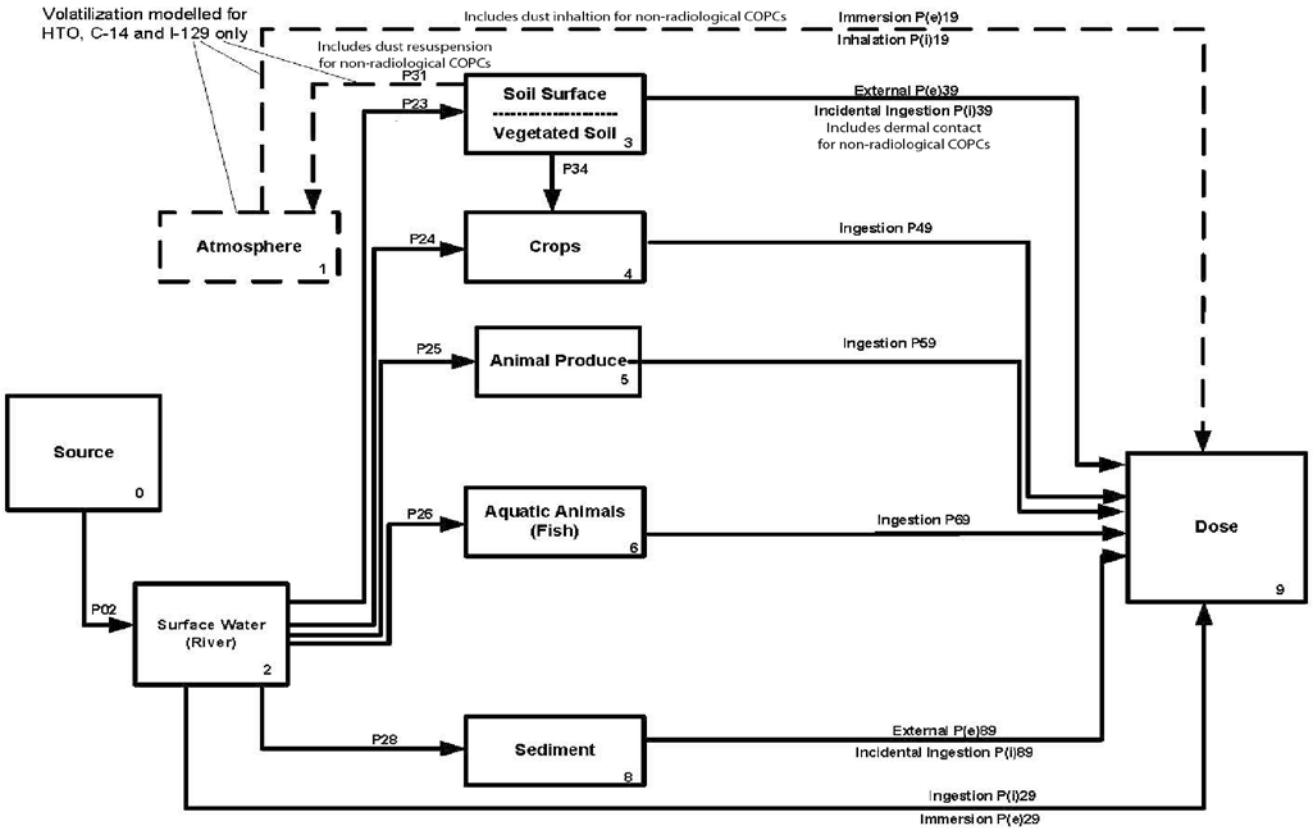


Figure 6.7.1-6: Conceptual Model for Human Receptors during the Post-closure Phase for Farm A and On-site Farm

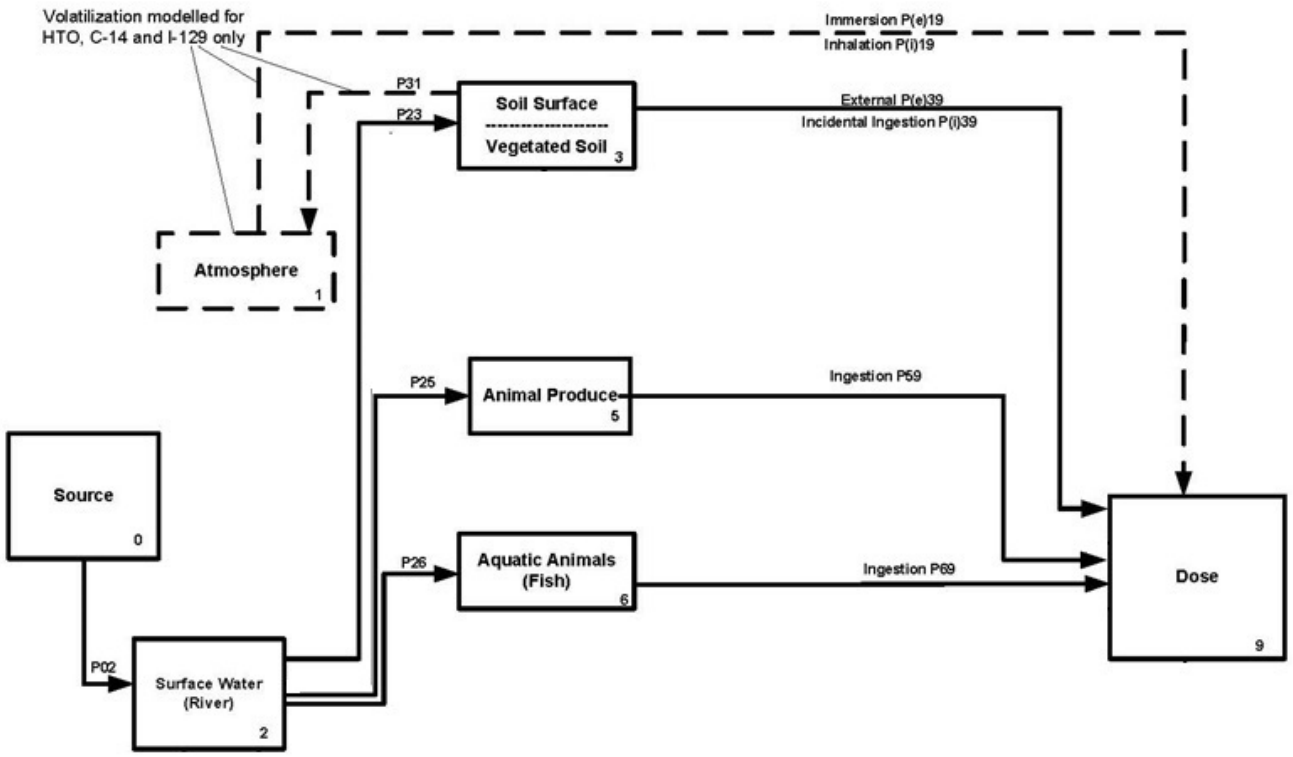


Figure 6.7.1-7: Conceptual Model for Human Receptors during the Post-closure Phase for Harvester

6.7.1.6.2.2 Results

An environmental transport and pathways model was used to evaluate the transport and effects of contaminants on the local environment including human and ecological receptors. A more detailed description of the model is provided in the ERA (EcoMetrix 2017).

The public dose limit for radiation protection is 1 mSv/a, as described in the Radiation Protection Regulations under the *Nuclear Safety and Control Act*. This limit is defined as an incremental dose, and is set at a fraction of natural background exposure to radiation. For the Project an established dose constraint to the public from all nuclides and all pathways for the long-term expected evolution of 0.25 mSv/a is applied for the Project (CNL 2016c). The total radiation dose to human receptors during the post-closure phase are below the CNSC public dose limit of 1 mSv/a, as well as the dose constraint for the Project of 0.25 mSv/a. Since the dose estimates are a small fraction of the public dose limit, no discernable health effects are anticipated due to exposure of potential critical groups to radioactive releases from the WL site during post-closure.

The maximum dose was assessed at a single point in time, corresponding to the peak loading rate from groundwater to the Winnipeg River. However, to assess the total radiation dose for each identified human receptor over the groundwater modelling timeframe, the modelling timeframe was split into five time windows based on inspecting the time of peak loading rates (0 to 60 years, 60 to 40,000 years, 40,000 to 175,000 years, 175,000 to 300,000 years and 300,000 to 500,000 years). The doses for all radionuclides with peak dose in a given time

window were added to obtain the total dose in that time window. This is conservative because the peaks within a time window were not exactly coincident.

The results are shown in Table 6.7.1-11 for Farm A, On-site Farm and the Harvester for each time window. As shown in the table, the total dose peaks during the beginning portion of the modelling timeframe and is greatly reduced as time progresses (EcoMetrix 2017). Individual dose results for each radionuclide is provided in the ERA completed for the Project, in Tables 5-10 through 5-14 (EcoMetrix 2017); total doses are provided in Table 6.7.1-12. As shown in the table, the total dose peaks during the beginning portion of the modelling timeframe and is greatly reduced as time progresses.

Table 6.7.1-11: Sum of Dose Peaks for all Radionuclides in Each of Five Time Windows During Post-Closure

Time Window	Dose (mSv/a)			
	Adult	Child	Infant (1 year)	Infant (3 months)
On-site Farm				
0 to 60	3.94E-07	3.60E-07	4.37E-07	1.21E-06
60 to 40,000	4.68E-05	5.29E-05	7.50E-05	5.39E-04
40,000 to 175,000	1.95E-07	2.08E-07	2.43E-07	1.16E-06
175,000 to 300,000	7.94E-08	8.50E-08	7.96E-08	1.39E-08
300,000 to 500,000	4.06E-08	4.74E-08	4.83E-08	9.36E-09
Farm A				
0 to 60	7.39E-09	6.74E-09	8.19E-09	2.26E-08
60 to 40,000	8.80E-07	9.96E-07	1.41E-06	1.01E-05
40,000 to 175,000	3.66E-09	3.92E-09	4.57E-09	2.19E-08
175,000 to 300,000	1.49E-09	1.60E-09	1.50E-09	2.60E-10
300,000 to 500,000	7.62E-10	8.91E-10	9.07E-10	1.76E-10
Harvester				
0 to 60	1.09E-07	7.96E-08	1.09E-07	—
60 to 40,000	9.75E-05	7.08E-05	9.65E-05	—
40,000 to 175,000	4.17E-07	3.79E-07	6.10E-07	—
175,000 to 300,000	1.71E-07	1.96E-07	3.86E-07	—
300,000 to 500,000	8.42E-08	1.05E-07	2.35E-07	—

Notes:
Bold cells indicate exceedance of the dose constraint of 0.25 mSv/a; **bold and shaded** cells indicate exceedance of the public dose limit of 1 mSv/a.
A dose of 0.0025 mSv/a is equivalent to 1% of the dose constraint.
— = not calculated
mS/a = millisieverts per year; N/A = not available; < = less than; % = percent.

Table 6.7.1-12: Summary of Total Dose during the Post-closure Phase Human Health Valued Components

Age Group	Dose (mSv/a)					
	On-site Farm		Farm A		Harvester	
	Dose	Percent of Dose Constraint	Dose	Percent of Dose Constraint	Dose	Percent of Dose Constraint
Adult	4.69E-05	0.019%	8.82E-07	0.00035%	9.77E-05	0.039%
Child	5.30E-05	0.021%	9.97E-07	0.00040%	7.11E-05	0.028%
Infant (cow's milk)	7.51E-05	0.030%	1.41E-06	0.00056%	9.69E-05	0.039%
Infant (formula)	1.91E-05	0.0076%	3.59E-07	0.00014%	N/A	N/A
3 month old (nursing)	5.39E-04	0.22%	1.01E-05	0.0040%	N/A	N/A
3 month old (formula)	5.88E-07	0.00024%	1.11E-08	0.0000044%	N/A	N/A

Notes:
Bold cells indicate exceedance of the dose constraint of 0.25 mSv/a; **bold and shaded** cells indicate exceedance of the public dose limit of 1 mSv/a.
A dose of 0.0025 mSv/a is equivalent to 1% of the dose constraint.
mS/a = millisieverts per year; N/A = not available; < = less than; % = percent.

The dominant contributor to the total dose is carbon-14 through ingestion of terrestrial plants and animals, and aquatic animals, except for the 3 month old drinking formula, which has tritium as the dominant contributor to dose. The total dose is based on maximum mass loadings for each radionuclide. For carbon-14, the time of maximum mass loadings to the Winnipeg River occurs at year 1,020.

The doses to human receptors that could be exposed to the non-radiological COPCs (i.e., cadmium and lead) in surface water during post-closure were calculated based on total concentration (background plus Project contribution) (Table 6.7.1-13).

Table 6.7.1-13: Summary of Total Exposure to Non-radionuclides during the Post-closure Phase to Human Health Valued Components

Dose (mg/kg bw/day)	Cadmium		Lead	
	Adult	Toddler	Adult	Toddler
On-site Farm	3.55E-07	1.01E-06	4.44E-05	2.52E-04
Farm A	3.55E-07	1.01E-06	4.44E-05	2.52E-04
Harvester	1.43E-05	2.03E-05	2.69E-04	3.86E-04

Risk was quantified for the human receptor based on the calculation of a hazard quotient (HQ) by dividing the estimated exposure by a toxicity reference value (TRV) that is known to be protective. If the total HQ (sum of individual HQs) doesn't exceed one, no adverse effects are likely (i.e., no additional assessment work is required to define risk). To account for uncertainty in pathways beyond Project activities it was determined that to be protective a benchmark HQ value of 0.8 would be used for the assessment. Incremental HQs were compared to a benchmark HQ of 0.2, which is consistent with approach taken by Health Canada (2010) in their guidance on human health quantitative risk assessment.

The HQs for the harvester On-Site Farm, and Farm A are below the acceptable risk level of 0.2 for cadmium and lead for all ingestion pathways for the toddler and adult. For the toddler harvester, the total ingestion HQ slightly exceeded 0.2 for lead (HQ = 0.24). The HQs for the harvester, On-Site Farm, and Farm A are based on background plus project exposure to cadmium and lead. If only the project contribution is considered, the HQs are reduced even further and total lead ingestion for the toddler harvester is below the target level. As indicated, the project contribution to the total is 0.0021% for cadmium and 0.00002% for lead.

6.7.1.7 Prediction Confidence and Uncertainty

The HHRA problem formulation is conservative in its assumptions to accommodate inherent uncertainties in the modelling and meet the objective of protecting human health during the closure and post-closure phases. Areas where conservative assumptions were incorporated include: source-terms and contaminant release rates, as well as the performance of grouting, building foundation, and engineered cover to contain and isolate the waste.

Maximum predicted concentrations were selected for COPC screening in air; this is considered conservative and is not reflective of typical human exposures. The conceptual model for human health is considered to be complete for the majority of general public exposures in the vicinity of the WL site. The selected receptors are expected to lead to conservative estimates of health risks. The selected exposure pathways are consistent with available guidance (e.g., CSA N288.1-14), and are expected to account for primary exposure pathways for human receptors in the area.

There is uncertainty in the estimated inventory of radioactive and non-radioactive hazardous material that could be present within the WR-1 Building. There is also uncertainty in how long each closure activity will take (e.g., how long it will take to grout the heavy water moderator system). As such, there is uncertainty in the COPC release rates to the atmosphere and geosphere. To address this uncertainty, appropriate assumptions are integrated into the model to provide an appropriate level of conservatism. For example, although the duration of demolition prior to grouting may be carried out in 1 to 2 months, it has been conservatively assumed that it will occur for 6 months. Prior to the execution of closure activities, system characterizations and radiological surveys will be completed to inform detailed work planning. This work will provide greater accuracy, however, it is expected that any variation would be well encompassed by the conservatism build into the model.

The IMPACT™ model was used to predict dose to identified human receptors during the closure phase. The IMPACT™ model used is a steady state model; however, it includes time dependent equations to account for buildup in soil from irrigation, for all radionuclides released. It includes progeny buildup through use of progeny inclusive dose coefficients. Progeny-inclusive dose coefficients were developed for each radionuclide that has progeny expected to be at or above 10% of parent activity after 40 years of ingrowth. This timeframe is used in CSA N288.1-14 for development of progeny-inclusive dose coefficients for sediment and soil exposure.

Exposure factors were based on best-available information from literature with preference for exposure factors identified in CSA N288.1-14. For parameters that did not have exposure factors in CSA N288.1-14, surrogate parameters were identified based on proximity in the periodic table, which is considered appropriate.

The uncertainties in the characterization of risk consist of those in the exposure and toxicity assessments (as described in the above paragraphs), since these two assessments are the inputs to the risk characterization. Considering the conservatism in the estimation of releases, and in the air model, it is reasonable to conclude that doses arising from closure activities have not been underestimated. The uncertainties from the exposure assessment include model uncertainty and uncertainty in the exposure factors selected. The uncertainties from the toxicity assessment include conservatisms built into the radiation dose constraint. Taken together, the approaches to exposure and toxicity assessment have ensured that the characterization of dose and risk has been undertaken in a manner that has not underestimated dose or risk.

The closure activities were determined to be well encompassed by existing engineering and administrative controls in place at the WL site. Although there are some uncertainties to be defined (e.g., exact quantities of substances present), the existing programs and procedures can be applied to manage these potential hazards. Proven operational programs will be in effect so that worker doses are below regulatory criteria and are as low as reasonably achievable (ALARA). Uncertainty and sensitivity analyses illustrated that there is a high confidence level in the predicted exposure doses, and the assumptions made for the assessment provide exposures are not underestimated.

6.7.1.8 Residual Effects Classification and Determination of Significance

The residual effects analysis methods for the HHRA 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 benchmarks, and (ii) the degree of conservatism and uncertainty in the analysis.

Results of the radiological dose assessment for the closure and post-closure phases indicates that doses to human health VCs are below the CNSC public dose limit of 1 mSv/a, as well as the dose constraint for the Project of 0.25 mSv/a. The hazard quotients derived for constituents of potential concern were below the protective benchmark for all receptors, with the exception of a toddler harvester during post-closure, which slightly exceeded the benchmark. If only the project contribution is considered, the HQs are reduced even further and hazard quotients are well below for all receptors (the project contribution to the total is 0.0021% for cadmium and 0.00002% for lead). 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 human health VCs during the closure and post-closure phases.

6.7.1.9 Monitoring and Follow-up

As part of the CNL Licence NRTEDL-W5-8-04/2018, environmental monitoring of the WL site is required. It is anticipated that for closure, the monitoring of environmental media at the WL site and surrounding area will continue to proceed as described in CNL's ongoing Environmental Monitoring Program for the WL site. This includes sampling and analysis of ambient air, surface water and groundwater, including the Winnipeg River, sediment, vegetation, garden produce, game animals, and fish. The Environmental Monitoring Program includes assessment of dose to members of the public, based on emissions monitoring and measurements in environmental media. Additionally, the dose to workers at WL site is monitored and reported to the CNSC annually. As decommissioning of the site proceeds, the environmental monitoring for the site is anticipated to evolve to reflect the creation, removal or limitation of hazards during the period of active institutional control.

The WR-1 Environmental Assessment Follow-up Program will be undertaken during the closure and post-closure stages of the Project. This program will serve to address the uncertainties associated with the effects predictions and the performance of mitigation, verify the effects predictions, and identify any unanticipated effects and provide for the implementation of adaptive management to limit these effects. This monitoring and follow-up will be carefully integrated with the existing Environmental Assessment Follow-up Program for the WL site, where possible. Once the WL site has been decommissioned, monitoring to support the areas of institutional control will continue, as well as any other requirements identified in the WR-1 Environmental Assessment Follow-up Program.

The WR-1 Environmental Assessment Follow-up Program will expand on the regulatory requirements of CSA N288.5 for the management of emissions from the Project. The WR-1 Environmental Assessment Follow-up Program is required to demonstrate compliance with the WL site public dose limit of 0.25 mSv, as well as the effective dose limit of 1 mSv/a for members of the public established by the *Nuclear Safety and Control Act*. For a comprehensive summary of the monitoring and follow-up recommendations made based on the results of the environmental assessment refer to Section 11.

6.7.1.10 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, scientists, government agencies, First Nation and Métis peoples, or the public (the Agency 2014). The HHRA focused on worker and public health. Assessment endpoints are qualitative expressions used to assess the significance of residual effects on human health VCs and represent the key properties of the VCs that should be protected for future human generations (i.e., incorporates sustainability). The assessment endpoint is the protection of human health. Measurement endpoints represent properties of the environment, that when changed, could result in or contribute to an effect on an assessment endpoint. Measurement endpoints for the human health assessment include changes in air quality, groundwater quality, and surface water quality.

The receptors for the HHRA were selected to be appropriate for assessment of both radiological and non-radiological stressors on human health. Off-site members of the public will potentially be exposed to low levels of airborne contaminants from decommissioning of the WR-1 Building. The most-affected off-site members of the public are defined as the "critical group" which include:

- Farm A and Farm F (year-round occupants, with livestock) for closure and post-closure;
- On-site Farm for post-closure; and
- Harvesters for closure and post-closure.

For the closure phase, the relevant COPCs are expected to be released via atmospheric releases from the WR-1 Building as reactor systems are dismantled, transported off-site or entombed within the WR-1 ISD structure. It has been assumed that the WR-1 Building stack is removed during the closure phase; therefore, atmospheric releases are assumed to occur at ground level. Doses to workers will be monitored and managed as part of CNL's Radiation Protection Program and Occupational Safety and Health Program. The application of the Radiation Protection Program provides that exposures will be kept ALARA and below the effective dose limit of 100 mSv over 5 years, and below 50 mSv in any single year.

An environmental transport and pathways model was used to evaluate the transport and effects of contaminants on the local environment including human receptors. The calculated radiological doses for the Project are all below the 0.25 mSv/a limit, for all human receptors in the candidate critical groups. Since the dose estimates are a small fraction of the public dose limit, no discernable health effects are anticipated due to exposure to radioactive releases from Project activities. For the closure phase, all predicted air concentration for non-radiological COPCs were below their relevant ambient air quality criteria; therefore, no non-radiological COPCs were identified for the closure phase and no health effects are anticipated as a result of airborne effluents from the Project.

The total radiation dose to human receptors during the post-closure phase are below the CNSC public dose limit of 1 mSv/a, as well as the dose constraint for the Project of 0.25 mSv/a. Since the dose estimates are a small fraction of the public dose limit, no discernable health effects are anticipated due to exposure of potential critical groups to radioactive releases from the WL site during post-closure.

The doses to human receptors that could be exposed to the non-radiological COPCs (i.e., cadmium and lead) in surface water during post-closure were calculated based on total concentration (background plus Project contribution). Risk was quantified for the human receptor based on the calculation of a HQ by dividing the estimated exposure by a toxicity reference value TRV that is known to be protective. Incremental HQs were compared to a benchmark HQ of 0.2, which is consistent with approach taken by Health Canada (2010) in their guidance on human health quantitative risk assessment. The hazard quotients derived for constituents of potential concern were below the protective benchmark for all receptors, with the exception of a toddler harvester, which slightly exceeded the benchmark. If only the project contribution is considered, the HQs are reduced even further and hazard quotients are well below for all receptors (the project contribution to the total is 0.0021% for cadmium and 0.00002% for lead).

Although uncertainties in the assessment exist, conservatism has been included in the modelling so that residual effects are not greater than predicted. The closure activities are well encompassed by existing engineering and administrative controls currently in place at the WL site. Although there are some uncertainties to be defined (e.g., exact quantities of hazardous substances), the existing programs and procedures can be applied to manage these potential hazards. Proven operational programs will be in effect ensuring worker doses are below regulatory criteria and are ALARA.

Overall, residual effects are considered to be not significant for all human health VCs during the closure and post-closure phases. Monitoring and follow-up programs include implementation of CNL's existing Environmental Monitoring Program. These activities will verify effects predictions for human health.

6.7.2 Ecological Health

6.7.2.1 Scope of the Assessment

The scope of the assessment focuses on summarizing the potential health effects to non-human biota from Project activities. The general approach to ISD for the WR-1 Building involves preparing systems and structures for grouting, then the below-grade structure will be filled with grout to encapsulate and immobilize radiological sources and hazardous materials for a defined period of Institutional Control. The decommissioning activities proposed as part of the Project include:

- preparation for ISD;
- grouting of below-grade structures and systems;
- removal of above-grade WR-1 Building;
- installation of an engineered cover over the WR-1 ISD structure;
- final site restoration;
- preparation of Institutional Control; and
- Institutional Control.

The above-grade uncontaminated structures will be demolished and removed. Some above-grade structures (e.g., section of the PHT system) will be demolished and placed within the WR-1 Building prior to ISD. An engineered cover will then be constructed over the below-grade structure (refer to Section 3.5 for more detail) and the Project site will be regraded and reclaimed. Environmental and performance monitoring will be completed to confirm that the ISD of WR-1 is functioning as intended in the long-term.

The ecological health risk assessment (EcoRA) follows the overall environmental assessment approach and methods described in Section 6.1 Environmental Assessment Approach. The assessment is completed in the following steps:

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries, and assessment cases** (refer to Section 6.7.2.2 Valued Components and Section 6.7.2.3. Assessment Boundaries) for the EcoRA. The VCs, assessment endpoints, and measurement indicators used to assess Project related changes to ecological 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 6.7.2.4 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 6.7.2.5 Project Interactions and Mitigation). Project components and/or activities with the potential to affect ecological health 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 ecological health by evaluating the different effect pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. The pathways analysis considers interactions that may result during normal or routine activities.

Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. Where effects are adequately mitigated and are not forwarded to 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 6.7.2.6 Residual Effects Analysis). This section outlines the methods used to predict and characterize residual effects to ecological health from primary effect pathways. The analysis results are also presented including the characterization of: (i) residual incremental effects of the Project and the effects of the Project in combination with past and present developments on ecological health (Application Case); and (ii) residual effects of the Project in combination with past and present developments, as well as other reasonably foreseeable developments (Reasonably Foreseeable Development [RFD] Case). A key outcome of this section is the predicted effects to ecological health 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 6.7.2.7 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** (refer to Section 6.7.2.8 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 of the Project on ecological health is made. Relative to other sections, the EcoRA 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** (refer to Section 6.7.2.9 Monitoring and Follow-up) required to confirm effect predictions and address uncertainty.
- **Step 8 – Present a consolidated summary of conclusions and outcomes of the assessment** (refer to Section 6.7.2.10 Conclusions) of residual effects on ecological health.

This section also describes how the input from engagement activities influenced the scope of the EcoRA, and identifies the sources of information used to support the assessment. Information and concerns raised by the public, communities of interest, regulators, and First Nation and Métis communities during engagement that influenced the scope of the assessment are summarized in Table 6.7.2-1.

Table 6.7.2-1: Summary of Issues Raised During Engagement Activities that Influenced the Scope of the Ecological Health Risk Assessment

Issue	How the Issue Was Included in the Assessment
Concerns about fish, and how contaminants can accumulate in fish over time. Concerns about potential impacts to wildlife and to human health.	Potential changes in ecological health considered a broad suite of ecological valued components, including a number of fish and wildlife species (see Section 6.7.2.2. The ecological risk assessment considered multiple exposure pathways, including, for example, contact with water and contaminant uptake from water via bioaccumulation.

6.7.2.2 Valued Components

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, Aboriginal peoples, or the public (the Agency 2014). It is generally an impractical task to assess the effect of radiological and non-radiological emissions on all the species of biota within a natural ecosystem, and specifically within the ecosystem around the WL site. Therefore, representative organisms are chosen for dose and risk analysis. These organisms are selected because they are known to exist on the site, and are representative of major taxonomic groups or exposure pathways, or have a special importance or value. During closure, the focus is on terrestrial VCs because releases are only expected via atmospheric pathways. During post-closure phase, the focus is on aquatic and riparian VCs, because releases are only expected via groundwater to surface water pathways. Valued components and rationale for their selection for the EcoRA are provided in Table 6.7.2-2.

Table 6.7.2-2: Valued Components for the Ecological Health Risk Assessment

Category	Valued Component	Rationale
Closure Phase		
Terrestrial Invertebrates	Earthworm	Detritivore. Exposure to atmospheric release through soil.
Terrestrial Birds	American Robin	Observed on-site. Exposure to atmospheric release through the ingestion of soil invertebrates. A surrogate for insect eating birds including various Species at Risk (SAR) under COSEWIC, ESEA or SARA.
	Loggerhead Shrike	Historically observed on-site. Exposure to atmospheric release through the ingestion of soil invertebrates, small mammals and birds. Identified as a SAR under COSEWIC, ESEA or SARA. A surrogate for other predatory birds identified as SAR under COSEWIC, ESEA or SARA.
Terrestrial Plants	Grass and shrubs	Present on-site. Exposure to atmospheric release through soil. Food source for other VCs.
	Berries	Present in the area. Exposure to atmospheric release through soil. Food source for VCs.
Terrestrial Mammals	Meadow Vole	Common in the area. Exposure to atmospheric release through ingestion of terrestrial plants. A food source for VCs.
	Common Shrew	Common in the area. Exposure to atmospheric release through ingestion of soil invertebrates. A food source for VCs.

Table 6.7.2-2: Valued Components for the Ecological Health Risk Assessment

Category	Valued Component	Rationale
	Snowshoe Hare	Common in the area. Exposure to atmospheric release through ingestion of terrestrial plants. A game species.
	White-tailed Deer	Common in the area. Over winters on-site. Exposure to atmospheric release through ingestion of terrestrial plants. A game species. An important game species for Traditional Communities.
	Red Fox	Common in the area. Exposure to atmospheric release through the ingestion of small mammals and birds. A surrogate for the Grey Fox identified as a SAR under COSEWIC, ESEA or SARA.
	Little Brown Myotis	Bats observed roosting in forested areas of the WL site. Exposure to atmospheric release through ingestion of soil invertebrates. Exposure to aquatic release through ingestion of aerial stages of benthic invertebrates. Identified as a SAR under COSEWIC, ESEA or SARA. A surrogate for other bats identified as SAR under COSEWIC, ESEA or SARA.
Post-closure Phase		
Terrestrial Birds	Barn Swallow	Observed on-site. Exposure to aquatic release through ingestion of aerial stages of benthic invertebrates. Identified as a SAR under COSEWIC, ESEA or SARA. A surrogate for aquatic insect eating birds including various SAR under COSEWIC, ESEA or SARA.
Terrestrial Mammals	Little Brown Myotis	Bats observed roosting in forested areas of the WL site. Exposure to atmospheric release through ingestion of soil invertebrates. Exposure to aquatic release through ingestion of aerial stages of benthic invertebrates. Identified as a SAR under COSEWIC, ESEA or SARA. A surrogate for other bats identified as SAR under COSEWIC, ESEA or SARA.
Fish	Carmine Shiner	Present in the Winnipeg River. Exposure to aquatic release through surface water and sediment. Identified as a SAR under COSEWIC, ESEA or SARA. Small bodied forage fish. A food source for other VCs.
	Lake Sturgeon	Present in the Winnipeg River. Exposure to aquatic release through surface water and sediment. Identified as a SAR under COSEWIC, ESEA or SARA.
	Walleye	Present in the Winnipeg River. Exposure to aquatic release through surface water. A sport fish. A surrogate for other pelagic fish in the Winnipeg River such as Northern Pike and Mooneye.
Aquatic Plants	Aquatic Plants	Present in the Winnipeg River. Exposure to aquatic release through surface water. Food source for other VCs.
Aquatic Invertebrates	Benthic Invertebrate	Present in the Winnipeg River. Exposed to aquatic release through surface water and sediment. Food source for other VCs.
Riparian Birds	Horned Grebe	Present in the area. Exposure to aquatic release through ingestion of water and fish. Identified as a SAR under COSEWIC, ESEA or SARA. Food source for other VCs. Surrogate for other important species such as the common loon and red-necked grebe.
	Trumpeter Swan	Observed on-Site. Exposure to aquatic release through ingestion of water and aquatic plants. Identified as a SAR under COSEWIC, ESEA or SARA.

Table 6.7.2-2: Valued Components for the Ecological Health Risk Assessment

Category	Valued Component	Rationale
	Mallard	Representative of waterfowl. Exposure to aquatic release through ingestion of water, aquatic plants and benthic invertebrates. Food source for other VCs and human receptors.
Riparian Mammals	Mink	Present in the area. Exposure to aquatic release through ingestion of water, waterfowl and fish.

SAR = Species at Risk; COSEWIC = Committee on the Status of Endangered Wildlife in Canada; ESEA = Manitoba's *Endangered Species and Ecosystems Act*; SARA = *Species at Risk 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 human generations (i.e., incorporates sustainability). Measurement endpoints represent properties of the environment, that when changed, could result in or contribute to an effect on an assessment endpoint. The measurement endpoints for the ecological health assessment are outlined in Table 6.7.2-3.

Table 6.7.2-3: Assessment Endpoints and Measurement Indicators for the Ecological Health Risk Assessment

Valued Components	Assessment Endpoint	Measurement Indicator
Terrestrial Invertebrates (Earthworm)	Protection of ecological health	■ Changes to air quality ■ Changes to groundwater quality ■ Changes to surface water quality ■ Changes to soil quality ■ Changes to vegetation quality
Terrestrial Birds (American Robin, Loggerhead Shrike, Barn Swallow)		
Terrestrial Plants (Grasses, shrubs, berries)		
Terrestrial Mammals (Meadow Vole, Common Shrew, Snowshoe Hare, White-Tailed Deer, Red Fox, Little Brown Myotis)		
Aquatic Plants		■ Changes to air quality ■ Changes to groundwater quality ■ Changes to surface water quality ■ Changes to sediment quality
Aquatic Invertebrates (Benthic Invertebrates)		
Fish (Carmine Shiner, Lake Sturgeon, Walleye)		
Riparian Birds (Horned Grebe, Trumpeter Swan, Mallard)		■ 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
Riparian Mammals (Mink)		

COPC = contaminants of potential concern.

6.7.2.3 Assessment Boundaries

6.7.2.3.1 Spatial Boundaries

In order to assess the potential effects of the Project on ecological health, an appropriate spatial boundary was defined, with consideration given to locations where VCs could be affected by Project activities directly or where they could be indirectly affect by interacting with other aquatic and terrestrial VCs affected by Project activities (Figure 6.7.1-1).

- **Site Study Area (SSA):** is the WR-1 Building and represents the Project footprint (i.e., where project activities will be undertaken). The area size of the SSA is 0.07 hectares (ha).
- **Local Study Area (LSA):** is defined as the area within which there is potential for measurable changes to measurement indicators resulting from the proposed Project activities. The LSA was adapted from the surface water RSA and is designated to include receptors from both the human health risk assessment and ecological risk assessment. Therefore, the south boundary of the LSA extends from the west shore of the Winnipeg River to the east fence on the property line about 400 m north of Provincial Highway 211. The eastern boundary of the LSA follows the fence on the property line to the north property line. The north boundary follows the north fence on the property line about 1.6 km and then turns north for about 400 m before turning west and extending to the west side of the Winnipeg River. The west boundary follows the west bank of the Winnipeg River for about 1.5 km and then turns west for 370 m, north for 1.4 km and then turns east for 630 m to the west side of the Winnipeg River. The LSA has an approximate size of 4,174 ha.
- **Regional Study Area:** is defined as the area within which the potential effects of the Project may interact with the effects of other existing or reasonably foreseeable projects. The RSA was adapted from the air quality study area and is defined as a 12 kilometre (km) by 12 km rectangle surrounding the LSA.

6.7.2.3.2 Temporal Boundaries

The temporal boundaries of the assessment include effects observed under existing (Base Case) conditions, the timeframe during which Project activities are actively occurring, and 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 if the effect is predicted to last so far into the future that the duration cannot be predicted with any level of certainty (e.g., residual effect lasts for thousands of years). The following phases were identified for the Project:

- **Closure Phase:** Preparation and implementation of In Situ Decommissioning (ISD), which includes preparation for ISD, grouting of below-grade structures and systems, removal of above-grade WR-1 structures and systems, installation of the engineered cover and environmental controls and final site restoration. These activities last from 2019 to 2024.
- **Post-closure Phase:** The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. The Institutional Control period includes implementation of both active and passive control throughout 2024 to 2324 (i.e., 300 years). During active Institutional Control, long-term performance monitoring and maintenance activities will continue through to 2124 to demonstrate compliance with the safety case assumptions. The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions) and will continue through 2024 to 2324. Post-institutional Control occurs after year 2324 and continues indefinitely.

6.7.2.3.3 Assessment Cases

The assessment cases considered for ecological health include the Base Case, Application Case, and the Reasonably Foreseeable Development (RFD) 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 WL facilities and operations, for example, are considered part of the Base Case. In addition, effects from the decommissioning and reclamation activities already completed at the WL site are also considered as part of the Base Case. The base case is represented in the assessment by baseline air quality (Section 6.2) and surface water quality (Section 6.4.1); for guidelines that limit total exposures, the Project contribution and background are included.
- **Application Case**: The scenario represents the effects of the Base Case combined with predicted effects from the Project. The Application Case includes post-closure activities, and therefore, the associated effects during the post-closure phase of the Project represent the bounding case.
- **RFD Case**: This scenario represents the predictions of the cumulative effects of the Application Case, plus projects that are currently under application review or that have officially entered a regulatory application process and which overlap with the ecological health RSA. There are no RFDs expected in the RSA other than the continued decommissioning of the remaining WL facilities, as the Comprehensive Study Report (AECL 2001). Results of the Comprehensive Study Report indicated that no decrease in water quality is expected and effluent emissions to the Winnipeg River are expected to decline following decommissioning. Results of the assessment concluded that no effect on aquatic species is expected as doses were below the limit at which no effects on aquatic populations is expected. Current effects from the existing WL facilities and operations are considered part of the Base Case (i.e., existing conditions). Consequently, cumulative effects of the Base Case and the potential effects from the Project are evaluated in the Application Case. As such, an RFD Case is not applicable to the EcoRA and is not further discussed.

6.7.2.4 Description of the Existing Environment

Monitoring of environmental media at the WL site and surrounding area will proceed as described in CNL's ongoing Environmental Assessment Follow-up Program. This includes sampling and analysis of ambient air, surface water and groundwater, including the Winnipeg River, sediment, vegetation, garden produce, game animals, and fish. A summary of concentrations of radionuclides and non-radionuclide concentrations within the various environmental media are discussed in the "Description of the Existing Environment" section of the relevant discipline section in the EIS.

6.7.2.5 Project Interactions and Mitigation

6.7.2.5.1 Methods

This section describes the process by which interactions between Project components and activities and ecological health were identified and evaluated. Potential effect 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 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 Section 6.7.2.6 Residual Effects Analysis. 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 Project. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. The next step in the analysis was the development of environmental design features and mitigation practices that could be incorporated into the Project to eliminate and/or reduce adverse effects to ecological 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 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 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 pathway –** 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 to ecological health.
- **Secondary pathway –** the pathway could result in a measurable minor environmental change, but would have a negligible residual effect on ecological health 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 past, present 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 ecological health.

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 ecological health 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.

6.7.2.5.2 Results

Pathways through which the Project may interact with the ecological health VCs are summarized in Table 6.7.2-4. Accidents and malfunctions related to Project activities are also possible and are assessed separately in Section 7.0 Accidents and Malfunctions.

Table 6.7.2-4: Pathways Analysis for the Ecological Health Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
General Project activities during the closure phase	Closure activities will result in the release criteria air contaminants (CACs) and fugitive dust emissions.	■ Implementation of CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring, air verification monitoring and environmental monitoring. ■ Implementation of CNL's Occupational Safety and Health Program, including work permit system and PPE&C. ■ Implementation of dust management techniques. ■ On-site vehicles and equipment engines will meet Tier 3 emission standards, where possible, and be maintained in good working order. ■ Limit idling of vehicles on-site and speed on roads. ■ Use of enclosure for raw material handling.	Secondary

Table 6.7.2-4: Pathways Analysis for the Ecological Health Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
General Project activities during the closure phase (continued)	Closure activities will result in the atmospheric release of radiological and non-radiological compounds from the WR-1 Building	■ Implementation of CNL's Radiation Protection Program and Procedure, which includes Radiation Safety Zones, detailed work planning to limit doses to as low as reasonably achievable (ALARA), dose monitoring, and contamination control procedures (e.g., stabilizing and immobilizing agents). ■ Implementation of CNL's Occupational Safety and Health Program, including work permit system and training requirements. ■ Implementation of CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring, air verification monitoring and environmental monitoring.	Primary
Long-term performance during the post-closure phase	Release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time may cause changes in groundwater quality which could migrate towards the Winnipeg River	■ Installation of a multi-component final cover system to mitigate moisture infiltration into the WR-1 ISD structure and hence limit release of solutes into the groundwater. ■ Environmental / Performance monitoring will be completed throughout the post-closure phase for the Project to confirm that the cover and grout is functioning as intended, and to confirm modelling predictions.	Primary

6.7.2.5.2.1 No Linkage Pathway

There are no pathways identified as having no linkages to effects to the ecological health VCs.

6.7.2.5.2.2 Secondary Pathways

In some cases, a Project source of effect and an interaction with an assessment endpoint exists but mitigation is expected to cause minor changes to ecological health relative to the existing Base Case and/or guidelines. The following pathway is expected to result in negligible effects on the ecological health VCs and will not be evaluated further in the EIS.

- **Closure activities will result in the release criteria air contaminants (CACs) and fugitive dust emissions.**

Closure activities will result in the release of CACs and fugitive dust emissions. Sources of dust deposition and air emissions include stack emissions, fuel use, aggregate material handling, on-site batch mixing plant, and road dust. Environmental design features and mitigation have been incorporated into the Project to reduce potential adverse effects from dust deposition and air emissions. CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions (CNL 2013) includes operational control monitoring, air verification monitoring, and implementation of dust management techniques developed for the Project.

The release of CACs (particulate matter, nitrogen oxides, sulphur dioxide, and carbon monoxide) and fugitive dust were assessed as part of the air quality VC in Section 6.2 Air Quality. Predicted concentrations for the Application Case (Section 6.2.1.8) are below applicable air quality guidelines and/or standards. Therefore, the release of CACs and fugitive dust is not expected to result in effects to ecological health.

6.7.2.5.2.3 Primary Pathways

The following primary pathways were identified between the Project and ecological health and therefore, are carried forward to the residual effects analysis:

- Closure activities will result in the atmospheric release of radiological and non-radiological compounds from the WR-1 Building.
- Release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time may cause changes in groundwater quality which could migrate towards the Winnipeg River.

6.7.2.6 Residual Effects Analysis

An ERA (EcoMetrix 2017) was completed for the Project to assess potential adverse effects of the Project on ecological health during the closure and post-closure phases of the Project. A summary of the methods and results of this assessment during the closure and post-closure phases of the Project is provided in Sections 6.7.2.6.1 (Application Case – Closure Phase) and 6.7.2.6.2 (Application Case – Post-closure Phase), respectively.

6.7.2.6.1 Application Case – Closure Phase

6.7.2.6.1.1 Methods

This section summarizes the specific methods used to assess the residual effects on ecological health during the closure phase for the Project activities and pathways identified as primary in Table 6.7.2-4. Policies, guidelines and standards considered in the analysis, as well as the model used to predict residual effects are described.

Receptor Selection and Characterization

As described in Section 6.7.2.2, the focus for the closure phase is on terrestrial VCs because releases are only expected via atmospheric pathways. The following VCs are evaluated for the closure phase, rationale for their selection is provided in Table 6.7.2-2:

- earthworm;
- American robin;
- loggerhead shrike;
- grass and shrubs;
- berries;
- meadow vole;
- common shrew;
- snowshoe hare;
- white-tailed deer;
- red fox; and
- little brown myotis.

Contaminants of Potential Concern

For the closure phase, the relevant COPCs may be released via atmospheric releases from the WR-1 Building. It has been assumed that the WR-1 Building stack is removed during the closure phase; therefore, any atmospheric releases are assumed to occur at ground level.

Selection of Radiological COPCs

The radionuclides that are considered in the ERA for the closure phase are those radionuclides that have been found in WL's airborne effluent or are reasonably expected to be found in the airborne effluent (CNL 2016b). Radionuclides are considered of public and regulatory interest and therefore all radionuclides identified were carried forward quantitatively in the ERA.

During closure, operational controls and procedures in place to prevent or limit the release of airborne radionuclides will be in effect (e.g., during demolition the above-grade building will be in place, the waste collection system and proven emergency response plans and personnel will all be operational, and adequate ventilation and infiltration will be established). As well, decontamination, and the use of stabilizing and immobilizing agents prior to dismantling the WR-1 Building will be used to control the release of airborne radionuclides. Release of radionuclides to the atmosphere during closure are not anticipated to be above those observed during the operation phase of the facility. During demolition of above-grade structures, radionuclides may be released from

the PHT system, and some existing surface radionuclides may become airborne. During grouting, remaining radionuclides may be released from the reactor core and biological shield (Table 6.7.2-5). Tritium may also be released, for example, when disruptive activities on the helium and heavy water system are executed during closure. In accordance with REGDOC-2.9.1 (CNSC 2017b), average and maximum emission rates have been provided for the Application Case (refer to Section 6.2.1, Tables 6.2.1-9 and 6.2.1-10).

Table 6.7.2-5: Potential Radionuclide Release during the Closure Phase

Reactor Core	Biological Shield	Primary Heat Transport System
■ C-14 ■ Fe-55 ■ Co-60 ■ Ni-59 ■ Ni-63 ■ Nb-94 ■ H-3	■ Cl-36 ■ Ca-41 ■ Ni-63 ■ C-14 ■ Co-60 ■ Eu-152	■ Sr-90 ■ Cs-137 ■ Eu-154 ■ Eu-155 ■ Tc-99 ■ I-129 ■ Np-237 ■ Np-239 ■ Pu-238 ■ Pu-239 ■ Pu-240 ■ Pu-241 ■ Am-241 ■ Am-243 ■ Cm-244 ■ Co-60

Selection of Non-Radiological COPCs

A select number of non-radiological airborne COPCs have been identified as potentially being released during the closure phase from the WL site. These include:

- asbestos (friable [contains more than 1% asbestos by weight or area and can be crumbled by the human hand] and non-friable [material that contains more than 1% asbestos and cannot be crumbled under hand pressure] asbestos containing materials);
- organic coolant (HB-40 used as reactor coolant, also known as OS-84, primarily hydrogenated terphenyl) in the primary heat transport system;
- lead based paint and lead shielding;
- polychlorinated biphenyls (PCBs) in fluorescent light fixture ballasts;
- small quantities of mercury in thermostats and switches; and
- mould.

With the exception of HB-40, the identified hazardous substances are routinely addressed in construction projects. HB-40 consists mainly of hydrogenated terphenyl (74-87%), with smaller fractions of partially hydrogenated terphenyls and terphenyl. Since HB-40 is an oil, or a tar if irradiated, its release to air with dust should be limited. However, volatilization could be a release pathway.

Non-radiological COPCs are identified through an official screening process and these COPCs are carried forward into the EcoRA. The screening consists of comparing the maximum predicted concentration in the groundwater (prior to entering the Winnipeg River) to conservative benchmarks. If concentration exceed benchmarks it indicates additional risk assessment work is required to demonstrate protection of the public and environment. For closure it was identified that no non-radiological COPCs were required to be carried forward into the EcoRA.

Exposure Pathways

During the closure phase, releases to surface water are not expected, because any release from the grouted reactor would occur after closure, and contaminant transport via groundwater to surface water would take additional time. Relevant exposure for ecological receptors are presented in Table 6.7.2-6 and illustrated in Figure 6.7.2-1. Exposure pathways include the routes of contaminant dispersion from the source to the receptor location, and the routes of contaminant transport through the food chain or other media to the receptor organism.

Airborne COPCs partition to soil and plants, and ingestion pathways dominate over inhalation and air immersion for most COPCs. The latter pathways are omitted for ecological receptors in this assessment, except for COPCs such as noble gases, if released, since inhalation and air immersion pathways for these are expected to be important.

Table 6.7.2-6: Exposure Pathways for Selected Valued Components during the Closure Phase

Receptor Category	Receptor	Exposure Pathways	Environmental Media
Terrestrial Invertebrates	Earthworm	Direct Contact	■ In Soil
Terrestrial Plants	Grasses/Shrubs	Direct Contact	■ On Soil
	Berries	Direct Contact	■ On Soil
Terrestrial Birds	American Robin	Direct Contact	■ On Soil
		Ingestion	■ Soil ■ Earthworms ■ Fruit/Berries
	Loggerhead Shrike	Direct Contact	■ On Soil
		Ingestion	■ Soil ■ Earthworms ■ American Robin ■ Meadow Vole

Table 6.7.2-6: Exposure Pathways for Selected Valued Components during the Closure Phase

Receptor Category	Receptor	Exposure Pathways	Environmental Media
Terrestrial Mammals	Meadow Vole	Direct Contact	■ On Soil
		Ingestion	■ Soil ■ Grasses ■ Fruit/Berries
	Common Shrew	Direct Contact	■ On Soil
		Ingestion	■ Soil ■ Earthworms
	Snowshoe Hare	Direct Contact	■ On Soil
		Ingestion	■ Soil ■ Grasses ■ Fruit/Berries ■ Shrubs
	White-tailed Deer	Direct Contact	■ On Soil
		Ingestion	■ Soil ■ Grasses ■ Fruit/Berries
	Red Fox	Direct Contact	■ In and on Soil
		Ingestion	■ Soil ■ Grasses ■ Fruit/Berries ■ American Robin ■ Loggerhead Shrike ■ Meadow Vole ■ Snowshoe Hare
	Little Brown Myotis	Direct Contact	■ On Soil
		Ingestion	■ Soil ■ Earthworm

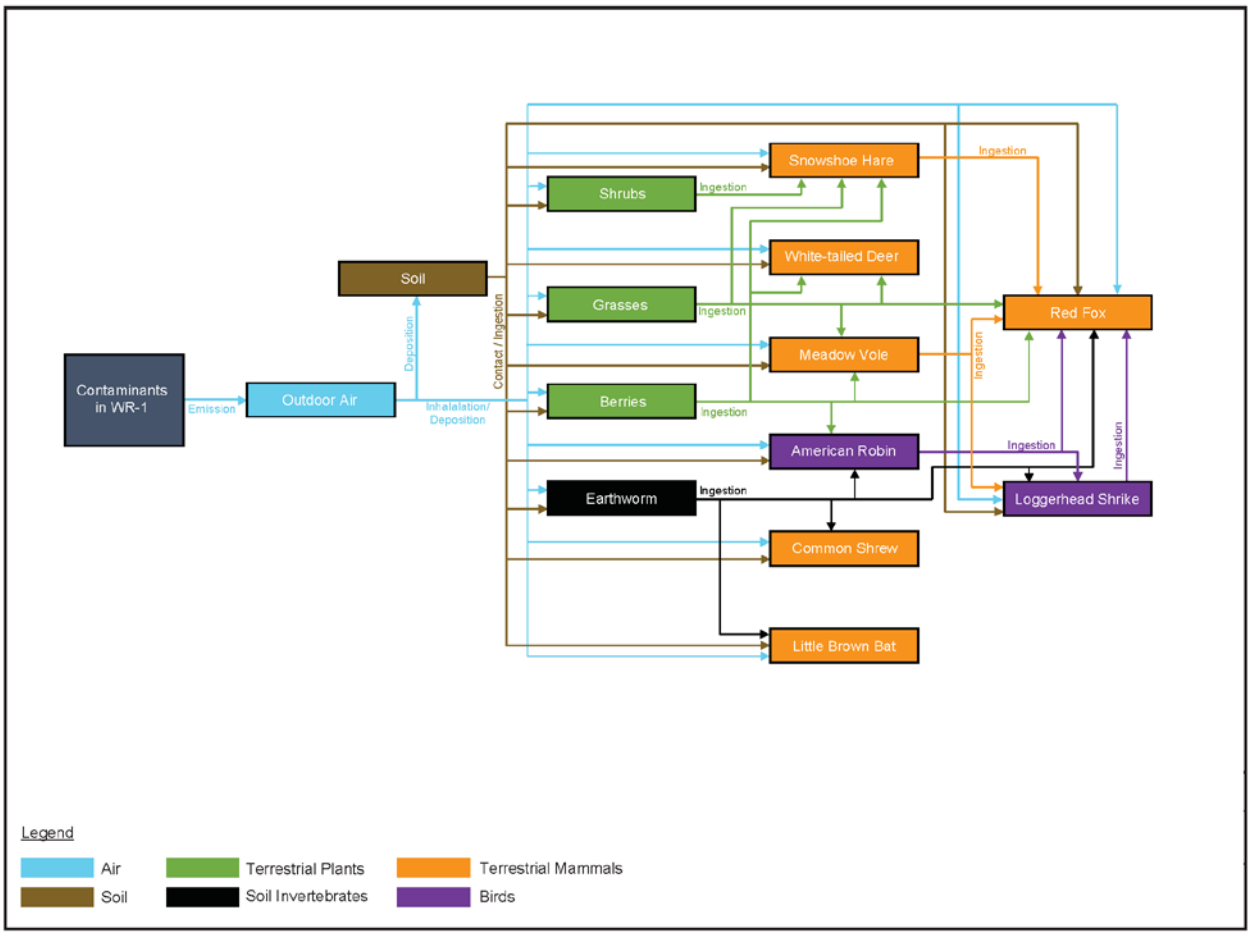


Figure 6.7.2-1: Ecological Conceptual Model for Closure Phase

6.7.2.6.1.2 Results

An environmental transport and pathways model was used to evaluate the transport and effects of contaminants on the local environment including human and ecological receptors. A more detailed description of the model is provided in the ERA (EcoMetrix 2017).

A radiation dose benchmark of 0.1 mGy/h (2.4 mGy/d) (UNSCEAR 2008) was selected for the WL assessment of effects on terrestrial biota (Table 6.7.2-7) as recommended in the CSA N288.6-12 standard (CSA 2012). This is a total dose benchmark, therefore the dose to biota due to each radionuclide of concern is summed to compare against this benchmark.

Table 6.7.2-7: Summary of Total Dose during Closure Phase for Selected Valued Components

Ecological Receptor	Dose (mGy/d)			
	Demolition Prior to Grouting (Max)	Demolition Prior to Grouting (Avg)	Grouting (Max)	Grouting (Avg)
American Robin	4.19E-05	1.10E-05	9.09E-07	9.04E-07
Loggerhead Shrike	1.37E-05	3.60E-06	8.31E-07	8.27E-07
Meadow Vole	9.32E-06	2.46E-06	7.55E-07	7.50E-07
Common Shrew	3.65E-06	9.67E-07	7.49E-07	7.44E-07
Deer	1.36E-04	3.57E-05	7.31E-07	7.27E-07
Rabbit	1.70E-03	4.48E-04	8.34E-07	8.28E-07
Red Fox	1.25E-04	3.30E-05	6.09E-07	6.05E-07
Little Brown Bat	2.01E-06	5.35E-07	5.99E-07	5.96E-07
Forage	8.85E-05	2.33E-05	1.46E-06	1.46E-06
Grass	9.26E-05	2.44E-05	1.80E-06	1.79E-06
Fruits	3.95E-05	1.04E-05	1.32E-06	1.32E-06
Earthworm	9.17E-05	2.41E-05	1.44E-06	1.43E-06

Notes:
Bold and shaded cells indicate exceedance of the terrestrial benchmark of 2.4 mGy/d.

There are no exceedances of the 2.4 mGy/d radiation benchmark for terrestrial VCs on or near the WL site. All predicted doses are well below this level. Therefore, it is unlikely that there would be significant adverse effects on terrestrial populations or communities as a result of radionuclide releases from closure activities. For the closure phase, all predicted air concentration for non-radiological COPCs were below their relevant ambient air quality criteria (see Section 6.2.1); therefore, no non-radiological COPCs were identified for the closure phase and no health effects are anticipated as a result of airborne effluent from the Project.

6.7.2.6.2 Application Case – Post-Closure Phase

6.7.2.6.2.1 Methods

This section describes the specific methods used to assess the residual effects on ecological health, during the post-closure phase, for the Project activities and pathways identified as primary in Table 6.7.1-5. Policies, guidelines and standards considered in the analysis, as well as the model used to predict residual effects are described.

Receptor Selection and Characterization

As described in Section 6.7.2.2, the focus for the post-closure phase is on aquatic and riparian VCs because releases are only expected via groundwater to surface water pathways. The following VCs are evaluated for the post-closure phase, rationale for their selection is provided in Table 6.7.2-2:

- barn swallow;
- little brown myotis;
- carmine shiner;
- lake sturgeon;
- walleye;
- aquatic plants;
- benthic invertebrates;
- horned grebe;
- trumpeter swan;
- mallard; and
- mink.

Contaminants of Potential Concern

For the post-closure phase, no atmospheric releases are expected as the grouting will be completed and the above-grade building and components will have been removed. An engineered cover will have been installed on top of the buried material. During the post-closure phase the site will be under institutional control. The main potential release mechanism during post-closure is via leakage through the WR-1 ISD structure to groundwater and subsequent migration of groundwater to surface water at the Winnipeg River.

Selection of Radiological COPCs

The radionuclides that are considered in the ERA for the post-closure phase include those that have been historically been found in WL's liquid effluent or are reasonably expected to be found in the grout and have the potential to migrate from groundwater to surface water during the post-closure phase (CNL 2016b). Radionuclides are considered of public and regulatory interest and therefore all radionuclides identified were carried forward quantitatively in the ERA. The radionuclides included for the post-closure scenario include:

- Am-241;
- Am-243;
- C-14;
- Ca-41;
- Cl-36;
- Cm-244;
- Co-60;
- Cs-137;
- Eu-152;
- Eu-154;
- Eu-155;
- Fe-55;
- I-129;
- Nb-94;
- Ni-59;
- Ni-63;
- Pu-238;
- Pu-239;
- Pu-240;
- Pu-241;
- H-3
- Sr-90; and
- Tc-99.

Selection of Non-Radiological COPCs

CNL has determined that a select number of non-radiological waterborne COPCs have been identified as potentially being released from the WL site during the post-closure phase (CNL 2017b). These include:

- Boron;
- Cadmium;
- Chromium;
- HB-40;
- Mercury;
- Palladium;
- Potassium hydroxide; and
- Xylene.

The groundwater model predicted mass loadings for non-radiological parameters from WR-1 to groundwater for the duration of the modelling assessment timeframe (500,000 years). Maximum mass loadings for each non-radiological parameter were converted to groundwater concentrations using the anticipated flowrate through the ISD for the time period of maximum mass loadings. The maximum predicted groundwater concentrations were compared to the more conservative of available federal and provincial guidelines and objectives to determine potential COPCs relevant to ecological health. If there was no such guideline or objective, screening criteria were obtained from conservative toxicity benchmarks (e.g., no effect levels) in the literature.

Non-radiological parameters with maximum concentrations exceeding the most conservative of these benchmarks according to the hierarchy shown in Figure 6.7.2-2 were carried forward as non-radiological COPCs in this assessment. Based on the screening process, cadmium, lead, HB-40 and xylene are carried forward for further quantitative assessment in the ERA for the post-closure phase.

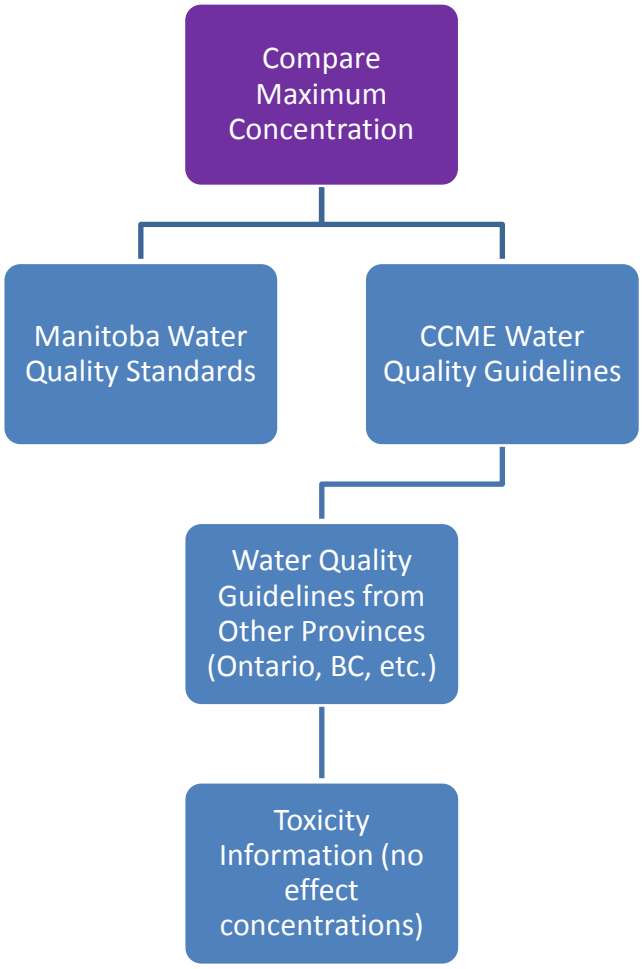


Figure 6.7.2-2: Selection Process for Ecological Health Screening of Non-Radiological COPCS

Exposure Pathways

Exposure pathways include the routes of contaminant dispersion from the source to the receptor location, and the routes of contaminant transport through the food chain or other media to the receptor organism. The post-closure phase is not expected to result in airborne effluent, as the grouting will have been completed, the above-grade building will have been completely decommissioned, and an engineered cover will have been installed over the WR-1 ISD structure. The relevant chemical and radiological contaminants may be released via leakage through the grouting to groundwater and subsequent migration via groundwater to surface water at the Winnipeg River.

Exposure pathways for aquatic and riparian biota are described in Table 6.7.2-8 and illustrated in Figure 6.7.2-3. Exposure pathways include the routes of contaminant dispersion from the source to the receptor location, and the routes of contaminant transport through the food chain or other media to the receptor organism. Airborne COPCs are not relevant during the post-closure phase. For fish and aquatic plants, contact with water and contaminant uptake from water via bioaccumulation represents the main exposure pathway. The dominant exposure pathways for birds and mammals are through the uptake of contaminants via the ingestion of water, incidental ingestion of soil or sediment, and ingestion of food.

Table 6.7.2-8: Exposure Pathways for Selected Valued Components during the Post-closure Phase

Receptor Category	Receptor	Exposure Pathways	Environmental Media
Bottom Feeding Fish	Lake Sturgeon	Direct Contact	■ In Water ■ On Sediment
	Carmine Shiner	Direct Contact	■ In Water ■ On Sediment
Pelagic Fish	Walleye	Direct Contact	■ In Water
Aquatic Plants	Aquatic Plant	Direct Contact	■ In Water
Aquatic Invertebrates	Benthic Invertebrate	Direct Contact	■ In Water ■ In Sediment
Riparian Birds	Horned Grebe	Direct Contact	■ On Sediment
		Ingestion	■ Water ■ Sediment ■ Fish (forage) ■ Benthic Invertebrates
	Trumpeter Swan	Direct Contact	■ On Sediment
		Ingestion	■ Water ■ Sediment ■ Aquatic Plants
	Mallard	Direct Contact	■ On Sediment
		Ingestion	■ Water ■ Sediment ■ Benthic Invertebrates ■ Aquatic Plants
Riparian Mammals	Mink	Direct Contact	■ On Sediment
		Ingestion	■ Water ■ Sediment ■ Benthic Invertebrates ■ Fish (forage)
Terrestrial Birds	Barn Swallow	Direct Contact	■ On Sediment
		Ingestion	■ Water ■ Sediment ■ Benthic Invertebrates
Terrestrial Mammals	Little Brown Myotis	Direct Contact	■ None
		Ingestion	■ Water ■ Benthic Invertebrates

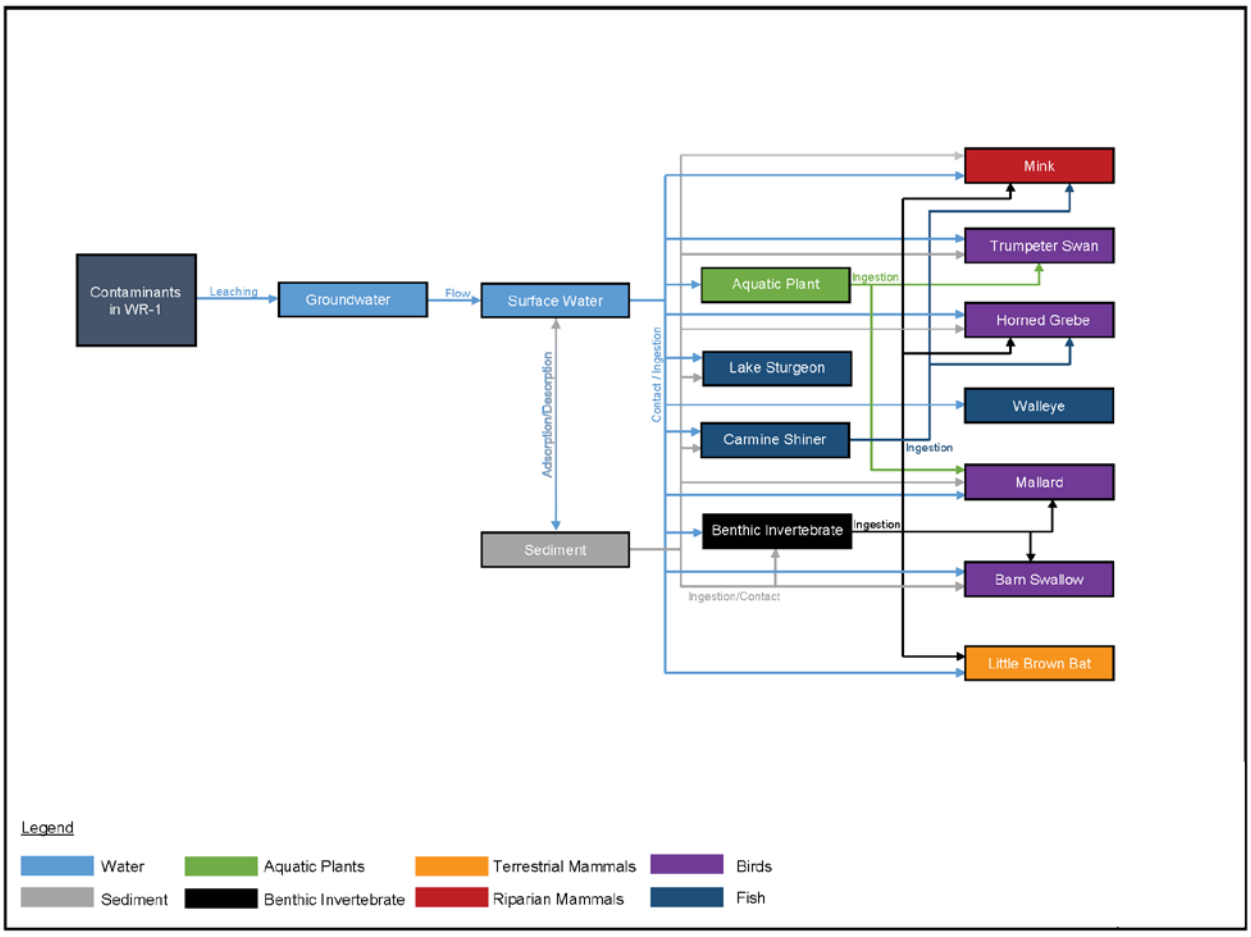


Figure 6.7.2-3: Ecological Conceptual Model for Post-closure Phase

6.7.2.6.2.2 Results

An environmental transport and pathways model was used to evaluate the transport and effects of contaminants on the local environment including human and ecological receptors. A more detailed description of the model is provided in the ERA (EcoMetrix 2017).

The total doses are compared to dose benchmarks of 9.6 mGy/d for aquatic biota and 2.4 mGy/d for terrestrial and riparian biota (Table 6.7.2-9), respectively, as recommended in the CSA N288.6-12 standard (CSA 2012). This is a total dose benchmark, therefore the dose to biota due to each radionuclide of concern is summed to compare against this benchmark.

Table 6.7.2-9: Summary of Total Dose during the Post-closure Phase for Select Valued Components

Ecological Receptor	Dose (mGy/d)
Barn Swallow	7.96E-06
Little Brown Bat	6.56E-06
Carmine Shiner	4.03E-06
Lake Sturgeon	4.03E-06
Walleye	4.03E-06
Freshwater plant	4.12E-06
Benthic Invertebrate	3.59E-06
Horned Grebe	7.96E-06
Trumpeter Swan	8.02E-06
Wild Waterfowl	8.00E-06
Mink	6.55E-06

Notes:
Bold and shaded cells indicate exceedance of the aquatic benchmark of 9.6 mGy/d or the terrestrial benchmark of 2.4 mGy/d.

There are no exceedances of the 9.6 mGy/d radiation benchmark for the aquatic biota in the Winnipeg River. Similarly, there are no exceedances of the 2.4 mGy/d radiation benchmark for terrestrial and riparian biota on or near the WL site. All predicted doses are well below these levels. Therefore, it is unlikely that there would be significant adverse effects on either aquatic or terrestrial populations or communities as a result of radionuclide releases from post-closure activities.

The HQs for non-radiological COPCs for aquatic receptors are presented in Table 6.7.2-10 and the HQs for mammals and birds are presented in Table 6.7.2-11.

Table 6.7.2-10: Non-Radiological Hazard Quotients for Aquatic Valued Components

Parameter	Benthic Invertebrates (unitless)	Fish (unitless)	Aquatic Plants (unitless)
Cadmium	6.67E-02	5.88E-03	5.00E-03
HB-40	2.27E-05	5.27E-07	9.64E-07
Lead	2.12E-01	1.38E-01	5.20E-03
Xylene	4.83E-07	1.80E-08	1.24E-08

Notes:
Bold and shaded values indicate a HQ greater than 1.

Table 6.7.2-11: Non-Radiological Hazard Quotients for Birds and Mammal Valued Components

Parameter	Barn Swallow (unitless)	Horned Grebe (unitless)	Trumpeter Swan (unitless)	Wild Waterfowl (unitless)	Little Brown Myotis (unitless)	Mink (unitless)
Cadmium	5.34E-05	1.85E-05	9.84E-04	1.22E-03	4.95E-05	1.91E-05
HB-40	NV	NV	NV	NV	2.35E-04	1.21E-04
Lead	6.87E-03	2.15E-03	4.54E-02	5.65E-02	3.58E-04	1.42E-04
Xylene	4.00E-07	1.40E-07	2.38E-08	6.20E-08	2.97E-08	1.15E-08

Notes:
Bold and shaded values indicate a HQ greater than 1.
NV = no value available to calculate HQ.

There are no exceedances of the HQs identified for exposure of the ecological receptors to cadmium, lead, HB-40 and xylene. Therefore, it is unlikely that there would be significant adverse effects on either aquatic or terrestrial populations or communities as a result of these chemical releases.

There were no data to determine HB-40 benchmarks for birds. As such there is uncertainty around the potential health risks to birds due to HB-40 exposure. Nevertheless, considering that the major constituent of HB-40 (e.g., hydrogenated terphenyl) is closely related to the aromatic hydrocarbon group and that petroleum hydrocarbons are metabolized by vertebrates (CCME 2008), it can be suggested that exposure of birds to HB-40 is likely to be limited because HB-40 will be readily metabolized by birds and therefore is not anticipated to accumulate. In addition, assuming that birds are similar to mammals in terms of HB-40 toxicity, if the HB-40 TRV for mammals is used for birds, all bird doses are far below the TRV.

6.7.2.7 Prediction Confidence and Uncertainty

The ERA problem formulation is conservative in its assumptions to accommodate inherent uncertainties in the modelling and meet the objective of protecting ecological health during the closure and post-closure phases. Areas where conservative assumptions were incorporated include: source-terms and contaminant release rates, as well as the performance of grouting, building foundation, and engineered cover to contain and isolate the waste.

The conceptual model for ecological health is considered to be complete for the majority of ecological exposures in the vicinity of the WL site. The comprehensive selection of COPCs and receptors is expected to represent all important exposures to contaminants in the vicinity of the WL site. There were no data to determine an HB-40 screening benchmark for birds, however, the major constituent in HB-40 is similar to aromatic hydrocarbon group and petroleum hydrocarbons are known to be metabolized by vertebrates (EcoMetrix 2017). The HB-40 toxicity for birds was assumed to be similar to that of mammals. The selected receptors are expected to lead to conservative estimates of ecological risks.

There is uncertainty in the estimated inventory of radioactive and non-radioactive hazardous material that could be present within the WR-1 Building. There is also uncertainty in how long each closure activity will take (e.g., how long it will take to grout the heavy water moderator system). As such, there is uncertainty in the COPC release rates to the atmosphere and geosphere. To address this uncertainty appropriate assumptions are integrated into the model to provide an adequate level of conservatism.

There are uncertainties in the predicted radiological and non-radiological release rates to the atmosphere; however, the estimates are expected to be appropriate as they are based on best available information on existing inventory of radiological and non-radiological contaminants in WR-1. Conservative assumptions were made about duration of release and particulate release rates.

Uncertainties in the exposure assessment include the representativeness of the predicted concentrations used in the assessment at each location. Maximum predicted concentrations of COPCs were used for each location and environmental medium as an upper bound on exposure. These values are, by definition, not representative for mobile organisms that can move around the site, effectively averaging their exposure concentrations. Maximum values are representative for exposures of any sessile organisms that reside at the location of the maximum value. Therefore, maximum concentrations are considered to overestimate exposure for all mobile receptors.

Exposure factors were based on best-available information from literature with preference for exposure factors identified in CSA N288.1-14. For parameters that did not have exposure factors in CSA N288.1-14, surrogate parameters were identified based on proximity in the periodic table, which is considered appropriate. Since the exposure assessment is predictive, BAFs were used to calculate uptake into tissues. The BAFs used for the exposure assessment were taken from reputable sources (e.g., CSA N288.1-14) and are considered to be representative of the conditions found at the site. Wildlife exposure factors, such as intake rates and diets, are a potential source of uncertainty. Reputable sources are used for these factors and they are considered to be representative for the organisms assessed.

Dose coefficients were obtained from reputable sources for reference organisms, but have not been derived specifically for all the organisms assessed. Dose coefficients for surrogate organisms were often used. They were selected with attention to similar body size and exposure habits, and are believed to adequately represent the organism assessed. Dose coefficients for each receptor were not adjusted for body size and dimensions.

The IMPACT model was used to predict dose to identified ecological receptors during the closure phase. The IMPACT model used is a steady state model; however, it includes time dependent equations to account for buildup in soil from irrigation, for all radionuclides released. Uncertainties in predictions of media concentrations arise from inherent uncertainty in the air model in IMPACT. The model reports an average concentration, and typically over-predicts this concentration by a factor of 1.5. Considering the conservatism in the estimation of releases, and in the air model, it is reasonable to conclude that doses arising from closure activities have not been underestimated.

There are uncertainties associated with the components contributing to the overall risk assessment. This includes receptor exposure factors, such as transfer factors, intake rates and bioaccumulation factors, and dose coefficients, as well as benchmark values used to determine risk of potential effects. Overall, considering uncertainties in the exposure assessment and in the benchmark values, the risk characterization has been undertaken in a manner that has not underestimated risk; the results are either overestimates or realistic estimates of risk, both of which are considered acceptable.

6.7.2.8 Residual Effects Classification and Determination of Significance

The residual effects analysis methods for the EcoRA are different in some notable ways from those used by other VCs. Specifically, the assessment of potential effects to ecological 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 ecological health is evaluated based on: (i) the potential magnitude of the response, as indicated by the comparison to benchmarks, and (ii) the degree of conservatism and uncertainty in the analysis.

There are no exceedances of the 9.6 mGy/d radiation benchmark for the aquatic biota in the Winnipeg River for maximum releases during the post-closure phase. Similarly, there are no exceedances of the 2.4 mGy/d radiation benchmark for terrestrial and riparian biota on or near the WL site for maximum releases during the closure and post-closure phases. In addition, there are no exceedances of the HQs identified for exposure of the ecological receptors to cadmium, lead, HB-40 and xylene during the post-closure phase. Therefore, it is unlikely that there would be significant adverse effects on either aquatic or terrestrial populations or communities as a result of maximum chemical releases. 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 closure and post-closure phases.

6.7.2.9 Monitoring and Follow-up

As part of the CNL Licence NRTEDL-W5-8-04/2018, environmental monitoring of the WL site is required. It is anticipated that for closure, the monitoring of environmental media at the WL site and surrounding area will proceed as described in CNL's ongoing Environmental Monitoring Program. This includes sampling and analysis of ambient air, surface water and groundwater, including the Winnipeg River, sediment, vegetation, garden produce, game animals, and fish. The WR-1 Environmental Assessment and Follow-up Program includes assessment of dose to members of the public, based on emissions monitoring and measurements in environmental media. Additionally, the dose to workers at WL is monitored and reported to the CNSC annually. As decommissioning of the site proceeds the environmental monitoring for the site is anticipated to evolve to reflect the creation, removal or limitation of hazards.

The WR-1 Environmental Assessment and Follow-up Program will be undertaken during the closure and post-closure stages of the Project. This program will serve to address the uncertainties associated with the effects predictions and the performance of mitigation, verify the effects predictions, and identify any unanticipated effects and provide for the implementation of adaptive management to limit these effects. This monitoring and follow-up will be carefully integrated with the existing Environmental Assessment and Follow-up Program for the WL site, where practical. Once the WL site has been decommissioned, monitoring to support the areas of institutional control will continue, as well as any other requirements identified in the WR-1 Environmental Assessment and Follow-up Program. The WR-1 Environmental Assessment and Follow-up Program will expand on the regulatory requirements of CSA N288.5 for the management of emissions from the Project. For a comprehensive summary of the monitoring and follow-up recommendations made based on the results of the environmental assessment refer to Section 11.

6.7.2.10 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, First Nation and Métis peoples, or the public (the Agency 2014). It is generally an impractical task to assess the effect of radiological and non-radiological emissions on all the species of biota within a natural ecosystem, and specifically within the ecosystem around the WL site. Therefore, representative organisms are chosen for dose and risk analysis. These organisms are selected because they are known to exist on the site, and are representative of major taxonomic groups or exposure pathways, or have a special importance or value. During closure, the focus is on terrestrial VCs because releases are only expected via atmospheric pathways. During post-closure phase, the focus is on aquatic and riparian VCs, because releases are only expected via groundwater to surface water pathways.

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 endpoints represent properties of the environment, that when changed, could result in or contribute to an effect on an assessment endpoint. Measurement endpoints for the EcoRA include changes in air quality, groundwater quality, surface water quality, sediment quality, soil quality, and vegetation.

An environmental transport and pathways model was used to evaluate the transport and effects of contaminants on the local environment including ecological receptors. Results of the radiological dose assessment for the closure and post-closure phases indicates that doses to ecological health VCs are below their respective benchmark values. In addition, all predicted non-radiological concentrations were less than their selected guidelines or alternate benchmarks. 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 closure and post-closure phases.

Although uncertainties in the assessment exist, conservatism has been included in the modelling so that residual effects are not greater than predicted. Overall, residual effects are considered to be not significant for all ecological health VCs during the closure and post-closure phases. Monitoring and follow-up programs include implementation of CNL's existing Environmental Monitoring Program. These activities will verify effects predictions for ecological health.

6.8 Land and Resource Use

This section of the Environmental Impact Statement (EIS) for the Canadian Nuclear Laboratories (CNL) In Situ Decommissioning of WR-1 at the Whiteshell Laboratories Site (the Project) seeks to understand and characterize the potential residual effects of the Project and past, present, and reasonably foreseeable developments on land and resource use. The assessment of land and resource use includes consideration of both Aboriginal land and resource use and non-Aboriginal land and resource use activities in proximity to the Project.

6.8.1 Scope of the Assessment

The assessment on land and resource use follows the overall environmental assessment approach and methods described in Section 6.1 Environmental Assessment Approach. The assessment is completed in the following steps.

- **Step 1 – Identify Valued Components (VCs) and define the spatial boundaries, temporal boundaries and assessment cases** (refer to Sections 6.8.2 Valued Components and Section 6.8.3 Assessment Boundaries) for the assessment of land and resource use. The VCs, the assessment endpoints and measurement indicators used to assess the Project related changes to land and resource use; the spatial and temporal boundaries at which the assessment occurred; and, the assessment cases considered.
- **Step 2 – Describe the existing conditions** (refer to Section 6.8.4 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 historical and current land and resource use.
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 6.8.5 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 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. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. 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 described. Primary pathways that may lead to residual effects to land and resource use 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 6.8.6 Residual Effects Analysis). This section outlines the methods used to predict and characterize residual effects to land and resource use from primary effect pathways. The analysis results are also presented including the characterization of incremental effects from the 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 6.8.7 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 6.8.8 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 is made of the significance of the predicted residual effects from the Project for the land and resource use VCs.
- **Step 7 – Identifying monitoring and follow-up** (refer to Section 6.8.9 Monitoring and Follow-up) required to confirm effects predictions and address uncertainty.
- **Step 8 – Present a consolidated summary of conclusions and outcomes of the assessment** (refer to Section 6.8.10 Conclusions) of residual effects on land and resource use.

This section also describes how the input from engagement influenced the scope of the land and resource use assessment. Information and concerns raised by the public, communities of interest, regulators, First Nation and Métis communities during engagement activities that influenced the scope of the land and resource assessment are summarized in Table 6.8.1-1.

Table 6.8.1-1: Summary of Issues Raised During Engagement Activities that Influenced the Scope of the Land and Resource Use Assessment

Issue	How the Issue Was Included in the Assessment
The public, First Nations and the Manitoba Metis Federation identified the importance of the Winnipeg River.	The Winnipeg River was included as a valued component, and potential effects on it are assessed in this section.
Interests regarding future land use in relation to the overall site closure.	Land Tenure was included as a valued component, and potential effects on it were assessed in this section.

6.8.2 Valued Components

Valued components refer to socio economic and environmental features that may be affected by a project and that have been identified to be of concern by the proponent, scientists, government agencies, First Nation and Métis communities, or the public (the Agency 2014). The land and resource use VCs chosen for the Project to reflect identified concerns, professional judgement and/or standard practice in environmental assessment are Land Tenure, Outdoor Recreation and Tourism, Cultural and Archaeological Sites, Traditional Land and Resource Use by Aboriginal People, and the Winnipeg River. The rationale for selecting these VCs is discussed in Table 6.8.2-1.

Table 6.8.2-1: Valued Components for the Land and Resource Use Assessment

Valued Component	Rationale for Selection
Land Tenure	Land tenure considers the uses, allocations, and ownership of lands in proximity to the Project, including the WL site itself. The change in decommissioning for the WR-1 Building will decrease the proportion of the WL site available for future land tenure by private or public entities. The use of ISD may also change the perceived suitability of land use surrounding the WL site.
Outdoor Recreation and Tourism	The WL site is located in an area with several provincial parks, including the Whiteshell Provincial Park, that offer a variety of outdoor recreation opportunities while also being located near towns and Rural Municipalities (RMs) that rely on cottagers and tourism to contribute to their local economies.
Cultural and Archaeological Sites	Cultural and archaeological sites are important for revealing past and present land use, cultural identity and relationships with other cultures and the social and biophysical environments. Potential alteration or loss of cultural and archaeological sites can have an effect on Aboriginal people. Consideration of physical and cultural heritage is a requirement under Section 5 of the *Canadian Environmental Assessment Act, 2012*.
Traditional Land and Resource Use by Aboriginal People	Traditional land and resource use by Aboriginal people is important for maintaining meaningful connections with cultural identity and community history. Traditional land and resource use can also promote intergenerational connections within communities as knowledge is passed down from elders to community members, including youth. Potential changes to traditional land and resource use by Aboriginal people can have an adverse effect on Aboriginal people by preventing them from fully expressing their cultural identity and Treaty rights. Consideration of current land and resources use for traditional purposes is a requirement under Section 5 of *CEAA, 2012*.
Winnipeg River	The public and First Nations and Métis communities identified the importance of the Winnipeg River. A number of communities depend on the river for drinking water, recreation, and food. The river flows into the Lake Winnipeg, one of the largest lakes in the world. The eastern shore of the lake is included in a United Nations World Heritage Site proposal (UNESCO 2016). This watershed is valued for many reasons by many people and groups.

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 assessments of each VC will incorporate community and/or traditional knowledge where available. 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 land and resource assessment are outlined in Table 6.8.2-2.

Table 6.8.2-2: Assessment Endpoints and Measurement Indicators for the Land and Resource Use Assessment

Valued Component	Assessment Endpoints	Measurement Indicators
Land Tenure	Capacity for continued land use	■ Availability of portions of WL site for alternative future uses. ■ Ability to maintain current land uses/tenures in proximity to the Project.
Outdoor Recreation and Tourism	Continued opportunity for outdoor recreation and tourism activities such as hunting, fishing and trapping.	■ Relative abundance and distribution of fish species. ■ Relative abundance and distribution of wildlife species. ■ Continued opportunity for recreational land use. ■ Perceived suitability of area for outdoor recreation and tourism activities.
Cultural and Archaeological Sites	Protection and preservation of cultural and archaeological sites.	■ Value and quantity of cultural and archaeological sites.
Traditional Land and Resource Use by Aboriginal People	Continued opportunity for traditional activities such as hunting, fishing, trapping, and plant and berry gathering.	■ Relative abundance and distribution of fish species. ■ Relative abundance and distribution of plant species. ■ Relative abundance and distribution of wildlife species. ■ Continued opportunities for traditional land use ■ Perceived changes to the area's suitability for land use and/or quality of harvested resources.
Winnipeg River	Maintenance of self-sustaining and ecologically effective fish populations that are available for traditional use	■ Changes to ambient levels of surface water parameters ■ Relative abundance and distribution of fish species.

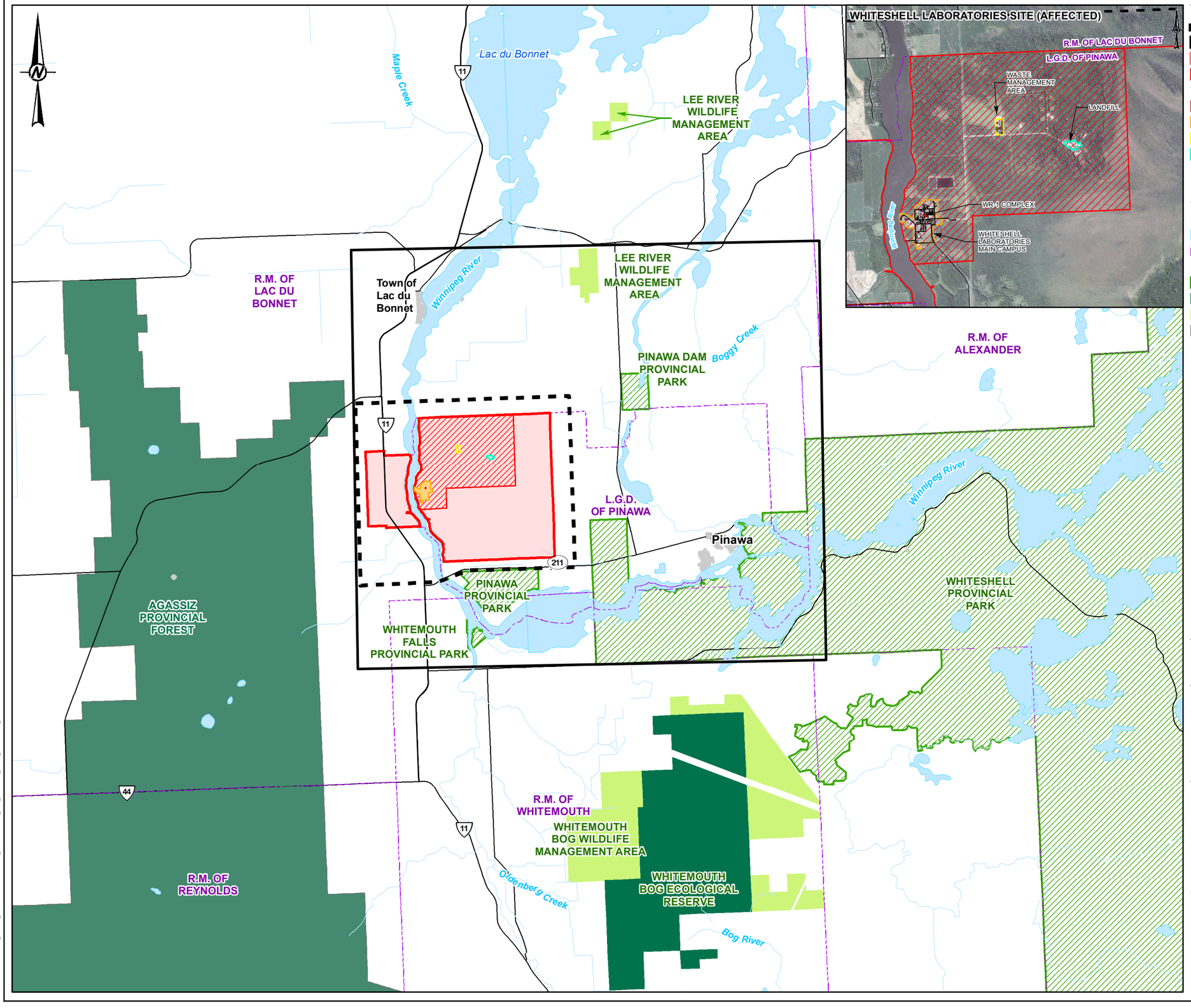
6.8.3 Assessment Boundaries

6.8.3.1 Spatial Boundaries

The spatial boundaries selected for the land and resource use assessment were chosen because they permit description of Base Case 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 Project to cumulative effects. These boundaries were developed in consideration of known land and resource use around the WL site, including resource harvesting and traditional land and resource use by Aboriginal persons and the study areas of other disciplines (e.g., Terrestrial Environment; Human Health) that may have an effect on land and resource use. The spatial boundaries selected for the land and resource use assessment are presented on Figure 6.8.3-1 and are described below.

- **Site Study Area (SSA)** is the WR-1 Building and represents the Project footprint (i.e., where Project activities will be undertaken).
- **Local Study Area (LSA)** is defined as the area within which there is potential for measurable changes resulting from the proposed Project activities. The LSA is intended to capture land and resource use within proximity of the WL site and extends approximately 1 km beyond the WL site boundaries with the exception of the western boundary, which follows Provincial Trunk Highway 11.
- **Regional Study Area (RSA)** represents the area where potential effects on land and resource use are expected to be experienced at a broader scale. The RSA includes the LGD of Pinawa in its entirety and the stretch of the Winnipeg River from the WL site downstream to the northern boundary of the Town of Lac du Bonnet (i.e., to capture recreational use of the Winnipeg River by residents of Lac du Bonnet).

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LEGEND

- LOCAL STUDY AREA
- REGIONAL STUDY AREA
- WHITESHELL LABORATORIES SITE (UNAFFECTED)
- WHITESHELL LABORATORIES SITE (AFFECTED)

WHITESHELL LABORATORIES

- WR-1 COMPLEX
- APPROXIMATE MAIN CAMPUS
- WASTE MANAGEMENT AREA
- LANDFILL

BASE FEATURES

- CITY/TOWN
- MAJOR ROAD
- WATERCOURSE
- WATERBODY
- MUNICIPAL BOUNDARY

PROTECTED AREAS

- PROVINCIAL PARK
- ECOLOGICAL RESERVE
- WILDLIFE MANAGEMENT AREA
- PROVINCIAL FOREST

0 5 10
1:170,000 KILOMETRES

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
SPATIAL BOUNDARIES FOR THE LAND AND RESOURCE USE ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE/PR
REVIEWED	JO
APPROVED	

PROJECT NO. 1656897 | CONTROL | REV. 1 | FIGURE **6.8.3-1**

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6.8.3.2 Temporal Boundaries

The temporal boundary of the assessment includes effects observed under existing conditions, the timeframe during which Project activities are actively occurring and 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 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 Project:

- **Closure Phase**: Preparation and implementation of In Situ Decommissioning (ISD) includes preparation for ISD, grouting of below-grade structures and systems, removal of above-grade WR-1 Building structures and systems, installation of the engineered cover and environmental controls and final site restoration. These activities last from 2019 to 2024.
- **Post-closure Phase:** The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. The Institutional Control period includes implementation of both active and passive control throughout 2024 to 2324 (i.e., 300 years). During active Institutional Control, long-term performance monitoring and maintenance activities will continue through to 2124 to demonstrate compliance with the safety case assumptions. The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions) and will continue through 2024 to 2324. Post-institutional Control occurs after year 2324 and continues indefinitely.

6.8.3.3 Assessment Cases

The assessment on land and resource use has three assessment cases.

- **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 WL facilities and operations, for example, are considered part of the Base Case. In addition, effects from the decommissioning and reclamation activities already completed at the WL site are also considered as part of the Base Case.
- **Application Case**: The Application Case represents predictions of the effects that may results from the Project combined with the existing effects of the Base Case.
- **Reasonably Foreseeable Developments (RFD) Case**: This scenario represents the effects of the Base Case combined with the predicted incremental effects from the Project, as well as effects from other RFDs within the RSA that are currently under application review or that have officially entered a regulatory application process. There are no RFDs expected in the RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). A smaller proportion of the WL site will not be available for unrestricted use as was previously anticipated because of the Project, therefore, the cumulative effects from the Project in combination with the decommissioning of the remaining infrastructure and support facilities, and reclamation of the affected areas at the WL site are presented as part of this assessment.

6.8.4 Description of the Environment

This section describes the setting and characterization for land and resource use as relevant for the assessment of the Project. It describes the existing conditions against which potential changes from the Project are compared and evaluated.

6.8.4.1 Methods

The characterization of the existing environment for land and resource use reflects review of both primary and secondary data sources. Data collection began with a review of existing literature and databases from a variety of public sources. Where sufficient detail was not available from secondary data sources to describe the existing environment, primary data collection was undertaken in the form of key person interviews.

6.8.4.1.1 Literature Review

The review of literature and databases included the following sources:

- Federal, provincial, and municipal government reports and data;
- documents produced for other environmental assessment processes (e.g., environmental impact statements, regulatory submissions);
- academic literature (dissertations, cultural chronologies);
- archival research;
- the Whiteshell Laboratories Decommissioning Project: Comprehensive Study Report (AECL 2001);
- the Environmental Assessment Follow-up Program for Whiteshell Laboratories (CNL 2002); and
- online sources (e.g., community websites, online business profiles).

6.8.4.1.2 Key Person Interview Program

A limited key person interview (KPI) program was undertaken to address gaps that could not be readily filled by secondary sources and to gain an understanding of land and resource use surrounding the WL site. Interviews were conducted with four individuals primarily from Manitoba Sustainable Development. Interview guides for the KPIs were developed to address the subject areas discussed in this section of the environmental assessment.

6.8.4.1.3 Public and Aboriginal Engagement

Information shared by the public and from First Nation and Métis communities was also used to inform both the base case and application case. Further detail on the outcomes of engagement processes can be found in Section 4.0 Aboriginal Engagement and Section 5.0 Public and Regulatory Engagement. Where applicable within this section (Section 6.8), interests and information gained through the engagement program relevant to land and resource use has been highlighted for each community.

6.8.4.2 Results

6.8.4.2.1 Land Tenure

This section describes land tenure and use in proximity of the WL site, including parcels on both sides of the Winnipeg River. Land interests in the area include wildlife management and protected areas, trapping and outfitting concessions, mineral and quarry reserves, agricultural lands and forestry.

6.8.4.2.2 Whiteshell Laboratories Site

The Project is located within the WL site, which is situated in the northwest corner of the LGD of Pinawa, and borders the RM of Lac du Bonnet to the north, east and west. The LGD of Pinawa was established in 1962 as the site of the Whiteshell Laboratories (LGD of Pinawa 2004). The WL site was established in the early 1960s to facilitate research and development of higher temperature versions of the Canada Deuterium Uranium (CANDU) reactor. The WL site included WR-1, an organic cooled reactor, which became operational in 1965 (AECL 2001). In the early 1970s, the organic cooled reactor program was eliminated and full focus was concentrated on the heavy water-cooled CANDU reactor system. In 1985, WR-1 was permanently shut down (CNL 2016b).

The site occupies 4,375 ha of land that was either privately owned or Crown land before the establishment of Whiteshell Laboratories. Currently, AECL, a federal government crown corporation, holds the title to the WL site lands. Access to these areas has generally been restricted for security and safety. The WL site occupies four different land use designations in the LGD of Pinawa (2004).

- **AG – General Agriculture:** AECL land on the western side of the Winnipeg River is zoned for agricultural use, which is considered a minor land use in the LGD of Pinawa. The purpose of the designation is to protect existing agricultural developments and to protect environmentally sensitive areas from the potential effects of agricultural practices.
- **MH – Heavy Industrial:** AECL land including the WL main campus, waste management area and landfill are zoned for industrial use. The purpose of this designation is to encourage industrial development while limiting potential land use conflicts and potential adverse environmental effects.
- **RR – Rural Residential:** AECL land to the west of Ara Mooradian Way to the Winnipeg River and south of the WL main campus is zoned institutional. The purpose of this designation is partially to encourage accessibility and a wide range of public institutions.
- **Natural Area:** The majority of the WL site located on the east side of the Winnipeg River, is designated as natural areas, the purpose of which is to protects areas from development and to ensure access for residents of Pinawa to spaces for passive recreational uses.

6.8.4.2.2.1 Wildlife Management and Protected Areas

The WL site is located near the following management and protected areas (Figure 6.8.3-1).

- **Pinawa Dam Provincial Park:** Located on Provincial Route (PR) 520 approximately 10 km northeast of the WL site. The park commemorates Manitoba's first year-round hydroelectric generating station. The park is 193 ha in size. The park is a day-use recreation area. It contains picnic areas, a picnic shelter, trails and interpretive facilities. In the winter, a snowmobile trail runs through the park (Manitoba Conservation and Water Stewardship 2012a).
- **Whitemouth Falls Provincial Park:** Located approximately 6 km southeast of the WL site and is 483 ha in size. The park is at the confluence of the Whitemouth and Winnipeg rivers. The portion of the park south of the Winnipeg River is a day-use recreation area, while the area north of the Winnipeg River is to protect great gray owl habitat (Manitoba Conservation and Water Stewardship 2012b).
- **Whiteshell Provincial Park** is directly east of the WL site and is 276,400 ha in size. Pinawa is located in the park boundaries. The park is intended to be a key recreational area in the Canadian Shield, provide cottaging opportunities, provide an accessible wilderness zone, accommodate resource harvesting, and maintain

a diverse sport fishery. The park offers swimming, boating, biking, golf, hiking, cross country skiing and snowmobiling. There are a range of accommodations located in the park, including several campgrounds (Department of Natural Resources 1983).

- **Pinawa Provincial Park** is located south of PR 211 on the east short of the Winnipeg River. It is less than 1 ha in size. The park is intended to provide a point of access to the Winnipeg River for boating and fishing and day-use opportunities (Manitoba Conservation and Water Stewardship 2012c).
- **Lewis Bog Ecological Reserve** is located in Agassiz Provincial Forest southwest of the WL site. It was recently expanded from 570 ha to 5,240 ha. The reserve supports several types of bogs and forests. Rare orchid species and rare wildlife species have been seen in the reserve. The expansion is expected to help reduce the risk to the area and the rare species it supports from the effects of nearby commercial peat harvesting and agricultural activities. (Manitoba Sustainable Development n.d.a).
- **Lee River Wildlife Management Area** is located east of the Town of Lac du Bonnet off PR 520 and north of the WL site, and is 1,187 ha in size. It features a variety of grouse, white-tailed deer and moose. Coyotes, wolves and foxes use the area for denning and it is within a breeding and migration corridor for northern forest owls (Manitoba Sustainable Development n.d.b.).

6.8.4.2.2.2 Agricultural Lands

Land to the north and west of the WL site have been zoned by the RM of Lac du Bonnet for agricultural purposes. This agricultural zoning designation is intended to provide a buffer around the Town of Lac du Bonnet. The zoning designations allow a full range of agricultural activities, however, only existing livestock operations can be expanded (RM of Lac du Bonnet 2016). Other areas west of the Winnipeg River have been designated for mixed use, including residential and rural uses. Rural residential zones are low-density residential developments that use on-site waste management facilities, while residential areas allow for single-family and multi-family dwellings. There is conditional allowance of commercial resorts in these zones (RM of Lac du Bonnet 2016).

On the west side of the Winnipeg River, AECL permits agricultural use within the WL site lands. This land is in the LGD of Pinawa and comprises the majority of agricultural property in the LGD (LGD of Pinawa 2004).

6.8.4.2.2.3 Forestry

To the south and west of the WL site, in the RM of Lac du Bonnet is the Agassiz Provincial Forest. Provincial forests were established as a source of sustainable timber supply (Manitoba Conservation n.d.). The Agassiz Provincial Forest is approximately 795 km^2 in size. It is also used for peatmoss extraction and snowmobile trails.

Forestry has historically been important to the region, but there has traditionally been little forestry activity near the WL site (AECL 2001). Since the previous Comprehensive Study Report (AECL 2001) was filed, the forestry industry has decreased. Tembec, which owned and operated the Pine Falls Mill in Powerview-Pine Falls, stopped production there in 2009 and permanently closed the facility in 2010; Tembec later sold the site (Tembec 2011). Overall, the forestry industry in Manitoba has shrunk due to a variety of factors, including the collapse of the US housing market in 2006 and the closure of multiple mills in the province (Manitoba Conservation and Water Stewardship 2012c).

6.8.4.2.2.4 Mineral Claims and Leases

There are quarry permits to the northeast and southwest of the WL site and several quarry withdrawals in the area, including near the northeast boundary of the WL site. There are no other mineral claims or leases in proximity of the WL site (Manitoba Growth, Enterprise and Trade n.d.).

6.8.4.2.2.5 Water Use

There are multiple municipal water rights licences and an irrigation water rights licence for the Winnipeg River in the RSA. The municipal water rights licences are held by the Town of Lac du Bonnet and Pinawa, along with various water co-ops and a residential development (Manitoba Sustainable Development 2017). The WL site also draws water from the Winnipeg River. Water from the Winnipeg River is likely also used for domestic purposes as there are residences along the shore, but water withdrawals of less the 25,000 litres (L) per day do not generally require licensing.

6.8.4.2.3 Outdoor Recreation and Tourism

The WL site is in eastern Manitoba west of the Whiteshell Provincial Park on the Winnipeg River. The region is popular for cottagers and campers as it is the gateway for access to a number of Provincial Parks, including Old Pinawa Dam Provincial Park, Nopiming Provincial Park and the Whiteshell Provincial Park. The area around the WL site, including Pinawa, along with the Town and RM of Lac du Bonnet are important areas for outdoor recreation and related cottaging and tourism in southern Manitoba. Section 6.9.4.2.3 Employment and Income discusses the economic impact of cottaging and tourism for Pinawa and the Town and RM of Lac du Bonnet, which is an important economic driver for all three municipalities.

Pinawa is located adjacent to the boundary of the Whiteshell Provincial Park and offers many outdoor activities to year round and seasonal cottage residents including sailing, canoeing, fishing, hiking, swimming, golfing, snowmobiling and cross country skiing (LGD of Pinawa 2016a). Whiteshell Provincial Park is a four-season park that boasts rushing rivers, clear deep lakes, and sandy beaches. There are numerous self-guided hiking trails, canoe routes, camp grounds, picnic areas, among other amenities (Manitoba Sustainable Development n.d.c). Pinawa also has a number of tourist attractions that draw visitors to the area including the Pinawa Heritage Sundial, the Pinawa Suspension Bridge, and Pinawa's section of the Trans Canada Trail which includes the Pinawa Channel Heritage Walk, the Ironwood Trail, and the Alice Chambers Trail which is internationally recognized as Manitoba's Pine to Prairie Birding Trail (LGD of Pinawa 2016b). The Pinawa Dam Provincial Park, showcasing concrete ruins, highlights the first hydroelectric power dam in Manitoba including interpretive signage, self-guiding interpretive brochures, an amphitheatre, the Heritage Walk Picnic Shelter, picnic facilities, Centennial Spillway Trail and bridge access to an interpretive nature trail (Pinawa Community Development Corporation 2016).

Pinawa has a local beach, two launching ramps for powerboats and watercraft, a boat marina, and canoe rentals. The Pinawa Channel, between the diversion dam and the suspension bridge, is popular for tubing and provides exceptional canoeing and kayaking through to the Pinawa Dam Provincial Park. The Pinawa Rowing and Sailing Club are located near the marina and offer lessons, equipment for members and accommodation for non-motorized watercraft (Pinawa Community Development Corporation 2016).

The Winnipeg River, including the stretch from the WL site downstream to the Town of Lac du Bonnet is lined with residential developments, which include year-round and seasonal residences. The other waterways in the RM of Lac du Bonnet, including Lac du Bonnet and the Lee River also attract seasonal residents who want to remain relatively close to a population centre and still enjoy a rural lifestyle. During the KPI Program, it was noted that

many people who decide to eventually move to either the Town or RM of Lac du Bonnet originally spent their summers in the area (WR-1 Decommissioning Project KPI Program 2016).

There are three marinas on the Winnipeg River in the RM of Lac du Bonnet. The LaVerendrye Boat Launch at the north end of the Town of Lac du Bonnet on Provincial Route 520, one on the east side of Provincial Route 313 and the Winnipeg River Bridge and the board launch at Roadside Park, which is off Highway 11 north, 15 km away from the Town of Lac du Bonnet.

6.8.4.2.3.1 Sport Fishing

Sport fishing is popular in the region due to the number of waterways, which include the Winnipeg River and the Lee River. Major species include walleye, northern pike, sturgeon, smallmouth bass, mooneye, sauger and channel cat fish. These species are common in the region and are known to have stable populations (WR-1 Decommissioning Project KPI Program 2016). The WL site is located in the Southern Division, which includes all of southern Manitoba. The fishing season is generally closed from the beginning of April through to mid-May annually and typically opens on Saturday before the long-weekend. Catch limits vary by species and for some species also vary by fish size. Lake sturgeon also occur in the Winnipeg River near the WL site and favour the outfall of the WL site, because lake sturgeon is a protected species, it must be released if caught (AECL 2001).

Fishing locations on the Winnipeg River vary by the species desired by an angler. Popular locations include the Town Pier in Lac du Bonnet, the Winnipeg River Bridge and the dike along Highway 11, “Pickerel Point” (located upstream of the town of Lac du Bonnet where there is a constriction in the river), and near the McArthur Falls generating station (WR-1 Decommissioning Project KPI Program 2016). It is also possible to ice fish around Lac du Bonnet (Town and RM of Lac du Bonnet 2012).

Individuals interested in fishing on the Winnipeg River near the Town of Lac du Bonnet are able to do so in their own boats or there are outfitters who offer guiding services on the Winnipeg River. Fishing guides in the area are popular with American and Manitoban tourists, and the species pursued are dependent on the interests of the fishers.

6.8.4.2.3.2 Outfitting

Outfitters are located in and around Pinawa, the Town of Lac du Bonnet, Point Du Bois, and Eriksdale. These outfitters provide black bear, whitetail deer, wolf, and waterfowl hunts, while others offer local trophy fishing trips and fly-in fishing expeditions to Atikaki, Nopiming and Whiteshell Provincial Parks (Hoards Hunting Camps 2011-2016, Jackson’s Lodge and Outposts n.d, Trail End Camp and Outfitters 2016, Agassiz Outfitters 2016, Eagle Nest Lodge 2016, Big Track Outfitters 2016). Outfitting activities tend to be geared towards a client’s interests, and will vary accordingly (WR-1 Decommissioning Project KPI Program 2016).

6.8.4.2.3.3 Hunting

The WL site is located in Game Hunting Area (GHA) 26 (Figure 6.8.4-1). White-tailed deer hunting in the area around the WL site, especially northwest of the Project, is popular (WR-1 Decommissioning Project KPI Program 2016). General rifle hunting season for white-tailed deer in GHA 26 is open November 14 through to December 18 with the bag limit of one buck (antlered) deer per licence per year. Deer muzzleloader and deer general rifle seasons have been extended in GHA 26 and 36, an area directly south of GHA 26 along the Manitoba-Ontario border (Manitoba Sustainable Development 2016b). This season extension has been implemented to reduce white-tailed deer numbers; additionally GHA 26 is one of the few areas to offer a second and third purchase of deer licences for Manitoba residents who are Canadian citizens. The effort to reduce white-tailed deer numbers

is driven by the brain worm and liver fluke parasites carried by white-tailed deer that negatively affect the struggling moose population (Manitoba Sustainable Development 2016b).

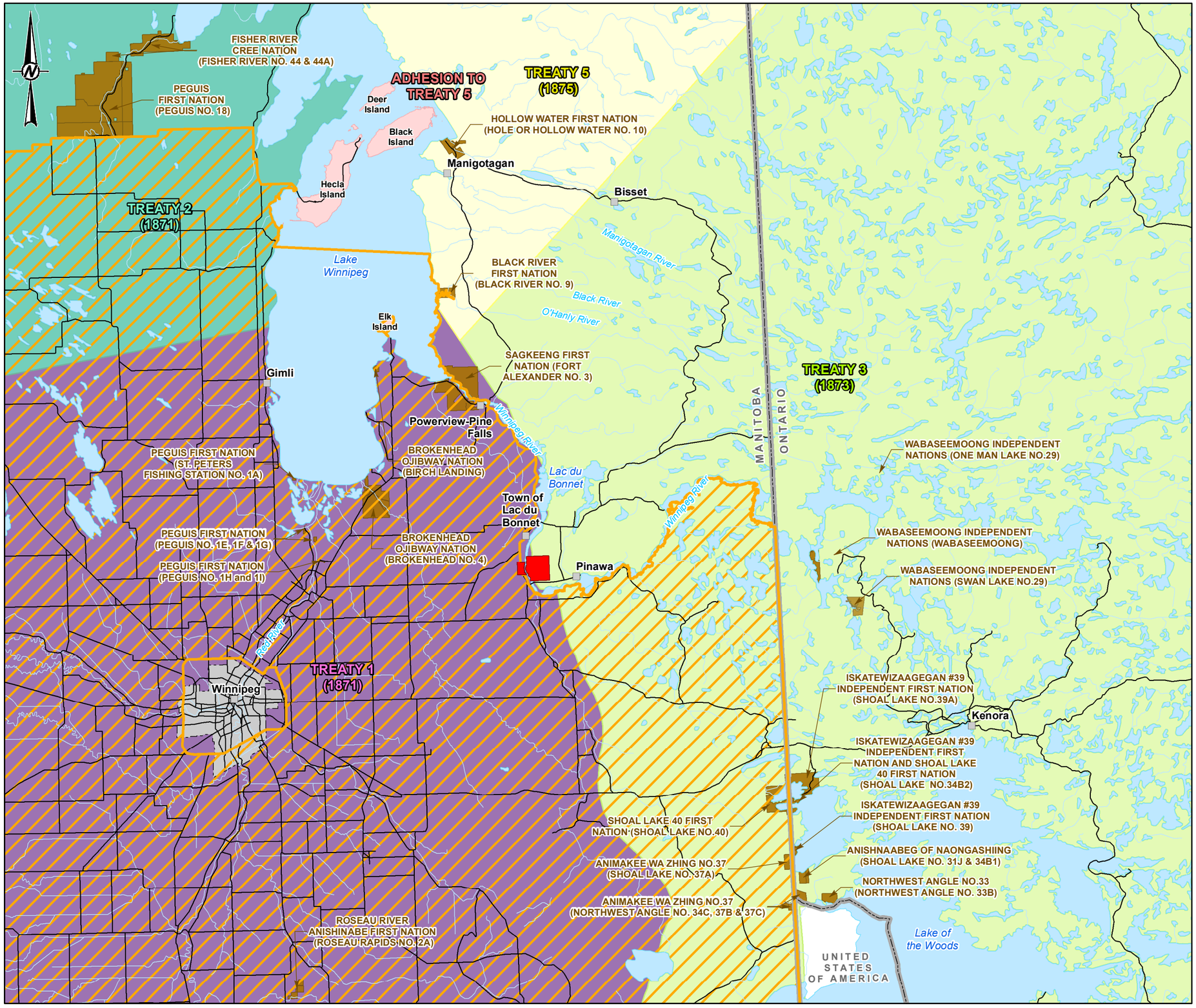
Upland game birds and migratory waterfowl are also hunted, with a population of rough grouse and sharptail grouse noted in proximity to the site. Grouse season is open between early September through to mid-December, with a daily bag limit of six, and possession limit of 12. Migratory bird seasons vary by species, but are typically open between September 1 and November 30, with daily limits for eight ducks, coots, and dark geese and possession limits of 24. Snow geese have a daily limit of 50, and no possession limited. (Manitoba Sustainable Development 2016b).

Moose populations in the southeast region of the province are known to be rapidly declining due to disease and overhunting. In an effort to allow moose population levels to recover, cancellation of all licensed moose hunting seasons are in effect for 13 of the GHAs across the province, including GHA 26. A partial area closure for all licensed hunters and rights-based hunters, including First Nations, has been implemented north of the Black River to the northern boundary of GHA 26. In addition to prohibiting hunting, Manitoba Sustainable Development is researching and implementing other programs to aid in moose population recovery. One of two wildlife biologists hired by the Province to implement moose recovery programs is located in the Town of Lac du Bonnet. Other programs established to aid in moose population recovery include extension of the white-tailed deer hunting season and wolf trapping season, increasing staff dedicated to enforcement, establishing moose management committees, and engagement with Indigenous communities (Manitoba Sustainable Development 2016b).

Black bear hunting in GHA 26 is limited to Manitoba residents who are Canadian citizens and opens April 25 to June 19 with a bag limit of one adult black bear. Females with cubs may not be taken and Manitoba Sustainable Development puts forth detailed description on how to identify female black bears in their annual Hunting Guide (Manitoba Sustainable Development 2016b).

A gravel pit located just northeast of the LSA is a popular staging point for resource use activities (Manitoba Sustainable Development 2016b). Hunting within the WL site is prohibited due to safety concerns.

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LEGEND

- WHITESHELL LABORATORIES SITE

BASE FEATURES

- CITY/TOWN
- PROVINCIAL BOUNDARY
- MAJOR ROAD
- WATERCOURSE
- WATERBODY
- FIRST NATION RESERVE
- METIS HARVESTING AREA

TREATY BOUNDARIES

- TREATY 1 (1871)
- TREATY 2 (1871)
- TREATY 3 (1873)
- TREATY 5 (1875)
- ADHESION TREATY 5

0 20 40 60
1:1,000,000 KILOMETRES

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. METIS HARVESTING AREAS - BIG GAME HUNTING AREAS DEVELOPED BY MANITOBA WILDLIFE MANAGEMENT AREAS, PROVINCE OF MANITOBA
4. TREATY BOUNDARIES - HISTORIC FIRST NATIONS TREATIES IN CANADA DELEVOPED BY GLOBAL FOREST WATCH, WORLD RESOURCES INSTITUTE, 2000
5. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
TREATY AREAS AND METIS HARVESTING AREA

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE/PR
REVIEWED	JO/CB
APPROVED	

PROJECT NO.	CONTROL	REV.	FIGURE
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6.8.4.2.3.4 Trapping

There are no registered traplines (RTL) in the WL site. Registered trapline 23 runs along the southern border of the site (Figure 6.8.4-1). The holder of the RTL is active and traps a variety of species, including marten, red fox, otter, fisher weasel, muskrat and mink. There are no other RTLs that share a boundary with the WL site. The majority of RTLs are east of the WL site in the Whiteshell Provincial Park.

6.8.4.2.3.5 Winter Activities

Outdoor winter activities in Pinawa include skating, snowmobiling, ice fishing, bird watching, snowshoeing and hiking. Whiteshell Cross Country Ski Club maintains over 40 km of ski trails and 24 km of Trans Canada Trail throughout the winter. SnoMan (Snowmobilers of Manitoba) actively maintains trails all through Pinawa and the Town and RM of Lac Du Bonnet.

6.8.4.2.4 Archaeological and Cultural Sites

A review of the documented archaeological site data from the Government of Manitoba's Historic Resources Branch, Sport, Culture and Heritage provided the following cultural overview. As no site can be examined in isolation, archaeological sites recorded within 5,000 m (5 km) of the Winnipeg River, from the Manitoba/Ontario border to the mouth were reviewed to consider the wider landscape and establish the wider context of contemporary sites in the broader region.

Human occupation of the Winnipeg River system most likely began after the meltwater of glacial Lake Agassiz drained from the area *ca*. 8,500 years ago, prior to that the area was covered by the Late Wisconsinan ice sheet (MAS 1998; Teller and Clayton 1983; Steinbring 1980; Bowe 1999). A cultural chronology or time line has been created, which is based on technological innovations and historical happenings. The chronology comprises two major time periods: Pre-European Contact and Post-European Contact. These are further divided into Early (Paleo-Indian [Northern Plano]), Middle (Archaic [Shield, Plains]) and Late (Woodland [Initial, Terminal]) sub-periods.

Human movement in the Winnipeg River system possibly began during the Paleo Indian Period (*ca*. 11,000 to 7,000 years ago) after the continental glacier and associated glacial Lake Agassiz retreated from the area approximately *ca*. 8,500 years ago (MAS 1998; Teller and Clayton 1983). During the period of deglaciation and meltwater drainage, the plant succession progressed northwards, followed by a wide range of animal species and by people. These semi-nomadic people were big game hunters, whom archaeologists refer to as the Plano (Pettipas 1984). Archaeological sites from this period are represented by solely lithic assemblages, which include slender leaf-shaped points, knives, scrapers and other tools. Over 30 registered archaeological sites within 5,000 m of the Winnipeg River system have been identified as being occupied during the Paleo-Indian Period.

Several important cultural adaptations are found within the Middle Period, including the appearance of notched or stemmed projectile points, end scrapers, adzes and other cutting implements (OAS 2011). The appearance of new style projectile points and the introduction of the atlatl (a spear extender, which provided leverage to the spear thus increasing the velocity and accuracy of the projectile) suggest adaptive technological changes for procuring food resources. Raw materials used by the Archaic period people became much more diverse, including the appearance and use of native copper which was used for making tools and adornments. The range of dates suggests cultural interaction and movement across a vast landscape (Wright 1972). Culturally, this was a society of hunters, fishers and gatherers whose members subsisted on a seasonally-diverse diet of large game, fish and local plants (Wright 1972, Kennett and Winderhalder 2006). The lithic tool kit included plains grasslands projectile point/dart forms such as Logan Creek (*ca*. 500 - 6,500 years ago), Oxbow (*ca*. 3,500 – 5,300 years ago),

McKean (*ca*. 2,800 – 3,200 years ago) and Pelican Lake (*ca*. 1,600 – 3,200 years ago), along with stone knives and scrapers. However, most Shield Archaic projectile points were “home-grown” stemmed and side-notched variants. An Archaic occupation is represented at over 80 sites along the Winnipeg River. Ancient copper mines located at Isle Royale on Lake Superior have been identified as the source material for projectile points within the southern part of Manitoba (Wright 1972, Steinbring 1980, Bouge 2007), to which at least seven sites have been documented along the Winnipeg River.

The introduction of native clay pottery marks the differentiation between the Woodland (*ca*. 3,000 to 360 years ago) (Wright 1972) and Archaic periods. The Eastern Woodland Tradition has shown to have first developed in eastern North America and moved westwards. In Manitoba, the Woodland Period is further divided into two temporal periods, Middle and Late, which is based on vessel construction and stylistic attributes.

The Middle Woodland people using pottery in Manitoba are represented by the Laurel Culture (*ca*. 2,700 to 1,000 years ago) and the type of ceramic ware produced during this time period. Pottery was conical in shape, manufactured using a coiling method and was decorated with various stamping techniques and incised design. The Laurel lithic toolkit consisted of a variety of lithic tools including triangular projectile points and copper awls and beads (Stoltman 1973). The Middle Woodland Culture is also characterized by people representing a shift from a reliance on grassland to forest and aquatic resources, including fish and wild rice harvesting (MAS 1998).

The Late Woodland Tradition contains several important pottery types that represent local variations that made them distinctive. Although pottery construction is believed to use similar techniques, there are signature differences within this tradition. For the Winnipeg River study area, Blackduck, Minontoba and Selkirk pottery styles are the three main derivatives (Hyslop 2014, 2012). The peoples associated with these types of pottery constructed globular shaped vessels made from masses of wet clay, using a lamination technique. Archaeologists believe that these pots were pre-formed in a woven bag that left a distinct fabric impression on the exterior. Vessel rims, necks and lips were embellished with combinations of design attributes such as decorative punctates, small cord-wrapped-stick impressions, or incising (OAS 2011).

Lithic tools associated with the Late Woodland Tradition include small triangular and side-notched projectile points, stone drills and smoking pipes (Wright 1972). Over 200 sites along the Winnipeg River contain the cultural materials of a Woodland occupation.

The largest concentration of petroform sites in Manitoba is found within the Winnipeg River’s drainage system (Steinbring 1980). These rock mosaics were created by placing stones and/or boulders on bedrock surfaces to achieve the desired outline, usually human or animal effigies. There has been no success in assigning these cultural features to a particular time period. However, there is a direct link between the people of the Late Pre-Contact Period and the Anishinaabe who continued to use and occupy this area, and who continue to use some of the major petroforms in their ceremonies (Manitoba Sustainable Development n.d.d). There are over 20 documented sites comprised of boulder foundations within 5,000 m of the Winnipeg River.

With guidance from the local Aboriginal people who had well-established trade routes for thousands of years, French explorers and early traders first gained entry into the interior by way of the Winnipeg River (Steinbring 1980). With the help of Auchagah, a Cree guide, La Vérendrye identified the Winnipeg River as a trade route and established fur trade forts near native camps throughout the area, including Fort Maurepas (1735) (Burpee 1927). Gradually European trade goods filtered into the local Aboriginal settlements and traditional products, such as clay pottery and stone tools were generally replaced by copper and brass pots, metal knives and guns.

The Winnipeg River became an important travel route in accessing lands west of the Great Lakes (Rich 1967; Burpee 1935). With the granting of a charter in 1670 to the London, England based Hudson's Bay Company (HBC) the commercial fur trade began and a long term relationship with local Aboriginal people was established. Aboriginal individuals and groups acted as traders and middlemen and undoubtedly benefited from the increased competition between the HBC and the Montreal-based independents, which were generally referred to as "les Canadians." In 1779, the Montreal traders formed an organization to reduce expenses and ease the rivalry between traders, which became the North West Company. Later on, the intense rivalry between the Hudson's Bay Company and the Northwest Company for control the fur trade sparked the establishment of numerous trade houses in close proximity to one another; this had the effect of increasing the trading opportunities for Aboriginal trappers. Fort Bas de la Riviére was established by the Northwest Company in 1792 at the mouth of the Winnipeg River. The HBC built Fort Alexander in 1795 to counter the Northwest Company post.

Extreme demands in Europe for fur coats and beaver hats and the intense competition between the two companies led to a severe depletion of the fur resources. In 1821, the social and financial stress of both the Hudson's Bay Company and North West Company resulted in the companies amalgamating under the banner of the Hudson Bay Company, a fur trading monopoly resulted that covered one-quarter of North America. Reorganization caused closure of numerous unprofitable posts and outpost, affecting local employment opportunities.

According to the site database, cultural materials of the historic period have been documented at over 50 sites along the Winnipeg River. This is most likely an inaccurate representation as material culture from Pre-European Contact Periods would take precedence in recording value.

During the early twentieth century, physical changes to the Winnipeg River began with the construction of the hydroelectric dams. Hydro development began on the Winnipeg River in 1903 with the construction of the Pinawa Dam, completed in 1906. Subsequently six more dams were constructed, Pointe du Bois (1926), Great Falls (1928), Slave Falls (1948) Seven Sisters (1952), Pine Falls (1952) and McArthur (1955) (Manitoba Hydro n.d.). The Pinawa Dam ceased operation in 1951 and has since been designated a Provincial Heritage Site (Manitoba Sustainable Development n.d.e).

6.8.4.2.4.1 Archaeological Sites

The tangible history of the Winnipeg River is documented by physical artifacts and features that are distributed over the landscape. Much of this rich history was recorded by archaeologist Anthony Buchner, who conducted a two year archaeological investigation of the waterway between Great Falls to McArthur Falls and Seven Sisters to Sturgeon Falls. The cultural materials collected during the Winnipeg River Archaeological Project (1980 to 1982) documented a human occupation dating back to the Late Paleo Indian Period (*ca*. 8,500 to 6,000 years ago) (Buchner 1982a).

A review of the registered archaeological site data provided by the Historic Resource Branch reveals the presence of 434 sites within 5,000 m of the Winnipeg River spanning from the Manitoba/Ontario border to the mouth at Lake Winnipeg. While there are no documented archaeological sites within the WL property boundary, it should not be assumed that sites are not present as the Sieg Serpent Site (formally called Sweet Creek Petroform) is located approximately 1,700 m south of the property (AECL 2001). In addition, three important sites can be found approximately 3,500 m south at the confluence of the Whitemouth and Winnipeg Rivers. Excavated in the 1960s and 1970s by Dr. Jack Steinbring, sites EaLa-01, 02, 03 (Whitemouth Falls Site, Porth Site, Bjorkland Site) comprised of multi-component campsites and burial mounds indicate that the area was frequented as much as 5,000 years ago. (Pettipas 2015; Buchner 1982b).

6.8.4.2.4.2 Historical Sites

One provincially recognized historic site, the Pinawa Dam Provincial Heritage Park, is located with the 5,000 m of the Winnipeg River. This park is under the management of Manitoba Sustainable Development. During the construction of the amphitheatre Historic Resources Branch staff conducted some archaeological investigations, and a cultural component related to the dam construction was identified. The site was assigned an archaeological site designation (AECL 2001).

6.8.4.2.5 Traditional Land and Resource Use by Aboriginal People

The Project is located on Treaty 3 land, while the overall WL site which extends west of the Winnipeg River falls on Treaty 1 land. Communities that form part of these Treaties and Treaty 5 also have historical and current land use ties with the area. Anishinaabe and Ojibway communities with historic traditional territories that have expressed some level of interest in the Project include the Sagkeeng and Brokenhead First Nations in Treaty 1; Black River and Hollow Water First Nations in Treaty 5; and Wabaseemoong Independent Nations in Treaty 3 (TRCM n.d.; Ontario Ministry of Aboriginal Affairs 2014).

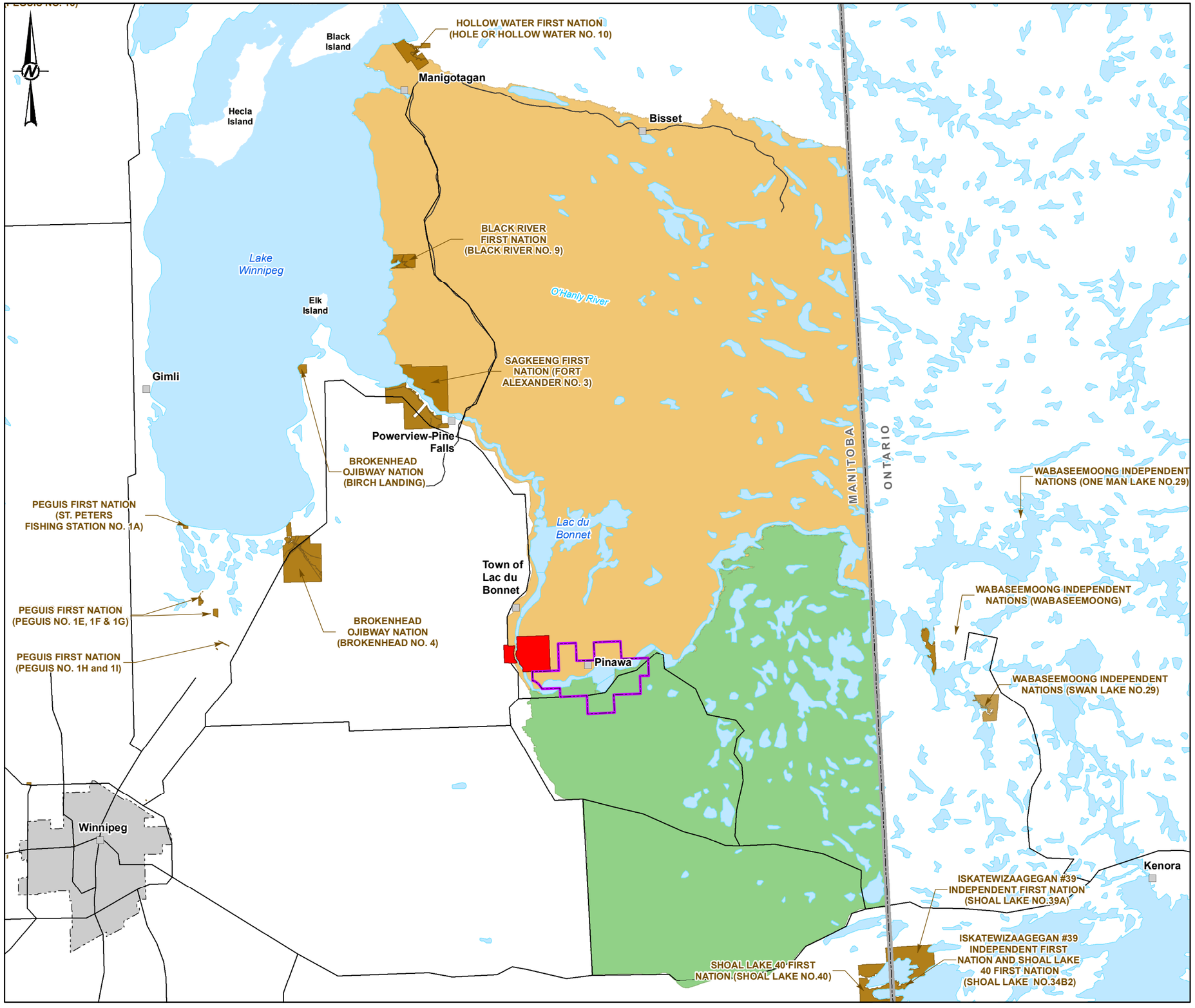
Community locations in vicinity to the WL site are described below and presented in Figure 6.8.4-2:

- **Sagkeeng First Nation**, an Anishinaabe community, is the closest Aboriginal community to the WL site. Sagkeeng reserve land is located 66 km directly downriver from the WL site and includes land parcels on either side of the Winnipeg River.
- **Brokenhead Ojibway Nation** is located near the southern basin of Lake Winnipeg, 73 km from the WL site. Brokenhead is primarily surrounded by the RM of St. Clements.
- **Black River First Nation** is an Ojibway community located along the eastern shoreline of Lake Winnipeg at the confluence of the Black and O'Hanly Rivers. The Black River reserve land is 92 km from the WL site and 36 km north of Fort Alexander.
- **Hollow Water First Nation**, an Anishinaabe community, is located along the eastern shore of Lake Winnipeg approximately 75 km north of Pine Falls, 136 km north of the WL site.
- **Wabaseemoong Independent Nations** is comprised of four communities, Whitedog First Nation, serving as the main reserve parcel; One Man Lake; Swan Lake and Agency 30 (shared with 12 other First Nations). The main reserve is located along the English River system approximately 53 km northwest of Kenora, Ontario, approximately 16 km east of the Manitoba-Ontario border and 78 km east of the WL site.

The Project is also located in the homeland of the Métis Nation, as represented by the Manitoba Métis Federation (MMF). While Statistics Canada identified Métis residents in many communities in proximity to the Project, Métis communities that historically emerged in the region include:

- **Bas de la Rivière –** this Métis community first became known as Fort Alexander and then eventually Pine Falls. Situated on both shores of the Winnipeg River and established in 1732, the community served as a wintering post and trading depot. Fishing and agriculture were particularly important in the area. Originally a North West Company outpost, following amalgamation with the Hudson's Bay Company in 1821 the post lost its importance as a provisioning and transportation hub.
- **Berens River –** an initial trading post was built at the mouth of the river in 1814 and was a thriving Métis community until fishing was banned on Lake Winnipeg in 1970 as a result of mercury contamination.
- **Fort Alexander –** built by the Hudson's Bay Company on the Winnipeg River to counter the North West Company's Fort Bas de la Rivière, this post also had ties to the Métis in the area (Barkwell 2016).

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LEGEND

- WHITESHELL LABORATORIES SITE

BASE FEATURES

- CITY/TOWN
- PROVINCIAL BOUNDARY
- MAJOR ROAD
- WATERCOURSE
- WATERBODY
- FIRST NATION RESERVE
- REGISTERED TRAPLINE NO. 23

BIG GAME HUNTING AREA

- AREA NO. 26
- AREA NO. 36

0 20 40
1:700,000 KILOMETRES

NOTE(S)

REFERENCE(S)

1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. BIG GAME HUNTING AREAS - DEVELOPED BY MANITOBA WILDLIFE MANAGEMENT AREAS, PROVINCE OF MANITOBA
4. REGISTERED TRAPLINE NO. 23 - PROVIDED BY THE MANITOBA LAND INITIATIVE, 2017
5. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
GAME HUNTING AREAS AND REGISTERED TRAPLINES

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-13
DESIGNED	CGE
PREPARED	CGE/PR
REVIEWED	MM
APPROVED	

PROJECT NO. 1656897 | CONTROL | REV. 1 | FIGURE **6.8.4-2**

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6.8.4.2.5.1 Historic and Present Day Traditional Land Use

The First Nations within the area have resided at or near their respective reserve parcels since time immemorial (Sagkeeng Anicinabe n.d.). In the nineteenth century, First Nations living near Fort Alexander, present day Sagkeeng First Nation, were nomadic and would make frequent trips north to the Hudson's Bay post to trade and obtain food supplies (n.a. 2000). The Winnipeg River has historically provided a network of travel routes for local communities (Petch 2005). Present day traditional land and resource use activities, including trapping and wild rice harvesting, continue to supplement the diet and income of local First Nation communities in the RSA. Wild rice harvesting was originally for domestic purposes but eventually became a commercial economy (Manitoba Hydro and Golder Associates Ltd. 2012).

Sagkeeng First Nation

Sagkeeng's reserve is located where the Winnipeg River empties into Lake Winnipeg and their traditional territory encompasses land within Treaty 1 along with land north and west of the Winnipeg River, falling within four Treaty areas (Sagkeeng First Nation 2015). Sagkeeng First Nation is currently in Treaty Land Entitlement specific claims discussions with the Government of Canada (Sagkeeng Anicinabe n.d.).

The land and waterways have historically been an important part of the economic well-being and transportation system for the Sagkeeng First Nation. "A strongly held conviction among members is that the lands and waterways are the sustaining factors for all life. To members, the land and waters are indivisible and anything that is done to either will have far reaching effects for all life" (Sagkeeng First Nation 2015). Sagkeeng First Nation members historically travelled southwest along the Winnipeg River throughout the summer to the Rainy River area in Ontario to fish and make medicine. In early spring and late fall, fishing was preferred near Catfish Creek and at Point au Mitasse on Lake Winnipeg (n.a. 2000). Travel in the fall was typically to the Lac du Bonnet area, where the Pinawa Channel meets the Winnipeg River, to harvest wild rice (n.a. 2000). Family units had preferred hunting areas which included areas close to Fort Alexander and spanned north to Black River First Nation and over 200 km southeast to Dalles and Big Island First Nations in Ontario (n.a. 2000). Previous studies have confirmed that Sagkeeng First Nation participates in traditional activities of harvesting wild rice, sturgeon fishing, gathering plants and medicines and berry picking (AECL 2001). Members of Sagkeeng First Nation continue to have a fundamental attachment to the physical environment, lands and waterways, as a way of life (Sagkeeng First Nation 2015). Sagkeeng First Nation currently uses the Winnipeg River as its source for water supply to the community (Penn-Co Construction n.d., J.R. Cousin Consultants Ltd. n.d.).

During the engagement process for the Project, Sagkeeng First Nation identified several interests and concerns in traditional to land and resources use (further details are provided in Section 4.3.2.1). These issues are not always specifically linked directly to the Project, but rather the overall operation and closure of the WL site; however, due to their overall importance to the community they are noted herein:

- Concerns about the long term effects of the WL site and the Project on water quality and fish. There is a perceived deterioration of fish quality in the Winnipeg River, which may in part be attributed to the paper mill that previously operated in Pinefalls-Powerview.
- An interest in fish monitoring at locations in proximity to the community.
- Wild rice and medicinal plants (calamus root, Laborador tea, wild ginger, and waterlily roots) collected by Sagkeeng First Nation members are present in the Whiteshell area.

- Concerns about the transport of nuclear materials, particularly in the event of an accident and associated contamination within their traditional territory.
- Interests regarding future land use in relation to the overall site closure.

Brokenhead Ojibway Nation

Brokenhead resource harvesters currently use traditional areas north of the Manigotogan River and as far south as the RM of Brokenhead (Brokenhead Ojibway Nation 2015). This traditional use area spans Treaties 1, 3 and 5 (TRCM n.d.). Brokenhead Ojibway Nation resource harvesting activities occur within wildlife management areas, parks and within reserve boundaries. Resource harvesting sites within this area include locations along the Winnipeg and Brokenhead Rivers (Brokenhead Ojibway Nation 2015). Current resource harvesting activities include, but are not limited to, moose hunting and trapping for muskrat and beaver (Brokenhead Ojibway Nation 2015). Brokenhead continues to address outstanding Treaty Land Entitlement specific claims discussions with the Province of Manitoba and Government of Canada. Included in these discussions is the selection of land within the Whiteshell Provincial Park Petroform area located east and south of Pinawa (Brokenhead Ojibway Nation 2015).

Brokenhead Ojibway Nation identified the following interests and concerns during the engagement process (further details are provided in Section 4.3.2.2). These issues are not always specifically linked directly to the Project, but rather the overall operation and closure of the WL site; however due to their overall importance to the community are noted herein:

- Traditional and cultural perspectives are important in relation to the Project.
- Interests regarding future land use in relation to the overall site closure.
- Concerns regarding water quality, particularly as waters flow from the east, from the west, into the Winnipeg River system, and into Lake Winnipeg. The watershed extends all the way to Hudson Bay.
- Concerns about contamination in the Winnipeg River and a distrust in monitoring results and the ability to predict future effects were expressed.
- Concerns about potential impacts to wildlife and to human health.

Black River First Nation

The Black River First Nation's traditional lands are primarily located south of the Manigotogan River, west of the Manitoba-Ontario border, and north of the Winnipeg River in Treaties 3 and 5 (Handkamer 2016, TRCM n.d.). Prior to the 1940s, Black River First Nation members participated in cattle ranching along with horses and hay fields, established in proximity to the community, which were important activities for the community (Black River 2015). In the following years members of Black River maintained an economy based on commercial fishing, logging and cutting cord wood (Black River 2015).Traditional resource use has historically been and continues to be important to members of Black River. Resource use activities include hunting, fish, trapping, wild rice harvesting and plant collection both a far a field and near the community (Black River 2015). Members of Black River have historically used the Black and Winnipeg Rivers most frequently for travel (Handkamer 2016). The Black River served as an access route for resource harvesting in the east, specifically wild rice harvesting and hunting near Nopiming Provincial Park (Handkamer 2016). Black River First Nation is currently pursuing a claim with the federal government regarding the Treaty 5 Disparity Claim concerning per capita reserve land allotment and the lack of free and informed consent to this disparity at the time of the later adhesion to Treaty 5 document (Maurice 2016; Manitoba Keewatinowi Okimakanak Inc. 2012).

During the engagement process for the Project, Black River First Nation identified several interests and concerns in traditional to land and resources use (further details are provided in Section 4.3.2.2). These issues are not always specifically linked directly to the Project, but rather the overall operation and closure of the WL site; however due to their overall importance to the community are noted herein:

- The petroforms given to the Black River First Nation by Nanabush are present in the Whiteshell area.
- Black River First Nation holds ceremonies in the Whiteshell area during the period of the Harvest Moon.
- Wild rice was identified as a dietary staple.
- Concerns were expressed about water quality and contamination of the Winnipeg River.

Hollow Water First Nation

Hollow Water's traditional lands encompass an area south of the Bloodvein River, west of the Manitoba-Ontario border, and north of the Manigotagan River in Treaties 3 and 5 (TRCM n.d.). Historically Hollow Water's primary food source and economy was based on wild rice harvesting on the Wanipigow and Rice Rivers along with Clangula Lake and bays on Lake Winnipeg (Thompson and Bushie 2015). The woodlands were used for hunting and trapping in the winter, fishing along the shores of Lake Winnipeg was popular in the spring, and wild rice was harvested on the shallow rivers and lakes in the fall (Reder 2013). Hollow Water community members currently maintain the historic tradition of gathering on Black Island to harvest blueberries. Economic activities for the community currently include fishing, hunting, trapping and wild rice harvesting. Fishing is considered the most important of these activities as a majority of community residents are directly employed in the Lake Winnipeg fishery (Manitoba Eco-Network 2010). Hollow Water First Nation does not have any outstanding Treaty Land Entitlement claims (SERDC 2016).

Hollow Water First Nation identified the following interests and concerns during the engagement process (further details are provided in Section 4.3.2.2). These issues are not always specifically linked directly to the Project, but rather the overall operation and closure of the WL site; however due to their overall importance to the community are noted herein:

- Concerns about contamination of the soil and of the river were expressed.
- Concerns about fish.

Wabaseemoong Independent Nations

Wabaseemoong Independent Nations traditional land use area is located in Treaty 3 and is about 60 km wide and 120 km long spanning approximately 6,720 km^2 adjacent to the Manitoba – Ontario border, north of the Town of Kenora (WIN n.d.). The southwest boundary of the traditional land use area is established by the White Dog Parkway, approximately 50 km, which extends along Provincial Road 525 from the intersection of Highway 596. The Parkway continues north through White Dog reserve to the terminus at Caribou Falls located at the confluence of the English River system and the Winnipeg River system (WIN n.d.). This Parkway provides access to approximately one third of the Wabaseemoong Independent Nations traditional land use area and allows the only road access to the north (WIN n.d.). Wabaseemoong Independent Nations has historically used and currently utilizes the English and Winnipeg River systems for traditional land and resource use activities (Energy East Project 2015). Water routes from these two systems have provided resource use access to hundreds of kilometres in all directions (WIN n.d.). Previous discussions with Wabaseemoong Independent Nations, have confirmed interest in the area where traditional land and resource use activities regularly occur (AECL 2001).

Wabaseemoong Independent Nations identified the following interests and concerns during the engagement process (further details are provided in Section 4.3.2.3). These issues are not always specifically linked directly to the Project, but rather the overall operation and closure of the WL site; however due to their overall importance to the community are noted herein:

- Although not close to the communty by road, Whitedog is approximately 30 air miles from the site. Many of their members reply on the land – so even though they reside upstream, they are located downwind of the Project.
- Concern was expressed about air emissions, and in particular about the earlier operation of the WL site.
- Concern was expressed that animals do no obey the same sorts of boundaries as humans and could come into contact with hazardous materials.
- Concerns were expressed about fish, and how contaminants can accumulate in fish over time.
- Concerns were expressed about water quality – specifically about the release of hazardous and radioactive materials to the Winnipeg River.

Manitoba Métis

The Manitoba Métis community is widely dispersed throughout the province and highly mobile in regards to geographic extent of traditional resource use (Barkwell 2016). In September 2012, based on presently available historic research, the Manitoba Government implemented a harvesting agreement with the MMF that recognizes that Manitoba Métis possess collectively-held Métis Harvesting Rights, within the meaning of Section 35 of the *Constitution Act 1982* throughout a territory of approximately 750,000 km^2 in size (Supreme Court of Canada 2003, Provincial Court of Manitoba 2008; Government of Manitoba et al. 2012). Recognized Métis Natural Resource Harvesting Areas 36, 34 34B and 25A and Game Hunting Area 26, presented in Figure 6.8.4-1, are situated in the vicinity of the WL site (Manitoba Sustainable Development n.d.f). Métis resource harvesters may harvest throughout these areas on “all unoccupied Crown Lands in Manitoba and occupied provincial Crown lands, including provincial parks, wherever First Nation Members are allowed to harvest; and on any privately owned lands in Manitoba on which that Métis Harvester has been given permission by the owner or occupant, or Indian Reserve lands with permission of Band Council” (MMF 2013).

Métis traditional land and resource in the region generally consists of hunting, trapping, fishing as well as harvesting of plants. Plant harvesting has been undertaken for food, crafts and medicines and has included birch, cedar, dandelion, milkweed, berries, wood products, roots, nuts and mushrooms. These activities were typically undertaken in the summer months, and are known to occur in areas southwest of the Project. During the public and aboriginal engagement process, the MMF noted that their citizens’ place of residence did not always correlate with their resource use areas, as the population is mobile, and land use tends to be associated with where an individual learned to harvest. As such, their citizens often travel to other locations across the province when undertaking harvesting activities, which reflects the location in which they learned, e.g., whether their grandfather taught them.

With respect to hunting, Métis are known to have hunted and currently hunt deer across much of southern Manitoba, which has been documented south of WL site and east to the Ontario border. Other game known to be harvested include grouse, partridge, ptarmigan, waterfowl and rabbit. Métis trapping activities, most of which are undertaken for commercial purposes, have focused on beaver, coyote, fisher, fox, lynx, marten, mink, muskrat, otter, rabbit, raccoon, squirrel, weasel, wolf and wolverine. Moose, white-tailed deer and elk are also important game species for Métis resource harvesters (Manitoba Hydro 2016).

Additional information about the Manitoba Métis Federation's persecpectives as shared during the engagement process for the Project are found in Section 4.3.2.4.

6.8.4.2.6 Winnipeg River

As described in Section 6.4.2 Surface Water Quality, the Winnipeg River is considered to be a medium sized lowland river (AECL 2001). Its drainage area is approximately 150,000 km^2, originating in Ontario at Lake of the Woods. The Winnipeg River tributaries include the Rainy River (flows into the Lake of the Woods), Black Sturgeon River, English River, Bird River, Lee River, Whiteshell River, Whitemouth River and the Macfarlane River. There are six hydroelectric dams on the river, the closest approximately 7.5 km upstream of the WL site. These dams have extensively modified flow patterns in the river (AECL 2001). Adjacent to the WL site, the river is approximately 0.3 km wide and 7 m deep, and flows northerly between 436 cubic metres per second (m^3/s) and 1,842 m^3/s to Lake Winnipeg (2010 to 2015 average at Seven Sisters Generating Station; [Manitoba Hydro 2016]).

Historically, liquid effluent from the Active Liquid Waste Treatment Center (ALWTC) was discharged to the Winnipeg River via the process sewer at the sewer outfall located about 8 metres (m) offshore in approximately 5 m of water (AECL 2001). The Winnipeg River Task Force (1995) looked at potential sources of Winnipeg River water quality degradation near the community of Sagkeeng. The Task Force found that WL has not had an adverse effect on water quality in the Winnipeg River for downstream communities (AECL 2001). The task force included members from the Sagkeeng First Nation, Environment Canada, Indian and Northern Affairs Canada, and Health Canada.

The monthly average of water chemistry for 2011 to 2015 for the intake water at the WL site had concentrations of copper, iron, and lead exceeding the Manitoba Water Quality Standards, Objectives, and Guidelines (WQSOG; see Section 6.4.2.4.2.2 Surface Water and Sediment Quality). Phosphorous concentrations in the river also exceed the WQSOG and increased between 2011 and 2015. Recently, the Winnipeg River has been classified as meso-eutrophic (ECCC 2015). This indicates that nutrient levels are moderate, which may lead to plant growth and reduced water clarity. Samples collected upstream of the WL site (Pinawa) has consistently had cesium-137 and strontium-90 concentrations below the federal drinking water standard (see Section 6.4.2.4.2.2 Surface Water and Sediment Quality).

During the 2000 sediment investigation, the sediment downstream of the outfall was determined to be erosional, with a clay bottom covered in parts with sand, gravel, cobble, and boulders (AECL 2001). The highest measured Cs-137 level in a sediment sample during the 2000 study was 2,610 Bq/kg (AECL 2001). This exceeds the NSRDR Clearance Level of 100 Bq/kg for Cs-137. Although the activity level in the sediment at the K03 location is above NSRDR unconditional clearance level, it is well below a human external exposure level of concern 2.8×10^6 Bq/kg. It is also well below the Tier 2 ENEV for benthic invertebrates' value of 1.5×10^5 Bq/kg. The Cs-137 levels detected in the samples collected during routine monitoring at locations OFL, K03, K05, K14 and K23 from 2010 to 2015 were one to two orders of magnitude lower than the highest 2000 sample (CNL 2016a). Cesium-137 levels at all locations except OFL and KO5 were below the NSRDR Clearance Level of 100 Bq/kg. The activity at OFL has historically varied from less than 5 Bq/kg to 75,500 Bq/kg (CNL 2016a). Variation of activity is not unexpected for all samples due to the highly localized and spotty nature of the contamination in the river sediments. This variability is the likely reason for the unusually high Cs-137 activity noted in the K05 sample in 2015 (CNL 2016a).

As part of the routine monitoring at the WL site, river bottom sediments were collected from twelve locations along the Winnipeg River, ranging from 0.8 km upstream to 13.1 km downstream of the Outfall. In 2015, the gross alpha activity detected in the samples ranged from 214 to 410 Bq/kg (CNL 2016a). In five years prior, average minimums and maximums activities ranged from 268±14 to 520±35 Bq/kg. The alpha activity in these samples is due to naturally occurring isotopes such as uranium-238 (U-238) or thorium-232 (Th-232) and their progeny, as both upstream and downstream samples contain similar levels. All samples are below the NSRDR Clearance Level for naturally occurring U-238 and Th-232 of 1,000 Bq/kg (CNL 2016a).

The gross beta activity in sediment ranged from 488 to 781 Bq/kg in 2015 at the twelve sampling locations apart of the routine monitoring (CNL 2016a). The previous five years average minimums and maximums ranged from 390±94 to 2,128±1233 Bq/kg. The variability of the average maximum five year range is large due to extremely high concentrations measured in 2012 at K23 of 7,058 Bq/kg. Beta activity includes contributions from naturally occurring potassium-40 (K-40) and from Cs-137. The majority of the beta activity for all locations continues to be from naturally occurring K-40 (CNL 2016a). The NSRFR Clearance Level for K-40 is 10,000 Bq/kg.

The Winnipeg River supports a diverse fish community and affords spawning, rearing and foraging habitats. A total of 61 native species are reported for the river (Stewart and Watkinson 2004) and two species-at-risk are known to be present within the vicinity of the WL site: Lake Sturgeon (*Acipenser fulvescens*) and Carmine Shiner (*Notropis percobromus* [COSEWIC 2016]). Fish occurring within the study reach include species that are primarily resident (present year-round), as well as migratory (passing through). Fish habitat is generally similar throughout the assessment area.

The Town of Lac du Bonnet and Pinawa draw water from the Winnipeg River System and treat it at their water treatment plants (Province of Manitoba 2004; LGD of Pinawa 2015). Sagkeeng First Nation is the only First Nation in the socio-economic RSA known to draw water from the Winnipeg River for residential purposes (Penn-Co Construction n.d.; J.R. Cousin Consultants Ltd. n.d.).

6.8.5 Project Interactions and Mitigation

6.8.5.1 Methods

This section describes the process by which interactions between Project components and activities and land and resource use VCs were identified and evaluated. Potential effect 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 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 described. 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 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 Project. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. The next step in the analysis was the development of environmental design features and mitigation practices that could be incorporated into the Project to eliminate and/or reduce effects to land and resource use 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 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 pathway** – pathway is removed by environmental design features or mitigation such that the 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 Project effects or to the effects of other past, present 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 land and resource use VCs.

Environmental design features and mitigation that have been or could be incorporated into the 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 simple qualitative or semi-quantitative evaluation of the pathway were also not advanced for further assessment.

6.8.5.2 Results

Pathways through which all stages of the Project may interact with and result in changes to measurement indicators for land and resource use VCs is provided in Table 6.8.5-1.

Table 6.8.5-1: Pathways Analysis for Land and Resource Use Valued Components

WR-1 Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Overall activities associated with WL site preparation, In Situ Decommissioning of WR-1 and above-ground facilities	■ Changes to outdoor recreational activities and tourism resulting from changes to vegetation, fish and wildlife and their habitats, and surface water quality in the Winnipeg River. ■ Changes to traditional land use resulting from changes to vegetation, fish and wildlife and their habitats, and surface water quality in the Winnipeg River.	■ The Project footprint is located in an already disturbed area. ■ Temporary supporting infrastructure will be located within the LSA (i.e., previously disturbed and developed area). ■ Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the RSA will be used during decommissioning activities around disturbed areas, where appropriate. ■ Project activity will typically be limited to daytime hours, where possible, and noise will be short-term and sporadic. ■ Decommissioning of the WR-1 Building will be completed in a controlled manner, and no blasting will be required. ■ Implementation of CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring, air verification monitoring and environmental monitoring. ■ As part of CNL's licence with the CNSC, environmental monitoring around the WL site is required and will continue for the Project. ■ Follow-up monitoring during the post-closure phase will be completed to verify effects predictions and to provide information for use in adaptive management to address potential unforeseen effects.	Secondary

Table 6.8.5-1: Pathways Analysis for Land and Resource Use Valued Components

WR-1 Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
	■ Nuisance factors such as dust and noise may affect the desirability of engaging in traditional land and resources use. ■ Nuisance factors such as dust and noise may affect the desirability of engaging in outdoor recreational or tourism activities.	■ Access to the WL site is restricted for any resources use. ■ Implementation of CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring, air verification monitoring and environmental monitoring. ■ Road watering and chemical dust suppressant when necessary. ■ Use of enclosure for raw material handling. ■ Decommissioning activity will be limited to daytime hours and noise will be short-term and sporadic. Decommissioning of the WR-1 Building will be completed in a controlled manner, and no blasting will be required.	No linkage
	■ Project activities could affect unidentified or unknown heritage resources.	■ Implementation of the Environmental Assessment Follow-up Program which describes the commitment to protection and preservation of cultural and archaeological sites. ■ If Project activities occur outside of previously disturbed areas of the WL site, especially near the Winnipeg River, an archaeologist will be available to monitor Project activities and assess the importance of any finds. ■ Per the *Heritage Resources Act*, if unanticipated heritage resources are encountered during Project activities, the following will apply: ▪ all Project activity in the immediate vicinity will cease; ▪ the Heritage Resources Branch will be contacted; ▪ based on the information provided, a mitigation plan will be formulated and implemented in consultation with the Heritage Resources Branch; and ■ Project activity at the site can resume only after the Heritage Resources Branch has granted permission.	No Linkage

Table 6.8.5-1: Pathways Analysis for Land and Resource Use Valued Components

WR-1 Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Installation of engineered cover over Grouted WR-1 Area and Final WL site Restoration	■ The use of ISD as the decommissioning method for the WR-1 Building will change the proportion of the site that can be released for unrestricted use ■ The Project may change the perceived suitability of the LSA for outdoor recreation and tourism and traditional land and resource uses.	■ Continued activities through the Community Regeneration Partnership to help the region develop economically. ■ Communication of environmental monitoring results to confirm the safety of the WL site and lands around it. ■ Final ISD design so that projections of doses to members of the public are well below the average Canadian individual background dose rate. ■ Final ISD design will be done to maximize hazard reduction.	Secondary
Preparation for and implementation of Institutional Control	■ Changes to access restrictions associated with the WL site end state as a result of the Project may result in changes to future land tenure and uses of the site itself.	■ Communication of environmental monitoring results to confirm the safety of the WL site and lands around it. ■ Continued activities through the Community Regeneration Partnership to help the region develop economically.	Secondary
Closure of the entire WL site	■ Decommissioning and reclamation of the entire WL site, including the Project, may change the future land tenure and uses of the WL site.	■ The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. ■ Affected areas will be remediated to meet the WL preliminary soil cleanup and the non-radiological and radiological clearance and release criteria in accordance with the target end state of the associated land-use category.	Secondary

6.8.5.2.1 No Linkage Pathway

The following pathway was assessed as having no measurable environmental change and hence, no linkage to residual effects on land and resource use VCs.

- **Project activities could affect unidentified or unknown heritage resources.**

Although there are currently no archaeological sites located on the WL site, there is a site located approximately 1,700 m south of the WL site (AECL 2001) and the Winnipeg River has been an important travel route throughout history, potentially beginning in the Paleo Indian Period (*ca.* 11,000 to 7,000 years ago). Project activities that could affect cultural and archaeological sites include those activities that could cause ground disturbance of any previously undisturbed area, especially if the undisturbed area is located between the western edge of the WL site's built infrastructure and the Winnipeg River.

The Environmental Assessment Follow-up Program for the WL site describes CNL's commitment to the protection and preservation of cultural and archaeological sites. Decommissioning activities are not expected to include any undisturbed land or areas on the WL site. If, however, activities require use of undisturbed areas, and in particular any activities in proximity to the Winnipeg River, CNL will have an archaeologist available to monitor Project activities and assess any potential finds. If an unexpected discovery of a heritage resource is made during Project activities, CNL will, in accordance with the *Heritage Resources Act*, cease activities until the Heritage Resources Branch can be consulted on the need to conduct a Heritage Resource Impact Assessment before resuming decommissioning activities. With this mitigation in place, this pathway is considered to have no linkage to effects on land and resource use.

- **Nuisance factors such as dust and noise may affect outdoor recreational or tourism experiences.**
- **Nuisance factors such as dust and noise may affect traditional land and resource use experiences.**

Land and resources use are restricted on site, although continue to persist in locations adjacent to the WL site. Project activities, including site preparation, WR-1 Building demolition and operation of the batch mixing plant, are expected to increase the level of nuisance factors (dust and noise) in the LSA; however they are not expected to have a substantial effect on an individual's land and resource use experience or on harvested species because of mitigation and management practices put in place for the Project.

Nuisance factors could make land and resource use activity experience on the Winnipeg River to the west of the WL site less enjoyable but changes are expected to be temporary and people will still be able to access the river upstream and downstream of the WL site to engage in activities. No emissions from Project activities are anticipated to exceed the appropriate standards and guidelines (Table 6.2.1-13). Project activity will typically be limited to daytime hours, where possible, and noise will be short-term and sporadic. Decommissioning of the WR-1 Building will be completed in a controlled manner, and no blasting will be required. The loudest decommissioning activity will likely be noise from a percussion hammer on an excavator, which will be used to break up reinforced concrete walls and floors during demolition. This activity will be limited to the interior of the building envelope, which will serve to reduce the level of noise outside the building, and in the surrounding area. The WL site has also retained heavy tree coverage, which provides a natural noise barrier (AECL 2001).

Due to the restricted access to the WL site, the nature of Project-related noise, the absence of threshold exceedances for emissions and mitigation for minimizing dust, which includes implementation of dust management techniques to control dust generated by the Project, nuisance factors as a result of Project activities are not expected to have an effect on recreation and tourism activities and on traditional land and resource use in the LSA. This pathway is therefore considered to have no linkage to effects on land and resource use.

6.8.5.2.2 Secondary Pathways

In some cases, a potential interaction with an assessment endpoint exists but mitigation is expected to cause minor changes to the environment and a negligible effect on land and resource use relative to the existing Base Case. The following are expected to result in negligible effects on land and resource use and will not be examined further in the EIS.

- **Changes to outdoor recreational activities and tourism resulting from changes to vegetation, fish and wildlife and their habitats, and surface water quality in the Winnipeg River.**
- **Changes to traditional land use resulting from changes to vegetation, fish and wildlife and their habitats, and surface water quality in the Winnipeg River.**

The Project could affect outdoor recreation and tourism activities, and traditional land use through changes to vegetation, fish and wildlife and their habitats, and surface water quality in the Winnipeg River. Changes to these VCs could result from a change in the abundance and distribution of resources, the quality of the resource, and the ability to access the resource including fish, wildlife and vegetation. Any of these changes could subsequently affect the ability and the desire to engage in activities in the LSA.

The Project footprint (i.e., SSA) is 0.07 ha; and it is located in an area that has been previously disturbed, where wildlife habitat value is considered to be negligible to low. In addition, temporary supporting infrastructure will be located within the LSA on previously disturbed and developed areas. Therefore, the Project is not expected to result in an incremental loss of wildlife habitat from current conditions at the WL site. Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the RSA will be used during decommissioning activities around disturbed areas, where appropriate. This will reduce the potential for effects on adjacent natural areas that provide suitable wildlife habitat. Once decommissioning of the WR-1 Building is completed and the engineered cover installed, the area will be graded and restored with native vegetation. Once Institutional Control begins in 2024, there will be monitoring activities, but the Project site will remain otherwise undisturbed.

Nuisance Factors

Project activities, including site preparation, demolition of the WR-1 Building and the development of temporary infrastructure, will increase noise levels and the amount of dust produced in the LSA, which could affect the distribution of wildlife species harvested by resource users. Changes to the distribution of wildlife species could in turn affect outdoor recreation and tourism activities and traditional land and resources use, as they constitute some of the resources on which these activities are dependent. Due to the nature of the noise produced by Project activities (sporadic, short-term, no blasting), wildlife species that live near the WL site are not expected to experience habitat loss (AECL 2001). Increases in dust are expected to be short-term, reversible, and not exceed the appropriate guidelines and standards. Noise and dust are not expected to result in changes of wildlife distribution that could affect land and resource use.

Airborne Dispersion of Contaminants

The Project may result in airborne contaminants that could deposit to soil and surface water, where they could affect vegetation, wildlife/wildlife habitat, fish/fish habitat and surface water quality. Changes to vegetation, wildlife/wildlife habitat, and fish/fish habitat could in turn affect outdoor recreation and tourism activities and traditional land and resources use, as they constitute some of the resources on which these activities are dependent. The ERA predicated that there will be no exceedances of the 2.4 mGy/d radiation benchmark for terrestrial and riparian biota on or near the WL site resulting from atmospheric releases (Section 6.7.2). All predicted doses are well below this level. Therefore, it is unlikely that there would be significant adverse effects on terrestrial populations or communities (including terrestrial plants [e.g., berries] and terrestrial wildlife [e.g., snowshoe hare, white-tailed deer and red fox]) as a result of radionuclide releases from closure activities. In addition, the ERA predicts that the total radiation dose to all human receptors (including harvesters) during closure activities is well below the public dose limit of 1 mSv/a (Section 6.7.1). Since the dose estimates are a small fraction of the public dose limit, no discernable health effects are anticipated due to exposure of potential critical groups to radioactive releases from the WL site during closure.

Waterborne Dispersion of Contaminants

The Project may result in waterborne dispersion of contaminants that could affect vegetation, wildlife/ wildlife habitat, fish/fish habitat and surface water quality. Waterborne dispersion may occur after the start of Institutional Control through leakage via the grouting to groundwater. Groundwater may then migrate to surface water at the Winnipeg River, where contaminants could travel downstream and affect vegetation, wildlife/wildlife habitat and fish/fish habitat. Changes to water quality or fish/fish habitat could in turn affect outdoor recreation and tourism activities and traditional land and resources use, as they constitute some of the resources on which these activities are dependent. The ERA predicts that there will be no exceedances of the 9.6 mGy/d radiation benchmark for the aquatic biota in the Winnipeg River (Section 6.7.2). Similarly, there are no predicted exceedances of the 2.4 mGy/d radiation benchmark for terrestrial and riparian biota on or near the WL site (Section 6.7.2). All predicted doses are well below these levels. For non-radiological contaminants of potential concern, the ERA predicts no exceedances of cadmium, lead, HB-40 and xylene exposure to ecological receptors. Therefore, it is unlikely that there would be significant adverse effects on either aquatic or terrestrial populations or communities as a result of radionuclide releases or the release of non-radiological contaminants from post-closure activities.

There are no anticipated exceedances for the radiation benchmarks for human receptors, including an on-site harvester, a farm north of the WL site on the Winnipeg River, and on-site farm, which is a human receptor located on the WL main campus between the built infrastructure and the Winnipeg River. The on-site farm receptor was assessed because the temporal boundary of the post-closure phase extends past a number of human generations. The total radiation dose for all receptors are below the public dosage limit of 1 mSv/a and the dose constraint for the Project of 0.25 mSv/a for all age groups (Section 6.7.1). Since the dose estimates are a small fraction of the public dose limit, no discernable health effects are anticipated due to exposure of these receptors to radioactive releases from the WL site during the post-closure phase.

The doses to human receptors that could be exposed to the non-radiological constituents of potential concern in surface water during post-closure were calculated based on total concentration (background plus Project contribution). Incremental hazard quotients were compared to a benchmark hazard quotient of 0.2, which is consistent with Health Canada. The hazard quotients derived for constituents of potential concern were below the protective benchmark for all receptors, with the exception of a toddler harvester, which slightly exceeded the benchmark. If only the project contribution is considered, the HQs are reduced even further and hazard quotients are well below for all receptors (the project contribution to the total is 0.0021% for cadmium and 0.00002% for lead). Therefore, no discernable health effects are anticipated due to exposure of potential critical groups from the Project during Post-closure.

Conclusion

Through these pathways, the Project is expected to have a negligible effect on recreation and tourism activities and on traditional land and resource use. There are not anticipated to be any threshold exceedances in harvested receptors through atmospheric releases and waterborne dispersion of contaminants. In addition, the mitigation measures proposed to minimize Project effects on surface water quality, the aquatic environment, the terrestrial environment, human health and ecological health are anticipated to eliminate or mitigate any potential adverse effects to the resources on which recreation and tourism activities and traditional land and resource use are dependent. These pathways are therefore characterized as secondary.

- **The use of ISD as the decommissioning method for the WR-1 Building will change the proportion of the site that can be released for unrestricted use.**
- **Changes to access restrictions associated with the WL site end state as a result of the Project may result in changes to future land tenure and uses of portions of the site itself.**
- **Decommissioning and reclamation of the entire WL site, including the Project, may change the future land tenure and uses of the WL site.**

The WL site has been operational since the 1960s, with public access generally restricted for safety and security reasons. Exceptions to this include parcels of the WL site on the west side of the Winnipeg River that have been continuously used for agricultural purposes under agreements with AECL. The area to the east of the WL main campus has been left undeveloped and is meant to act as a buffer to the industrial site (LGD of Pinawa 2004). No outdoor recreation and tourism activities or traditional land and resources uses are permitted on the WL site. Land and resource use activities have persisted adjacent to the site, including uses of the Winnipeg River. It is expected that all activities and land uses adjacent to the site will be able to continue in the future with the Project as the Project will have no effect on land tenure or usage beyond the WL site boundaries.

Future use of the WL site will depend on the ability of AECL to release parts of the site for unrestricted use upon completion of the Project. CNL is developing appropriate criteria for site remediation and clean-up activities of the WL site. In general, affected areas will be remediated to meet the WL preliminary soil cleanup and the non-radiological and radiological clearance and release criteria in accordance with the target end state of the associated land-use category. However, some lands will have restrictions of the future use and/or development of the land to ensure there are no adverse effects to the safety assessment and modelling assumptions associated with the ISD of infrastructure and facilities, such as WR-1 and the Waste Management Area. These areas will require ongoing controls including Institutional Control, access restrictions, and performance monitoring. However, the amount of land associated with all of these areas is negligible relative to the size of the WL site that will have unrestricted land use.

The Local Government District of Pinawa has expressed a desire to develop economic activity at the Whiteshell Labs site to offset lost jobs due to closure of the site. The Whiteshell Laboratories Community Regeneration Partnership is evaluating business opportunties, including new industries that could be located on site. This is a potential outcome for the WL site and will require agreement by AECL as the land owner, and potentiallly the Province of Manitoba. As noted in Section 6.9.6.1.2 Application Case Results, the previous decommissioning plan assumed that radioactive wastes would eventually be removed and placed in permanent disposal facilities with the assumption that a national disposal facility for low level radioactive waste would be available by 2025 and a national disposal facility for medium-level waste operational by 2050 (CNSC 2002). Under the original decommissioning plan, a smaller percentage of the site (the waste management area) would have had restricted access than with the Project; however, the area with anticipated restricted access under the Project is still small when compared with the remainder of the WL site. Although the Project will result in long-term institutional controls for a small portion of the WL site, the remaining land is safe and appropriate for other use. This may include transfer of the land to other parties following engagement with stakeholders, Aboriginal groups and the public. Future uses/zoning have not been determined, but it is assumed that the land will meet Canadian Council of Ministers of the Environment (CCME) land use criteria.

Although a smaller proportion of the WL site will be available for unrestricted use as was previously anticipated because of the Project, it is still anticipated that the majority of the site would be safe and appropriate for other use. Overall, this will result in an increase in the amount available for future use in the LSA. As such, these pathways are categorized as secondary.

The Project in combination with the decommissioning and reclamation of the WL site is also anticipated to contribute to positive effects the environment, which will indirectly positively affect land and resource use within the RSA (e.g., less industrial activity that could affect outdoor recreation, hunting, fishing, trapping, and plant and berry gathering). Consequently, cumulative effects from the Project in combination with the decommissioning of the remaining infrastructure and support facilities, and reclamation of the affected areas at the WL site are anticipated to be negligible.

- **The Project may change the perceived suitability of the LSA for outdoor recreation and tourism and traditional land and resource uses.**

The WL site was established in the 1960s with WR-1 becoming operational in 1965. Since that time, there have been nuclear research and more recently, decommissioning activities at the site. The area around the WL site in the LSA is currently used for agricultural activities, wildlife harvesting activities, fishing and private residences. This has not altered land and resources use in proximity to the WL site with activities, as such deer hunting, agricultural activities, fishing and other uses of the Winnipeg River still popular. The presence of the encapsulated WR-1 Building is not expected to cause changes in these existing activities, although a small number of users may perceive areas in proximity to the site as less optimal than if the reactor had been removed in its entirety.

The Project will be engineered to demonstrate long-term safety through a combination of site characteristics and engineered design features and to isolate and contain contamination inside the reactor vault and limit releases of hazardous substances, including radiological substances. According to the ERA, thresholds for airborne and waterborne contaminants will not be exceeded as a result of the Project (EcoMetrix 2017). Therefore, there is no need to change land use in land released by the AECL for unrestricted use or on the land in the LSA around the WL site; however, the presence of an encapsulated reactor and associated perceptions may make engaging in activities in the LSA less desirable for some users.

To mitigate perceptions related to the suitability for use of the WL site and the lands around it, CNL will support robust communication of environmental monitoring results to confirm the safety of the WL site and help address concerns about future uses. Members of the Project Liaison Committee (PLC) are currently expected to share outcomes with residents of their respective home communities and it is anticipated that they will have a substantial role with sharing monitoring results with community members once decommissioning is complete. Similar efforts for the sharing of monitoring results will be extended to First Nations and the MMF, however the exact mechanism of these efforts is to be defined. Canadian Nuclear Laboratories will provide communication support to committee members, to help disseminate monitoring results. Other communication models, such as the Environmental Quality Committee in northern Saskatchewan, have demonstrated that effective communication is an important tool to increase understanding and decreasing misconceptions associated with nuclear activities. The Environmental Quality Committee was designed to be “a bridge between northerners, government and the uranium mining industry” and over the course of the past 21 years, and has “become a more informed and regular voice, providing input into the decisions of both provincial and federal regulators concerning uranium mining industries” (Government of Saskatchewan n.d.).

Canadian Nuclear Laboratories will continue to use a public website and other media mechanisms to share information and receive feedback from the immediate local communities, First Nations and the MMF through the duration of the Project. Future communication mechanisms to keep local communities, First Nations and the MMF informed will be determined as necessary, and in consultation with these groups. Overall, with mitigation in place, Project effects on land and resource use are expected to be negligible. These pathways are therefore characterized as secondary.

6.8.5.2.3 Primary Pathways

There are no interactions with primary linkages to effects to the land and resource use VCs.

6.8.6 Monitoring and Follow-up

As there are no primary pathways for land and resource use, monitoring is not anticipated. However, CNL will implement a WR-1 Environmental Assessment Follow-up Program to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented (see Section 11). In addition, CNL will continue to engage with local communities, municipalities, and First Nation and Métis communities.

6.8.7 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, scientists, government agencies, Aboriginal peoples, or the public (Canadian Environmental Assessment Agency [the Agency] 2014). The land and resource use VCs chosen for the Project to reflect identified concerns, professional judgement and/or standard practice in environmental assessment are Land Tenure, Outdoor Recreation and Tourism, Cultural and Archaeological Sites, Traditional Land and Resource Use by Aboriginal People, and the Winnipeg River.

The Project could affect outdoor recreation and tourism activities, and traditional land use through effects to vegetation, fish and wildlife and their habitats, and surface water quality in the Winnipeg River. Changes to these VCs could result from a change in the abundance and distribution of resources, the quality of the resource, and the ability to access the resource including fish, wildlife and vegetation. Any of these changes could subsequently affect the ability and the desire to engage in activities in the LSA. There are not anticipated to be any threshold exceedances in harvested receptors through atmospheric releases and waterborne dispersion of contaminants. In addition, the mitigation measures proposed to minimize Project effects on surface water quality, the aquatic environment, the terrestrial environment, human health and ecological health are anticipated to eliminate or mitigate any potential adverse effects to the resources on which recreation and tourism activities and traditional land and resource use are dependent.

The WL site has been operational since the 1960s, with public access generally restricted for safety and security reasons. Exceptions to this include parcels of the WL site on the west side of the Winnipeg River that have been continuously used for agricultural purposes under agreements with AECL. No outdoor recreation and tourism activities or traditional land and resources uses are permitted on the WL site. Land and resource use activities have persisted adjacent to the site, including uses of the Winnipeg River. It is expected that all activities and land uses adjacent to the site will be able to continue in the future as the Project will have no effect on land tenure or usage beyond the WL site boundaries.

Canadian Nuclear Laboratories is developing appropriate criteria for site remediation and clean-up activities of the WL site. Although a smaller proportion of the WL site will be available for unrestricted use as was previously anticipated because of the Project, it is still anticipated that the majority of the site will be safe and appropriate for other use. Overall, decommissioning of the WL site will result in an increase in the amount available for future use in the LSA. Although the Project will result in long-term institutional controls for a small portion of the WL site, the remaining land is safe and appropriate for other use. This may include transfer of the land to other parties following engagement with stakeholders, Aboriginal groups and the public. Future uses/zoning have not been determined, but it is assumed that the land will meet CCME land use criteria. Consequently, the Project is expected to have a negligible effect on land and resource use VCs.

CNL will implement a WR-1 Environmental Assessment Follow-up Program to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. In addition, to mitigate perceptions related to the suitability for use of the WL site and the lands around it, CNL will support robust communication of environmental monitoring results to confirm the safety of the WL site and help address concerns about future uses. CNL will continue to engage with local communities, municipalities, and Aboriginal Groups.

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6.9 Socio-economic Environment

This section of the Environmental Impact Statement (EIS) for the Project seeks to understand and characterize the potential residual effects of the Project and past, present, and reasonably foreseeable developments on the socio-economic environment. Potential residual effects of the Project on land and resource use, including sites of cultural or archaeological significance are assessed in Section 6.8 Land and Resource Use.

6.9.1 Scope of the Assessment

The socio-economic assessment follows the overall environmental assessment approach and methods described in Section 6.1 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** (refer to Sections 6.9.2 Valued Components and Section 6.9.3 Assessment Boundaries) for the socio-economic assessment. The VCs, assessment endpoints and measurement indicators used to assess Project related changes to socio-economics, 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 6.9.4 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 socio-community characteristics, including non-tangible features and the "built" environment (e.g., community infrastructure).
- **Step 3 – Evaluate Project interactions and mitigation** (refer to Section 6.9.5 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 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 effect pathways to determine if, after incorporation of mitigation, there is still potential to cause residual effects. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. 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 described. Primary pathways that may lead to residual effects to socio-economics 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 6.9.6 Residual Effects Analysis). This section outlines the methods used to predict and characterize residual effects to socio-economics from primary effect pathways. The analysis results are also presented including the characterization of incremental effects from the 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 6.9.7 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 6.9.8 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 the Project for the socio-economics VCs is made.
- **Step 7 – Identifying monitoring and follow-up** (refer to Section 6.9.9 Monitoring and Follow-up) required to confirm effects predictions and address uncertainty.
- **Step 8 – Present a consolidated summary of conclusions and outcomes of the assessment** (refer to Section 6.9.10 Conclusions) of residual effects on socio-economics.

Information and concerns raised by the public, communities of interest, regulators and First Nations and Métis communities during engagement that influenced the scope of the socio-economic assessment are summarized in Table 6.9.1-1. Other general concerns and questions raised during First Nations and Métis communities and public engagement that pertain to the socio-economic assessment are documented in Section 4.0 Aboriginal Engagement and 5.0 Public Engagement.

Table 6.9.1-1: Summary of Issues Raised during Engagement Activities that Influenced the Scope of the Socio-economic Assessment

Issue	How the Issue Was Included in the Assessment
Potential access to the WL site after decommissioning activities are completed.	This issue was raised in connection with the future ability to attract an industrial customer to the WL site and has been considered in the assessment of the Community Well-being VC.
Atomic Energy Canada Limited will stop contributing the grant-in-lieu of taxes sooner than previously anticipated under the original decommissioning plan.	The accelerated timeline for determining the future of the Local Government District of Pinawa in connection with the grant-in-lieu of taxes is considered in the assessment of the Government Finances VC.
Interests regarding employment opportunities.	Changes in decommissioning activities for the WR-1 Building and the associated contracting opportunities are considered as part of the Business Opportunities VC.
Concerns about the transport of nuclear materials, particularly in the event of an accident and associated contamination.	Changes in the amount of radioactive waste transportation is considered as part of the Public Safety VC.

WL = Whiteshell Laboratories; VC = Valued Component.

6.9.2 Valued Components

Valued components refer to socio-economic and environmental features that may be affected by a project and that have been identified to be of concern by the proponent, scientists, government agencies, First Nation and Métis communities, or the public (the Agency 2014). The socio-economic VCs chosen for the Project to reflect identified concerns, professional judgement and/or standard practice in environmental assessment are Employment and Income, Business Opportunities, Government Finances, Community Infrastructure and Services, Community Well-being and Public Safety. The rationale for selecting these VCs is discussed in Table 6.9.2-1.

Table 6.9.2-1: Valued Components for Socio-economic Assessment

Valued Component	Rationale for Selection
Employment and Income	Local communities recognize that the decommissioning of the WL site will result in changes to local employment and income opportunities. There are concerns that the change in approach to decommissioning the WR-1 Building may result in challenges to attracting new businesses to the WL site and creating future opportunities.
Business Opportunities	The proposed changes in decommissioning activities for the WR-1 Building create a different set of opportunities for contractors than the previous decommissioning plan.
Government Finances	The Local Government District (LGD) of Pinawa relies on a grant-in-lieu of taxes from the AECL associated with the presence and operation of the WL site. The proposed changes in decommissioning activities will accelerate changes to the grant-in-lieu of taxes, which would change Pinawa's municipal revenue streams.
Community Infrastructure and Services	A wide range of essential human needs are fulfilled by infrastructure and services in communities. Projects can place additional demands on them and their ability to meet community needs. The Project may also affect how community infrastructure and services are funded in Pinawa as AECL pays the LGD a grant-in-lieu of taxes, which is used to fund infrastructure and services, including the School District of Whiteshell.
Community Well-being	Community well-being is affected by a variety of factors, including consideration of economic well-being, physical well-being, social well-being and the environment. Communities have expressed concern that attracting a new business/industry to the WL site is important for their continued viability, both in terms of employment/income and in terms of their long-term sustainability. The change in approach to decommissioning the WR-1 Building may restrict access to more of the WL site than previously anticipated and limit its subsequent development for other economic activities.
Public Safety	Public Safety has been a concern for the overall decommissioning of the WL site, which included medium-term storage of radioactive waste and eventual transport of radiological waste to permanent disposal facilities. The Project will reduce the amount of radiological waste being transported to disposal facilities, which will reduce one public safety hazard; however the shift to ISD will create a new public concern as some waste will be stored on the WL site permanently. Public safety related to the transportation of radiological waste off-site is considered in this assessment; while concern related to public exposure from ISD is evaluated in Section 6.7 Human and Ecological Health.

LGD = Local Government District; AECL = Atomic Energy Canada Limited; WL = Whiteshell Laboratories.

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 assessments of each VC will incorporate community and/or traditional knowledge where available. 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 6.9.2-2.

Table 6.9.2-2: Assessment Endpoints and Measurement Indicators for the Socio-economic Assessment

Valued Component	Assessment Endpoints	Measurement Indicators
Employment and Income	Employment opportunities and associated income for residents of communities in the LSA at the WL site during decommissioning, including Aboriginal peoples	The measurement indicators consider changes to local employment and income opportunities based on the change in decommissioning strategy for the Project and the ability to create future employment opportunities by attracting new businesses to the WL site.
Business Opportunities	Contracting opportunities for decommissioning work at the WL site provided to local and regional businesses, including Aboriginal people's businesses.	The measurement indicators consider incremental expenditures for procurement requirements created by the Project and implications to the existing industry and business profile in the local and regional study areas.
Government Finances	■ The grant-in-lieu paid by AECL to the Local Government District (LGD) of Pinawa. ■ Changes in the fiscal relationship among AECL, Provincial Government and the LGD of Pinawa.	The measurement indicators consider the continued economic viability of the communities and rural municipalities in proximity to the Project. Particular attention is paid to the LGD of Pinawa and its relationships with the federal government, which pays the grant-in-lieu of taxes, and the provincial government, which provides a reduced level of funding to the school district because of the grant-in-lieu of taxes.
Community Infrastructure and Services	■ Capacity of local and regional transportation infrastructure used by Project-related traffic to absorb Project-related traffic ■ Changes in traffic volumes on transportation infrastructure and their ability to absorb Project-related traffic ■ Capacity of Pinawa to continue providing the same level of infrastructure and services to residents as a result in potential changes to municipal funding.	■ Traffic volumes and road infrastructure will be considered in relation to employee traffic and waste hauling. ■ The Project is not expected to place stress on other infrastructure and services, but a change in the municipal revenue stream because of changes in the grant-in-lieu will alter the level of services offered in the LGD of Pinawa.

Table 6.9.2-2: Assessment Endpoints and Measurement Indicators for the Socio-economic Assessment

Valued Component	Assessment Endpoints	Measurement Indicators
Community Well-being	■ Nature of post-decommissioning uses of the WL site, which may change as a result of changes in the original decommissioning plan. ■ Capacity of the Community Regeneration Partnership to create a feasible socio-economic plan for the region to promote continued economic and community development. ■ Economic development opportunities available to the communities and RMs in the LSA.	The measurement indicators consider the continued sustainability and overall well-being of communities in proximity to the Project, with a particular focus on the LGD of Pinawa due to the community's historical ties with the WL site.
Public Safety	■ Safety related to transportation infrastructure. ■ Safety related to access to the WL site, including the consideration of radiation exposure and non-radiological exposure).	The measurement indicators considered for public safety for the Project are related to potential hazards associated with decommissioning activities including waste hauling and public access to the site during Institutional Control.

LSA = Local Study Area; LGD = Local Government District; WL = Whiteshell Laboratories; RM = Rural Municipality.

6.9.3 Assessment Boundaries

6.9.3.1 Spatial Boundaries

The Local Study Area (LSA) for the socio-economic VCs includes the municipalities and rural municipalities (RMs) most likely to be affected by the Project. The municipalities include the Local Government District (LGD) of Pinawa (Pinawa), the Town of Lac du Bonnet and the Town of Beausejour (Beausejour). The RMs include the Rural Municipality (RM) of Whitemouth, the RM of Lac du Bonnet and the RM of Brokenhead. The workforce at the WL site since it began operations in the 1960s has traditionally resided in these municipalities and RMs; the largest proportion of the current workforce also resides here. These communities have a historical relationship with the operators of the WL site and currently have a relationship with the operators through the Public Liaison Committee and the Whiteshell Laboratories Community Regeneration Partnership (the Partnership), which is intended to help the communities affected by decommissioning develop a socio-economic plan to promote the viability of the regional economy.

The Regional Study Area (RSA) is where potential effects are expected to be experienced at a broader scale, including potential economic activities and the use of transportation infrastructure. Economic effects could be a result of participation in Project employment or through contracting opportunities created by the Project. Effects on infrastructure and services would result from the use of transportation infrastructure to the WL site and between the WL site and the Chalk River Laboratories site. To capture the maximum extent of potential effects expected to be experienced, the RSA is the Southeast Region of Manitoba plus the City of Winnipeg, which includes population centres with well-developed business communities, residents with labour skills that could be relevant to the Project

and transportation infrastructure to be used by the Project. The Southeast Region is Census Divisions 1, 2 and 12, which follow RM boundaries. Approximate geographic landmarks for RSA boundaries are the Manitoba-Ontario border in the east, the Manitoba-US border in the south, the Red River/Provincial Trunk Highway 75 in the west and the Winnipeg River in the north. The major population centres outside of the municipalities in the LSA are the towns of Niverville, Powerview-Pine Falls and Ste-Anne; the City of Steinbach and the Village of St-Pierre-Jolys (Government of Manitoba 2012). The LSA and RSA are shown in Figure 6.9.3-1.

In addition to other Aboriginal residents, there are three First Nations communities included in the RSA located in relative proximity to the Project that may have an interest from a socio-economic perspective. These include:

- Sagkeeng First Nation (approximately 66 km northwest of the WL site);
- Black River First Nation (approximately 92 km northwest of the WL site);
- Brokenhead Ojibway Nation (approximately 73 km northwest of the WL site); and

In addition to these three First Nations communities, the Manitoba Metis Federation has locals throughout the RSA, including one in Lac du Bonnet (Manitoba Metis Federation 2012).

Additional Aboriginal Groups are identified with respect to land and resource use, which is discussed in Section 6.8 Land and Resource Use. As other Aboriginal Groups express interest in the Project from a socio-economic viewpoint, their inclusion in the effects assessment will be considered.

ARBORG
BIFROST
HNAUSA BEACH PROVINCIAL PARK
BLACK RIVER FIRST NATION (BLACK RIVER 9)
ELK ISLAND PROVINCIAL PARK
CAMP MORTON PROVINCIAL PARK
Lake Winnipeg
R.M. OF VICTORIA BEACH
SAGKEENG FIRST NATION (FORT ALEXANDER 3)
R.M. OF ARMSTRONG
BROKENHEAD OJIBWAY NATION (BIRCH LANDING)
POWERVIEW-PINE FALLS
NOPIMING PROVINCIAL PARK
R.M. OF GIMLI
GRAND BEACH PROVINCIAL PARK
WINNIPEG BEACH
Winnipeg Beach
WINNIPEG BEACH PROVINCIAL PARK
NORRIS LAKE PROVINCIAL PARK
Island Beach
R.M. OF ALEXANDER
Great Falls
PATRICIA BEACH PROVINCIAL PARK
DUNNOTTAR
PEGUIS FIRST NATION (ST. PETERS FISHING STATION 1A)
Lac du Bonnet
POPLAR BAY PROVINCIAL PARK
PEGUIS FIRST NATION (PEGUIS 1D)
R.M. OF ST. CLEMENTS
R.M. OF LAC DU BONNET
Town of Lac du Bonnet
BROKENHEAD OJIBWAY NATION (BROKENHEAD 4)
NETLEY CREEK PROVINCIAL PARK
PINAWA DAM PROVINCIAL PARK
R.M. OF ROCKWOOD
PEGUIS FIRST NATION (PEGUIS 1E)
PEGUIS FIRST NATION (PEGUIS 1F)
R.M. OF ST. ANDREWS
PEGUIS FIRST NATION (PEGUIS 1G)
L.G.D. OF PINAWA
Pinawa
PEGUIS FIRST NATION (PEGUIS 1H)
PEGUIS FIRST NATION (PEGUIS NO. 1G)
Selkirk
R.M. OF BROKENHEAD
PINAWA PROVINCIAL PARK
WABASEEMOONG INDEPEND
STONEWALL
LOCKPORT PROVINCIAL PARK
Stony Mountain
Garson
Tyndall
Town of Beausejour
WHITESHELL PROVINCIAL PARK
RIVER ROAD PROVINCIAL PARK
R.M. OF WEST ST. PAUL
BIRDS HILL PROVINCIAL PARK
ROSEAU RIVER ANISHINABE FIRST NATION (ROSEAU RIVER ANISHINABE 2B)
HYLAND PROVINCIAL PARK
Whitemouth
R.M. OF ROSSER
BROKENHEAD OJIBWAY NATION (NA-SHA-KE-PENAIS)
Oakbank
R.M. OF EAST ST. PAUL
R.M. OF SPRINGFIELD
R.M. OF WHITEMOUTH
ST. FRANÇOIS XAVIER
SWAN LAKE FIRST NATION (SWAN LAKE 8A)
Winnipeg
Dugald
Anola
Elma
LONG PLAIN FIRST NATION (LONG PLAIN MADISON INDIAN RESERVE NO.1
MEMORIAL PROVINCIAL PARK
CARTIER
WINNIPEG
R.M. OF REYNOLDS
ISKATEWIZAAGEGAN #39 INDEPENDENT FIRST NATION (SHOAL LAKE NO.39A)
BEAUDRY PROVINCIAL PARK
ST. NORBERT PROVINCIAL PARK
R.M. OF TACHÉ
R.M. OF MACDONALD
R.M. OF RITCHOT
R.M. OF STE. ANNE
ISKATEWIZAAGEGAN #39 INDEPENDENT FIRST NATION AND SHOAL LAKE 40
SHOAL LAKE 40 FIRST NATION (SHOAL LAKE NO.40)

LEGEND

- LOCAL STUDY AREA
- REGIONAL STUDY AREA
- WHITESHELL LABORATORIES SITE

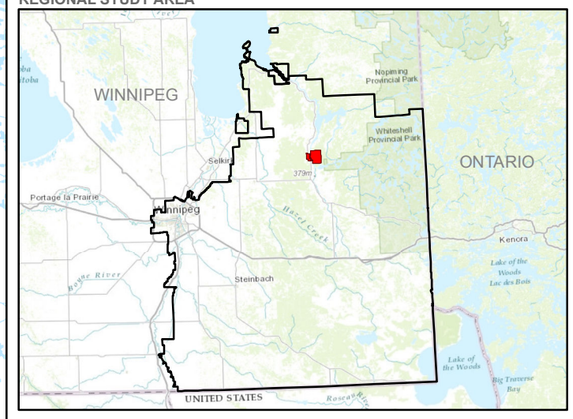
BASE FEATURES

- CITY/TOWN
- MAJOR ROAD
- WATERCOURSE
- WATERBODY
- MUNICIPAL BOUNDARY
- FIRST NATION RESERVE

PROTECTED AREAS

- PROVINCIAL PARK
- ECOLOGICAL RESERVE
- WILDLIFE MANAGEMENT AREA

REGIONAL STUDY AREA



0 10 20 30
1:550,000 KILOMETRES

NOTE(S)

REFERENCE(S)
1. BASE DATA - CANVEC AND MLI, 2016
2. PROJECT DATA - CNL, 2016
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE14N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
EIS FOR THE IN SITU DECOMMISSIONING OF WR-1 AT THE WHITESHELL LABORATORIES SITE

TITLE
SPATIAL BOUNDARIES FOR THE SOCIO-ECONOMIC ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-08-31
DESIGNED	CGE
PREPARED	CGE
REVIEWED	CS
APPROVED	MM

PROJECT NO. 1656897 | CONTROL | REV. 0 | FIGURE **6.9.3-1**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 0 25mm

Path: S:\Clients\Canadian_Nuclear_Laboratories\Manitoba\99_PROJ\1656897_CNL_Whiteshell_EA\40_PROD\0005_Social\1656897-0005-HIL-0001.mxd

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6.9.3.2 Temporal Boundaries

The temporal boundary of the assessment includes effects observed under existing conditions, the timeframe during which Project activities are actively occurring, and 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 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 Project:

- **Closure Phase:** Preparation and implementation of In Situ Decommissioning (ISD), which includes preparation for ISD, grouting of below-grade structures and systems, removal of above-grade WR-1 structures and systems, installation of the engineered cap and environmental controls and final site restoration. These activities last from 2019 to 2024.
- **Post-closure Phase:** The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. The Institutional Control period includes implementation of both active and passive control throughout 2024 to 2324 (i.e., 300 years). During active Institutional Control, long-term performance monitoring and maintenance activities will continue through to 2124 to demonstrate compliance with the safety case assumptions. The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions) and will continue through 2024 to 2324. Post-institutional Control occurs after year 2324 and continues indefinitely.

6.9.3.3 Assessment Cases

The socio-economic assessment considers the following three assessment cases.

- **Base Case:** this scenario represents existing conditions and includes effects from previous and existing developments and activities. For the socio-economic assessment, the effects of current and future decommissioning activities for the WL site are included in the Base Case. As described in the Comprehensive Study Report (AECL 2001), the original decommissioning approach for the WL site proposed three phases that would ultimately lead final decommissioning activities being completed over a 60 year period (i.e., 2061). Since the environmental assessment decision in 2002, the overall approach to decommissioning, in keeping with international best practices, has shifted to an accelerated process with reduced deferment periods with a targeted timeframe for closure by 2024.
- **Application Case: for** the socio-economic assessment, the Application Case represents predictions of the effects that may result from the Project. As described above, the Base Case already includes effects from the eventual decommissioning of the entire WL site. Consequently, the Application Case for the Project only considers effects from the accelerated process with reduced deferment periods (i.e., accelerated from 2061 to 2024).

- **Reasonably Foreseeable Developments (RFD) Case:** this scenario represents the predictions of the cumulative effects of the Application Case, plus projects that are currently under application review or that have officially entered a regulatory application process and which overlap with the socio-economic RSA. The following two projects are identified as overlapping with the socio-economic RSA.
  - **Manitoba-Minnesota Transmission Project** is a 213 km-long international powerline in southeastern Manitoba. After circling the south side of Winnipeg, the transmission line would track east-west south of Provincial Trunk Highway (PTH) 15 until just after Anola, where it would beginning tracking south south-east to the Canada-US border near Piney. The Manitoba-Minnesota Transmission Project includes construction of the line, modifications to three existing stations and operations. Construction would begin in summer 2017 until the in-service date, summer 2020 (Manitoba Hydro 2016).
  - **Energy East Pipeline** is 4,500 km crude oil pipeline system from an oil supply complex in Alberta to an existing oil refining and marine terminal facility near Saint John, New Brunswick. The pipeline segment crossing southern Manitoba is a converted mainline and a series of pump stations. Construction is expected to begin in 2018 with the earliest in-service dates scheduled for the fourth quarter of 2021 (TransCanada Corporation 2017).

  While the Manitoba-Minnesota Transmission Project and Energy East Pipeline are located in the RSA, their locations suggest that there is no overlap with the residual effects of the Project to the community well-being. Consequently, there is no RFD case assessed for the socio-economic assessment.

6.9.4 Description of the Environment

This section describes the setting and characterization for socio-economics as relevant for the assessment of the Project. It describes the existing conditions against which potential changes from the Project are compared and evaluated.

6.9.4.1 Methods

The characterization of the existing socio-economic environment reflects review of both primary and secondary data sources. Data collection began with a review of existing literature and databases from a variety of public sources. Where sufficient detail was not available from secondary data sources to describe the existing environment, primary data collection was undertaken in the form of key person interviews.

6.9.4.1.1 Literature Review

The review of literature and databases included the following sources:

- statistical data sources (e.g., Statistics Canada, Indigenous and Northern Affairs Canada);
- federal, provincial and municipal government reports and data;
- health reports and data;
- regional-level documents (i.e., Community Futures Winnipeg River);
- the previous Whiteshell Laboratories Decommissioning Project: Comprehensive Study Report (AECL 2001); and
- online sources (e.g., community websites, online business profiles).

Data from these sources was used to characterize the existing environment, based upon the most recently available data.

6.9.4.1.1.1 Limitations of Statistics Canada Data

It should be noted that data from the Statistics Canada 2011 National Household Survey (NHS) were supressed for several communities considered in the LSA, including the Town of Lac du Bonnet, the RM of Brokenhead and Brokenhead Ojibway Nation (BON). Statistics Canada suppresses data for confidentiality or data quality. Data suppression for confidentiality reasons is meant to prevent the disclosure of data that could be used to identify individuals. It is often used for income characteristic data in geographic areas where the population or private households do not meet a certain threshold. Data suppression due to data quality is done for a variety of reasons, including locations identified by Statistics Canada as “Indian reserves and Indian settlements that were ‘incompletely enumerated’” or a global non-response rate of higher than or equal to 50% (Statistics Canada 2013, 2015). The EIS was developed after Statistics Canada conducted the 2016 Census of Canada, but before all data sets were released. Population data for the 2016 Census of Canada are included in Table 6.9.4-1.

6.9.4.1.2 Key Person Interview Program

A limited key person interview (KPI) program was undertaken to address gaps that could not be readily filled by secondary sources to provide perspectives on community interests and concerns in Pinawa, the Town and RM of Lac du Bonnet, Beausejour, the RM of Brokenhead and the RM of Whitemouth. Interview guides for the KPIs were developed to address the subject areas discussed in this section.

6.9.4.2 Results

6.9.4.2.1 Historical Background

The WL site was established in the early 1960s by Atomic Energy of Canada Limited (AECL) to facilitate research and development of higher temperature versions of the Canada Deuterium Uranium (CANDU) reactor. The WL site included WR-1, an organic cooled reactor which became operational in 1965 (AECL 2001). In the early 1970s, the organic cooled reactor program was eliminated and full focus was concentrated on the heavy water-cooled CANDU reactor system. In 1985, WR-1 was permanently shut down (CNL 2016d). Over the years many nuclear research, management and safety programs were developed at the WL site which led to its reputation as a diverse centre for research (CNL 2016a, AECL 2001).

As a result of a federal review process that led to the significant reduction in funding to nuclear research, the Federal Government decided in 1997 to discontinue research programs at the WL site (AECL 2001). The initial efforts to secure a private owner to run the facility were unsuccessful and in 1998 AECL determined the WL site must be closed and decommissioned to meet regulatory requirements. A comprehensive study report for the decommissioning of the WL site was completed in 2001 and the Environmental Assessment decision to approve the project was announced in March of 2002 (CNL 2016b). In 2003, the decommissioning framework for the WL site received approval. This decommissioning framework included a completed Environmental Assessment and the subsequent site decommissioning license by the Canadian Nuclear Safety Commission (CNSC) (CNL 2016c).

Phase 1 of the WR-1 decommissioning began in 1989 and was completed in 1995. The initial shutdown and Phase 1 decommissioning of WR-1 included, amongst other decommissioning activities, removal of fuel and removable radioactive material and preparation of WR-1 for a lengthy deferment period by which radioactivity levels will be significantly decreased through natural decay prior to subsequent decommissioning activities. In 2001, a surveillance and monitoring program began for WR-1 (AECL 2001, CNL 2016b).

CNL was established on May 30, 2014 as part of the Government of Canada's restructuring of AECL, and preparation for full implementation of a Government-owned, Contractor-operated (GoCo) model. While CNL was initially created as a wholly-owned subsidiary of AECL, upon the completion of the restructuring of AECL, CNL became a private-sector entity with the transfer of ownership to Canadian National Energy Alliance, a private-sector entity. Once CNL was established, AECL applied to the CNSC to transfer the WL site licence to CNL. This licence transfer was approved by the CNSC on October 22, 2014 (CNSC 2014). Canadian Nuclear Laboratories currently operates the WL site on behalf of AECL. It has been mandated by AECL to proceed with decommissioning work to reduce public risk, reduce operational costs and to generally align with international best practices (CNL 2016a).

6.9.4.2.2 Population

Over the last 15 years the communities within the LSA have generally displayed a population increase, with the exception of the RM of Whitemouth, which has experienced an overall decline. These population increases may be a reflection of people moving out of urban centres, choosing to commute to work while maintaining a rural lifestyle and/or an increase of retirees moving out of city centres or away from family farming in appreciation of rural lifestyle, access to municipal services and easy access to outdoor recreation. Table 6.9.4-1 presents the total population from 2001, 2006, 2011 and 2016.

According to Statistics Canada (2001, 2006, 2011a, 2016), the population of Pinawa decreased from 2001 to 2011, while increasing between 2011 and 2016. This initial decline has been linked to the departure of individuals and families associated with layoffs at the WL site, which began in 1998. Meanwhile, retirees have been attracted to the LGD, reportedly because it is considered to be a safe community and health care is readily accessible; however, this has not offset the overall population decline (WR-1 Decommissioning Project KPI Program 2016).

The towns of Lac du Bonnet and Beausejour have experienced population increases since 2001. In Beausejour, an aging population in the town is partially attributed to the shift from small family farms to industrial farming. As farmers retire, they have tended to sell their farms and move to the town (WR-1 Decommissioning Project KPI Program 2016).

Two of the RMs closest to the Project, the RM of Lac du Bonnet and the RM of Brokenhead, have also experienced population growth between 2001 and 2016, while the population in the RM of Whitemouth has decreased since 2001. The RM of Brokenhead has younger demographics than the other municipalities in the LSA. There has been an influx of young families into the villages of Garson and Tyndall. These communities are on PTH 44 between Winnipeg and Beausejour. Many residents of the villages commute to Winnipeg for employment (WR-1 Decommissioning Project KPI Program 2016).

Table 6.9.4-1: Total Population for Communities in the LSA, 2001, 2006, 2011, 2016[a]

Community	2001	2006	2011	2016	Population Change 2001 to 2016[b] (%)
Municipalities					
LGD of Pinawa	1,500	1,450	1,444	1,504	0.27%
Town of Lac du Bonnet[c]	1,089	1,009	1,328	1,089	0.00%
Town of Beausejour	2,772	2,823	3,126	3,219	16.13%
Rural Municipalities					
Lac du Bonnet[c]	2,405	2,812	2,671	3,121	29.77%
Brokenhead	3,527	3,940	4,635	5,122	45.22%
Whitemouth	1,617	1,480	1,548	1,557	-3.71%

Source: Statistics Canada 2001, 2006, 2011a, 2012, 2016.

a) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.

b) Population Change 1996-2011 was calculated by InterGroup Consultants based on Statistics Canada data.

c) In a review of the 2011 Census, Statistics Canada originally misallocated population and dwellings belonging in the RM of Lac du Bonnet to the Town. This is the revised population counts (Statistics Canada 2012).

LSA = Local Study Area; LGD = Local Government District.

Aboriginal Population

The Aboriginal population of municipalities in the LSA and RSA are presented in Table 6.9.4-2. The Aboriginal population in Pinawa has increased since 1996; however, the 2006 Aboriginal population was more than double the 2011 population. The Aboriginal population in both the towns of Lac du Bonnet and Beausejour has steadily increased since 1996. Beausejour's Aboriginal population has shown the largest change between 1996 and 2011 with an increase of 255 people. Although this Aboriginal population increase was notable for Beausejour, the Town of Lac du Bonnet had a proportionately larger percentage of the total population identified as Aboriginal (15.9%) as compared to Beausejour (6.5%) in 2006. All three municipalities have shown a steady increase in Aboriginal population since 1996. Although the RM of Lac du Bonnet comparatively has the largest percentage of the total population identified as Aboriginal (12.0%), the RM of Whitemouth has shown the largest change between 1996 and 2011 with an increase of approximately 105 people.

Table 6.9.4-2: Aboriginal Population of Communities in the LSA, 1996, 2001, 2006, 2011(a)

Community	Population	1996	2001	2006	2011	Population Change 1996 to 2011[(b)] (%)
		(# and% Population)				
Municipalities						
LGD of Pinawa	Total Population	1,672	1,500	1,450	1,444	-13.6%
	Total Aboriginal Identity[(c,d)]	0 (0%)	N/A[5]	180 (12.4%)	75 (5.2%)	-58.33%
	North American Indian[(f)]	0 (0%)	N/A	70 (38.9%)	35 (46.7%)	-50.0%
	Métis[(g)]	10[2]	N/A	110 (61.1%)	20 (26.7%)	100%
	Inuit[(h)]	0 (0%)	N/A	0 (0%)	0 (0%)	0.0%
Town of Lac du Bonnet	Total Population	1,070	1,089	1,009	1,328[9]	24.1%
	Total Aboriginal Identity[(c,d)]	135 (12.6%)	N/A	160 (15.9%)	N/A	N/A
	North American Indian[(f)]	105 (77.8%)	N/A	30 (18.8%)	N/A	N/A
	Métis[(g)]	30 (22.2%)	N/A	130 (81.3%)	N/A	N/A
	Inuit[(h)]	0 (0%)	N/A	0	N/A	N/A
Rural Municipalities						
Town of Beausejour	Total Population	2,712	2,772	2,823	3,126	15.2%
	Total Aboriginal Identity[(c,d)]	40 (1.5%)	N/A	185 (6.5%)	295 (9.4%)	637.5%
	North American Indian[(f)]	30 (75.0%)	N/A	40 (21.6%)	140 (47.5%)	366.6%
	Métis[(g)]	15 (37.5%)	N/A	115 (62.2%)	150 (50.8%)	900.0%
	Inuit[(h)]	0 (0%)	N/A	30 (16.2%)	0 (0%)	0.0%

Table 6.9.4-2: Aboriginal Population of Communities in the LSA, 1996, 2001, 2006, 2011(a)

Community	Population	1996	2001	2006	2011	Population Change 1996 to 2011[b] (%)
		(# and% Population)				
Rural Municipalities (cont'd)						
Lac du Bonnet	Total Population	2,280	2,405	2,812	2,671	17.1%
	Total Aboriginal Identity[c,d]	230 (10.1%)	N/A	380 (13.5%)	320 (12.0%)	39.1%
	North American Indian[f]	15 (6.5%)	N/A	40 (10.5%)	75 (23.4%)	400.0%
	Métis[g]	190 (82.6%)	N/A	315 (82.9%)	245 (76.6%)	28.9%
	Inuit[h]	25 (10.9%)	N/A	10 (2.6%)	0 (0%)	-100.0%
Brokenhead	Total Population	3,495	3,527	3,940	4,635	32.6%
	Total Aboriginal Identity[c,d]	130 (3.7%)	N/A	310 (7.9%)	N/A	N/A
	North American Indian[f]	55 (42.3%)	N/A	85 (27.4%)	N/A	N/A
	Métis[g]	70 (53.8%)	N/A	225 72.6%)	N/A	N/A
	Inuit[h]	0 (0%)	N/A	0 (0%)	N/A	N/A
Whitemouth	Total Population	1,639	1,617	1,480	1,548	-5.5%
	Total Aboriginal Identity[c,d]	20 (1.2%)	N/A	70 (4.7%)	125 (8.0%)	525.0%
	North American Indian[f]	10 (50.0%)	N/A	25 (35.7%)	80 (64.0%)	700.0%
	Métis[g]	15 (75%)	N/A	45 (64.3%)	40 (32.0%)	166.7%
	Inuit[h]	0 (0%)	N/A	0 (0%)	0 (0%)	0.0%

Source: Statistics Canada 1996, 2001, 2006, 2011a, 2012.

a) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.

b) Where 1996 and 2011 data is available, population changes are expressed for 1996-2011; where 1996 data is not available, population changes are expressed for 2006-2011.

c) Total Aboriginal identity population' is composed of those persons who reported identifying with at least one Aboriginal group, that is, North American Indian, Métis or Inuit and/or those who reported being a Treaty Indian or a Registered Indian, as defined by the Indian Act of Canada and/or those who reported they were members of an Indian band or First Nation.

d) Percentage of Total Aboriginal Identity has been calculated based on Total Population of the community.

e) Not available (N/A) indicates data for this area has been suppressed for data quality or confidentiality reasons.

f) Percentage of North American Indian has been calculated based on Total Aboriginal Identity for the community.

g) Percentage of Métis has been calculated based on Total Aboriginal Identity for the community.

h) Percentage of Inuit has been calculated based on Total Aboriginal Identity for the community.

i) In a review of the 2011 Census, Statistics Canada originally misallocated population and dwellings belonging in the Rural Municipality of Lac du Bonnet to the Town. This is the revised population counts (Statistics Canada 2012).

LSA = Local Study Area; LGD = Local Government District.

The Aboriginal population of First Nation communities in the RSA are presented in Table 6.9.4-3. Between 1996 and 2011 the population of Sagkeeng First Nation grew by approximately 409 people which was an increase of almost 25% of the total population. Although data are not available for 2011 for Brokenhead Ojibway Nation, the population increased from 1996 to 2006 by approximately 135 people (40%). The population of Black River First Nation grew by 181 people between 1996 and 2011 representing a population increase of over 50%. All three First Nation communities include people that identify as Métis; however, no Inuit are recorded in these communities.

Table 6.9.4-3: Aboriginal Population for First Nations in the RSA 1996, 2001, 2006, 2011(a)

Community	Population	1996	2001	2006	2011	Population Change 1996 to 2011[b] (%)
		(# and% Population)				
Sagkeeng First Nation[c]	Total Population	1,690	1,998	2,121	2,099	24.2%
	Total Aboriginal Identity[d,e]	1,675 (99.1%)	N/A[6]	2,110 (99.5%)	2,025 (96.5%)	20.9%
	North American Indian[g]	1,650 (98.5%)	N/A	2,080 (98.6%)	2,000 (98.8%)	21.2%
	Métis[h]	15 (0.9%)	N/A	30 (1.4%)	15 (0.7%)	-50.0%
	Inuit[i]	0 (0%)	N/A	0 (0%)	0 (0%)	0.0%
Brokenhead Ojibway Nation[j]	Total Population	332	372	467	N/A	N/A
	Total Aboriginal Identity[d,e]	320 (96.4%)	N/A	450 (96.4%)	N/A	N/A
	North American Indian[g]	310 (96.9%)	N/A	430 (95.6%)	N/A	N/A
	Métis[h]	10 (3.1%)	N/A	20 (4.4%)	N/A	N/A
	Inuit[i]	0 (0%)	N/A	0 (0%)	N/A	N/A

Table 6.9.4-3: Aboriginal Population for First Nations in the RSA 1996, 2001, 2006, 2011(a)

Community	Population	1996	2001	2006	2011	Population Change 1996 to 2011[b] (%)
		(# and% Population)				
Black River First Nation[k]	Total Population	340	389	460	521	53.2%
	Total Aboriginal Identity[d,e]	335 (98.5%)	N/A	460 (100%)	525 (100.8%)	56.7%
	North American Indian[g]	335 (100%)	N/A	455 (98.9%)	520 (99.0%)	55.2%
	Métis[h]	0 (0%)	N/A	0 (0%)	10 (1.9%)	0.0%
	Inuit[i]	0 (0%)	N/A	0 (0%)	0 (0%)	0.0%

RSA = Regional Study Area

Source: Statistics Canada 1996, 2001, 2006, 2011a, 2012.

a) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.

b) Where 1996 and 2011 data is available, population changes are expressed for 1996-2011; where 1996 data is not available, population changes are expressed for 2006-2011.

c) Statistics Canada refers to Sagkeeng First Nation as Fort Alexander 3.

d) Total Aboriginal identity population' is composed of those persons who reported identifying with at least one Aboriginal group, that is, North American Indian, Métis or Inuit and/or those who reported being a Treaty Indian or a Registered Indian, as defined by the Indian Act of Canada and/or those who reported they were members of an Indian band or First Nation.

e) Percentage of Total Aboriginal Identity has been calculated based on Total Population of the community.

f) Not available (N/A) indicates data for this area has been suppressed for data quality or confidentiality reasons.

g) Percentage of North American Indian has been calculated based on Total Aboriginal Identity for the community.

h) Percentage of Métis has been calculated based on Total Aboriginal Identity for the community.

i) Percentage of Inuit has been calculated based on Total Aboriginal Identity for the community.

j) Statistics Canada refers to Brokenhead Ojibway Nation as Brokenhead 4.

k) Statistics Canada refers to Black River First Nation as Black River 9.

Population data for Sagkeeng First Nation, Brokenhead Ojibway Nation and Black River First Nation are available from Indigenous and Northern Affairs Canada (INAC). Several sources have been cited throughout this section as data collection methods vary by source. Variations in data collection methods can lead to differences among sources with respect to reported population. Actual population levels are expected to be somewhere within the ranges reported. Table 6.9.4-4 presents on- and off-reserve population data according to Indigenous and Northern Affairs Canada (INAC).

Table 6.9.4-4: On- and Off-reserve Population for First Nations in the RSA, September 2016

First Nation	Members On-reserve	Members Off-reserve[a]	Total Number of Members
Sagkeeng First Nation[b]	3,419	4,391	7,810
Brokenhead Ojibway Nation	747	1,244	1,991
Black River First Nation	930	395	1,325

Source: INAC 2016a.
a) Off-reserve members include registered members who live on crown land and on other reserves.
b) Indigenous and Northern Affairs Canada refers to Sagkeeng First Nation as Fort Alexander.
RSA = Regional Study Area.

6.9.4.2.3 Employment and Income

6.9.4.2.3.1 Employment by Sector

Major employers in the LSA include the CNL Whiteshell Laboratories; Manitoba Hydro, which has a district office in the Town of Lac du Bonnet, SunGro Horticulture, the Government of Manitoba, which has offices in Beausejour and Lac du Bonnet (Manitoba Conservation) and the Interlake-Eastern Regional Health Authority (RHA; WR-1 Decommissioning Project KPI Program 2016). Employment specifics for the CNL Whiteshell Laboratories are provided in greater detail in Section 6.9.4.2.3.2 Employment.

Participants in the KPI program also noted the presence and importance of local businesses. In multiple communities, it was noted that local governments are trying to foster an entrepreneurial sensibility in order that residents establish businesses in their home communities. The communities in the LSA have a variety of programs in place to encourage and support the establishment and development of local businesses (WR-1 Decommissioning Project KPI Program 2016).

Table 6.9.4-5 outlines employment by key occupational industries for residents of municipalities in the LSA for which National Household Survey (NHS) data are available, as well as residents of Manitoba for comparison purposes. Data indicate that the key occupational categories in Pinawa are in the social science, education, government service and religion (17.9%); natural and applied sciences (16.3%); and trades, transport and equipment operators and related occupations (13.8%). In Beausejour, occupations in social science, education, government service and religion (18.7%) and trades, transport and equipment operators and related occupations (17.1%) are also key occupational categories. Natural and applied sciences and related occupations describe the employment of a smaller proportion of the population in Beausejour since sales and service occupations employ 18.1% of the population. Comparatively, the key occupational categories in Manitoba include occupations in sales and service occupations (22.1%), business, finance and administration (15.4%) and trades, transport and equipment operators (14.9%). Of note, the Pinawa percentage of occupation in natural and applied sciences (16.3%) is well above the provincial average (5.3%).

Table 6.9.4-5: Employment by Sector for Communities in the LSA, 2011[a]

Occupation Classification	Pinawa	Beausejour	RM of Lac du Bonnet	RM of Whitemouth	Manitoba
	(# and% of Total Labour Force Population)				
Total labour force population aged 15 years and over by occupation - National Occupational Classification (NOC) 2011[b]	615	1,550	1,160	865	636,835
Occupation – not applicable	0	0	0	0	11,030
All occupations	615	1,540	1,155	865	625,810
Management occupations	50 (8.1%)	150 (9.7%)	110 (9.5%)	185 (21.4%)	69,775 (11.0%)
Business; finance and administration occupations	65 (10.6%)	210 (13.5%)	125 (10.8%)	60 (6.9%)	97,840 (15.4%)
Natural and applied sciences and related occupations	100 (16.3%)	130 (8.4%)	50 (4.3%)	0 (0.0%)	33,630 (5.3%)
Health occupations	35 (5.7%)	75 (4.8%)	25 (2.2%)	25 (2.9%)	46,560 (7.3%)
Occupations in education; law and social; community and government services	110 (17.9%)	290 (18.7%)	115 (9.9%)	165 (19.1%)	82,195 (12.9%)
Occupations in art; culture; recreation and sport	15 (2.4%)	40 (2.6%)	0 (0.0%)	0 (0.0%)	13,470 (2.1%)
Sales and service occupations	80 (13.0%)	280 (18.1%)	285 (24.6%)	115 (13.3%)	140,965 (22.1%)
Trades; transport and equipment operators and related occupations	85 (13.8%)	265 (17.1%)	295 (25.4%)	210 (24.3%)	95,085 (14.9%)
Natural resources; agriculture and related production occupations	15 (2.4%)	30 (1.9%)	60 (5.2%)	80 (9.2%)	17,380 (2.7%)
Occupations in manufacturing and utilities	50 (8.1%)	65 (4.2%)	75 (6.5%)	10 (1.2%)	28,895 (4.5%)

Source: Statistics Canada 2011b.

a) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.

b) Occupation classification data for the 2011 NHS were derived from 30% data.

c) Statistics Canada uses the National Occupational Classification (NOC) for Statistics. Occupations are based on the type of job the person holds and the description of his or her duties; it considers the kind of work done by persons aged 15 and over.

LSA = Local Study Area; RM = Rural Municipality.

CNL has traditionally been an important employer for residents of municipalities in the LSA. Canadian Nuclear Laboratories employees reside primarily in Pinawa, Beausejour and the Town of Lac du Bonnet; some employees reside in other locations. CNL employment has typically been seen as providing high-quality opportunities in terms of both the pay scale and the education requirements associated with many of the jobs (WR-1 Decommissioning Project KPI Program 2016).

First Nation Communities – Employment by Sector

Table 6.9.4-6 outlines employment by key occupational industries for First Nations in the RSA for which NHS data are available. Almost half the on-reserve population of Sagkeeng First Nation is engaged in either occupations in education, law and social, community and government services or in sales and service occupations. Almost half of the Black River First Nation on-reserve population is engaged in either occupations in education, law and social, community and government services or in trades, transport and equipment operators and related occupations.

Table 6.9.4-6: Employment by Sector for First Nations in the RSA, 2011[a]

Occupation Classification[b]	Sagkeeng First Nation[c]	Black River First Nation[d]	Manitoba
	(# and % of Total Labour Force Population)		
Total labour force population aged 15 years and over by occupation – National Occupational Classification (NOC) 2011[e]	600	115	636,835
Occupation – not applicable	95	20	11,030
All occupations	510	100	625,810
Management occupations	30 (5.0%)	10 (8.7%)	69,775 (11.0%)
Business; finance and administration occupations	45 (7.5%)	10 (8.7%)	97,840 (15.4%)
Natural and applied sciences and related occupations	0 (0.0%)	0 (0.0%)	33,630 (5.3%)
Health occupations	30 (5.0%)	0 (0.0%)	46,560 (7.3%)
Occupations in education; law and social; community and government services	145 (24.2%)	25 (21.7%)	82,195 (12.9%)
Occupations in art; culture; recreation and sport	10 (1.7%)	0 (0.0%)	13,470 (2.1%)
Sales and service occupations	135 (22.5%)	15 (13.0%)	140,965 (22.1%)
Trades; transport and equipment operators and related occupations	75 (12.5%)	30 (26.1%)	95,085 (14.9%)
Natural resources; agriculture and related production occupations	30 (5.0%)	10 (8.7%)	17,380 (2.7%)

Table 6.9.4-6: Employment by Sector for First Nations in the RSA, 2011[a]

Occupation Classification[b]	Sagkeeng First Nation[c]	Black River First Nation[d]	Manitoba
	(# and % of Total Labour Force Population)		
Occupations in manufacturing and utilities	0 (0.0%)	0 (0.0%)	28,895 (4.5%)

Source: Statistics Canada 2011b.

a) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.

b) Occupation classification data for the 2011 NHS were derived from 30% data. However, on Indian reserves and in remote communities, Statistics Canada attempts to obtain data from 100% of the population.

c) Statistics Canada refers to Sagkeeng First Nation as Fort Alexander 3.

d) Statistics Canada refers to Black River First Nation as Black River 9.

e) Statistics Canada uses the National Occupational Classification (NOC) for Statistics. Occupations are based on the type of job the person holds and the description of his or her duties; it considers the kind of work done by persons aged 15 and over.

RSA = Regional Study Area.

The First Nations in the RSA have local businesses. Sagkeeng First Nation operates the Sagkeeng Superstore (not affiliated with Loblaws Corporation) and a Tim Hortons. Sagkeeng First Nation has also suggested that it may have members and businesses that could aid with decommissioning activities (e.g., trucking, excavation) (CNL 2016d). Brokenhead Ojibway Nation owns Wavers, a gas station and confectionary, and Chief Jim Bear currently sits on the Board of Directors for the South Beach Casino, which benefits all First Nations communities in Manitoba (Brokenhead Ojibway Nation 2014). Black River First Nation has a window plant, a truss plant and a gas bar/general store (Black River First Nation 2009).

Mining

The Tanco Mine, located 60 km east of the Town of Lac du Bonnet, produces cesium, tantalum and spodumene; it is currently reducing its operations. The decrease in Tanco Mine operation is primarily the result of reduced demand for spodumene (WR-1 Decommissioning Project KPI Program 2016; Department of Growth, Enterprise and Trade n.d.). The True North Gold Mine (formerly the Rice Lake Gold Mine), owned and operated by Klondex Mines Ltd., is located approximately 250 km northeast of Winnipeg near the Town of Bissett and approximately 100 km northeast of Pinawa. Klondex Mines Ltd. recently filed a technical report and pre-feasibility study for the True North Gold Mine and has generally been pleased with the amount of ore extracted from reprocessing tailings (Klondex Mines Ltd 2016a, 2016b). The site recently held employment sessions around the Town of Lac du Bonnet (WR-1 Decommissioning Project KPI Program 2016). There are also quarry licences in the area and quarries were noted as providing employment to residents of LSA (WR-1 Decommissioning Project KPI Program 2016).

Tourism

Although tourism is not the primary economic driver in the region, seasonal recreational uses and cottaging remain important sources of revenues for all the municipalities and RMs in the LSA. The Whiteshell Provincial Park runs along the eastern boundary of the municipalities in the LSA and provides a steady draw of outdoor enthusiasts to the area. More specifically, the economies of the Town and RM of Lac du Bonnet rely on revenue from tourism as the RM is a prime area for summer cottaging and the population increases substantially in the summer. Retail and

services in the Town of Lac du Bonnet benefit from this annual influx. There are plans to improve the town as a tourist destination. The bridge on Provincial Route 313 needs repairs and the community has successfully lobbied the Province of Manitoba to raise the height of the bridge so that a wider variety of boats can pass through the river underneath. This upgrade will help the town to develop a new harbour, which is expected to attract an increased quantity and diversity of marine user groups, including seasonal boaters (WR-1 Decommissioning Project KPI Program 2016).

The economies of Pinawa and Beausejour do not rely as heavily on tourism. Pinawa does not have sufficient accommodations to support a tourist industry. Its location also hampers its ability to take advantage of tourism dollars as it is located at the end of the highway, with no through traffic. Beausejour has other economic drivers that reduce the importance of tourism and cottaging relative to other communities in the LSA (WR-1 Decommissioning Project KPI Program 2016).

The communities are part of the Eastman Tourism Region, which includes Birds Hill Provincial Park, Cooks Creek Heritage Museum, Grand Beach Provincial Park, Mennonite Heritage Village, South Beach Casino and Resort and the Whiteshell Provincial Park. In 2014, 20% of Manitoba's visitors (about 2,223,000 people) traveled to and through the region and spent $138.4 million in the region. Tourism resulted in an estimated $29 million in direct tax revenues (Tourism Manitoba 2016).

Agriculture

Agriculture in the LSA has been evolving. Smaller-scale family-owned farms had previously been characteristic of agricultural operations, especially in the RM of Brokenhead. These smaller operations have given way to larger agricultural firms with a more corporate organization (Community Futures Winnipeg River 2016). In the RMs of Whitemouth and Brokenhead, Sun Gro Horticulture is one of the main employers. The RM of Brokenhead is home to rich agricultural lands, with the production of wheat, canola, alfalfa, barley and oats comprising the majority of crops. Agriculture creates important seasonal employment (WR-1 Decommissioning Project KPI Program 2016).

6.9.4.2.3.2 Employment

WL Site Employment

Overall employment rates in the region have been affected by activities at the WL site. The WL site received a decommissioning licence in 2002; however, it has been scaling back employment since the overall peak employment of 1,168 workers in fall 1984. A series of major layoffs occurred in 1998, when the total employment went from 802 employees to 349 (AECL 2001). This number has remained fairly consistent over the past two decades and at the beginning of September 2016, there were 348 employees employed on-site, with almost all of them (342) working directly on or supporting decommissioning projects. Positions included engineering, scientific and technical staff; licensed skilled trades; unskilled trades; managers; and administrative and business professionals. Of these employees, approximately 6 full-time equivalents (FTEs) work directly on WR-1 and approximately 14 FTEs support the ongoing storage with surveillance of the WR-1 (CNL 2016d). The decommissioning workforce is planned to be maintained at about 350 employees for the next few years, increasing to approximately 400 staff in 2021 followed by a decline through to the anticipated WL site closure in 2024. Employment opportunities related to future site monitoring due to the Project have not yet been determined but they are not anticipated to be substantial (CNL 2016d).

Employment areas for the Project include skilled trades, heavy equipment operators, radiation surveyors and utility workers (CNL 2016d). When opportunities arise to fill vacant positions or hire local contractors, CNL will attempt to fill positions or hire contractors with local individuals or contractors; however, certain positions may require expertise from beyond the local communities. Canadian Nuclear Laboratories has a goal of developing skilled local talent, including participating in local skill development fairs and expos. More specific to the WL site, CNL maintains a communication protocol with Sagkeeng First Nation and provides job postings to the band office (CNL 2015).

Employment in the LSA

The majority of CNL employees currently reside in Pinawa (95 employees), Beausejour (63 employees) and Lac du Bonnet (62 employees) (CNL 2016d). There are currently programs in place at the Whiteshell Laboratories to help employees transition to other employment. Programs include access to a certified career coach, training tuition reimbursement and resume preparation (CNL 2016d).

Table 6.9.4-7 presents the 2011 labour force characteristics for residents of municipalities and RMs in the LSA for which there are data. Labour force characteristics include participation, employment and unemployment rates. The participation rate is the percentage of the population eligible to participate in the labour force (i.e., individuals aged 15 years and over). Less than half of the eligible population in Pinawa participated in the labour force (45.2%) representing the lowest rate of all municipalities compared. This combined with the considerably low unemployment rate (1.6%) as compared to the Manitoba provincial rate (6.2%) is likely a function of the retiree demographic of the town. The participation rate in Beausejour (63.1%) is higher than Pinawa (45.2%) yet lower than the Manitoba provincial rate (67.3%). Beausejour's unemployment rate (5.2%), although lower, is comparatively closer to the provincial rate (6.2%).

Table 6.9.4-7: Labour Force Characteristics for Communities in the LSA, 2011

Labour Force Characteristics[a,b]	Pinawa	Beausejour	RM of Lac du Bonnet	RM of Whitemouth	Manitoba
Total population 15 years and over by labour force activity	1,360	2,455	2,120	1,195	946,945
In the labour force	615	1,550	1,160	865	636,835
Employed	600	1,470	995	820	597,290
Unemployed	10	80	165	40	39,550
Not in the labour force	745	910	960	330	310,105
Participation rate	45.2%	63.1%	54.7%	72.4%	67.3%
Employment rate	44.1%	59.9%	46.9%	68.6%	63.1%
Unemployment rate	1.6%	5.2%	14.2%	4.6%	6.2%

Source: Statistics Canada 2011b.

a) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.

b) Labour force characteristics for the 2011 NHS were derived from 30% data.

LSA = Local Study Area; RM = Rural Municipality.

First Nation Communities – Employment Rates

Table 6.9.4-8 presents the 2011 labour force characteristics for First Nations in the RSA for which NHS data are available. Less than half the eligible population in both Sagkeeng (46.7%) and Black River (41.4%) First Nations participated in the labour force. The unemployment rate in Sagkeeng (25.8%) and Black River (20.8%) First Nations is considerably higher than for Manitoba as a whole (6.2%).

Table 6.9.4-8: Labour Force Characteristics for First Nations in the RSA, 2011

Labour Force Characteristics[a,b]	Sagkeeng First Nation[c]	Black River First Nation[d]	Manitoba
Total population 15 years and over by labour force activity	1,285	290	946,945
In the labour force	600	120	636,835
Employed	445	90	597,290
Unemployed	155	25	39,550
Not in the labour force	685	170	310,105
Participation rate	46.7%	41.4%	67.3%
Employment rate	34.6%	31.0%	63.1%
Unemployment rate	25.8%	20.8%	6.2%

Source: Statistics Canada 2011b

a) Labour force characteristics for the 2011 NHS were derived from 30% data. However, on Indian reserves and in remote communities, Statistics Canada attempts to obtain data from 100% of the population.
b) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.
c) Statistics Canada refers to Sagkeeng First Nation as Fort Alexander 3.
d) Statistics Canada refers to Black River First Nation as Black River 9.
RSA = Regional Study Area.

6.9.4.2.3.3 Income

Table 6.9.4-9 presents personal income for the residents of municipalities and RMs in the LSA. Among the municipalities, residents of Pinawa had the highest average personal income after taxes in 2010 at $42,668 which is also comparatively higher than the Manitoba provincial average ($36,696). Residents of Pinawa also had the highest proportion of its population 15 years of age and older with income over $60,000, at roughly one quarter (25.3%). This is higher than the Manitoba provincial rate (17.0%).

The RM of Whitemouth had the lowest average personal income after taxes in the LSA in 2010 at $29,090 and the smallest proportion of the population 15 years of age and older with income earning $60,000 at nearly 8%. The majority of residents in all municipalities had personal incomes between $10,000 and $60,000. This is also true for the province where about 58% of individuals 15 years of age and older with income also had personal incomes between $10,000 and $60,000.

Table 6.9.4-9: Personal Income for Communities in the LSA, 2011[(a,b)]

	Pinawa	Beausejour	RM of Lac du Bonnet	RM of Whitemouth	Manitoba
Total number of individuals 15 years of age and older with income	1,325	2,405	2,070	1,175	901,035
Average personal income after taxes ($)	$42,668	$35,996	$35,786	$29,090	$36,696
Under $10,000	160	345	305	265	162,905
$10,000-$19,999	215	430	365	225	164,195
$20,000-$29,999	135	500	305	215	135,385
$30,000-$39,999	105	310	365	135	123,090
$40,000-$49,999	235	255	260	130	95,695
$50,000-$59,999	140	90	225	115	66,930
$60,000 and over	335	475	245	90	152,835

Source: Statistics Canada 2011b.

a) Income data for the 2011 NHS were derived from 30% data
b) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.

LSA = Local Study Area; RM = Rural Municipality

Table 6.9.4-10 presents household income for residents of municipalities and RMs in the LSA. The majority (67.6%) of private households in Pinawa had an income over $60,000, with just over 20% having an income of $100,000 and over. Beausejour was the only municipality compared that had private households with income under $10,000 (3.6%). As compared to other municipalities, households in Beausejour with income was more evenly distributed among those with incomes under $60,000 (56.4%) and those with incomes over $60,000 (44.4%). The RM of Lac du Bonnet had just over 50% of private households with an income over $60,000, with about 16% having an income of $100,000 and over. The RM of Whitemouth had a higher proportion of private households with income of less than $60,000 (47.0%) than over $60,000 (41.9%). Comparatively Manitoba had just over 50% of private households with an income under $60,000, around 48% of private households with an income over $60,000 and of that, just over 22% had an income of $100,000 and over.

Table 6.9.4-10: Household Income for Communities in the LSA, 2011[a,b]

	Pinawa	Beausejour	RM of Lac du Bonnet	RM of Whitemouth	Manitoba
Total number of private households with income	695	1,375	1,055	585	465,805
Under $10,000	0	50	0	0	24,960
$10,000-$19,999	0	155	50	20	41,375
$20,000-$29,999	35	210	100	55	44,110
$30,000-$39,999	30	140	130	100	47,695
$40,000-$49,999	45	130	55	50	45,370
$50,000-$59,999	90	90	125	50	39,855
$60,000-$79,999	125	165	185	110	68,350
$80,000-$99,999	195	185	215	60	51,095
$100,000 and over	150	260	165	75	102,985

Source: Statistics Canada 2011b.

a) Income data for the 2011 NHS were derived from 30% data.

b) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.

LSA = Local Study Area; RM = Rural Municipality.

Table 6.9.4-11 presents sources of total income for residents of the municipalities in the LSA. Income from employment (wages, salaries and self-employment income) was the most prevalent source of income for residents in the municipalities in the LSA. Of the municipalities compared, residents of Pinawa had the lowest employment income at just over half the population (53.3%) yet also had the highest income from other sources (31.3%) including dividends, interest and other investment income, retirement pensions, superannuation and annuities and other money income. This is likely reflective of the large population of retirees in Pinawa. Beausejour had just under 70% of income from employment and, when compared to other municipalities in the LSA, had the second lowest income from both government transfer payments (15.8%) and other sources (14.2%). The residents of the RM of Lac du Bonnet had a relatively low percentage of income from employment (54.4%) along with a comparatively high percentage of income from other sources (28.7%). Similar to residents of Pinawa, this may reflect the growing retiree demographic of the RM of Lac du Bonnet. Both the RM of Whitemouth employment (73.9%) and other (9.4%) income were lower than the provincial rates (75.4% and 12.2% respectively), while the government transfer payments for the RM of Whitemouth were roughly 4% higher than the provincial percentage of around 13%. All the municipalities in the LSA had employment income levels below the Manitoba provincial level (75.4%).

Table 6.9.4-11: Sources of Total Income for Communities in the LSA, 2011[a,b,c]

	Pinawa	Beausejour	RM of Lac du Bonnet	RM of Whitemouth	Manitoba
Employment Income (%)[d]	53.3	69.9	54.4	73.9	75.4
Government transfer payments (%)[e]	15.2	15.8	16.9	17	12.5
Other (%)[f]	31.3	14.2	28.7	9.4	12.2

Source: Statistics Canada 2011b.

a) The composition of the total income of a population group or a geographic area refers to the relative share of each income source or group of sources, expressed as a percentage of the aggregate total income of that group or area. Total of income is considered from all sources, including employment income, income from government programs, pension income, investment income and any other money income.

b) Income data for the 2011 NHS were derived from 30% data.

c) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.

d) Employment income includes income from wages and salaries and self-employment income.

e) Government transfer payments include Old Age Security pension and Guaranteed Income Supplement, Canada and Quebec Pension Plan benefits, Employment Insurance benefits, Child Benefits and other income from government sources (Statistics Canada 2013).

f) Other income includes dividends, interest and other investment income; retirement pensions, superannuation and annuities; and other money income (Statistics Canada 2013).

LSA = Local Study Area; RM = Rural Municipality

First Nation Communities – Income

Table 6.9.4-12 presents personal income for the First Nations in the RSA for which NHS data are available. For Sagkeeng and Black River First Nations, the majority of individuals 15 years of age and older with income, had personal incomes of under $10,000. Sagkeeng First Nation has just over 50% of individuals 15 years of age and older with income under $10,000. Black River First Nation has 53% of individuals 15 years of age and older with income under $10,000. These proportions of individuals 15 years of age and older with income under $10,000 are in contrast to the Province of Manitoba as a whole (18.0%).

Table 6.9.4-12: Personal Income for First Nations in the RSA, 2011[a,b]

	Sagkeeng First Nation[c]	Black River First Nation[d]	Manitoba
Total number of individuals 15 years of age and older with income	1,170	255	901,035
Average personal income after taxes ($)	$14,986	$12,984	$36,696
Under $10,000	590	135	162,905
$10,000-$19,999	260	60	164,195
$20,000-$29,999	140	30	135,385
$30,000-$39,999	80	15	123,090
$40,000-$49,999	30	0	95,695
$50,000-$59,999	30	0	66,930
$60,000 and over	40	0	186,575

RSA = Regional Study Area.

Source: Statistics Canada 2011b

a) Income data for the 2011 NHS were derived from 30% data. However, on Indian reserves and in remote communities, Statistics Canada attempts to obtain data from 100% of the population.

b) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.

c) Statistics Canada refers to Sagkeeng First Nation as Fort Alexander 3.

d) Statistics Canada refers to Black River First Nation as Black River 9.

Table 6.9.4-13 presents household income for the First Nations in the RSA for which NHS data are available. For Sagkeeng First Nation the majority of on-reserve households with income had incomes of less than $60,000 (83.0%), with most households having incomes of $19,999 or less (43%). Sagkeeng First Nation had just over 16% of private households with an income over $60,000 and of this, almost 4% had an income of $100,000 and over. In contrast, roughly 14% of households had incomes of $19,999 or less provincially. Household income data for Black River First Nation were suppressed.

Table 6.9.4-13: Household Income for First Nations in the LSA, 2011[a,b]

	Sagkeeng First Nation[c]	Black River First Nation[d]	Manitoba
Total number of private households with income	525	125	465,805
Under $10,000	110	N/A	24,960
$10,000-$19,999	115	N/A	41,375
$20,000-$29,999	75	N/A	44,110
$30,000-$39,999	60	N/A	47,695
$40,000-$49,999	50	N/A	45,370
$50,000-$59,999	25	10	39,855
$60,000-$79,999	45	N/A	68,350
$80,000-$99,999	20	N/A	51,095
$100,000 and over	20	N/A	102,985

Source: Statistics Canada 2011b

a) Income data for the 2011 NHS were derived from 30% data. However, on Indian reserves and in remote communities, Statistics Canada attempts to obtain data from 100% of the population.

b) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.

c) Statistics Canada refers to Sagkeeng First Nation as Fort Alexander 3.

d) Statistics Canada refers to Black River First Nation as Black River 9.

LSA = Local Study Area.

First Nation Communities – Total Income

Table 6.9.4-14 presents sources of total income for the First Nations in the RSA. For both Sagkeeng and Black River First Nations, a higher proportion of on-reserve total income came from employment income, while between 35% and 50% came from government transfer payments (35.5% for Sagkeeng First Nation and 48.3% for Black River First Nation). The Sagkeeng First Nation had next to no on-reserve total income from other sources (1.1%), while other sources did not contribute to any on-reserve total income for the Black River First Nation. Both Sagkeeng and Black River First Nations had higher percentages of on-reserve total income from government transfer payments (35.5% and 48.3%, respectively) as compared to the provincial percentage (12.5%).

Table 6.9.4-14: Sources of Total Income for First Nations in the RSA, 2011[a,b,c]

	Sagkeeng First Nation[d]	Black River First Nation[e]	Manitoba
Employment Income (%)[f]	63.5	52	75.4
Government transfer payments (%)[g]	35.5	48.3	12.5
Other (%)[h]	1.1	0	12.2

Source: Statistics Canada 2011b.

a) The composition of the total income of a population group or a geographic area refers to the relative share of each income source or group of sources, expressed as a percentage of the aggregate total income of that group or area. Total of income is considered from all sources, including employment income, income from government programs, pension income, investment income and any other money income.

b) Income data for the 2011 NHS were derived from 30% data. However, on Indian reserves and in remote communities, Statistics Canada attempts to obtain data from 100% of the population.

c) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.

d) Statistics Canada refers to Sagkeeng First Nation as Fort Alexander 3.

e) Statistics Canada refers to Black River First Nation as Black River 9.

f) Employment income includes income from wages and salaries and self-employment income.

g) Government transfer payments include Old Age Security pension and Guaranteed Income Supplement, Canada and Quebec Pension Plan benefits, Employment Insurance benefits, Child Benefits and other income from government sources (Statistics Canada 2013).

h) Other income includes dividends, interest and other investment income; retirement pensions, superannuation and annuities; and other money income (Statistics Canada 2013).

RSA = Regional Study Area.

6.9.4.2.4 Government Finances

In the 1960s, AECL and the Provincial Government signed the Master Agreement, which stipulates that AECL will contribute to Pinawa a grant-in-lieu of taxes since AECL is not required to pay property or business taxes. The original purpose of the grant-in-lieu of taxes was to ensure that Pinawa offered services that were comparable to those offered elsewhere to attract employees to the region (AECL 2001). These grant-in-lieu contributions from AECL have in part allowed Pinawa to provide the community with a relatively high level of services and lower property tax rates. The grant-in-lieu from AECL to Pinawa currently represents about 40% of the LGD's revenue base. The majority of the grant (57%) goes to the School District of Whiteshell, which oversees the two schools in Pinawa (WR-1 Decommissioning Project KPI Program 2016). The community has received a stable amount of money for the grant-in-lieu of taxes since 2002 with the amount adjusted for inflation.

6.9.4.2.5 Community Infrastructure and Services

This section reviews existing facilities and services within the LSA.

6.9.4.2.5.1 Roads

The WL site is accessed from Winnipeg via Highway 44 east, Highway 11 north and Highway 211 east. Highway 44 begins at Lockport, runs through Garson to Beausejour (33 km) and is a four lane divided highway. East of Beausejour, Highway 44 is a two-lane highway and continues southeast from the junction with Highway 11 terminating at the Trans-Canada Highway near West Hawk Lake. Connecting Lake Winnipeg to the north and the Trans-Canada Highway to the south, Highway 11 is a two-lane paved road spanning 9 km from Highway 44 to Highway 211 east. Highway 11 continues past the Highway 211 junction past Lac du Bonnet and northward to Highway 59.

For the majority of the year within the LSA, there are no load restrictions on any of the paved roads in the area; restrictions apply in the spring to portions of PTH 211 and PTH 11 and may also apply in the spring on unpaved roads (Manitoba Infrastructure 2016, n.d.). The bridge nearest to the Whiteshell Laboratories site, at Highway 211 over the Winnipeg River, has no load restrictions (Manitoba Infrastructure n.d.). At the WL site, the main access roads to the facility are paved, with access roads to facilities beyond the main complex, for example the waste management facility, generally unpaved. Spatial boundaries, including highways, for the socio-economic assessment are displayed in Figure 6.9.3-1.

6.9.4.2.5.2 Water Supply

The Town of Lac du Bonnet and Pinawa draw water from the Winnipeg River System and treat it at their water treatment plants (Province of Manitoba 2004, LGD of Pinawa 2015).

Pinawa has an emergency generator for the water and lift stations to maintain services if hydroelectric power is interrupted (LGD of Pinawa 2016a). The LGD of Pinawa has approximately 660 residential and 20 commercial water system connections. A 50-plus housing complex (Ironwood Housing) and subdivision (Trillium Ridge), along with two campgrounds (Pioneer Bay and Tim Horton's Children's Camp), have been recently connected to the water system. These additions will serve over 281 tenants (LGD of Pinawa 2015). All in-ground infrastructure requires updating and the Pinawa Public Works Committee has recently completed development of a 5-year plan for strategic water main renewal.

The Town of Lac du Bonnet water system has approximately 500 customers, the majority of which are residential, along with a few small commercial customers. The Town of Lac du Bonnet's bulk water station is also heavily used by seasonal customers located outside of the town's limits. The Town Lac du Bonnet serves a few customers beyond the town's limits (11 customers), provides water services to the RM of Lac du Bonnet and additionally has an agreement with the RM to directly serve the Glen Howard Inn (Province of Manitoba 2007). In general, the town's infrastructure is aging and the water lines need to be replaced. The community has begun replacing the water lines, the north half of the town has been replaced with work on the southern half awaiting grant application approval (WR-1 Decommissioning Project KPI Program 2016).

First Nation Communities – Water Supply

Sagkeeng First Nation is the only First Nation in the RSA known to draw water from the Winnipeg River for residential purposes (Penn-Co Construction n.d, J.R. Cousin Consultants Ltd. n.d.).

6.9.4.2.5.3 Community Facilities

A summary of the facilities available in each of the LSA communities is provided in Table 6.9.4-15.

Table 6.9.4-15 Community Facilities for LSA Communities

Facility	Pinawa	Beausejour	Town of Lac du Bonnet
School	■ F.W. Gilbert School (K-6) ■ Pinawa Secondary School (7-12)	■ Beausejour Early Years School (K-5) ■ École Edward Schreyer School (6-12)	■ Centennial School (K-6) ■ Lac du Bonnet Senior School (7-12)
Child care	■ Children's Place Co-op Day Care	■ Beausejour Kids Centre	■ Centennial School Daycare

Table 6.9.4-15 Community Facilities for LSA Communities

Facility	Pinawa	Beausejour	Town of Lac du Bonnet
Healthcare	■ Ambulance/Emergency Medical Services ■ Hospital /Community Health Centre (17 bed facility) ■ Community Cancer Program (at hospital) ■ Supportive Housing ■ Community Health Services (Public & Mental Health/Home Care) ■ Services to Seniors (Day Programs/ Meals on Wheels) ■ Medical Clinic ■ Dental clinic ■ Pharmacy	■ Ambulance/Emergency Medical Services ■ Hospital/Community Health Centre (30 bed facility) ■ Personal Care Home ■ Supportive Housing ■ Primary Health Care ■ Services to Seniors (Day Programs/Meals on Wheels/Outreach for Seniors) ■ Handivan Transportation ■ Medical Clinics (Beausejour Clinic and First Street Medical Clinic) ■ Dental Clinic ■ Pharmacy	■ Ambulance/Emergency Medical Services ■ Community Health Centre ■ Personal Care Home ■ Community Health Services (Public & Mental Health/Home Care) ■ Services to Seniors (Day Programs/Senior Resource) ■ Two Rivers Transit ■ Medical Clinic ■ Dental Clinic ■ Pharmacy
Recreational Facilities	■ Community Centre ■ Orville Acres Arena (indoor and outdoor ice rink) ■ Public Pool ■ Tennis courts ■ Library ■ Pinawa Golf and Country Club ■ Marina ■ Cross-country ski trails ■ Vanier Centre	■ Sun Gro Centre (indoor ice rink, curling club, outdoor pool and indoor walking track) ■ Beausejour Bush Golf Course.	■ Community Centre ■ Curling Club ■ Arena (indoor ice rink) ■ Lac du Bonnet Granite Hills Golf Club
Temporary Accommodations	■ Pinawa Motel ■ Deer Ridge Cabins ■ Wilderness Edge Retreat & Conference Centre ■ ■ Pioneer Bay Campground ■ Relax Ridge Seasonal Park	■ Howland Hotel ■ Beausejour Hotel ■ Beausejour Motel ■ Superior Inn & Conference ■ Glass Lake B&B ■ Great Woods Park and Campground ■ Brokenhead River Park and Campground	■ Drifters Inn ■ Glenn Howard Inn ■ Lakeview Inn ■ Casey's Motor Inn ■ Champagne's RV Park ■ White Spruce on the Lake ■ Ember Ranch B&B

Source: http://pinawa.com/community/education/#.WMmyP28rKpo; Sunrise School District n.d.a.; Sunrise School District n.d.b.; Sunrise School District n.d.c.; Beausejour Kids Centre 2012; Province of Manitoba n.d.; LGD of Pinawa 2016d; Interlake-Eastern RHA. n.d.a.; Interlake-Eastern RHA n.d.b.; The Town and Lac du Bonnet 2012c; Interlake-Eastern RHA. n.d.c.; Beausejour Dental Centre 2016; LGD of Pinawa 2016e; Sun Gro Centre n.d.; Granite Hills Golf Centre n.d.; Golf Link 2016; LGD of Pinawa 2016g; Pinawa Golf and Country Club n.d.; Interlake Eastern RHA 2015

LSA = Local Study Area.

Physician recruitment and retention is a challenge in Pinawa and Beausejour; the goal of a family doctor for everyone and 24/7 operation of the Emergency Room remains a current pursuit (LGD of Pinawa 2016b).

First Nation Communities – Community Facilities

Of the three First Nations in the RSA, Sagkeeng First Nation and Brokenhead Ojibway Nation both have schools while Black River First Nation maintains a Head Start Program. All three First Nations offer health care within the community; see summary in Table 6.9.4-16.

Table 6.9.4-16 Community Facilities On-reserve for RSA First Nations

Facility	Sagkeeng First Nation	Black River First Nation	Brokenhead Ojibway Nation
School	■ Sagkeeng Anicinabe School (N-8) ■ Sagkeeng Anicinabe High School (9-12)	■ Head Start Program ■ Black River School (N-9) ■ Alternative Education Program	■ Sergeant Tommy Prince School (N-9)
Childcare	■ Information not available	■ Information not available	■ Sergeant Tommy Prince School Daycare/Head Start Program
Healthcare	■ Sagkeeng Health Centre ■ Sagkeeng Mino Pimatiziwin Family Treatment Centre (Family Addictions Treatment Centre) ■ George M. Guimond Care Centre – Personal Care Home	■ Health Centre	■ Brokenhead Health Centre
Recreational Facilities	■ Sagkeeng Arena	■ Information not available	■ Brokenhead Ojibway Nation (BON) Entertainment Centre ■ Brokenhead Recreational Centre

Source: Sagkeeng Anicinabe 2016; Manitoba First Nations Education Resource Centre Inc. 2016; Sagkeeng Health Centre 2016a; Black River First Nation 2009; Southeast Resource Development Council Corporation (SERDC) n.d.a; SERDC n.d.b; Brokenhead Ojibway Nation 2014.
RSA = Regional Study Area.

6.9.4.2.5.4 Housing

A summary of the housing available in each of the communities is provided in Table 6.9.4-17. The average number of rooms per dwelling was 6.75 across all four municipalities (2011 NHS data). Additionally, none of the municipalities had more than one person per room. Compared to other communities in the LSA, the RM of Whitemouth had the greatest percentage of households requiring major repairs (10.3%).

In addition to private dwellings, Pinawa also maintains a 50-plus facility (The Ironwood), as well as the new residential development–of Trillium Ridge, which is a locally owned subdivision and the Awanipark residential development (Trillium 2016, WR-1 Decommissioning Project KPI Program 2016). It was noted through the WR-1 Decommissioning KPI Program that while there is ample housing available in the RM of Lac du Bonnet, there is a shortage of affordable housing. The housing market in the RM of Lac du Bonnet has been driven by the cottage market, which has increased the cost of housing throughout the RM.

Table 6.9.4-17 Housing Characteristics for LSA Communities, 2011

Housing Characteristics	Pinawa	Beausejour	RM of Lac du Bonnet	RM of Whitemouth
Total number of occupied private dwellings	695	1,380	1,060	580
Average number of rooms per dwelling	7.1	6.1	6.6	7.2
Number of households with more than one person per room	0	0	0	0
Percentage of households requiring major repairs	2.2%	3.8%	7.6%	10.3%

Source: Statistics Canada 2011b.

a) Housing characteristic data for the 2011 NHS were derived from 30% data.

b) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.

LSA = Local Study Area; RM = Rural Municipality.

First Nation Communities – Housing

A summary housing characteristics in First Nation communities is provided in Table 6.9.4-18. Over half of the on-reserve households required major repair in both Sagkeeng and Black River First Nations. In addition, almost one-quarter of on-reserve households (24.0%) had more than one person per room in Black River First Nation.

Table 6.9.4-18 Housing Characteristics for RSA First Nations, 2011

Housing Characteristics[a,b]	Sagkeeng First Nation[c]	Black River First Nation[d]
Total number of occupied private dwellings	520	125
Average number of rooms per dwelling	5.3	5.5
Number of households with more than one person per room	100	30
Percentage of households requiring major repairs	63.5%	60.0%

Source: Statistics Canada 2011b.

a) Housing characteristic data for the 2011 NHS were derived from 30% data. However, on Indian reserves and in remote communities, Statistics Canada attempts to obtain data from 100% of the population.

b) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.

c) Statistics Canada refers to Sagkeeng First Nation as Fort Alexander 3.

d) Statistics Canada refers to Black River First Nation as Black River 9.

RSA = Regional Study Area.

6.9.4.2.5.5 Services

A summary of the services offered in the municipalities are displayed in Tables 6.9.4-19.

Table 6.9.4-19: Community Services for LSA Communities

Services	Pinawa	Beausejour	RM of Lac du Bonnet
RCMP	24 hr/day 7 days a week		
Fire	Volunteer	Volunteer paid on-call	Fire Department
Ambulance	Winnipeg River Ambulance Service		
Telephone/ Television/ Internet	Manitoba Telephone Services (MTS)		
	Shaw satellite service; Bell satellite service; MTS; Rogers NetSet Communications (Internet; operational in January 2017)	Information not available	Waterside Wireless (Internet)
Transportation	Two Rivers Transit Services	Handivan	Two Rivers Transit Services

Source: LGD of Pinawa 2016f; Government of Canada 2013a; Government of Canada 2013b; WR-1 Decommissioning Project KPI Program 2016; LGD of Pinawa 2016h; Beausejour Brokenhead Fire Department 2016; Interlake-Eastern RHA n.d.a; LGD of Pinawa 2016j; LGD of Pinawa 2016i; LGD of Pinawa 2016b; LGD of Pinawa 2016c; The Town and Lac du Bonnet 2012d; Beausejour Brokenhead Development Corporation 2016.

LSA = Local Study Area; RM = Rural Municipality; RCMP = Royal Canadian Mounted Police.

Two Rivers Transit Services is available in Pinawa and the RM of Lac du Bonnet. This service is available to seniors 55 years or older, or those unable to operate a motor vehicle. Service is provided throughout the Town and RM of Lac du Bonnet, Pinawa and the RM of Alexander by one handivan that can accommodate 18 passengers and two wheelchairs (LGD of Pinawa 2016f, Government of Canada 2013). Beausejour offers a handivan service which provides door-to-door transportation to seniors and persons with disabilities via three wheelchair accessible vans. This service provides transportation throughout Beausejour, the RM of Brokenhead and travel to Winnipeg via special booking (Government of Canada 2013).

Pinawa maintains a volunteer fire department which currently has 13 members, a pumper truck, a wildfire response trailer and a rescue vehicle equipped with the Jaws of Life. A new fire hall was built in 2011 to accommodate the newly acquired pumper truck and the goal is to purchase a new tanker truck (WR-1 Decommissioning Project KPI Program 2016). The Volunteer Fire Department is a member of the North East Mutual Aid District which draws on 13 other Fire Departments for additional resources (LGD of Pinawa 2016h). The RM of Whitemouth has plans to build a new fire hall in the spring of 2017 and maintains four helicopter pads throughout the RM (WR-1 Decommissioning Project KPI Program 2016).

In addition to housing the local RM of Lac du Bonnet fire department, the town of Lac du Bonnet is home to the new Manitoba Sustainable Development, Fire Operations Centre. This regional fire operations centre improves firefighting capacity and forest protection in eastern and central Manitoba (WR-1 Decommissioning Project KPI Program 2016). The Beausejour Brokenhead Fire Department services Beausejour, Garson, Tyndall and the residents of the RM of Brokenhead (Beausejour Brokenhead Fire Department 2016). Pinawa, Lac du Bonnet and Beausejour have ambulance services provided by Interlake Regional Emergency Medical Services 911, the Winnipeg River Ambulance Service (Interlake-Eastern RHA n.d.a, LGD of Pinawa 2016j).

The Pinawa waste disposal service collects household and yard waste and offers recycling services at the Pinawa Recycling Depot where residents are encouraged to drop off material. Recycling is supported by Pinawa Recycling Inc. which offers pick up services for commercial businesses, the post office and hospital (LGD of Pinawa 2016i). LGD of Pinawa recently entered into an agreement with Whitemouth, Reynolds, North Whiteshell Waste Management Facility (WRNWWMF) to receive recycled materials. This effort will reduce materials headed for and extend the life of, the landfill facility (LGD of Pinawa 2016b). The Town of Lac du Bonnet provides garbage and recycling collection services for residents. Grass clippings and electronic waste curb-side pick-up is also available. Battery recycling and yard wastes can be dropped off at designated locations for recycling (The Town and Lac du Bonnet 2012d). Beausejour offers garbage tags which must be attached to bags to be picked up. Curbside recycling is offered via blue box collection and seasonal lawn and garden waste can be dropped off at the Lawn and Garden Compost Site (Beausejour Brokenhead Development Corporation 2016).

First Nation Communities – Services

Sagkeeng First Nation has First Nations Safety Officers, a fire department and medical transportation (Sagkeeng Anicinabe 2016; Sagkeeng Health Centre 2016b). Brokenhead Ojibway Nation has a security team that patrols the community as well as the buildings owned by the First Nation (Brokenhead Ojibway Nation 2014). A summary of the services offered in the First Nation communities is displayed in Table 6.9.4-20.

Table 6.9.4-20: Community Services for RSA First Nations

Services	Sagkeeng First Nation	Black River First Nation	Brokenhead Ojibway Nation
RCMP	First Nations Safety Officers	Information not available	Brokenhead Security
Fire	Fire Department	Information not available	Information not available
Ambulance	Pine Falls Ambulance Service	Information not available	Information not available
Telephone/ television/ internet	Information not available	Information not available	Information not available
Other Transportation	Sagkeeng Health Centre Medical Transportation	Information not available	Information not available

Source: Sagkeeng Anicinabe 2016; Sagkeeng Health Centre 2016b; Brokenhead Ojibway Nation 2014; RCMP = Royal Canadian Mounted Police.

6.9.4.2.6 Community Well-being

Community well-being can be defined by a variety of factors. The most common elements of community well-being and quality of life include economic well-being (e.g., employment and income to meet the basic needs of food, shelter, clothing, etc.), physical well-being (e.g., personal health and safety), social well-being (e.g., family stability and social supports) and the environment. This section outlines a variety of factors that contribute to the communities' overall sense of well-being, including their relationship to the WL site.

6.9.4.2.6.1 Community Goals and Plans

During the KPI Program, participants noted that they wanted to ensure that their respective communities were able to thrive. Further description of community values shared through the KPI Program included the self-identification as nuclear communities, the high value placed on rural living and proximity and accessibility to remote wilderness (WR-1 Decommissioning Project KPI Program 2016).

To contribute to the continued development of each community, all had some degree of focus on economic development. Economic development was seen as an important driver in maintaining quality of life and attracting and retaining residents. Most of the municipalities in the LSA have a community or economic development corporation with a dedicated economic development officer. Pinawa has a community development corporation and a dedicated economic development officer. Beausejour and the RM of Brokenhead have a joint economic development corporation (Beausejour-Brokenhead Development Corp. [BBDC]) and an economic development officer. In the Town of Lac du Bonnet, a community development corporation has been incorporated and a committee is currently working on the operational details, such as determining funding sources and by-laws (WR-1 Decommissioning Project KPI Program 2016). Those municipalities that did not have a dedicated resource or development corporation at the time of the KPI Program (RM of Whitemouth, RM and Town of Lac du Bonnet) were still actively engaged in economic development. In the RM of Whitemouth, for example, the Chief Administrative Officer and a member of Council were working on economic development. The RM of Lac du Bonnet is currently in the process of expanding their airport in response to the new Manitoba Conservation – Fire Operations Centre. It is hoped that the expansion will help attract future businesses to the area (WR-1 Decommissioning Project KPI Program 2016).

Each municipality fosters economic development with a variety of means. In Pinawa, the LGD provides tax incentives, an incubator program (funded by CNL), the possibility of negotiating flexible business agreements and available commercial, industrial and retail space (LGD of Pinawa 2016k). While the community has commercial and industrial lots available, due to limited demand, they are undeveloped. The BBDC provides a variety of supports, excluding tax incentives, to attract business (WR-1 Decommissioning Project KPI Program 2016).

The municipalities consider their development activities to be successful at the current time. Pinawa is the home of an eastern Manitoba office (North Forge East) of the North Forge Technology Exchange, which is an economic development agency with offices and a fabrication lab in Winnipeg (North Forge Technology Exchange 2016). North Forge East began operations in October 2016. Interest in participating in the incubator program, which helps entrepreneurs develop their ideas into viable businesses, secure funding, and build prototypes at a reduced price, has been higher than originally anticipated. The organization is also seeking to expand its outreach efforts so residents of eastern Manitoba have a better understanding of entrepreneurship and will then be interested in taking advantage of the services North Forge East offers. The LGD has also established a relationship with a Chinese travel agency and will be hosting a winter hockey camp. The BBDC has attracted national retail and service chains (Tim Hortons and Home Hardware) to open locations in Beausejour. These operations provide local jobs and raise the profile of the municipalities (WR-1 Decommissioning Project KPI Program 2016).

While each municipality is focused on developing its own economy, they also acknowledge that regional development activities are critical to their success. A large employer in any of the municipalities is anticipated to provide direct and indirect employment to residents of all the municipalities. One current initiative is the development of a technical school in Beausejour. Multiple municipalities have contributed funding for a feasibility study that is currently underway. The hope is that once a technical school is established in Beausejour, it can help attract and/or retain younger residents (WR-1 Decommissioning Project KPI Program 2016).

Whiteshell Laboratories Community Regeneration Partnership

In spite of their efforts to increase the economic development of the region, the communities have remained concerned about the closure of the WL site and the prospect of attracting a new industry or user for the location. The Partnership was formed in 2015 to address this concern and is facilitated and funded by CNL (Pinawa LGD 2014). According to the Terms of Reference from October 21, 2015: “The proposed mandate of the Community Regeneration Partnership will be to develop a Socio Economic Plan for the region impacted by the WL decommissioning activities, to subsequently implement the Plan and to review, update and report on the Plan annually” (qtd. in Skinner 2016). Overall, the goal of the Partnership’s activities is to replace the positions lost in the past, along with the jobs that will be lost by the time decommissioning is complete. Partnership members are pleased with the current activities and tangible outcomes of the Partnership; there is a sense of greater commitment to Partnership efforts (WR-1 Decommissioning Project KPI Program 2016).

The communities in the LSA strongly identify with the nuclear industry (e.g., atomic energy) and the past activities at the Whiteshell Laboratories and would like to attract a future industry to the site either during or after decommissioning activities (WR-1 Decommissioning Project KPI Program 2016). They feel that the site is an asset to attracting business because of the site’s basic characteristics (e.g., inexpensive land, good power supply, good and abundant water), which discussions with a site selector have confirmed. While the Partnership is open to pursuing both nuclear and non-nuclear options for the site, they acknowledge that ISD of the WR-1 Building may limit its attractiveness (Whiteshell Laboratories Community Regeneration Partnership 2016). There is still uncertainty regarding the future uses of the WL site once CNL transfers control to AECL for Institutional Control.

Public Liaison Committee

In addition to working with the communities through the Partnership, CNL also engages them through the Public Liaison Committee. This committee meets twice annually and the focus is on building relationships and creating dialogue between CNL, stakeholder groups and communities and RMs around the WL site. Discussions focus on environmental practice and performance of CNL. Members of the committee are expected to share information from the meetings with their home communities and/or organizations.

6.9.4.2.6.2 Community Well-being Index

The Community Well-being Index (CWB) uses data from Statistics Canada about education, labour force, income and housing to provide "a relatively quick and convenient measure of well-being, focusing on the socio-economic dimensions" (Murphy 2010). A community's CWB index score is a single number that can range from zero to 100. The lower a community's Community Well-being Index, the poorer that community's well-being is considered to be.

The component scores consider the following:

- **Income,** which is based on income per capita;
- **Education,** which factors in the proportion of a community's population, 20 years and older, that has at least a high school certificate and the proportion of a community's population, 25 years and older, that has at least a bachelor's level degree;
- **Housing,** which comprises indicators of housing quantity and quality; and
- **Labour Force Activity,** which quantifies the labour force participation and employment rates in the community (INAC 2010).

The CWB index is calculated as follows:

$$CWB = \frac{Income\ [(2/3)\ Literacy + (1/3)\ HSP] + (HQual + HQuant/2) + (LFP + Employment/2)}{4}$$

Where: HSP: High School Plus;
HQual: Housing Quality;
HQuant: Housing Quantity; and
LFP: Labour Force Participation.

Table 6.9.4-21 presents the Community Well-being Index for communities in the LSA. Pinawa has a 2011 CWB index score of 87. Two of its component scores, for income and housing, were 96 and 99 respectively. Its labour force activity score was 81, while its education score was 70. Beausejour also had a CWB index score of 80, while the two RMs for which CWB index scores were available both had scores of 78. Across all four areas, education was the lowest of the four component scores with the RM of Whitemouth and the Town on Beausejour having component scores of 48 and Pinawa having a component score of 70. All four areas had housing component scores of 99 through 96.

Table 6.9.4-21: Community Well-being Index for Communities in the LSA, 2011

Community Well-being Index	Pinawa	Beausejour	RM of Lac du Bonnet	RM of Whitemouth
Income	96	86	89	80
Education	70	48	53	48
Housing	99	97	97	96
Labour Force Activity	81	89	76	88
Community Well-being Index	87	80	78	78

Source: INAC 2016b.
RM = Rural Municipality.

First Nation Communities – Community Well-being Index, 2011

Table 6.9.4-22 presents the First Nation Community Well-being Index. The First Nations in the RSA for which data were available, had substantively lower CWB index scores. Both have a 2011 CWB index score in the 40s with component scores ranging from 18 (Education for Black River First Nation) to 65 (Labour Force Activity for Sagkeeng First Nation).

Table 6.9.4-22: Community Well-being Index for First Nations in the RSA, 2011

Community Well-being Index	Sagkeeng First Nation	Black River First Nation
Income	46	35
Education	35	18
Housing	52	52
Labour Force Activity	65	61
Community Well-being Index	41	42

Source: INAC 2016b.

6.9.4.2.6.3 Regional Health Overview

Health is influenced by a wide variety of factors, which makes it difficult to describe a community's overall health status. Drinking water, food choices, personal behaviours, such as smoking and physical activity and air quality, among others, all affect health. Socio-economic factors, including housing, income, social status, education, early childhood development and family and community support, are also considerations. Measuring these determinants of health can be challenging due to the breadth of factors and the lack of availability of data, since this type of information is not routinely collected.

This section presents data regarding five indicators of community health, as follows:

- infant and maternal health;
- life expectancy and causes of death;
- chronic diseases;
- service delivery; and
- non-medical determinants of health.

These data are often not available at the community-level for confidentiality reasons; therefore, community health data are presented at the regional health authority level. The municipalities and RMs of the LSA are located in the Interlake-Eastern RHA. The RHA extends east to the Ontario border, north to the 53rd parallel, west to the eastern shores of Lake Manitoba and south to Winnipeg's north perimeter dipping down just past Winnipeg to slightly below the Trans-Canada (Interlake-Eastern RHA 2015).

Infant and Maternal Health

This section outlines infant and maternal health, including recent statistics regarding birth rates, birth weight and infant mortality data. Birth rates and infant health, such as high- and low-birth weights, provide useful indications of the health of a community.

The Interlake-Eastern RHA had a lower birth rate per 100,000 population in 2011/12 than the province (11 births per 100,000 population as compared with 12.4). Different regions of the RHA had substantively different birth rates per 100,000 population with the Northern Remote Zone having the highest at 27.5 births per 100,000 population. The Pinawa/Lac du Bonnet Region had a birth rate of 7.6 births per 100,000 population in 2011/12. There has been a decline in the RHA in rate at which teens (ages 15-19) have been giving birth. The most recently reported birth rate was 12.6 births per 1,000 population. The low-birth weight rate in the RHA was 4.8% of all births in 2007-08-2011/12 (Interlake-Eastern RHA 2014).

Life Expectancy and Cause of Death

Life expectancy is an indicator that can measure the overall effectiveness of a health care system in maintaining the health of the population. While it measures the quantity of life (i.e., the number of years), it does not measure the quality of life. In the Interlake-Eastern RHA, the life expectancy for males and females has remained stable between 2002-2006 and 2007-2011 and did not differ substantially from the provincial average, see Table 6.9.4-23 (Interlake-Eastern RHA 2014).

Table 6.9.4-23: Male and Female Life Expectancy in the Interlake-Eastern RHA and Manitoba, 2002 to 2006 and 2007 to 2011

	2002 to 2006	2007 to 2011
Female	81.6	82.2
Manitoba Female Average	81.5	82.2
Male	76.3	76.8
Manitoba Male Average	76.5	77.5

Source: Interlake-Eastern RHA 2014.

Between 2002-2006 and 2007-2011 the ranking for leading causes of death in the Interlake-Eastern RHA did not change but the proportion of causes of death did. The proportion of deaths by injury and poisoning increased from 8.1% to 8.8%, respiratory disease (7.5% to 8.1%), digestive disease (3.2% to 3.9%) and cancer (29.7% to 30.4%). Declines were seen in the proportion of deaths from circulatory disease and disease of the genitourinary system. These rates were similar to provincial rates for the same time periods except for deaths due to injury and poisoning and cancer, which were higher (Interlake-Eastern RHA 2014).

Chronic Diseases

Chronic disease includes cancer, heart disease, diabetes, chronic lung disease, kidney disease and arthritis. Chronic disease is an important measure of a community's overall health because not only does it reflect a community's demographics, but also has negative impacts on the quality of life of affected individuals, causes premature deaths and creates adverse economic effects on families, communities and societies (World Health Organization 2005). In the Interlake-Eastern RHA, the prevalence of diabetes has been increasing, 9.7% to 10.8% from 2004/05-2006/07 to 2009/10-2011/12 and is higher than the average provincial prevalence rate of 10%. The prevalence rate for hypertension (27.1%) and congestive heart failure (1.9%) in the RHA are also higher than provincial rates (25.8% and 1.6% respectively). The 2008-2010 regional cancer incidence rate was 471.8 per 100,000 residents which is comparable to the provincial average of 471.2. The proportion of residents with arthritis has remained relatively stable, increasing from 21% in 2005/06-2006/07 to 22% in 2010/11-2011/12 which was similar to the provincial average of 21%. Chronic lung diseases include asthma, chronic obstructive pulmonary disease, lung cancer, cystic fibrosis, sleep apnea and occupational lung disease. Although total respiratory morbidity declined from 10.6% in 2006/07 to 10.0% in 2011/12 this rate was still higher than the provincial average of 9.5%. Focus groups in the Interlake-Eastern RHA have mentioned that chronic diseases were an area that needs improvement, along with a need for local services such as rehabilitation and support groups (Interlake-Eastern RHA 2014).

Service Delivery

According to Interlake-Eastern RHA (2014), there were 97 physicians practicing full- or part-time in the RHA and 83 of those had hospital admitting privileges. Nearly 85% of residents in the RHA have a medical doctor and 88% of those who visited their doctor were satisfied with the experience. The LSA municipalities, however, note that there has been a physician shortage in their communities and are working together on a regional level to recruit physicians to the area (WR-1 Decommissioning Project KPI Program 2016).

The rate of hospitalizations in the RHA has been decreasing. Of those hospitalized, 37.7% spent time in RHA hospitals, while over half spent hospital days in Winnipeg hospitals. According to the RHA, this means that residents who require more complex and/or longer-term care are more likely to spend time outside of the RHA. This can have an adverse effect on them and their families (Interlake-Eastern RHA 2014).

Non-medical Determinants of Health

Non-medical determinants of health include factors such as education, income and employment. These three factors are linked, since education presents pathways to employment and higher income potential. Improved job security and education provide people with a feeling of control over their life (Health Council of Canada 2005), which influences overall health. People who are unemployed are more likely to experience “psychological distress, anxiety, health problems, hospitalization, etc. than the employed” (Health Canada 2004). There is a growing body of evidence to indicate that income and social status are the most important social determinants of health, since “health status improved at each step up the income and social hierarchy” (Health Council of Canada 2005). Higher income is also associated with improved living conditions and the ability to access resources. These predominantly economic factors contributing to health in the LSA are described in greater detail in Section 6.9.4.2.3 Employment and Income.

Living conditions are also among the factors of the physical environment that contribute to health. Housing, for example, can contribute to quality of life, since the average number of persons per room, indoor air quality and need for repairs are indicators related to housing that influence overall health status. Accessibility of services, such as proximity to a hospital, also contributes to health (Atlas of Canada 2009). These factors that contribute to health in the LSA are described in greater detail in Section 6.9.4.2.5 Community Infrastructure and Services.

6.9.4.2.6.4 Aboriginal Health

Health Overview

Data on Aboriginal Health are also presented at the RHA level, which is described above. In the Interlake-Eastern RHA, 25% of residents self-identify as Aboriginal (Interlake-Eastern RHA 2016). The region's First Nations population is generally young and growing with a high birth rate, although the on-reserve birth rates for First Nations in the RHA have declined gradually between 1993 and 2012, especially among the 15-19 and 20-24 age categories (Interlake-Eastern RHA 2014).

First Nations persons living on-reserve in the Interlake-Eastern RHA were hospitalized primarily for injury, poisoning and respiratory conditions, while non-First Nations residents were hospitalized most frequently for digestive and circulatory conditions (Interlake-Eastern RHA 2014).

The overall cancer incidence rate among First Nations in the Interlake-Eastern RHA was 629.6 cases per 100,000 people, substantively higher than the Manitoba average of 471.2. First Nations incidence for lung, rectal, prostate and breast cancer were all above the regional and provincial averages but these differences were not statistically significant (Interlake-Eastern RHA 2016).

Non-medical Determinants of Health

Raphael (2004), in his analysis of Canadian health determinants, identifies Aboriginal status as one of the key determinants of health in Canada. Aboriginal people are more likely than other Canadians to experience inequalities and disadvantages that act as barriers to overall health. Examples of these inequalities include the following:

- **Education:** Aboriginal people have lower education levels than their non-Aboriginal counterparts. Aboriginal youth are less likely to complete high school. Insufficient education diminishes the level of skills people have to enter the labour market.
- **Employment:** Unemployment rates are higher for Aboriginal people than the general Canadian population. See Sections 6.9.4.2.3.1 Employment by Sector and 6.9.4.2.3.2 Employment for additional detail on Aboriginal employment.
- **Income and Social Status:** Aboriginal people are typically overrepresented in the low income bracket. Annual earnings are lower than other Canadians, irrespective of whether they are working full-time or part-time. See Section 6.9.4.2.3.3 Income for additional detail on Aboriginal income.
- **Social Support Networks:** Colonialism resulted in losses of land, language and socio-cultural resources. The residential school system furthered these losses by removing young children from their communities, which has been linked to Aboriginal people being unable to establish effective family relationships.
- **Physical Environments:** Aboriginal communities often face housing shortages and people are more likely to live in crowded conditions or in homes in need of major repairs. This can result in stressors, such as children having little room to study or play, or adults lacking private space to relax.
- **Access to Services:** Aboriginal communities are less likely to have community facilities and infrastructure to promote healthy lifestyle choices/behaviours, such as recreation centres, playgrounds, swimming pools (Loppie et. al. 2009, Health Council of Canada 2005).

6.9.4.2.7 Public Safety

6.9.4.2.7.1 Road Safety

Traffic volume near the WL site can be estimated through coverage count stations (CCS) surveyed by the Province of Manitoba on a three-year cycle. Table 6.9.4-24 presents the annual average daily traffic counts for the three CCS locations near the WL site. The CCS station (No. 692) on Highway 211, west of the WL site access road and east of Highway 11, showed an annual average daily traffic count of 1,420 vehicles in 2011 and 1,440 vehicles in 2014. The CCS station (No. 657) on Highway 11, north of Highway 211, showed an annual average daily traffic count of 1,310 vehicles in 2011 and 1,380 vehicles in 2014. The station (No. 726) on Highway 11, north of Highway 307 and south of Highway 211, showed an annual average daily traffic count of 1,560 vehicles in 2011 and 1,630 vehicles in 2014 (Manitoba Infrastructure and University of Manitoba Transportation Information Group 2016).

Table 6.9.4-24: Traffic Statistics for Highways near the WL Site

Highway and Coverage Count Station (CCS) number	2009	2011	2014
Hwy 211, CCS 692	1,340	1,420	1,440
Highway 11, CCS 657	1,340	1,310	1,380
Highway 11, CCS 726	1,590	1,560	1,630

Source: Manitoba Infrastructure and University of Manitoba Transportation Information Group 2016.

Outside of off-road vehicle collisions, Manitoba Public Insurance does not break out collisions based on geographic location in its reporting beyond urban centres and all rural locations. Overall, the level of traffic collisions in Manitoba increased in 2015 as compared with the number in 2014 and with the previous five year annual average (2010 to 2014). The increase in the total number of collisions was driven by increases in collisions of all severity types. Traffic collisions in urban locations accounted for the majority of victims (i.e., people injured or killed in collisions) overall (86%); however of this 86%, the majority of traffic collisions resulted in minor injuries (87%). Rural locations account for the majority of people killed (77%) and seriously injured (44%) in Manitoba (Manitoba Public Insurance 2016).

6.9.4.2.7.2 Site Access

Access to the WL site is restricted. There is a security program in place that provides access control, visual monitoring and patrolling. There is an extensive surveillance system at the WL site to detect and deter unauthorized entry and diversion of materials and equipment. Part of the system is the use of progressive zones to provide increasing levels of security that are specific to certain areas in the WL site. This is in accordance with the *Nuclear Security Regulations* (AECL 2001).

6.9.5 Project Interactions and Mitigation

6.9.5.1 Methods

This section describes the process by which interactions between Project components and activities and socio-economic VCs were identified and evaluated. Potential effect 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 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 Section 6.9.6 Residual Effects Analysis. 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 Project. The pathways analysis considers interactions that may result during normal or routine activities. Potential effects from accidents and malfunctions are assessed in Section 7.0 Accidents and Malfunctions. The next step in the analysis was the development of environmental design features and mitigation practices that could be incorporated into the Project to eliminate and/or reduce effects to socio-economic 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 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 pathway** – pathway is removed by environmental design features or mitigation such that the 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 Project effects or to the effects of other past, present or reasonably foreseeable developments to cause a significant effect. Secondary pathways may also include Project effects that were identified as important to people during Project engagement, but that do not specifically fall under the requirements of CEAA 2012.
- **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 effects to socio-economic VCs.

Environmental design features and mitigation that have been or could be incorporated into the 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 socio-economic VCs 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 on socio-economic VCs (see Section 6.9.6 Residual Effects Analysis).

6.9.5.2 Results

Pathways through which all stages of the Project may interact with and result in changes to measurement indicators for socio-economic VCs is provided in Table 6.9.5-1.

Table 6.9.5-1: Pathways Analysis for Socio-economic Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Expenditures associated with the overall preparation, grouting, removal and remediation of WR-1 and above grade facilities	■ Changes to the current decommissioning plan will generate different employment opportunities. ■ Changes to the current decommissioning plan will generate different contracting opportunities	■ CNL may contract with a Manitoba-based contractor for the grouting work provided one with the necessary qualifications is available. ■ To the extent feasible, CNL will work with interested Aboriginal communities to provide employment opportunities during decommissioning activities. ■ To the extent feasible, CNL will fill positions with local qualified staff.	Secondary
Overall activities associated with WL site preparation, ISD of WR-1 and above-ground facilities	■ The Project will result in changes to local and regional traffic volumes in connection with contractor and new employee traffic requirements. ■ The Project will reduce the amount of transport required for off-site waste disposal, which will reduce traffic volumes and risks to public safety in the RSA.	■ The handling and disposition of waste material resulting from decommissioning will be conducted in accordance with CNL company-wide requirements, the WL waste materials management procedure and existing regulatory requirements. ■ Disposal methods for non-radioactive waste materials will meet all provincial and municipal requirements, with the order of preferred disposition of reuse/recycle, disposal in the CNL landfill, or disposal in a licensed off-site landfill.	Secondary

Table 6.9.5-1: Pathways Analysis for Socio-economic Valued Components

Project Activity	Effects Pathways	Management Practices and Mitigation Actions	Pathway Assessment
Installation of engineered cover over the grouted WR-1 Building and final WL site restoration	■ The perceived suitability of the site for future business ventures may change as a result of the presence of long-lived radioactive material as part of ISD. ■ The use of ISD as the decommissioning method for the WR-1 Building will change the proportion of the site that can be released for unrestricted use.	■ Continued activities through the Community Regeneration Partnership to help the region develop economically. ■ Communication of environmental monitoring results to confirm the safety of the WL site and lands around it. ■ Final ISD design so that projections of doses to members of the public are well below the average Canadian individual background dose rate. ■ Final ISD design will be done to maximize hazard reduction.	Primary
Preparation for and implementation of Institutional Control	■ Changes to the overall decommissioning plan may accelerate changes to the sources of municipal revenue for Pinawa. ■ Changes to the overall decommissioning plan may affect municipal revenue sources, which will change the provision of infrastructure and services in Pinawa.	■ AECL will work with the Province and Pinawa to provide certainty around municipal revenue that is currently provided by the grant-in-lieu of taxes and future use of the WL site.	Secondary

CNL = Canadian Nuclear Laboratories; ISD = In Situ Decommissioning; LGD = Local Government District.

6.9.5.2.1 No Linkage Pathway

There are no interactions with no linkages to effects to the socio-economic VCs.

6.9.5.2.2 Secondary Pathways

In some cases, a Project source of effect and an interaction with an assessment endpoint exists but mitigation is expected to cause minor changes to the environment and a negligible effect on the socio-economic environment relative to the existing Base Case. The following are expected to result in negligible effects on the socio-economic environment and will not be examined further in the EIS.

- **Changes to the current decommissioning plan will generate different employment opportunities.**
- **Changes to the current decommissioning plan will generate different contracting activities.**

There are currently about 350 employees on the WL site. Canadian Nuclear Laboratories anticipates employment to peak at 400 employees in 2021, when grouting of below-grade systems and structures is anticipated to occur. The size of the workforce after 2021 is anticipated to decrease to zero by 2024. A large workforce is not required during Institutional Control. Changes to the decommissioning of the WR-1 Building are not anticipated to substantively increase employment on the WL site relative to the previous decommissioning plan. In both scenarios, the employment generation is not anticipated to be considerable in relation to the surrounding population.

The CNSC approved the current decommissioning licence in 2002 and decommissioning activities have and will continue to be ongoing. Canadian Nuclear Laboratories assumed responsibilities for day-to-day operations of the WL site in 2014. Current employment at the WL site is contractual and understood to be finite. The implications of the change in decommissioning activities associated with the WR-1 Building does not necessarily alter the number of new employment and/or contracting opportunities, but rather changes the nature of the employment and/or contracting opportunities available; and the overall timing of these opportunities. Previously, the above- and below grade infrastructure of the WR-1 Building would have been dismantled, packaged and dispositioned to appropriate disposal sites depending on the nature of the waste generated. This would have resulted in construction and transport opportunities. The proposed change will increase the requirements for engineering and construction, while decreasing the amount of transportation labour required. In addition, the Project creates an opportunity, which may go to a local contractor, to encase the below grade structures with grout before constructing an engineered cover for the below-grade structure.

The change in decommissioning plan may also create additional employment and/or contracting opportunities for the Aboriginal Groups in the RSA. Sagkeeng First Nation in particular has expressed interest in employment opportunities and has noted that some of its members are qualified to work on the Project in certain capacities (e.g., transportation). Canadian Nuclear Laboratories is committed to hiring members of the Aboriginal communities where feasible.

The employment and contracting requirements for the Project are not anticipated to materially change the quantity of labour required, but rather the nature and timeframe. The termination of existing employment will be accelerated with the Project, including those science-based positions which typically pay at rates higher than the regional average. While the schedule for reducing employment has been accelerated, there is mitigation in place to enhance benefits for area communities and the Aboriginal communities in the RSA to the extent possible. Mitigation focuses both on supporting current employees in transitioning to new work and helping foster business opportunities in the area to replace lost employment. For current employees, CNL has programming for current employees at the WL site to explore other employment and take advantage of training opportunities.

In terms of fostering economic development in the region, CNL provides support for the Community Regeneration Partnership, which has been established to create a feasible socio-economic plan for the region, facilitate economic development, and hopefully provide high quality employment to replace the losses associated with the overall WL site closure. CNL has also provided substantial support to North Forge East, which offers services to entrepreneurs interested in establishing businesses in eastern Manitoba. The level of interest in participating in North Forge East has been higher than anticipated, and to date, North Forge East has accepted six proposals for their programming, which is above their initial target of two to four proposals. These proposals are from a diverse range of sectors, including social media and manufacturing. Due to the different requirements from different sectors of the economy, these projects are moving forward on their own timelines (WR-1 Decommissioning Project KPI Program 2016).

In light of the mitigation measures and the economic development activities undertaken by the municipalities and RMs in the LSA, the Project effects on employment and income, and business opportunities are expected to be negligible relative to the overall closure of the site despite the accelerated timeline.

- **The Project will result in changes to traffic volumes in the LSA in connection with contractor and new employee traffic requirements.**

Two factors are considered in determining the extent of effects changes to local traffic volumes could have: the size of the increased workforce and the capacity of transportation infrastructure near the WL site. The size of the workforce is not expected to substantially change between now and peak employment in 2021. Overall, CNL anticipates an increase in employment of about 50 employees between when approvals are received and the peak workforce in 2021, when grouting of below-grade systems and structures is anticipated to occur. After the below-grade structures are grouted, the size of the workforce will continue to reduce until Institutional Control begins. While the increase appears large in relative terms to the current workforce, it is small in absolute terms when compared to the peak workforce on the WL site in 1984.

With respect to transportation infrastructure, the WL site can be accessed from the communities and RMs in the LSA via RTAC routes (with a carrying capacity of 63,500 kg), Class A1 highways or Class B1 highways. Since the WL site can be accessed using relatively major roadways (as opposed to smaller, more rural roadways), the temporary increase of 50 passenger vehicles is not anticipated to pose a problem to the transportation infrastructure between communities in the LSA and the WL site. This includes the transportation infrastructure between the reserve parcels of the First Nations in the RSA and the WL site.

When the small number of additional employees required by the Project and the capacity of roadways leading to the Project are considered together, the increase in traffic volumes associated with Project-related employment will have a negligible effect on the transportation in the LSA.

- **The Project will reduce the amount of transport required for off-site waste disposal, which will reduce traffic volumes and risks to public safety in the RSA.**

The Project currently involves transporting up to 2,000 loads of waste from the WL site to the appropriate disposal site, which for radiological waste would be the Chalk River Laboratories site in Ontario. These shipments would occur over the course of five years, from 2019 to 2024, following pilot shipments in 2017 and 2018. This means that there would be an increase in current traffic of between two to three trucks a day (weekdays only). The lowest class of highway heavy Project-related traffic would likely use are Class B1 highways (e.g., PTH 211), which can carry a maximum gross vehicle weight load of 47,630 kg. The Trans-Canada Highway and PTH 44, which will also be used to haul waste to the Chalk River Laboratories site is a Roads and Transportation Association of Canada

route with a load limit of 62,500 kg for vehicles not conforming to RTAC standards and 63,500 kg for vehicles that do conform. Provincial Trunk Highway (PTH) 211 and PTH 44 have load restrictions between March 11 and May 31.

The Comprehensive Study Report for the previous decommissioning plan did not provide anticipated traffic volumes for transporting radioactive waste (AECL 2001) from the decommissioning of the WR-1 Building. Overall activities, however, included transporting low-level and intermediate-level radioactive material to permanent off-site disposal facilities, some of which would have been from the WR-1 Building. With ISD, below grade structures will be filled with grout and an engineered cap installed over it meaning there will be a reduced amount of radioactive waste transported, and thus a reduced amount of traffic generated.

The reduction in traffic will limit the potential for transportation incidents. The reduced potential for incidents will limit risks to public safety as the chance for injury and mortality will be reduced. Transportation of waste is routine and safe. Exposure to radioactive waste from transportation incidents was not considered a substantial risk to public safety as transportation involves specialized packaging and shipping containers.

Both of these pathways are anticipated to have a negligible effect on regional transportation infrastructure since the capacity of the roadways in the region is good and the Project will result in lower traffic volumes than previously planned. Together, this will reduce the demands placed on infrastructure and reduce the probability that the public may be exposed to radioactive material.

- **Changes to the overall decommissioning may accelerate changes to the sources of municipal revenue for Pinawa.**
- **Changes to municipal revenue streams for Pinawa may change the provision of infrastructure and services in the community.**

In the 1960s, AECL and the Provincial Government signed the Master Agreement, which stipulates that AECL will pay Pinawa a grant-in-lieu of taxes. Upon closure of the site, the agreement states that the LGD will be incorporated as a municipality when it is economically feasible and desirable. The agreement, however, does not contain a defined strategy for ending the grant-in-lieu or a process for negotiating a different fiscal relationship between the signatories. In light of some uncertainties associated with closing the Master Agreement and ending the grant-in-lieu of taxes paid to Pinawa, talks between AECL and the Province are expected to continue until a solution is reached that is satisfactory for the signatories.

When the Master Agreement is terminated it will have an effect on municipal finances for Pinawa. Although this was anticipated as part of the overall WL site closure, the Project accelerates the associated timelines. These changes may necessitate finding additional sources of revenue to compensate for budget shortfalls sooner than previously considered. To date, Pinawa has been focused on developing economic development options to increase municipal revenue. Economic development activities are supported through the Community Regeneration Partnership, which is examining future uses for the WL site. In addition to this, efforts through North Forge East are intended to promote entrepreneurial initiatives in eastern Manitoba. Pinawa-specific initiatives are also being explored through the Pinawa Community Development Corporation, and are intended to diversify the area's economic drivers (WR-1 Decommissioning Project KPI Program 2016).

While Pinawa is working to mitigate future changes in municipal funding through economic development, AECL and the Province will continue their discussions about closing the Master Agreement and ending the grant-in-lieu of taxes paid to Pinawa. These talks are currently ongoing, and Pinawa has expressed a desire to see a phased

approach to closing the Master Agreement and ending the grant-in-lieu (WR-1 Decommissioning Project KPI Program 2016). Changes to the grant-in-lieu and the eventual incorporation of Pinawa into a municipality are expected to go forward only when it is economically desirable and feasible to do so, which will help to address the overall acceleration of the timeline for these events.

6.9.5.2.3 Primary Pathways

The Project is expected to have the following primary pathway effects on the socio-economic environment that are carried forward to the residual effects analysis:

- **The perceived suitability of the site for future business ventures may change as a result of the presence of long-lived radioactive material as part of ISD.**
- **The use of ISD as the decommissioning method for WR-1 will change the proportion of the site for unrestricted use.**

6.9.6 Residual Effects Analysis

The residual effects analysis considers all primary interactions that are expected to result in effects on socio-economic VCs after implementing management practices and mitigation actions. The residual effects assessment is completed by calculating and estimating changes to measurement endpoints associated with the primary Project interactions. The VC affected by the primary interactions is Community Well-being.

6.9.6.1 Community Well-Being

6.9.6.1.1 Methods

The assessment of the community well-being VC characterizes future uses of the WL site after ISD of the WR-1 Building for potential economic development opportunities in the LSA. The communities and RMs in the LSA consider the WL site an asset in their economic and community development plans and have expressed concern that the Project will either limit the types of businesses that would be attracted to the site or that use of the site will be restricted permanently.

The assessment is qualitative and considers the potential changes in the attractiveness of and possible future uses of the WL site in light of the Project. This may affect overall community plans and goals as they relate to economic development. Information from economic and community development organizations and offices, the KPI Program, Project public engagement feedback, public feedback provided to the CNSC on the Project description and CNL inputs were considered in the analysis.

6.9.6.1.2 Application Case Results

The permanent presence of the encapsulated WR-1 Building will change the perceived suitability of the WL site for future uses due to the perceived risk associated with the long-lived radiological hazards of the reactor vessel. This is a major concern for communities in the LSA, as the Whiteshell Laboratories has traditionally been a source of high-quality, desirable jobs and the LSA had hoped to recruit a new industry to the site.

The previous decommissioning plan assumed that radioactive wastes, except for those designated to remain in the Waste Management Area and a limited area of radioactive contaminated sediment in the Winnipeg River, would eventually be removed and placed in permanent disposal facilities with the assumption that a national disposal facility for low-level radioactive waste would be available by 2025 and a national disposal facility for

medium-level waste operational by 2050 (AECL 2001). The communities had assumed that this would provide them with the ability to recruit a new industry (and associated employment) to the WL site, which features ample land, connection to the power grid, access to water from the Winnipeg River system and reasonable transportation network connectivity (1.5 hours to the James Richardson International Airport in Winnipeg, 20 minutes to the nearest railway and 45 minutes to the TransCanada Highway). This was combined with the understanding that the overall site (beyond the waste management area and a limited area of the Winnipeg River System) would eventually be available for unrestricted use. The WL site will now have restricted use in proximity to the encapsulated WR-1 Building over an indefinite period of time associated with institution control.

Participants in the KPI Program expressed concern with the Project because it would limit the types of businesses and industries that would consider using the WL site for future operations and therefore reduce the number of economic development opportunities available to them. The perception that the presence of WR-1 in ISD might harm goods being produced on site could discourage interest from potential investors or their customers with sensitivities to this concern. The perception that the WL site presents a potential safety concern, along with changes to access, is expected to have an adverse effect on potential economic development opportunities at the WL site. To reduce the potential effect of these perceived concerns CNL is committed to sharing information with the Partnership to help them develop a feasible socio-economic plan and a development of robust communication plan to convey and confirm the Project's safety.

Canadian Nuclear Laboratories is currently working with the communities and RMs in the LSA by funding the activities of the Community Regeneration Partnership. The goal of the Community Regeneration Partnership is to develop a socio-economic plan for the region. The plan is anticipated to lay out the steps needed to facilitate future economic development of the region. Through the KPI Program, participants expressed hope that activities through the Community Regeneration Partnership would replace the employment lost at the WL site with stable, high-quality employment in the region. It was felt that as a result of this development, people would stay or move to communities in the LSA for employment and they would flourish (WR-1 Decommissioning Project KPI Program 2016). About a year after its establishment, CNL has displayed a renewed commitment to the group through staffing changes to support the development of the socio-economic plan, sponsoring travel for community representatives to similar sites in the US and designating a board member of the Canadian National Energy Alliance, which owns CNL, to advocate for the WL site (WR-1 Decommissioning Project KPI Program 2016).

As there is uncertainty around future timelines and uses for the WL site, it is assumed that information regarding future uses and access to the WL site will be shared with the Partnership as it becomes available. This information will influence the actions described in the socio-economic plan that presents a feasible path forward containing realistic possibilities for future economic development. Depending on the future uses and access to the WL site, the plan is expected to help focus recruitment efforts and/or provide another route for achieving the same economic goals without reliance on the WL site.

While communication around future timelines and uses for the WL site are key for development of an implementable socio-economic plan, CNL will support robust communication of environmental monitoring results to confirm the safety of the WL site and help address concerns and mitigate perceptions about the site's suitability for future uses. Members of the Public Liaison Committee are currently expected to share monitoring results with residents of their respective home communities and it is anticipated that they will have a substantial role with sharing monitoring results with community members once decommissioning is complete. Canadian Nuclear Laboratories can provide communication support to committee members, to help disseminate monitoring results. One potential model for the Public Liaison Committee is the Environmental Quality Committee in northern Saskatchewan. The Environmental Quality Committee is intended to be "a bridge between northerners,

government and the uranium mining industry" and over the course of the past 21 years, the Environmental Quality Committee has "become a more informed and regular voice, providing input into the decisions of both provincial and federal regulators concerning uranium mining industries (Government of Saskatchewan n.d.). The Environment Quality Committee has helped increase the understanding of the uranium mining industry in northern Saskatchewan (Natural Resources Canada n.d.).

Canadian Nuclear Laboratories will continue to use a public website to share information and receive feedback from the immediate local communities. Communication efforts will build on the current Environmental Assessment Follow-up Program, which focuses on environmental monitoring, interim storage and end-state support and communications. The public communication component of the Environmental Assessment Follow-up Program is to develop and maintain communication mechanisms during decommissioning that support ongoing communication (CNL 2016a). They will also consider other mechanisms for disseminating monitoring results as they will help reduce the perceived risks associated with ISD. Sharing monitoring results, including activities that connect with whole communities and not just with leadership will be considered.

6.9.7 Prediction Confidence and Uncertainty

Like all scientific results and inference, residual effects predictions for the socio-economic environment will have uncertainty associated with the data and current knowledge of the system. The confidence in residual effect predictions is related to the following:

- adequacy of baseline data for understanding conditions in the local and regional study areas;
- the understanding of Project-related residual effects on the system; and
- knowledge of the effectiveness of environmental design features and mitigation at limiting effects on VCs.

6.9.7.1 Community Well-being

For effects associated to community well-being, satisfactory methods to quantitatively estimate outcomes or potential risk do not exist. As such, uncertainty is inherent in the analysis. Sources of uncertainty include:

- the ability to predict the success of the Partnership in developing and implementing a socio-economic plan for the region;
- the ability to attract an alternative industry to the WL site;
- if successful in attracting a new user, the ability of that industry to replace employment to a level similar to what is present today; and
- the effectiveness of the communication plan for monitoring results.

To manage this uncertainty, continued processes (e.g., the Partnership and Public Liaison Committee) with the communities and RMs in the LSA, with the support and participation of CNL is the suggested approach forward during decommissioning activities. As a better understanding of future timelines and uses of the WL site become available, the Partnership will be better able to develop an implementable socio-economic plan for the region, which will help reduce uncertainty. In addition, some of the uncertainty related to the WL site in the future stems from the perceived risks of ISD. Communication support for members of the Public Liaison Committee for disseminating results is expected to reduce levels of uncertainty connected with ISD risks.

6.9.8 Residual Effects Classification and Determination of Significance

6.9.8.1 Residual Effects Classification

The changes in measurement endpoints associated with primary interactions provide the foundation for determining significance from the Project on community well-being. Direction, magnitude, duration and geographic extent are the main factors of consideration used to predict significance. These criteria are defined in Table 6.9.8-1. For community well-being, the assessment of significance considers the scale of these factors, in addition to professional opinion, which is based on the context of the Project in combination with other relevant experience. The assessment of significance also analyzes the efficacy of the proposed mitigation to limit residual adverse effects to community well-being. The determination of significance assessment considers all primary interactions that are expected to result in residual socio-economic effects on economy.

Frequency is not considered in evaluating the significance of residual socio-economic effects on community well-being. For socio-economic changes, the residual socio-economic effects are generally continuous; therefore, the criterion frequency is typically not used. Similarly, reversibility is not used, as effects on the socio-economic environment associated with a project are typically part of an ongoing process of interdependent economic and social change extending into the future.

Table 6.9.8-1: Assessment Criteria for Classifying Predicted Residual Adverse Effects to Socio-economic VCs

Direction	Magnitude	Geographic Extent	Duration
■ **Negative:** An adverse effect relative to the existing environment. ■ **Neutral:** An effect with no discernible effect relative to the existing environment. ■ **Positive:** A beneficial effect relative to the existing environment.	■ **Low:** Effects are likely to result in a small, hardly discernible change relative to the existing environment. ■ **Moderate:** Effects are likely to result in a noticeable or detectable change relative to the existing environment. ■ **High:** Effects would be likely to result in a large, meaningful and readily detectable change relative to the existing environment.	■ **Local:** Changes would affect communities in the LSA including Pinawa, the Town of Lac du Bonnet and the Town of Beausejour and the RMs closest to the WL site, Whitemouth, Lac du Bonnet and Brokenhead. ■ **Regional:** Changes would extend to the RSA, which includes the Eastern Region and Winnipeg. ■ **Beyond Regional:** Changes would extend beyond the RSA to the Province of Manitoba.	■ **Short-term:** Effects will last through the decommissioning of the WR-1 Building up to the beginning of Institutional Control (i.e., 2024). ■ **Medium-term:** Effects will last for a portion of the Institutional Control period (i.e., 100 years). ■ **Long-term/Permanent:** Effects will last throughout the entire Institutional Control period (i.e., 300 years) and/or beyond.

LSA = Local Study Area; LGD = Local Government District, RM = Rural Municipality; RSA = Regional Study Area.

6.9.8.2 Determination of Significance

The classification of primary pathways and the associated predicted changes in measurement indicators provide the foundation for determining the significance of incremental and cumulative residual adverse effects on the assessment endpoints for socio-economic VCs. Although neutral and positive changes to measurement indicators will be described in Section 6.9.6 Residual Effects Analysis, a determination of significance is not provided for neutral and positive effects. When assessing effects of the Project on people, it is inherently challenging as issues may arise from differing perspectives, perceptions and values among different groups of affected individuals or communities. Effects that are considered to be moderate to high in magnitude, combined with being medium to long term in duration, have the potential to be considered as significant irrespective of geographic extent; however the social and economic context, uncertainty of outcomes, and potential for adaptation are also considered in the determination.

6.9.8.2.1 Community Well-being

Table 6.9.8-2 presents the classification of predicted residual adverse effects on community well-being for the application case. This analysis of residual effects on community well-being considers the effects on future use of the WL site by the communities and RMs in the LSA. Future use is associated with the perceived suitability and physical access to the WL site due to the ISD of the WR-1 Building.

Based on the assessment described in Section 6.9.6.1 Community Well-being, effects on community well-being are expected to be negative in direction, moderate in magnitude, local in geographic extent and medium-term in duration. The Project is anticipated to adversely affect the perceived suitability of the WL site for future business ventures and the ability of local communities to gain access to the WL site for other uses following Institutional Control. Since both effects are localized to the site and since use of and access to the site were objectives primarily of the communities and RMs in the LSA, the geographic extent is anticipated to be local. While ISD entails encapsulating radioactive material below grade for permanent disposal, good communication is expected to shift perceptions of site suitability before the end of the Institutional Control period (i.e., before Year 2324).

While the Project presents challenges to the future use of the WL site, the Partnership, including CNL, will make efforts to effectively identify and implement a path forward for economic development in the LSA. In addition, CNL will support robust communication of monitoring results. Members of the Public Liaison Committee are expected to share results with their communities. CNL can provide communication support if necessary to help disseminate monitoring results. CNL may want to consider other communication methods as well, such as a public website to share monitoring results. While the role of the WL site may change in economic and community development in the LSA, development is expected to continue; therefore there is no significant adverse effect of the Project on community well-being.

Table 6.9.8-4: Classification of Predicted Residual Adverse Effects on Community Well-being for the Application Case

Residual Effect	Direction	Magnitude	Geographic Extent	Duration
■ The perceived suitability of the site for future business ventures may change as a result of the presence of long-lived radioactive material as part of ISD. ■ The use of ISD as the decommissioning method for WR-1 will change the proportion of the site for unrestricted use.	Negative	Moderate	Local	Medium-term

ISD = In Situ Decommissioning.

6.9.9 Monitoring and Follow-up

Monitoring and follow-up programs associated with effects on vegetation, wildlife, fish and water quality are also relevant to community well-being, as the continued confirmation that ISD is safe will help assuage concerns regarding the suitability of the site for future business ventures.

To reduce the potential effect of these perceived concerns CNL will support robust communication of environmental monitoring results and sharing information with the Partnership to help them develop a feasible socio-economic plan and a development of robust communication plan to convey and confirm the Project's safety. It is assumed that the Public Liaison Committee and the Partnership will continue for the duration of the Project and provide a means through which CNL can disseminate information with the communities and RMs in the LSA and communities and RMs in the LSA can bring their concerns and issues regarding future use and access to the site forward to CNL. Communication efforts will build on the current Environmental Assessment Follow-up Program for the WL site, which focuses on environmental monitoring, interim storage and end-state support and communications. The public communication component of the Environmental Assessment Follow-up Program is to develop and maintain communication mechanisms during decommissioning that support ongoing communication (CNL 2016a).

6.9.10 Conclusions

Table 6.9.10-1 summarizes the predicted residual adverse effects for socio-economic VCs. For the most part, effects to socio-economic VCs are expected to be managed through management practices and mitigation actions, and thus have been categorized as secondary.

The Project will result in one residual effect to the socio-economic environment, which is changes to the perceived suitability of the WL site for future business ventures and altered access to the WL site for future uses. This residual effect is expected to have an adverse effect on community well-being; however, the Community Regeneration Partnership, including CNL, will make efforts to effectively identify and implement a path forward for economic development in the LSA. In addition, CNL will support robust communication of monitoring results. While the role of the WL site may change in economic and community development in the LSA, development is expected to continue, therefore there is no significant residual adverse effect of the Project on community well-being. In addition, the Partnership, which is developing a socio-economic plan for the participating communities and RMs, is anticipated to support future economic development and subsequently community development. Through this venue, the communities and RMs in the LSA should have the opportunity and expertise available to develop a meaningful and feasible path forward that would help maintain the continued vitality of the communities, especially Pinawa, in the LSA.

Table 6.9.10-1: Summary of Predicted Residual Adverse Effects for Socio-economic Valued Components

Valued Component	Assessment Endpoint	Residual Adverse Effects	Phase Project Effect Occurs in	Contributing Project Activity	Proposed Mitigation	Significance
Community Well-being	The assessment endpoint considers the continued sustainability and overall well-being of communities in proximity to the Project, with a particular focus on Pinawa.	■ The perceived suitability of the site for future business ventures may change as a result of the presence of long-lived radioactive material as part of ISD. ■ The use of ISD as the decommissioning method for WR-1 will change the proportion of the site for unrestricted use.	Closure and Post-closure	ISD of WR-1 Building	■ Continued activities through the Community Regeneration Partnership to help the region develop economically. ■ Communication of environmental monitoring results to confirm the safety of the WL site and lands around it. ■ Final ISD design so that projections of doses to members of the public are well below the average Canadian individual background dose rate. ■ Final ISD design will be done to maximize hazard reduction.	Not significant

ISD = In Situ Decommissioning

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7.0 ACCIDENTS AND MALFUNCTIONS

This section of the Environmental Impact Statement (EIS) seeks to understand and characterize potential effects of malfunctions and accidents of the Whiteshell Laboratories Closure Project WR-1 In Situ Decommissioning (the Project). The three objectives of the effects assessment for accidents and malfunctions are as follows:

- identification of the primary hazards for potential accidents and malfunctions in the Project facilities that could affect the environment, public safety or worker safety;
- identification of planned mitigation, including prevention measures that would minimize the probability of these hazards from occurring, and control measures to mitigate the severity of consequences from an accident or malfunction; and
- estimation of the residual risks following the implementation of mitigation, and prioritization of the resources for risk management based on the levels of residual risks identified.

Accidents and malfunctions could take place as internally-initiated events and externally-initiated events. Internal events are defined as those that are initiated within the Project footprint and are under CNL's direct control (e.g., equipment failures, undetected voids in the grout, or other unplanned releases). This section of the EIS focuses on internal events and external man-made events. External events are defined as those that are initiated outside the Project footprint and are outside of CNL's direct control. These events could be in the form of natural initiating events (e.g., ice-storms and flooding) or man-made initiating events (i.e., human intrusion and aircraft crash). Natural events, such as glaciation and seismic events, are assessed in Section 10 Effects of the Environment on the Project.

Internally or externally initiated events could result in radiological and/or non-radiological accidents. Radiological accidents refer to those that could result in the acute release of radioactivity to the environment and potentially affect the environment, the public or workers. Non-radiological accidents refer to those that involve only non-radiological substances and will not have any adverse radiological effects on the environment and humans (e.g., the spill of chemicals, lubricants and oils).

The accidents and malfunctions analysis encompasses closure activities required to encapsulate the remaining below-grade systems and contaminated portions of the above-grade Primary Heat Transport (PHT) System that have been placed below-grade (refer to Section 3.5 Project Components), as well as the post-closure phase including both Institutional Control and post-Institutional Control. This assessment is supported by the Decommissioning Safety Assessment Report (DSAR; CNL 2017a) that has been prepared in support of the EIS. This analysis and the DSAR is completed in accordance with Regulatory Guide G-320 Assessing the Long Term Safety of Radioactive Waste Management (CNSC 2006) and international guidance including Safety Assessment for the Decommissioning of Facilities Using Radioactive Material (IAEA 2008). The assessment also considers international guidance for radioactive waste management including Safety Requirements for Near Surface Disposal of Radioactive Waste (IAEA 2014) (CNL 2017a).

7.1 Methods

The environmental effects of accidents and malfunctions that could occur in connection with the Project are assessed in accordance with Section 19(1)(a) of the *Canadian Environmental Assessment Act, 2012 (CEAA 2012)*. The assessment was conducted using the Systems Failure Modes and Effects Criticality Analysis approach, which is a standard risk assessment method (CSA 1991, 1997; ISO 2009a,b). The approach includes hazard identification, risk measurement, and risk evaluation, as described below.

7.1.1 Hazard Identification

The assessment began by systematically identifying hazards associated with the Project components that could affect the environment, public safety or worker safety (CNL 2017a). The accidents and malfunctions were identified through the following hazard assessment activities:

- review of Canadian Nuclear Laboratories (CNL) documentation related to the WR-1 Building, including annual reports and environmental monitoring reports;
- review of EIS accidents and malfunctions reports for other similar facilities;
- review of lessons learned documents from previous decommissioning work, including Operating Experience (OPEX);
- engagement input collected as part of the CNL CW-513430-REPT-001 Public Information Program for Atomic Energy of Canada Limit, including public perception regarding long term waste storage options;
- structured Hazard and Operability Study (HAZOPs) *What-If* workshop and report based on five work packages identified for the In Situ Decommissioning (ISD) of the WR-1 Building (i.e., building systems, preparing reactor systems, grout installation, and building demolition and site remediation) (ISR 2017); and
- Features, Events, and Processes (FEPs) Analysis for post-closure.

The HAZOPs workshop and the FEPs process are based on the experience of technically diverse teams of professionals, including individuals with expertise with operational performance, activities to be completed, regulatory requirements, and proven mitigation measures. This team of technical leads established a list of potential hazards to be considered during the closure and post-closure phases, including accidents and malfunctions. The likelihood, consequence, and mitigating factors were discussed to determine which hazards were “credible events” (credible events are defined as having a reasonable probably of occurring).

Mitigation measures were considered and if required, additional prevention measures that would reduce the probability of an initiating event, and control measures to mitigate the severity of consequence from an accident or malfunction were identified. The hazards associated with the Project are grouped into four categories:

- radiological hazards;
- non-radiological hazards;
- internal initiating events and occupational hazards; and
- external initiating events.

The radiological and non-radiological hazards associated with specific initiating events and occupational hazards are considered. As well as "credible events" being carried forward for evaluation, unlikely events identified as having the potential to cause unacceptable radiological consequences (i.e., not adequately addressed by proposed mitigation measures) are carried forward into the assessment to determine the potential risk.

A human health risk assessment was completed as part of the Environmental Risk Assessment (ERA) for the Project (EcoMetrix 2017) to evaluate the potential for adverse effects on human health associated with exposure to chemical and radiological contaminants from the Project. Derived exposures are compared to dose limits for radiation protection as described in the Radiation Protection Regulations under the *Nuclear Safety Control Act, 2012* (NSCA) and relevant toxicity reference values. Natural deterioration of the WR-1 ISD structure that could result in consequences over long time-frames (i.e., Institutional Control and Post-institutional Control periods) are considered normal evolution and are evaluated in the ERA (EcoMetrix 2017) and Section 6.7 Human and Ecological Health.

7.1.2 Risk Measurement

After identifying accidents and malfunctions, the risk associated with each scenario was estimated as a function of magnitude and the likelihood (frequency) of its occurrence. Risk or credibility was estimated using a risk matrix that was developed for the Project (Table 7.1.2-1). The matrix includes a *Likelihood Index* and a *Consequence Severity Index*. The risk matrix developed for this assessment is an integration of a standard environmental assessment matrix with CNL's site specific dose acceptance criteria for accidents. The dose acceptance criteria is shown in Table 7.1.2-2.

Table 7.1.2-1: Project Risk Matrix

		CONSEQUENCE SEVERITY				
	Category	**1 Very Low**	**2 Low**	**3 Moderate**	**4 High**	**5 Very High**
	Environment	Negligible physical or biological effects	Short-term (<2 years) local effects (on-site and vicinity)	Medium-term (2 to 20 years) regional effects	Long-term (>20 years) regional effects	Long-term (>20 years) ecosystem effects
	Worker and Public Safety	Medical treatment not required	Reversible disability or injury requiring hospitalization	Irreversible moderate (<30%) disability to 1 or more people	Single fatality, single irreversible severe (>30%) disability	Multiple fatalities, multiple irreversible severe health effects
Likelihood						
Index	**Events/Year**					
A Probable	>1					
B Likely – Frequent	1 to 1/10					
C Possible – Occasional	1/10 to 1/100					
D Unlikely	1/100 to 1/1,000					
E Rare	1/1,000 to 1/10,000					
F Extremely Rare	1/10,000 to 1/1,000,000					
Beyond Extremely Rare	<1,000,000					

Note: Colour ranking is defined in Table 7.1-3.
<= less than, >= greater than; % = percent.

Table 7.1.2-2: Dose Acceptance Criteria for Accidents and Malfunctions

Likelihood Index	Off-site Doses (mSv)	On-site Doses (mSv)
Likely – Frequent	<0.1/event	<1/event
Possible – Occasional	0.1 to 0.5	1 to 5
Rare	0.5 to 5	5 to 50
Extremely Rare	5 to 100	50 to 100
Beyond Extremely Rare	—	—

mSv = millisieverts.

The *Likelihood Index* ranges from a “Rare” event to a “Probable” event, and is more formally defined through the events per year value. An order of magnitude of events per year values is defined for each *Likelihood* level. For example, the “Possible” level ranges from 1 event in 10 years to 1 event in 100 years.

The *Consequence Severity Index* ranges from “Very Low” to “Very High,” and is applied to two categories of consequences: 1) environment; and 2) worker and public safety. Therefore, there are a total of 2 risk matrices combined in the Project Risk Matrix. A description of the consequence levels from “Very Low” to “Very High” for each of the two categories is presented in Table 7.2.1-1. *Likelihood* and consequence severity were estimated based on industry and operation experience, Project-specific conditions, and the knowledge base of the Project team and risk assessment team. Consequence Severity takes into account anticipated and public perceived risks, including longevity of consequences.

7.1.3 Risk Evaluation

After identifying the hazards and estimating the risk of exposure through accidents and malfunctions, the risks are assigned management actions. Risk evaluation requires determining risk priority according to the Project Risk Matrix (Table 7.1.2-1). The colour ranking system for each risk level in the Project Risk Matrix and the associated management actions are shown in Table 7.1.3-1. The risks are ranked according to four priority levels, ranging from low (green) to moderate (yellow) to high (orange) to highest (red). The Project Risk Matrix (Table 7.1.2-1) is a resource for communicating results, prioritizing risks for risk management, and facilitating implementation of the most effective risk mitigation options.

Table 7.1.3-1: Risk Matrix Priority Levels

Risk Level		Management Action
	Highest	Action required. More detailed risk analysis may be required.
	High	Assess risk mitigation options and reduce risk where practical. Prioritize resources to manage these risks before Moderate or Low ranked risks. More detailed risk analysis may be required.
	Moderate	Assess risk mitigation options and reduce risk where practical.
	Low	Assess risk (and monitor).

7.2 Hazards

Essential to the assessment of potential accidents and malfunctions is identification of the sources of contamination currently present within the WR-1 Building. A high-level overview of the contaminated waste inventories anticipated to be encountered during Project activities is presented.

7.2.1 Radiological Hazards

Radiological hazards associated with decommissioning the WR-1 Building include potential exposure to beta, gamma, and alpha-emitting radionuclides produced during the operational period of the WR-1. These consist primarily of the following types of radiological hazards.

- **Fission products –** Fission products are normally contained within the fuel, although fuel defects or failures result in the release of fission products in small quantities, which are then circulated throughout the reactor core and heat transport system, during the operational life of the reactor.
- **Activation products –** Activation products are produced by irradiation of neutron absorbing materials, which become radioactive. They are most abundant in structures and components in or near the core of the reactor, such as the fuel channels.
- **Tritium –** Tritium is produced when heavy water captures neutrons. Residual moderator left from draining the WR-1 is expected to contain tritium.
- **Corrosion products –** Corrosion products are small, mobile activation products, produced when small debris from corrosion is transported through the core (e.g., in the moderator or coolant) and are irradiated.

The dominant radionuclides associated with the main systems and components of the WR-1 Building are provided in Table 7.2.1-1. Derived radionuclide inventories for the main systems and components are described in detail in the ERA (EcoMetrix 2017), and are summarized in Section 6.7 Human and Ecological Health. The bulk of the remaining radioactivity is expected to be within the reactor vessel (i.e., calandria, fuel channels, thermal shield, and biological shield) (CNL 2016a).

Table 7.2.1-1: Radionuclides Associated with Main Systems and Components of WR-1

System/Component	Radionuclide
Reactor Core	Carbon-14, Iron-55, Cobalt-60, Nickel-59, Nickel-63, Niobium-94
Primary Heat Transport	Cesium-137, Strontium-90, Cobalt-60, (small amounts of Niobium-94, Zirconium-95, Antimony-125, Europium-152, Radon-226, Americium-241), Isotopic Plutonium, Technetium-99, Iodine-129, Curium-244
Biological Shield	Carbon-14, Chlorine-36, Calcium-41, Nickel-63, Cobalt-60, Europium-152
Heavy Water and Helium System	Tritium, Carbon-14
Corrosion products	Carbon-14, Chlorine-36, Iron-55, Nickel-63, Nickel-59, Cobalt-60, Niobium-94
Surface contamination	Cesium-137, Strontium-90, Isotopic Plutonium, Americium-241

7.2.2 Non-Radiological Hazards

Non-radiological hazards present during the decommissioning of the WR-1 Building include conventional industrial hazards, chemical hazards, biological hazards and fire hazards. Conventional industrial hazards associated with the decommissioning activities include working at heights, working in confined spaces, working with energized systems, hoisting and rigging, and falling objects. Dismantling and demolition of the WR-1 Building will involve the use of cranes and movement of heavy loads. The use of saws, drills and compressors represent potential sources of physical injury to the operator, as well as changes in site condition (e.g., excavations). These conventional hazards are discussed further in Section 7.3.1. Hazardous materials present within the WR-1 Building include asbestos, lead, polychlorinated biphenyl compounds (PCBs), mercury, mould, and various chemicals.

As the bulk of the PCBs and limited asbestos material will be removed prior to ISD, a select number of non-radiological contaminates are identified as a potential concern and are evaluated in ERA (EcoMetrix 2017). These included: potassium hydroxide, boron, lead, xylene, palladium, chromium, cadmium, organic coolant (HB-40) and mercury. The hazardous materials within the WR-1 Building are summarized in Table 7.2-2. Details on derived non-radiological waste inventories are provided in the ERA (EcoMetrix 2017).

Table 7.2.1-2: Non-Radiological Hazards Associated with Main Systems and Components of WR-1

Chemical/Material	Expected Locations	Quantity (kg)
HB-40[(a)]	PHT System; Auxiliary Organic System and Gas System; Fuel Wash Down system, calandria tubes, tanks	87,700
Lead	Throughout the WR-1 Building	40,800
Xylene	Spent Fuel Handling and Storage System; Wash Down System	1.9
Boron	Heavy Water System; Auxiliary Systems, including Boron Addition System	0.0009
Palladium	Organic Supply System	15.5
	Helium System	
Potassium Hydroxide	Chemical Addition Tank in the Concrete Cooling System	0.01
Cadmium	WR-1	91.4
Chromium	Condenser Tubes; Boiler Tubes	148
Mercury	Throughout the WR-1 Building	0.33
Beryllium	WR-1 – Fuel Elements	Limited
Platinum	FLUX Detectors	Limited
Magnesium Oxide	FLUX Detectors	Limited
Gadolinium Nitrate	SLOWPOKE Demonstration Reactor Liquid Absorber Safety System	Limited
Ozone Depleting Substances	Multiple systems	Limited
Multiple Ion Exchange Columns	Heavy Water System, Distilled Water System, Spent Fuel Bay Circulation System, Concrete Cooling System, Boron Addition System, SLOWPOKE Demonstration Reactor Auxiliary Systems, WR-1 L2 Loop, Fast Neutron Loop	Limited

Note:

(a) Organic coolant, also known as OS-84 or HB-40, has been drained and properly disposed of; however, residual coolant anticipated to coat the PHT system, and found in some tanks, and some calandria tubes. The used organic coolant is potentially contaminated from fuel failure events and corrosion products. The properties of the organic coolant are known to change with irradiation, therefore, residual amounts are expected to be in the form of a viscous liquid sludge, or a dried coating. The volume of organic coolant remaining was very conservatively estimated by assuming 30% of the total organic cooling system volume remains. Subsequent source term investigations indicate that the volume remaining is much lower.

7.3 Accidents and Malfunctions

The credible accidents and malfunctions that may occur during decommissioning the WR-1 Building (i.e., closure phase) and the post-closure phase are described below. The probability of occurrence and control measures to mitigate the consequence severity of the hazard(s) from an accident or malfunction are also described. The risk evaluation for each accident and malfunction is provided in Section 7.4.

7.3.1 Conventional Occupational Accidents

Potential worker accidents and injury may arise from non-radiological hazards such as conventional industrial hazards, including working at heights, working in confined spaces, working with energized systems, hoisting and rigging, and falling objects. Dismantling and demolition of the WR-1 Building will involve extensive use of cranes and the movement of heavy loads, resulting in fall hazards and falling object hazards. Failure to isolate all energized systems (e.g., electrical, pressurized) during building isolation, either through improper isolation or accidental exclusion, may result in electrocution or physical shock hazards for workers. The use of saws, drills and compressors represent potential sources of physical injury to the operator, as well as changes in site condition (e.g., excavations).

In addition to the potential injury or accident itself, initiating incidents during decommissioning activities may result in increased exposures to other hazards present within the workplace. For example, if injured personnel require the assistance of rescuers or face delays in being removed from an unsafe location this could increase hazard exposure magnitude and timeframe. In particular, accidents or injuries in confined spaces increase potential exposure of the worker and rescuers to confined space hazards, such as exposure to poor air quality, chemicals and radiation. The hazard initiating the accident or injury may also pose a particular threat to rescuers.

Following the identification of hazards, a screening analysis is completed to remove conventional hazards that are not credible events. The risk of occupational accidents, such as trips, fall, strains, electrocution, crushing, and pinching are no different for the Project than at other industrial projects; these are likely to occur. Conventional industrial hazards associated with Project activities are limited to on-site personnel who are working on the Project under controlled and monitored conditions, and do not pose a threat to the public or the environment. Occupational health and safety aspects of these types of industrial projects are heavily regulated and programs must be compliant with federal regulations, ensuring that occupational hazards are appropriately managed.

The non-radiological, industrial hazards are systematically identified and assessed through CNL's Occupational Safety and Health (OSH) Program. The WL site has demonstrated the ability to develop and implement effective health and safety procedures and training programs to reduce the occurrence of an accident and limit the potential extent of personnel injury. The work required as part of the Project will be carefully executed and will be completed in accordance with established CNL procedures. Furthermore, CNL has a rigorous Emergency Preparedness Program and personnel at the WL site are adequately trained to prevent and respond to occupational accidents, including on-site fire fighters who are trained in confined space rescue and procedures for dealing with injured workers.

Addressing the human factor that is central to occupational health and safety accidents is not possible; however, the occupational hazards and risks associated with the Project are well understood. Proven workplace controls (e.g., job scope and safety analysis, signage, training, standard work procedures, and controlled access where applicable), and Personal Protective Equipment and Clothing (PPE&C) (e.g., hard hats, gloves, fall protection, and hearing protection) are expected to mitigate these hazards to an acceptable level. Over the past 10 years, decommissioning activities have been taking place on the WL site (e.g., SLOWPOKE demonstration reactor,

Van de Graff Accelerator and Neutron Generator). During this time period the WL site received a ranking from the CNSC of "Satisfactory" for Conventional Health and Safety.

The key performance measure for conventional Health and Safety is the Recordable Lost-time Injuries (RLTIs) (i.e., an injury that takes place at work and results in the worker being unable to return to work for a period of time). Both the frequency and severity of incidents for every 200,000 person-hours is considered in the performance measure. A summary of WL injury rate data is provided in Table 7.3.1-1. It was noted in 2013 by the CNSC that although most injuries were minor (i.e., only requiring first aid) there was an increasing trend in the number of days required to return to work (i.e., increasing event severity). As such, CNL has since implemented improvements, which have been successful as shown by the decline in RLTIs and working days lost in Table 7.3.1-1 (CNL 2017b, 2016a).

Table 7.3.1-1: Summary of WL Injury Rate Data

Year	2011	2012	2013	2014	2015	2016
Person Hours Worked	744,000	778,875	860,250	883.500	741,000	684,450
Lost-time Injuries	8	5	7	4	0	1
Working Days Lost	49	36	62	54	0	5
Frequency[(a)]	2.1	1.2	1.6	0.9	0	0.29
Severity[(b)]	13.1	9.2	14.4	12.2	0	1.46

(a) Frequency rate equals # of lost-time injuries x 200,000 hrs of exposure divided by person hours worked (based on 100 full time workers).

(b) Severity rate equals # of working days lost x 200,000 hrs of exposure divided by person hours worked (based on 100 full time workers).

The likelihood of an occupational health and safety accident occurring, considering controls and mitigation, is Unlikely. An accident resulting in a worker fatality is a Rare occurrence; however, the consequence severity of such a loss would be High. Consequently, the risk level is conservatively considered High, and requires prioritized ongoing assessment of controls and mitigation, the assessment of risk mitigation options, the reduction of risk as practical, and monitoring to verify the effectiveness of controls and mitigation. These management actions are consistent with the safety management system and safety culture already in effect at the WL site, where regular assessment of safety performance is conducted and lessons learned from experience are applied.

7.3.2 Spills and Leaks

Spills and leaks of hazardous substances are possible during all stages of Project activities, including hydraulic fluid or fuel leaks from vehicles or heavy equipment, failure of storage equipment (e.g., Low Level Waste Collection system) or operational errors. For example, during cutting and perforation of components and structures as part of dismantling, unknown or greater than expected quantities of radioactive and non- radioactive hazardous substances may be encountered. Accidental cuts or breaks of contaminated piping during decommissioning may also release radioactive substances from these systems. The CNL Emergency Plan, as part of the Emergency Preparedness Program, provides an analysis of potential emergencies that could occur focused and focuses on planned response to a release of hazardous material. As part of the Emergency Preparedness Program, this plan is revised annually to identify any changes required to keep the plan current. The results of monitoring program demonstrate that the controls for the release of potentially hazardous substances currently in place at the WL site continue to provide protection of the environment (CNL 2016b).

Non-radiological hazardous materials in excess of the regulated exemption quantities in the above-grade structure (as well as easily removed quantities in the WR-1 ISD structure) will be removed and disposed of at an appropriate disposal site. Spills and leaks are possible during removal, handling, and transport of these materials, including friable asbestos, lead, PCBs, and chemicals of various degrees of toxicity (refer to Table 7.2.1-2). Spills and leaks during worker activities could lead to external and internal exposures to workers. Volatile contaminants released to the atmosphere may be transported and deposited in a new location. Accidental releases of liquid contaminants during transport to an appropriate disposal area may contaminate soil, groundwater, surface water and air. CNL has plans and processes in place to deal with liquid spills (e.g., Emergency Response Plans, Transportation Plans).

During closure, operational procedures pertaining to spill response will be in effect (i.e., Emergency Preparedness Program including WL Emergency Plan). WL employees have basic training in the management of emergencies, while other personnel at the WL site have been highly trained to respond to incidents involving contamination dispersion and there are proven procedures in place to protect workers, the public, and environment during such an event. In addition to proven spill response procedures, engineering controls will still be in place during closure, including the Environmental Incident Reporting, Investigation and Mitigation. The waste collection system for the WR-1 Building will be operational (i.e., sump water collection, storage, and treatment) and adequate ventilation during decommissioning activities will reduce worker exposures to airborne contaminants, as well as filtration. The use of appropriate PPE&C (e.g., chemical resistant gloves, eye protection), routine inspections of equipment, spill trays, spill kits, and established emergency procedures will also be used to manage these hazards and mitigate the effects of spills and leaks. As required, chemical protection suits and self-contained breathing apparatuses will be deployed to protect workers who may be potentially exposed to toxic chemicals, such as potassium hydroxide. Due to its slow biodegradation and low water solubility, hydrogenated terphenyl will be collected to a practical extent and disposed of appropriately.

To minimize the potential effects of radiological spills and leaks, all work will be executed following the procedures and practices of CNL's Radiation Protection Program. Procedures developed under CNL's Environmental Protection Program, Waste Management Program, and OSH Program will also aid in protecting workers and the environment from radiological and non-radiological hazards. CNL's Radiation Protection Program is designed and implemented to ensure CNL complies with, or exceeds, the level of radiation safety that is required by the relevant regulations pursuant to the NSCA 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 (ALARA), social and economic factors being taken into account; and
- prevent detrimental non-stochastic (deterministic) health effects caused in employees and members of the public by CNL's use of radiation.

At all WL 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 (social and economic factors being taken into account).

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.

- **Environmental Policy**
  - Commitment to pollution prevention.
  - Setting environmental objectives and targets to support continual improvement of environmental performance.
  - Complying with applicable laws, recognized standards and guidelines applicable to CNL activities.
  - Reviewing the impacts of CNL facilities, projects, services and products on the environment.
- **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 ongoing suitability, adequacy and effectiveness of the Environmental Management System.

CNL's Waste Management Program includes requirements and processes for CNL activities that involve planning for, handling, processing, packaging, transporting, storage and disposal of wastes to ensure that they are performed in a manner that complies with applicable regulatory and licence requirements and protects workers, the public and the environment. The Waste Management Plan at the WL site 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.

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.

Essential to preventing spills and leaks is the consideration of contamination characterization (e.g., location and composition) during detailed work planning. All activities related to the Project will be covered by either CNL's work permits with completed Radiological Safety Assessments, as required, or by approved work procedures. A Work Permit System for all non-routine work involving potential health and safety hazards provides that hazards are evaluated and appropriate protective measures taken.

From 2011 through 2016, there were no incidents requiring the initiation of the WL Site Emergency Plan, including no reportable spills. Table 7.3.2-1 summarizes the number and types of spills and leaks recorded at the WL site over the past five years. Definitions and examples of the four levels of incident categories are provided below.

- **Level 4 (Negligible) –** Non-reportable or reportable environmental incidents with no potential for, or actual generation of public concern. For example, an on-site release immediately contained by on-site controls or readily cleaned up resulting in pollution or degradation with a short-term (less than 3-month), reversible detrimental effect on the environment.
- **Level 3 (Minor) –** Reportable environmental incident with no potential for, or actual generation of public concern. For example, an environmental nuisance release resulting in pollution or degradation with a persistent (greater than 3-month), reversible detrimental effect on the environment.
- **Level 2 (Moderate) –** Reportable environmental incident that could generate public concern and/or negative press. Incident requiring significant company resources and likely additional resources, to clean-up. The incident poses a potential serious threat to natural are sources, the environment, or public property. There are on-site and off-site effects.
- **Level 1 (Major) –** Reportable environmental incident that generates a significant amount of public concern. Refers to pollution or degradation which has or may have irreversible detrimental effects on the environment. Catastrophic environmental (extends to a wide scale beyond the site) impact requiring a full-scale response by outside agencies, and allocation of additional resources to conduct clean-up. Level 1 incidents may involve international boundaries; could seriously affect natural resources, the environment and/or public property; could have a major impact on production capability.

Table 7.3.2-1: WL Recorded Spills and Leaks

Year	Level 1	Level 2	Level 3	Level 4	Total
2011	0	0	0	5	5
2012	0	0	0	4	4
2013	0	0	0	11	11
2014	0	0	0	6	6
2015	0	0	0	9	9
2016	0	0	0	20	20

Note: Level 1 = Highly Significant Problem; Level 2 = Significant Problem; Level 3 = Problem / Minor Incident; and Level 4= Minor Problem / Improvement / Negligible Incident.

The likelihood of a spill or leak occurring as the result of an accident or malfunction, considering controls and mitigation, is Possible-Occasional, and the consequence severity of increased worker exposure would be Low. Consequently, the risk level is classified as Moderate, and requires the assessment of mitigation options, the reduction of risk as practical and monitoring to verify control and mitigation effectiveness. These required management actions are consistent with the safety management system and safety culture already in effect at the WL site, where regular assessment of safety performance is conducted and lessons learned from experience are applied.

7.3.3 Material Handling Accidents

Various ISD activities may involve lifting and moving of large, potentially contaminated materials. The heat exchangers from the PHT system may be placed inside the WR-1 ISD structure. Other contaminated items, such as fume hoods and active ventilation ducts that are not currently located within the WR-1 ISD structure, will be removed from the WR-1 Building and properly disposed. Wastes collected during decommissioning activities will be placed in containers and properly disposed.

Demolition activities will require handling of heavy loads. Drops of, or impacts from, large objects pose physical hazards for workers nearby, and dropped objects could also damage other equipment or structures, resulting in leaks and spills. Cleanup or remediation required following such an incident could result in higher worker exposures. Dropping of contaminated rubble or concrete could cause fine, radioactive particles to be suspended in air, posing an internal exposure hazard. Drops and ruptures of waste containers, or contaminated equipment, such as fume hoods, could also spread contamination and cause it to become airborne.

During closure, operational procedures pertaining to the prevention of spreading contamination will be in effect (i.e., Radiation Projection Plan) and the waste collection system for the WR-1 Building will be operational (i.e., sump water collection, storage, and treatment). The establishment of adequate ventilation in the workplace and the confinement of sources of contaminants from the ventilation system will curtail airborne releases. Contamination release as a result of accidents during the bulk of the demolition activities to be completed following ISD is anticipated to be limited because the majority of the contamination will be encased in the grout. In addition, the use of stabilizing and immobilizing agents prior to demolition can reduce the spread of any remaining contaminants present in the WR-1 Building. Adherence to the CNL procedures, including hoisting and rigging, will reduce the likelihood of a material handling accident. Therefore, the exposure hazards associated with a material handing accident are limited to on-site personnel who are working on the Project and accident do not pose a threat to the public or the environment.

CNL's Emergency Preparedness Program will reduce the consequences of an accident if it occurs and is designed to respond to any emergency at the WL site. The Emergency Preparedness Program provides guidelines for CNL's emergency management staff to ensure that adequate staff and materials are available to meet the requirements of provincial and municipal emergency plans. A four-tier classification of emergencies is used to assist the Emergency Preparedness Program in making preparations and in implementing response. The classification ranges from Emergency Classification 1 relating to industrial workplace hazards to Emergency Classification 4 relating to an emergency condition at the WL site having the potential to create significant consequences off-site.

The likelihood of a material handling accident occurring, considering controls and mitigation, is Unlikely, and the consequence severity of such a loss of control would be Low. Consequently, the risk level is Low, indicating monitoring is required to verify control and mitigation effectiveness. This required management action is consistent with the safety management system and safety culture already in effect at the WL site, where regular assessment of safety performance is conducted and lessons learned from experience are applied.

7.3.4 Offsite Transportation Accidents

Non-radiological hazardous wastes not planned for encapsulation will be transported to an appropriate off-site waste facility. Radioactive wastes not planned for encapsulation will be managed in the WMA or transported offsite (e.g., CNL's Chalk River Laboratories in Ontario). In addition to exposing emergency response personnel from the WL site, transportation accidents involving vehicles carrying hazardous and radiological wastes off-site may expose the driver or other members of the public, or release contaminants to the environment.

Transport of waste is routine and safe. The movement of hazardous and radioactive materials off-site is governed by the Packaging and Transport of Nuclear Substance Regulations (CNSC 2015), and WL staff and drivers are trained in response procedures. Transport containers for nuclear waste are designed taking into account foreseeable accidents. Packaging materials are tested to withstand conditions associated with fire, impact, wetting, pressure, heat and cold. Therefore, the risk of public exposure during transport is considered to be well known and controlled.

Procedures developed under CNL's Radiation Protection Program, Environmental Protection Program, Waste Management Program, Management of Non-Radiological Hazardous Chemical Waste and OSH Program will aid in protecting workers and the environment, and reduce the risk of transportation accidents and their potential severity. In addition, WL Emergency Preparedness Program has emergency plans for off-site accidents. WL personnel at the WL site have been highly trained to respond to incidents involving contamination dispersion and there are proven procedures in place to protect workers, the public, and environment during such an event requiring the management of radiological emergencies. Many of workers have extensive training and experience in those aspects of radiation hazard control and environmental hazard control that are likely to be relevant during an emergency.

In 2012, it was reported that just over 107 million tonnes of dangerous goods were transported on Canadian highways (Statistics Canada 2015). In 2011, 385 reportable accidents occurred involving the transport of dangerous goods by air, boat, rail and road (18% increase from 2010, but 5% below the five-year average for 2006 to 2010). Over 70% of these accidents occurred during material handling at transportation facilities, while the remaining less than 30% occurred during transit (TC 2012). The six-year average reportable accident rate for road is 102 (2006 to 2011). In 2009, the total distance travelled by trucks carrying dangerous goods in Canada was estimated at 308 million vehicle kilometers (Statistic Canada 2009). This translates into an accident rate of 0.33 accidents per million vehicle kilometres travelled. From 2004 to 2012, the average distance of all dangerous good shipments trucked in Canada was estimated to increase from 608 to 632 km (Statistics Canada 2015). CNL, and

AECL previously, have been transporting radioactive materials between sites across North America with no release of radioactive material to the environment. For this analysis the distance required for the Project (one-way trip to disposal facility) was assumed to be triple the average (1,896 km), translating into an accident likelihood of 0.0006 and an accident likelihood offsite of 0.0002.

The likelihood of an offsite transportation accident, considering controls and mitigation, is Rare, although the consequence severity of such a loss of control would be Moderate. Consequently, the risk level is Moderate, requiring the assessment of risk mitigation options, the reduction of risk as practical and monitoring to verify the effectiveness of controls and mitigation. These required management actions are consistent with the safety management system and safety culture already in effect at the WL site, where regular assessment of safety performance is conducted and lessons learned from experience are applied.

7.3.5 System and Equipment Failure

Equipment failure and malfunctions may result from improper operation or maintenance, loss of services, or extreme environmental conditions. Safety-significant systems and equipment, including alarm and monitoring systems (e.g., continuous air monitors), contamination collection and confinement (e.g., Low Level Liquid Waste Collection system, ventilation system, storage tanks), could potentially be affected. Such failures could result in the accumulation or release of airborne or liquid contaminants potentially affecting worker dose exposures. As secondary containment and Emergency Preparedness Plans already exit, these hazards associated with Project activities are limited to onsite personnel who are working on the Project and do not pose a threat to the public or the environment.

Failures of systems or equipment could result in radiological and non-radiological hazards through the accumulation or release of airborne and liquid contaminants, as well as increased worker exposure. Failure of alarm and monitoring systems could put workers at higher risks of exposures or fail to provide notification of unsafe conditions. Worker injuries and accidents are also possible with failed equipment or systems. Preventative maintenance is performed to prevent failures from occurring and to assure the continuing capability to perform designed function.

Design of equipment with fail-safe modes, use of reliable power supplies, maintenance programs, and depth-in-defense reduce the likelihood or effects of failures. Use of PPE&C and adherence to OSH procedures, contingency planning, and safe back-out procedures provide protection to workers from system and equipment failure. In addition, CNL employs a full-time fire protection team for prompt and appropriate response to fires involving radiological and non-radiological hazards.

From 2011 to 2016, there were no instances where criteria were exceeded as a result of equipment failure (i.e., no serious process failures). In addition, there were no unplanned events that resulted in unavailability of monitoring data as a result of equipment failure from 2011 to 2015. In 2015, there was one unplanned instance of failure of the Class 4 power affecting the WL site that was of sufficient duration to initiate the Class 3 emergency power generators. In 2012, 2013 and 2012, there were short-duration issues with the WL outdoor emergency siren that was believed to be the result of freezing rain and high wind events. Actions have been put in place to prevent this from happening in the future. In 2013, there was one unplanned event of unavailability of monitoring data when the outfall sampling pump lost its prime due to maintenance being performed on the main supply pump. This potential consequence of the maintenance was known and inspection of the outfall sampling pump was scheduled to occur, however, for 95 hours the pump was offline.

The likelihood of a system and/or equipment failure, considering controls and mitigation, is Unlikely, and the consequence severity of such a loss of function would be Low. Consequently, the risk level is Low, requiring monitoring to verify the effectiveness of controls and mitigation. This required management action is consistent with the safety management system and safety culture already in effect at the WL site, where regular assessment of safety performance is conducted and lessons learned from experience are applied.

7.3.6 Fires and Explosions

Fires may result by ignition of combustible materials, hot work, equipment malfunction, electrical faults, or lightning strikes. A number of systems and components will require cutting or perforating during reactor systems preparation. The use of saws, grinders, cutting torches, and drills pose a risk of ignition of combustible material. These hazards are consistent with decommissioning activities currently taking place within the WL site. In 2011 and from 2013 to 2016 there were no reportable fire events. In 2012, there was one reportable fire in Building 408 (an electrical fire in a heating unit).

Cutting of sealed components, which may be specifically targeted so that grout will infiltrate them and reduce voids, may pose an explosion hazard if they contain combustibles. During grouting, metals and alloys (i.e., aluminium) exposed to high pH (e.g., an improperly specified or mixed grout) produce hydrogen, which could potentially reach an explosive concentration above the grout surface.

Adequate ventilation will be provided to prevent the build-up of volatile components. If the ventilation is adversely affected by a fire in the building, there is possibility that workers exposure to airborne contaminates could be increased. The building contains standard emergency response equipment and required PPE&C will be provided. Small radioactive releases to the environment are also possible during fires from the burning of contaminated material. Waste generated from decontamination activities, such as wipes, protective clothing, and HEPA filters introduces combustible contaminated material, which could be released to the atmosphere during a fire. Firefighting methods may spread contamination, primarily inside the WR-1 ISD structure, but also outside of the WR-1 ISD structure (e.g., contamination spread in the 600 and 700 level from sections of the PHT system and ventilation system). The potential for contamination spread beyond the WR-1 ISD structure as the result of a fire would depend on the stage of decommissioning activities (e.g., if above-ground portions of PHT system have been dismantled and relocated below-grade. Controls are in place to limit the potential for liquid borne contamination as the result of firefighting to spread to the surrounding environment. Since most of the reactor hall outside of the WR-1 ISD structure will be removed, cross-contamination in these areas will burden the removal process with greater decontamination effort and higher dose rates.

There are limited quantities of combustibles in the WR-1 Building. Fire hazards can be reduced through further removal of combustibles, and preferential use of cold cutting equipment. Sealed components will be carefully surveyed prior to cutting or perforation, and remote and cold cutting equipment will be used as necessary. Grout specification and formulation will take into account the potential of hydrogen generation and radiolysis of water trapped in the grout. Waste from decontaminated activities will be packaged and managed in compliance with WL Waste Material Management reducing the likelihood of ignition and good housekeeping will reduce the fuel available for a fire. Wastes from decontamination activities will be packaged and managed in compliance with WL materials management procedures to reduce the likelihood of ignition. Worker doses during cleanup following a fire can be kept to a safe level through radiation protection practices.

Implementation of WL Fire Protection/Prevention Program will reduce the potential for a fire and the duration and consequences of a fire. CNL maintains a separate procedure for fires involving radioactive material at the WL site. CNL also maintains an Emergency Preparedness Program that reduces consequences from fires and explosions.

These plans are discussed in more detail below. Promoting fire safety and preventing fire losses at WL are the main objectives of the WL Fire Protection/Prevention Program. Program objectives are achieved by the following.

- **Promoting Fire Safety:** Provide fire safety information such as pamphlets, displays, presentations, newsletters and employee awareness bulletins, participate in facility safety meetings and provide portable fire extinguisher training to WL employees.
- **Monthly Fire Prevention Inspection:** Inspect all buildings at WL every month to identify and report fire deficiencies and infractions.
- **Monitoring:** Monitor the activities at WL to prevent fire, including the fire watch (for hot works), follow-up inspections following hot works, inspection of construction, demolition and renovation sites and fire prevention inspections to verify (visually) that identified deficiencies are rectified.
- **Fire Scene Investigation:** Examine the fire scene to determine the cause of fire by identifying physical evidence, and protect the scene until the investigation is complete and adopt measures to prevent re-occurrence.
- **Change Control:** Ensure that proposed changes on site are in line with governing fire and building code requirements and site operating licence conditions. Conduct fire screenings and provide recommendations to the Fire Protection Program Manager for consideration.
- **Training:** Training of on-site personnel, facility operations staff and Fire Prevention Inspector.
- **Documentation:** Maintain database to monitor fire prevention trends, compile a list of fire hazard analyses (FHAs) and update as required.

If a fire does occur, the Fire Response Involving Radioactive Material (CNL 2013) at WL manages the hazards for emergency personnel involved in fire suppression and/or rescue activities that potentially involve radioactive materials (AECL 2013). The plan includes the following requirements:

- keep individual doses below CNSC Emergency Response Dose Limits;
- keep potential radiation doses to fire fighters as low as reasonably achievable;
- minimize the potential spread of contamination after the fire is extinguished; and
- prevent possible nuclear criticality excursions for fires involving special fissionable materials.

At the WL site, a full-time well trained fire protection team is employed to ensure rapid and appropriate response to fires involving or potentially involving radiological material. CNL's Emergency Preparedness Program is designed to respond to any emergency at the WL site. The Emergency Preparedness Program provides guidelines for CNL's emergency management staff to ensure that adequate staff and materials are available to meet the requirements of provincial and municipal emergency plans. The program provides the earliest possible coordinated response to reduce the effects from an emergency to workers, the public, and the environment, as well as restore normal operations as quickly as possible to site.

A four-tier classification of emergencies is used to assist the Emergency Preparedness Program in making preparations and in implementing response. The classification ranges from:

- **Emergency Classification 1 –** an emergency condition relating to industrial workplace hazards within the facility boundary.
- **Emergency Classification 2 –** an emergency condition having the potential to create significant consequences within the facility boundary.
- **Emergency Classification 3 –** an emergency condition having the potential to create a significant consequence onsite, outside the facility boundary.
- **Emergency Classification 4 –** an emergency condition having the potential to create significant consequences off-site.

CNL also maintains an additional emergency procedure for the WR-1 Building (i.e., WR-1 Complex) that provides the requirements, responsibilities and the process for occupants to respond to likely building-specific emergencies within WR-1 Complex (CNL 2016c).

Radiological and hazard characterization of system components remaining in the WR-1 Building will be completed as necessary prior to closure activities to inform planning of grout application, safe work, and waste management as required for each decommissioning work package. The likelihood of a fire or explosion occurring as a result of an accident or malfunction, considering controls and mitigation, is Rare and the consequence severity of such an incident would be High. Consequently, the risk level is High, requiring prioritized ongoing assessment of controls and mitigation, the assessment of risk mitigation options, the reduction of risk as practical and monitoring to verify the effectiveness of controls and mitigation. These required management actions are consistent with the safety management system and safety culture already in effect at the WL site, where regular assessment of safety performance is conducted and lessons learned from experience are applied.

7.3.7 WR-1 ISD Structure Failure

Improper techniques and incorrect grout designs could compromise the integrity of the WR-1 ISD structure. The following two main pathways could result in a localized WR-1 ISD structure failure.

- **Non-Conformant Grout –** Improper curing of grout may be possible if the grout design is incorrect, or if the grout preparation and lift sequencing is not performed according to specifications. Extreme weather (e.g., extreme temperatures) may result in improper curing of the grout.
- **Excessive Voids –** Localized or larger voids that remain in the WR-1 ISD structure because improper grout installation resulted in structural damage to foundation floors and wall. These voids were not identified or were not practical to fill during preparation, or the result of thermal cracking driven by variation between the thermal expansion coefficients for grout and the features being encapsulated.

Effects of a WR-1 ISD structure failure include reduced isolation and reduced immobilization of contaminants. The formation of cracks near voids may provide a pathway for releases of contaminants to the environment and exposure to the public. The effectiveness of the containment and isolation achieved has been conservatively assessed, and encompasses the degradation of the WR-1 ISD structure over time (CNL 2017a). A sensitivity analysis was conducted to demonstrate the robustness of the design (i.e., illustrate the performance of the

WR-1 ISD structure). The design does not rely on one feature but rather a set of redundant barriers and layers of passive protection (Golder 2017). The modelling completed as part of the normal evolution assessment (see Section 6.7 Human and Ecological Health) addressed uncertainty regarding release rates, taking into consideration the normal evolution of the site with time, including the assumption that the grout and concrete barriers would fail over time. Therefore, the WR-1 ISD structure failure scenario evaluated represents an upset condition of a barrier failure sooner than anticipated.

Grout performance will be maximized by careful design, formulation, and sequencing during installation. Laboratory testing, including tests of the grout with the organic coolant, will be used to validate the reliability of the grouting method and performance of the formulations. CNL will use an experienced grout supplier with an appropriate QA Program for execution of the grouting program. Quality Control and Quality Surveillance will be incorporated during all phases of grout design and installation to confirm the grout formulations are supplied to correct specifications and that the grout system is implemented per the design. Field demonstration testing will also be performed to provide assurance of anticipated grout performance as necessary. The use of visual tools (e.g., 3D model, graphical method of display, video cameras during grouting) may be deployed to plan and execute a grout placement plan designed to reduce the likelihood of voids.

For monitoring requirements arising from the Project, an Environmental Assessment Follow-up Program is proposed for WR-1 (Section 11 Monitoring and Follow-up Programs), appropriate procedures will be developed that will meet or exceed federal and provincial regulatory requirements. A post-decommissioning monitoring program will also be developed that will provide the sampling and analysis objectives and procedures for sampling and testing the groundwater quality in the vicinity of the WR-1 Building. The program will include details concerning sampling locations and sampling frequencies, analysis, quality assurance/quality control requirements, and will be compliant with CSA N288.7-15. As part of CNL's licence (NRTEDL-W5-8.04/2018) with the CNSC, CNL will continue to implement the Environmental Assessment Follow-up Program for the WL site to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. The WR-1 follow-up monitoring program will be coordinated with this program, where practical.

The likelihood of a WR-1 ISD structure failure occurring as a result of an accident or malfunction, considering controls and mitigation, is Unlikely. After the adoption of best engineering practices and quality control, the probability of a non-conformance is greatly reduced. The consequence severity of such an incident would however be High. Further, the perceived risk of an ISD failure would be high. Consequently, the risk level is High, requiring prioritized ongoing assessment of controls and mitigation, the assessment of risk mitigation options, the reduction of risk as practical and monitoring to verify the effectiveness of controls and mitigation. These required management actions are consistent with the safety management system and safety culture that will be in place during the closure and post-closure phases.

This scenario was also considered in the Decommissioning Safety Assessment Report (CNL 2017a), demonstrate the importance of particular sources of uncertainty and provide meaningful illustration of future conditions to inform the Project design (CNL 2017a). For modelling the scenario, a fracture was assumed in the foundation of the WR-1 Building (2 m wide, with hydraulic conductivity greater than the below bedrock) that will remain in place as a component of the WR-1 ISD structure. Exposure pathway characterization is the same as was modelled in the Normal Evolution Scenario, except that groundwater loadings to the surface water are based on an open fracture. As emissions from the WR-1 ISD structure are changed under a failure scenario, both the human and ecological receptors in the vicinity of the WL site could be affected. Predicted exposures for human and non-human biota were compared to relevant dose guidelines for both radiological and non-radiological constituents of potential concern.

The maximum dose was assessed at a single point in time. However, to assess the total radiation dose to the identified human receptors over the groundwater modelling timeframe of 500,000 years, the modelling timeframe was split into five time windows based on inspecting the time of peak loading rates (0 to 60 years, 60 to 40,000 years, 40,000 to 175,000 years, 175,000 to 300,000 years and 300,000 to 500,000 years). The doses for all radionuclides with peak dose in a given time window were added to obtain the total dose in that time window. This is conservative because the peaks within a time window were not exactly coincident.

For the residents of an On-site farm (located on the WR-1 site), Farm A (located near the east bank of the Winnipeg River), and Harvester receptors, the total radiation dose during the post-closure period during WR-1 ISD structure failure scenario are well below the public dose limit of 1 mSv/a, as well as the WL site dose constraint of 0.25 mSv/a (Table 7.3.7 -1). The farm residents are year-round, full-time residents, and the Harvester represents Traditional user exposed through harvesting country foods spending part of their time on-site, near Farm A, and at an unexposed location.

Table 7.3.7-1: Summary of Post-closure Total Dose for Human Receptors under WR-1 ISD Structure Failure Conditions

Age Group	On-Site Farm		Farm A		Harvester	
	Dose (mSv/a)	Percent of Dose Constraint	Dose (mSv/a)	Percent of Dose Constraint	Dose (mSv/a)	Percent of Dose Constraint
Adult	4.78E-05	0.019%	8.99E-07	0.00036%	9.95E-05	0.040%
Child	5.40E-05	0.022%	1.02E-06	0.00041%	7.24E-05	0.029%
Infant (cow's milk)	7.64E-05	0.031%	1.44E-06	0.00058%	9.87E-05	0.039%
Infant (formula)	1.94E-05	0.0078%	3.66E-07	0.00015%	—	—
3-month Old (nursing)	5.49E-04	0.22%	1.03E-05	0.0041%	—	—
3-month Old (formula)	6.06E-07	0.00024%	1.14E-08	0.0000046%	—	—

Notes:
Bold and shaded cells indicate exceedance of the public dose limit of 1 mSv/a; bold cells indicate exceedance of the dose constraint of 0.25 mSv/a.
A dose of 0.0025 mSv/a is equivalent to 1% of the dose constraint and a dose of 0.01 mSv/a is equivalent to 1% of the public dose limit.

The risk to human receptors that could be exposed to the non-radiological contaminants potentially occurring at elevated concentrations (i.e., cadmium and lead) in surface water during post-closure were calculated based on total concentration (background plus Project contribution). Risk was quantified for the human receptor based on the calculation of a hazard quotient (HQ) by dividing the estimated exposure by a toxicity reference value (TRV) that is known to be protective. If the total HQ (sum of individual HQs) is below one, adverse effects are not likely (i.e., no additional assessment work is required to define risk). To account for uncertainty in pathways beyond Project activities, a protective benchmark HQ value of 0.8 would be used for the assessment. Incremental HQs were compared to a benchmark HQ of 0.2, which is consistent with approach taken by Health Canada (2010) for human health quantitative risk assessment. The HQs derived for both cadmium and lead were below the protective benchmark (Table 7.3.7-2, Table 7.3.7-3, and Table 7.3.7-4 for Harvester, On-site farm, and Farm A, respectively)

in all cases but one. The HQs for the harvester On-Site Farm, and Farm A are below the acceptable risk level of 0.2 for cadmium and lead for all ingestion pathways for the toddler and adult. For the toddler harvester, the total ingestion HQ exceeded 0.2 for lead. The HQs for the harvester, On-Site Farm, and Farm A are based on background plus project exposure to cadmium and lead. If only the project contribution is considered, the HQs are reduced even further and total lead ingestion for the toddler harvester is below the target level. As indicated, the project contribution to the total is 0.021% for cadmium and 0.00002% for lead.

Table 7.3.7-2: Summary of Post-closure Hazard Quotients for Harvester Receptors under WR-1 ISD Structure Failure Conditions

Parameter	Total River Contribution				Project Contritubtion			
	Ingestion of Fish	Ingestion of Wild Waterfowl	Ingestion of Deer	Total	Ingestion of Fish	Ingestion of Wild Waterfowl	Ingestion of Deer	Total
Adult								
Cadmium	1.75E-04	1.41E-02	1.32E-05	1.43E-02	7.76E-09	2.98E-06	2.78E-09	2.99E-06
Lead	4.39E-03	1.41E-01	1.08E-04	1.46E-01	1.30E-09	2.39E-08	1.82E-11	2.52E-08
Toddler								
Cadmium	3.74E-04	1.99E-02	1.56E-05	2.03E-02	1.66E-08	4.21E-06	3.30E-09	4.23E-06
Lead	9.40E-03	1.99E-01	6.39E-05	**2.09E-01**	2.79E-09	3.38E-08	2.12E-11	3.66E-08

Notes:

Bold cells indicate exceedance of HQ benchmark of 0.2, shaded cells indicated HQ values greater than 10% of the HQ benchmark (>0.02); **bold and shaded** cells indicate exceedance of HQ benchmark by greater than 1% (value of 0.202 represents exceedance by 1%).

Table 7.3.7-3: Summary of Post-closure Hazard Quotients for Farm A Receptors under WR-1 ISD Structure Failure Conditions

Pathway (mg/kg/day)	Cadmium		Lead	
	Farm Adult	Farm Toddler	Farm Adult	Farm Toddler
Soil Ingestion	3.86E-05	6.62E-04	6.34E-03	1.09E-01
Soil Dermal Contact	2.20E-06	4.29E-06	3.61E-03	7.05E-03
Dust Inhallation	2.44E-05	5.22E-05	4.00E-03	8.57E-03
Ingestion of Plants	7.44E-05	7.83E-05	3.62E-03	3.81E-03
Ingestion of Fish	1.12E-04	1.17E-04	2.80E-03	2.94E-03
Ingestion of Beef	1.18E-05	4.88E-06	1.32E-04	5.45E-05
Ingestion of Poultry	3.72E-05	3.39E-05	2.09E-03	1.91E-03
Ingestion of Pork	2.85E-05	2.17E-05	5.23E-05	3.98E-05
Ingestion of Eggs	2.21E-05	1.05E-05	1.04E-03	4.90E-04
Ingestion of Milk	3.43E-06	2.84E-05	3.30E-04	2.73E-03
Ingestion of Deer	2.18E-07	0.00E+00	1.78E-06	0.00E+00
Total	3.55E-04	1.01E-03	2.40E-02	1.36E-01

Notes:

Bold cells indicate exceedance of HQ benchmark of 0.2, shaded cells indicated HQ values greater than 10% of the HQ benchmark (>0.02); **bold and shaded** cells indicate exceedance of HQ benchmark by greater than 1% (value of 0.202 represents exceedance by 1%).

Table 7.3.7-4: Summary of Post-closure Hazard Quotients for On-site Farm Receptors under WR-1 ISD Structure Failure Conditions

Pathway (mg/kg/day)	Cadmium		Lead	
	Farm Adult	Farm Toddler	Farm Adult	Farm Toddler
Soil Ingestion	3.86E-05	6.62E-04	6.34E-03	1.09E-01
Soil Dermal Contact	2.20E-06	4.29E-06	3.61E-03	7.05E-03
Dust Inhallation	2.44E-05	5.22E-05	4.00E-03	8.57E-03
Ingestion of Plants	7.44E-05	7.83E-05	3.62E-03	3.81E-03
Ingestion of Fish	1.12E-04	1.17E-04	2.80E-03	2.94E-03
Ingestion of Beef	1.18E-05	4.88E-06	1.32E-04	5.45E-05
Ingestion of Poultry	3.72E-05	3.39E-05	2.09E-03	1.91E-03
Ingestion of Pork	2.85E-05	2.17E-05	5.23E-05	3.98E-05
Ingestion of Eggs	2.21E-05	1.05E-05	1.04E-03	4.90E-04
Ingestion of Milk	3.43E-06	2.84E-05	3.30E-04	2.73E-03
Ingestion of Deer	2.18E-07	0.00E+00	1.78E-06	0.00E+00
Total	3.55E-04	1.01E-03	2.40E-02	1.36E-01

Notes:

Bold cells indicate exceedance of HQ benchmark of 0.2, shaded cells indicated HQ values greater than 10% of the HQ benchmark (>0.02); **bold and shaded** cells indicate exceedance of HQ benchmark by greater than 1% (value of 0.202 represents exceedance by 1%).

Radiation dose benchmarks of 0.1 mGy/h (2.4 mGy/d) (UNSCEAR 2008) for terrestrial and riparian biota and 9.6 mGy/d for aquatic biota were used to evaluate effects to ecological receptors. These are total dose benchmarks, therefore the dose to biota due to each radionuclide of concern is summed to compare against this benchmark. All predicted doses are well below these levels. Therefore, it is unlikely that there would be significant adverse effects on either aquatic or terrestrial populations or communities as a result of radionuclide releases under a WR-1 ISD structure failure scenario (Table 7.3.7-5).

Table 7.3.7-5: Summary of Post-closure Total Dose for Ecological Receptors under WR-1 ISD Structure Failure Conditions

Ecological Receptor	Dose (mGy/d)	Percent of Dose Benchmark
Barn Swallow	8.11E-06	0.00034%
Little Brown Bat	6.68E-06	0.00028%
Carmine Shiner	4.10E-06	0.000043%
Lake Sturgeon	4.10E-06	0.000043%
Walleye	4.10E-06	0.000043%
Freshwater plant	4.20E-06	0.000044%
Benthic Invertebrate	3.65E-06	0.000038%
Horned Grebe	8.10E-06	0.00034%
Trumpeter Swan	8.17E-06	0.00034%

Table 7.3.7-5: Summary of Post-closure Total Dose for Ecological Receptors under WR-1 ISD Structure Failure Conditions

Ecological Receptor	Dose (mGy/d)	Percent of Dose Benchmark
Wild Waterfowl	8.14E-06	0.00034%
Mink	6.67E-06	0.00028%

Notes:
Bold cells indicate exceedance of the terrestrial and riparian benchmark of 2.4 mGy/d or the aquatic benchmark of 9.6 mGy/d.

The risk to ecological receptors that could be exposed to the non-radiological contaminants identified as potentially occurring at elevated concentrations (i.e., cadmium and lead) during post-closure in a ISD failure scenario were calculated based on total concentration (background plus Project contribution). Hazard quotients are summarized in Table 7.3.7-6. For the ecological health assessment, the HQ benchmark is 1, all calculated HQs were below 1% of protective HQ benchmark (i.e., all below 0.01). All predicted exposures are well below protective benchmark values, therefore, no adverse effects to human or ecological receptors are anticipated from a WR-1 ISD structure failure.

Table 7.3.7-6: Summary of Hazard Quotients for Ecological Receptors under WR-1 ISD Structure Failure Conditions

Receptor	Cadmium	HB-40	Lead	Xylene
Benthic Invertebrates	7.76E-09	1.30E-09	1.66E-08	2.79E-09
Fish	2.98E-06	2.39E-08	4.21E-06	3.38E-08
Aquatic Plants	2.29E-09	1.82E-11	2.72E-09	2.12E-11
Barn Swallow	5.34E-05	NV	6.87E-03	4.25E-07
Horned Grebe	1.85E-05	NV	2.15E-03	1.49E-07
Trumpeter Swan	9.84E-04	NV	4.54E-02	2.53E-08
Wild Waterfowl	1.22E-03	NV	5.65E-02	6.59E-08
Little Brown Myotis	4.95E-05	2.40E-04	3.58E-04	3.16E-08
Mink	1.91E-05	1.23E-04	1.42E-04	1.22E-08

Notes:
Bold cells indicate exceedance of HQ benchmark of 1, shaded cells indicated HQ values greater than 1% of the HQ benchmark (>0.01)
NV = no value available to calculate HQ.

7.3.8 External Events

7.3.8.1 Aircraft Crash

The WL site is about 13 kilometres (km) from the nearest airfield (Lac du Bonnet airport), and over 100 km away from the nearest international airport (Winnipeg Jameson Armstrong Richardson). As the local airports are small and relatively distant, the likelihood of an aircraft crashing into the WR-1 Building during closure or post-closure phase can be based on the general aircraft crash rate. The general risk factor of 26^{-4} square kilometre per year (10^{-4} per square mile) (U. S. Department of Energy 2006) applies to the Project. Decommissioning activities are

planned to begin in 2019 with demolition of the WR-1 Building complete by June 2022. The Project footprint encompasses approximately 0.0007 square kilometres (km^2). Given the small size of the WR-1 Building and the small footprint of the WR-1 ISD structure that will be present throughout post-closure, the likelihood of an aircraft crash directly affecting the Project is remote. As part of the Emergency Preparedness Plan, a regularly updated site inventory (radiological and non-radiological hazardous materials) is maintained. This inventory is used to characterize hazards and informed the execution of emergency response teams. If a crash does occur, damage may occur to the engineered cover and grout structure, potentially reducing the long-term performance.

The likelihood of an aircraft crash is Rare, the consequence severity of such an external event would be Low. Consequently, the risk level is Low, indicating monitoring is required to verify control and mitigation effectiveness. During closure the site's Emergency Preparedness Program would be in effect, which is updated regularly to reflect the hazards present on-site, and during post-closure the associated hazards are limited. This required management action is consistent with the safety management and monitoring system that would be in place during the closure and post-closure phases.

7.3.8.2 Human Intrusion and Human Habitation

The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. The Institutional Control period includes implementation of active controls throughout 2024 to 2124 (i.e., 100 years) and passive controls through 2024 to 2324. During active Institutional Control, long-term performance monitoring and maintenance activities will continue to demonstrate compliance with the safety case assumptions. During the passive Intuitional Control period, mechanisms will be used that are 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 (e.g., deed restrictions), and may also include certain physical controls (e.g., fences and gates). Post-institutional Control occurs after year 2324 and continues indefinitely.

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 failure, or continue to limit the potential for being vandalized or damaged by outside elements (natural or human) in any way. The Project is designed to promote safety through passive means during post-closure. Security and surveillance will be provided by site staff. The WL site security features may include signage, fencing, gate, and cameras. A chain-link fence will deter intruders and animals from accessing the WR-1 ISD structure restricted area. Cameras may be strategically placed to capture visual surveillance on the site. Features will be maintained and cared for with the intended use per manufacturer's specifications. All nighttime security lighting and other required security equipment will be provided as needed.

Extending beyond the Institutional Control period (i.e., post-Institutional Control period), necessary controls could also include methods to preserve knowledge and to inform current and future generations of potential hazards and risks. Such administrative or legal controls (e.g., land use restrictions) help to minimize the potential for human exposure to contamination or protect the integrity of a remedy. Institutional controls work by limiting land or resource use by providing information to modify or guide human behavior at the site.

It is conceivable that after the post-Institutional Control period when site controls to restrict access are no longer effective, human activity could result in undeliberate intrusion into the WR-1 site. The specific human activity considered in the assessment involved two specific scenarios:

- **Human Intrusion** through exploratory drilling that inadvertently intercepts the WR-1 ISD structure. To be protective, it is also assumed that current drilling exploration best practices and standards are not followed during the intrusion, for example, no proper containment or disposal of borehole material nor proper closure of the borehole. Exposure to (1) drill crew at the wellhead, (2) residents near to the site, (3) core transportation personnel, and (4) laboratory technicians were all considered possible. Sources of exposure include gas released from the borehole, the drill core itself, and contaminated groundwater.
- **Unplanned Human Habitation** of the WR-1 site after Institutional Control; specifically, the establishment of a farm near the site. Sources of exposure include drinking water, consumption of local foodstuffs (e.g., fish, game meat, garden vegetables, and honey). The assessment of effects in Section 6.7 Human and Ecological Health included an on-site farm receptor group with similar behaviours to other farmers in the area. This section postulates an on-site farm receptor group unanticipated behaviours, specifically the use of a groundwater well in an area affected by WR-1 for drinking water.

The assessment does not try to predict the future, rather it aims to demonstrate the importance of particular sources of uncertainty, providing meaningful illustration of future condition to inform the Project design (CNL 2017a). The human intrusion and human habitation scenarios represent the occurrence of very unlikely events that could lead to potentially high risk conditions. The ERA was used in an iterative process to ensure that the Project design would limit exposure predictions to 20 mSv meeting the regulatory requirement (EcoMetrix 2017). Exposure to human and non-human biota were also compared to other relevant exposure guidelines for both radiological and non-radiological constituents of potential concern.

A summary of the effects from the unplanned events of human intrusion and human habitation are presented below. Similar to the assessment completed in Section 6.7 Human and Ecological Health, the maximum dose was assessed at a single point in time. However, to assess the total radiation dose to the identified human receptors over the groundwater modelling timeframe, the modelling timeframe was split into five time windows based on inspecting the time of peak loading rates (0 to 60 years, 60 to 40,000 years, 40,000 to 175,000 years, 175,000 to 300,000 years and 300,000 to 500,000 years). The doses for all radionuclides with peak dose in a given time window were added to obtain the total dose in that time window. This is conservative because the peaks within a time window were not exactly coincident.

7.3.8.2.1 Unplanned Human Habitation Post-Institutional Control

For the residents of an on-site farm who drinks groundwater, the total radiation dose during the post-closure phase is below the public dose limit of 1 mSv/a, however, but above the WL site dose constraint of 0.25 mSv/a for most receptors (Table 7.3.8-1). The dominant contributor to the total dose is carbon-14 taken up through ingestion of local terrestrial plants and animals, and aquatic animals. For carbon-14 the time of maximum mass loading to the Winnipeg River occurs in approximately 1,000 years.

Table 7.3.8-1: Summary of Total Dose for Human Habitation Post-Institutional Control (with Groundwater Consumption)

Age Group	Dose (mSv/a)	Percent of Dose Constraint	Percent of Dose Limit
Adult	**6.36E-01**	254%	64%
Child	**3.43E-01**	137%	34%
Infant (cow's milk)	7.51E-05	0.030%	0.0075%
Infant (formula)	**4.80E-01**	192%	48%
3-month Old (nursing)	**4.61E-01**	184%	46%
3-month Old (formula)	**8.16E-01**	326%	82%

Notes:

Bold cells indicate exceedance of the dose constraint of 0.25 mSv/a; bold and shaded cells indicate exceedance of the public dose limit of 1 mSv/a.

A dose of 0.0025 mSv/a is equivalent to 1% of the dose constraint and a dose of 0.01 mSv/a is equivalent to 1% of the public dose limit.

The doses to human receptors that could be exposed to the non-radiological contaminants identified as potentially occurring at elevated concentrations (i.e., cadmium and lead) in surface water during post-closure were calculated based on total concentration (background plus Project contribution). Risk was quantified for the human receptor based on the calculation of a HQ using the same approach as described in Section 7.3.7. The HQs derived for both cadmium and lead were well below the protective benchmark (Table 7.3.8-2). A calculated HQ of 0.01 (1.00E-02) represents 5% of the HQ protective benchmark of 0.2 (2.00E-1). For non-radiological parameters the hazard quotient for lead exceeded the target value for both the adult and toddler. HQs greater than one are not statistical probabilities of harm occurring. Instead, they are a simple statement of whether (and by how much) an exposure concentration exceeds the reference concentration.

The likelihood of human habitation, considering controls and mitigation, including demarcations, are Rare, and the consequence severity of such a loss of structural integrity would be Moderate. Furthermore the likelihood of using groundwater for drinking water is Rare considering the availability of fresh water in the adjacent Winnipeg River. Consequently, the risk level is Moderate, requiring the assessment of risk mitigation options, the reduction of risk as practical and monitoring to verify the effectiveness of controls and mitigation. This required management action is consistent with the safety management and monitoring system that would be in place during closure and post-closure phases.

Table 7.3.8-2: Summary of Post-closure Hazard Quotients for Human Habitation Post-Institutional Control

Pathway (mg/kg/day)	Cadmium		Lead	
	Farm Adult	Farm Toddler	Farm Adult	Farm Toddler
Groundwater Ingestion	4.13E-02	7.08E-02	**4.56E+00**	**7.81E+00**
Soil Ingestion	3.86E-05	6.62E-04	6.34E-03	1.09E-01
Soil Dermal Contact	2.20E-06	4.29E-06	3.61E-03	7.05E-03
Dust Inhalation	2.44E-05	5.22E-05	4.00E-03	8.57E-03
Ingestion of Plants	7.44E-05	7.83E-05	3.62E-03	3.81E-03

Table 7.3.8-2: Summary of Post-closure Hazard Quotients for Human Habitation Post-Institutional Control

Pathway (mg/kg/day)	Cadmium		Lead	
	Farm Adult	Farm Toddler	Farm Adult	Farm Toddler
Ingestion of Fish	1.12E-04	1.17E-04	2.80E-03	2.94E-03
Ingestion of Beef	1.18E-05	4.88E-06	1.32E-04	5.45E-05
Ingestion of Poulty	3.72E-05	3.39E-05	2.09E-03	1.91E-03
Ingestion of Pork	2.85E-05	2.17E-05	5.23E-05	3.98E-05
Ingestion of Eggs	2.21E-05	1.05E-05	1.04E-03	4.90E-04
Ingestion of Milk	3.43E-06	2.84E-05	3.30E-04	2.73E-03
Ingestion of Deer	2.18E-07	0.00E+00	1.78E-06	0.00E+00
Total	4.17E-02	7.18E-02	**4.58E+00**	**7.95E+00**

Notes:

Bold cells indicate exceedance of HQ benchmark of 0.2, shaded cells indicated HQ values greater than 10% of the HQ benchmark (>0.02); **bold** and shaded cells indicate exceedance of HQ benchmark by greater than 1% (value of 0.202 represents exceedance by 1%).

7.3.8.2.2 Human Intrusion

For the occurrence of a human intrusion, the worst-case scenario was evaluated, which encompassed an unsealed borehole into the reactor and improperly disposed of material being left on the WR-1 site. The total dose to a drill crew member (adult exposed during drilling the borehole) was below the public dose limit of 1 mSv/a and the CNL dose constraint of 0.25 mSv/a. It was also considered that trespassers could interact with the site following a human intrusion (assumed to be spending 1 hour a day onsite). The dose predictions for this human receptor were slightly above the public dose limit of 1 mSv/a (refer to Table 7.3.8-2). All predicted doses, however, all well below the deterministic effects level or effective whole-body annual dose exposure limit of 20 mSv/a. The dominant contributor to the total dose is cobalt-60 through groundshine (i.e., from the drilled material improperly disposed of onsite). However, cobalt-60 is a relatively short-lived radionuclide and as with the majority of parameters, the maximum concentration was assumed to be at Year 0 of post-closure (i.e., 2024 during Institutional Control. The next greatest contributor to dose is niobium-94, which is the greatest contributor within the timeframe window of 300 to 500,000 years.

As the expected annual dose resulting from human intrusion is predicted to be above 1 mSv, but not exceed 20 mSv (ERA [EcoMetrix 2017]), reasonable effort is warranted to reduce the probability of this unplanned events (IAEA 2011). After post-Institutional Control, passive controls will be in place including the limited footprint (WR-1 ISD structure about 0.0007 km^2), the WR-1 ISD structure composition itself (i.e., high degree of imperviousness and made of material of no economic value), and the area's current land use (i.e., limited mineral resources potential and high industrial potential) will all act to reduce the likelihood of a human intrusion event.

Currently, the petroleum industry is located in the southwestern corner of the province, and the closest mining/drilling activity to have occurred is historical mining activity in the Bird Lake area, which is over 60 km to the northeast (e.g., Dumbarton Mine [Government of Manitoba 2013]). As an indication, if the borehole drilling rate is estimated to be 1^{-10} per metre squared per year (10 per 100 years per 10,000 km^2) the annual likelihood of a human intrusion event would be 3^{-7}. It is anticipated that the end-state of the WR-1 site will meet regulatory requirements for restricted industrial land use due to the presence of the WR-1 ISD structure.

The likelihood of a human intrusion, considering controls and mitigation, including a drill-resistant engineered cover, are Rare, and the consequence severity of such a loss of structural integrity would be Moderate. Consequently, the risk level is Moderate, requiring the assessment of risk mitigation options, the reduction of risk as practical and monitoring to verify the effectiveness of controls and mitigation. This required management action is consistent with the safety management and monitoring system that would be in place during closure and post-closure phases.

Table 7.3.8-3: Summary of Total Radiological Dose for Trespassers under Human Intrusion Conditions

Age Group	Dose (mSv/a)	Percentage of Dose Constraint	Percentage of Public Dose Limit
Adult	**1.21E+00**	484%	121%
Child	**1.22E+00**	488%	122%
Infant	**1.74E+00**	696%	174%
3-Month Old	**1.65E+00**	660%	165%
Driller	3.91E-02	16%	4%

Notes:

Bold cells indicate exceedance of the dose constraint of 0.25 mSv/a; bold and shaded cells indicate exceedance of the public dose limit of 1 mSv/a.

A dose of 0.0025 mSv/a is equivalent to 1% of the dose constraint and a dose of 0.01 mSv/a is equivalent to 1% of the public dose limit.

The doses to human receptors that could be exposed to the non-radiological contaminants identified as potentially occurring at elevated concentrations (i.e., HB-40 and palladium) as a result of a human intrusion event occurring during post-closure were calculated based on total concentration (background plus Project contribution). The HQ for HB-40 exceeded the target value for both the adult and the toddler for soil ingestion and soil dermal contact (i.e., exposure as a result of material being improperly disposed of onsite). Hazard quotients are summarized in Table 7.3.8-4. HQs greater than one are not statistical probabilities of harm occurring. Instead, they are a simple statement of whether (and by how much) an exposure concentration exceeds the reference concentration.

Table 7.3.8-4: Summary of Hazard Quotients for Human Intrusion Conditions

Age Group	Parameter	Soil Ingestion	Soil Dermal Contact	Dust Inhalation	Total
Adult	HB-40	**3.52E+00**	**4.57E-01**	1.16E-01	**4.09E+00**
	Palladium	1.30E-01	8.41E-03	4.26E-03	1.42E-01
Toddler	HB-40	**2.05E-01**	**2.34E-01**	5.40E-02	**4.93E-01**
	Palladium	7.56E-03	4.31E-03	1.99E-03	1.39E-02
Driller	HB-40	6.62E-03	7.55E-02	NA	8.21E-02
	Palladium	2.44E-04	1.39E-03	NA	1.63E-03

Notes:

Bold cells indicate exceedance of HQ benchmark of 0.2, shaded cells indicated HQ values greater than 10% of the HQ benchmark (>0.02); **Bold and shaded** cells indicate exceedance of HQ benchmark by greater than 1% (value of 0.202 represents exceedance by 1%).

7.3.8.2.3 Conclusions

The evaluation supports the conclusion that the Project design is protective of humans who are currently or in the future will be living in the vicinity of the WL site (e.g., industrial use), as well as under unexpected land use conditions (on-site farm). The assessment demonstrates that human habitation with groundwater use for drinking water could result in exposures to lead at levels above which are known to prevent any adverse effects from occurring. The failure of passive controls to prevent human intrusion into the WR-1 ISD structure and/or human habitation of the WR-1 site during the post-Institutional Control period (after 300 years) is conceivable. The assessment was conservatively conducted to predict exposures to human receptors under these future unlikely conditions. The assessment demonstrates that human intrusion into the WR-1 ISD structure, could result in exposures to human receptors using the WR-1 site regularly to exceed the public limit of 1 mSv/a and result in exposure to HB-40 at levels above which are known to prevent any adverse effects from occurring. As such, reasonable effort is warranted to reduce the probability of these unplanned events from occurring. During the post-Institutional Control period, passive controls will still be in place including the limited footprint, the WR-1 ISD structure composition being relatively imperviousness and made of material of no economic value, and the land use restriction will all act to reduce the likelihood of a human intrusion event.

7.4 Risk Evaluation of Accidents and Malfunctions

The potential accidents and malfunctions, applicable mitigation and estimates of residual risks following the implementation of the risk mitigation actions, are summarized in Table 7.4-1. None of the accidents and malfunctions described in Section 7.3 were classified as High (red) risk level, requiring additional assessment work to inform Project design or execution, as shown in the Project Risk Matrix (Table 7.1-3). Occupational accidents, material handling accidents, fires and explosions were all identified as High priority level during closure. Spills and leaks, offsite transportation accidents, and system and equipment failure, were all identified as Moderate priority level during closure. All of these potential hazards, however, are well understood and encompassed by existing and proven engineering controls, management program and standard operating procedures at the WL site. The potential for a WR-1 ISD structure failure, and human intrusion into the WR-1 ISD structure and human habitation on-site during the post-Institutional Control period, were classified as High and Moderate priority level, respectively. The WR-1 ISD structure failure event, and the human intrusion and human habitation events were identified as being Unlikely and Rare, respectively, but with the potential to lead to High risk conditions. Consequently, these events were encompassed by bounding scenarios assessed as part of the DSAR, which provides a safety case for the Project and informs the Project design in an iterative process (CNL 2017a). The residual risks for credible accidents and malfunctions are expected to be within regulatory requirements.

Table 7.4-1: Summary of Accidents and Malfunctions, Mitigation Actions, and Residual Risk Estimates

Accident/ Malfunction	Project Phase	Mitigation	Likelihood	Consequence Severity		Risk Matrix Priority Level
				Environmental	Public And Worker Safety	
Occupational accidents	Closure	■ Implementation of CNL procedures for hoisting and lifting, working at heights, confined space entry, and working with energized systems; use of cranes and movement of heavy loads; the use of saws, drills and compressors; and hazard identification regarding changing site conditions (e.g., excavations). ■ Workplace controls, and Personal Protective Equipment and Clothing (PPE&C)	Unlikely (D)	n/a	High (4)	High
Spills and leaks	Closure	■ Implementation of CNL's Radiation Protection Program, Environmental Protection Program, including Emergency Plan, and Occupational Safety and Health Program ■ Adequate ventilation during decommissioning activities ■ PPE&C (e.g., chemical resistant gloves, eye protection) ■ Routine inspections of equipment ■ Spill trays and spill kits ■ Chemical protection suits and self-contained breathing apparatuses	Possible - Occasional (C)	Low (2)	Low (2)	Moderate
Material handling accidents	Closure	■ Confinement from ventilation ■ Implementation of CNL procedures, including hoisting and rigging, and Emergency Preparedness plans	Unlikely (D)	n/a	High (4)	High

Table 7.4-1: Summary of Accidents and Malfunctions, Mitigation Actions, and Residual Risk Estimates

Accident/ Malfunction	Project Phase	Mitigation	Likelihood	Consequence Severity		Risk Matrix Priority Level
				Environmental	Public And Worker Safety	
Offsite transportation accidents	Closure	■ Proper packaging and handling of hazardous waste ■ Use of CNL's procedures on Management of Non-Radiological Hazardous Chemical Waste and WL Waste Materials Management ■ Emergency Preparedness Program has emergency plans for off-site accidents	Rare (E)	Moderate (3)	Moderate (3)	Moderate
System and equipment failure	Closure	■ Design of equipment with fail-safe modes, use of reliable power supplies, maintenance programs, depth-in-defense minimize the likelihood or effects of failures ■ Use of PPE&C and adherence to OSH procedures, contingency planning, and safe back-out procedures provide protection to workers from system and equipment failure	Unlikely (D)	n/a	Moderate (3)	Moderate

Table 7.4-1: Summary of Accidents and Malfunctions, Mitigation Actions, and Residual Risk Estimates

Accident/ Malfunction	Project Phase	Mitigation	Likelihood	Consequence Severity		Risk Matrix Priority Level
				Environmental	Public And Worker Safety	
Fires and explosions	Closure and Post-closure	■ Wastes from decontamination activities will be packaged and managed in compliance with WL materials management procedures to reduce the likelihood of ignition ■ Implementation of Whiteshell's Fire Protection Program and Emergency Preparedness Program ■ Removal of combustibles, and preferential use of cold cutting equipment ■ Careful surveying prior to cutting, and through preferential use of remote cutting equipment ■ This risk of hydrogen explosion is avoided through proper specification and formulation of the grout (i.e., appropriate pH) ■ Adequate ventilation during decommissioning activities ■ Worker doses during cleanup following a fire can be kept to a safe level through radiation protection practices	Rare (E)	n/a	High (4)	High

Table 7.4-1: Summary of Accidents and Malfunctions, Mitigation Actions, and Residual Risk Estimates

Accident/ Malfunction	Project Phase	Mitigation	Likelihood	Consequence Severity		Risk Matrix Priority Level
				Environmental	Public And Worker Safety	
WR-1 ISD Structure Failure	Post-closure	■ Careful design, formulation, and sequencing during installation ■ Field testing, including tests of the grout with the organic coolant, ■ Use of an experienced grout supplier with an appropriate QA Program ■ Quality Control and Quality Surveillance during all phases of grout design and installation ■ Field demonstration tests should be performed to provide a higher level of assurance of the grout performance	Unlikely (D)	High (4)	Moderate (3)	High
Aircraft crash	Closure and Post-closure	During closure implementation of WL Fire Protection Program and Emergency Preparedness Program	Rare (E)	Low (2)	n/a	Low
Human intrusion	Post-closure	■ Long-term controls included site setting, WR-1 ISD structure composition, and small project footprint ■ Administrative or legal controls to preserve knowledge and to inform current and future generations of potential hazards and risks ■ Design will limit possible annual dose to 20 mSv.	Rare (E)	Moderate (3)	Moderate (3)	Moderate

Note: Color coding refers to the risk level in the Project Risk Matrix shown in Table 7.1-3.

C = Closure; PC = Post-closure; n/a = not applicable.

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8.0 SUMMARY OF CUMULATIVE EFFECTS

8.1 Introduction and Approach

The *Canadian Environmental Assessment Act, 2012* (*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). The cumulative effects assessment is completed to evaluate the contribution of effects from the Project (i.e., Application Case) in combination with previous, existing, or reasonably foreseeable projects 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). Reasonably foreseeable projects 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 method for assessment of cumulative effects is outlined in Section 6.1 and is consistent with the Canadian Nuclear Safety Commission (CNSC) Generic EIS Guidelines (CNSC 2016) and the Agency's *Technical Guidance for Assessing Cumulative Effects under the Canadian Environmental Assessment Act, 2012* (the Agency 2014). 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 2014):

- **Step 1: Scoping:**
  - identifying valued components (VCs; see Section 6.1.2 Valued Components);
  - determining spatial boundaries (see Section 6.1.3.1 Spatial Boundaries);
  - determining temporal boundaries (see Section 6.1.3.2 Temporal Boundaries); and
  - examining physical activities that have been and will be carried out (see Section 6.1.3.3 Assessment Cases).
- **Step 2: Analysis** (see Section 6.1.5 Project Interactions and Mitigation and Section 5.1.6 Residual Effects Analysis);
- **Step 3: Mitigation** (see Section 6.1.5 Project Interactions and Mitigation and Section 5.1.6 Residual Effects Analysis);
- **Step 4: Significance** (see Section 6.1.8 Residual Effects Classification and Determination of Significance); and
- **Step 5: Follow-up** (see Section 6.1.9 Monitoring and Follow-up).

The decommissioning approach for the WL site as described in the Comprehensive Study Report was to remove all facilities entirely from the WL site with the exception of low level waste trenches in the Waste Management Area, which may be managed through on-site in situ disposal (AECL 2001). CNL is proposing a revised approach to the WR-1 decommissioning that includes partial dismantling and demolition, along with passive,

permanent disposal of the below-grade portions of the facility. The disposal approach is referred to as In Situ Decommissioning (ISD). ISD is a proven nuclear decommissioning approach that increases worker safety, provides protection of the environment and the public, reduces interim storage and multiple handling, enables permanent nuclear liability reduction and utilizes less resources. Other decommissioning activities for the WL site, documented in the Comprehensive Study Report, are unmodified. Removal of the east annex and service wings of the WR-1 Complex were assessed as part of the Comprehensive Study Report and are covered under the CNL's existing decommissioning licence for the WL site (Licence No. NRTEDL-W5-8.04/2018). Activities required to prepare for ISD, such as isolation of the WR-1 Complex and targeted remediation of hazardous materials, are also covered under CNL's existing decommissioning licence for the WL site.

The closure phase for the Project includes preparation for ISD, grouting of below-grade structures and systems, removal of above-grade structures and systems, installation of the engineered cover over the grouted below-grade structures, final site restoration, and preparation for Institutional Control. Closure activities last from 2019 to 2024. The post-closure phase has two discrete periods: Institutional Control and post-Institutional Control. The Institutional Control period includes implementation of active controls throughout 2024 to 2124 (i.e., 100 years) and passive controls through 2024 to 2324. During active Institutional Control, long-term performance monitoring and maintenance activities will continue to demonstrate compliance with the safety case assumptions. The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions). Post-institutional Control occurs after year 2324 and continues indefinitely.

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, First Nation and Métis communities, or the public (the Agency 2014). 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 VCs requiring an analysis under the RFD Case are determined by understanding whether the residual effects from the 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 with the effects of other developments.

The analysis of cumulative effects considers all primary pathways that are likely to result in residual effects on VCs, after implementing environmental design features and mitigation. Pathways determined to have no linkage to a VC or those that are considered secondary (i.e., negligible effect) are not expected to result in environmentally significant effects on the assessment endpoint of VCs, individually or cumulatively. 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.

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 Project and other existing, approved, and reasonably foreseeable developments on VCs. For some VCs, there may be no RFD Case and the assessment is limited to determining the significance of residual effects from the 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 future developments, including the Project (i.e., RFD Case).

The significance of incremental (i.e., Application Case) and cumulative (i.e., RFD Case) residual effects are summarized in Section 9.0 Summary of Significance.

Monitoring and follow-up 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 incremental and cumulative residual effects predictions. Monitoring is also used to identify any unanticipated incremental and cumulative residual effects and provide for the implementation of adaptive management to limit these effects. Monitoring and follow-up programs identified to verify the incremental and cumulative residual effects predictions are summarized in Section 11 Summary of Monitoring and Follow-up Programs.

8.2 Reasonably Foreseeable Projects

As described in Section 8.1, the Project has the potential to interact with past, existing and reasonably foreseeable projects 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 within Section 6 and summarized below (Section 8.3) as to whether they were likely to overlap spatially and temporally with VCs affected by the Project. As described in Section 1, CNL is in the process of executing activities associated with the ultimate decommissioning of the WL site. As such, decommissioning and reclamation activities are the primary reasonably foreseeable developments with the potential to act cumulatively with the Project. A Comprehensive Study Report (AECL 2001) under the *Canadian Environmental Assessment Act (1992)* was completed for the decommissioning and reclamation of the entire WL site. The Environmental Assessment decision to approve the project was announced by the Minister of the Environment in March 2002 and a decommissioning licence was issued to AECL and subsequently to CNL. Since receiving approval, various decommissioning and reclamation activities at the WL site have either been completed or are currently underway. As such, decommissioning and reclamation activities that have been already completed or that are currently underway at the WL site are considered as part of the Base Case. Future decommissioning and reclamation activities planned to continue and that will overlap spatially and temporally with decommissioning activities for the Project are considered as part of the RFD Case.

Table 8.2-1: Reasonably Foreseeable Developments considered in the Assessment

Type of Project	Location	Description	Timeframe
Infrastructure Decommissioning	WL	Decommissioning of remaining infrastructure on the WL site (includes ISD of the low-level waste trenches).	2016 to 2024
Environmental Remediation	WL	Remediation of affected lands, with the exception of the low-level waste trenches.	2016 to 2024
Manitoba-Minnesota Transmission Project	South-eastern Manitoba	The Manitoba-Minnesota Transmission Project is a 213 km-long international powerline in southeastern Manitoba and includes construction of the line, modifications to three existing stations and operations.	2017 to 2020
Energy East Pipeline	Southern Manitoba	The Energy East Pipeline is a 4,500 km crude oil pipeline system from an oil supply complex in Alberta to an existing oil refining and marine terminal facility near Saint John, New Brunswick.	2018 to 2021

8.3 Summary of Cumulative Effects

8.3.1 Atmospheric Environment

Potential for cumulative effects on air quality is considered at the regional scale, specifically within the atmospheric environment Regional Study Area (RSA). As described in Section 6.2, there are no reasonably foreseeable future developments expected in the atmospheric environment RSA other than the decommissioning of the remaining infrastructure and support facilities, and reclamation of affected areas at the WL site, as described in the Comprehensive Study Report (AECL 2001).

Results of the air quality assessment completed as part of the Comprehensive Study Report indicated that from time to time nuisance dust will be generated. Mitigation practices will be implemented to limit potential effects to air quality, including dust control measures (e.g., containment and active suppression [e.g., wetting prior to sidewalk and street sweeping]), curtailment of activities during periods of high winds and maintenance of on-site access routes (see Section 6.3.1 of AECL 2001). In addition, dust monitoring stations have been established on site to collect airborne particulate samples as part of routine environmental monitoring. Special enclosures to cover large areas may also be required to contain airborne emissions from decommissioning activities in some cases (e.g., decommissioning of the Waste Management Area [WMA]). The evaluation of effects to air quality from decommissioning and reclamation activities for the entire WL site concluded that release of air emissions is negligible (AECL 2001).

During the Application Case, Project activities will result in emissions associated with the operation of vehicles and equipment, as well as material handling emissions from the demolition and grouting and temporary batch mixing plant. Mitigation practices will be implemented to limit potential effects to air quality, including CNL's Procedure for Management and Monitoring of Emissions (CNL 2013), which includes operational control monitoring, air verification monitoring and environmental monitoring and dust management techniques. Predicted concentrations for the Application Case are below applicable air quality guidelines and/or standards.

Although the decommissioning strategy has changed for the WR-1, activities related to the decommissioning of the WR-1 are expected to less than previously approved. Consequently, the Project is not anticipated to result in a change in the conclusions of the 2001 Comprehensive Study Report related to air quality (see Section 6.2.1.6.2 Application Case Results for the Project air quality predictions). As such, the Project is not expected to contribute cumulatively to the effects of decommissioning of the remaining infrastructure and support facilities at the WL to cause a significant effect.

8.3.2 Geology and Hydrogeology

Potential for cumulative effects on geology and hydrogeology is considered at the regional scale, specifically within the geology and hydrogeology RSA.

8.3.2.1 Geology

As described in Section 6.3.1, there are no RFDs expected in the RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). Results of the Comprehensive Study Report (see Section 6.3.4 of AECL 2001) indicated that existing effects on soils are limited to contaminated soils within affected lands on the WL site. Affected lands and associated contaminated soils in these lands will be remediated and/or removed during the WL site decommissioning to

meet the WL preliminary soil clean up criteria and the non-radiological and radiological clearance and release criteria in accordance with the target end-state of the associated land-use category.

The assessment of potential pathways of effects for the Application Case in Section 6.3.1 Geology determined there are no primary pathways that would lead to residual effects on geology VCs. Erosion and sediment control practices (e.g., silt fences, runoff management) applicable to the region and already in place at the WL site will be used during decommissioning activities around disturbed areas, where appropriate. The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. Overall, cumulative effects from the Project in combination with the decommissioning of the remaining infrastructure and support facilities, and reclamation of the affected areas at the WL site are anticipated to positively affect soil. As such, an RFD Case is not presented as part of this assessment.

8.3.2.2 Hydrogeology

As described in Section 6.3.2, there are no RFDs expected in the RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). Results of the Comprehensive Study Report (see Section 6.3.4 of AECL 2001) indicated that major alterations of groundwater flow regimes from the decommissioning activities are not expected. Following decommissioning of the building sumps, groundwater levels will rebound to static conditions similar to the local environment. On the main campus of the WL site, groundwater heads indicate downward flow conditions exist. For the Project, as the conditions rebound in during the post-closure phase groundwater will flow downwards through the overburden and westward, ultimately discharging at the Winnipeg River. Consequently, although closure of the WL site and the project may slightly alter the drainage flow patterns to the Winnipeg River for a short period of time; the changes are expected to be within the natural range of variation. Overall, cumulative effects from the Project in combination with the decommissioning of the remaining infrastructure and support facilities, and reclamation of the affected areas at the WL site are anticipated to have a negligible effect on groundwater quantity.

Results in the Comprehensive Study Report (AECL 2001) indicate that for effects to groundwater quality, the main area of concern was the low-level waste (LLW) proposed to be managed in situ in the WMA. The assessment included a development of a conceptual model of the trench storage/disposal environment, as well as contaminant migration modelling and exposure pathway analysis. The evaluation of contaminant migration from the WMA trenches concluded that the nature of groundwater flow in the area around the WMA limits contaminant migration away from the WMA. There is no downward movement of groundwater flow from the WMA to the underlying permeable sandy zone which has the potential to act as a transmission zone to the Winnipeg River (see Section 6.3.4 and Appendix C of AECL 2001). Generally, the natural hydraulic head at 10 m depth is higher, meaning that the hydraulic head gradient is upward leading to potential water discharge towards the surface (i.e., artesian conditions).

Preliminary investigations undertaken in support of the Comprehensive Study Report found no evidence of significant movement upward of contamination even after over 20 years of contact with the waste in the trenches (AECL 2001). There was some evidence of a very small amount of upward movement of salts and contaminants from the trench into the cap materials in a few samples. Contaminant migration, if it occurred, is less than 10 cm over 20 years. Testing also provided no evidence of a “bathtub effect” (i.e., flooding of the trenches such that they have a higher conductivity than the trench wall), and associated near-surface lateral movement of

contaminants, although further testing was recommended to support a future detailed safety analysis (AECL 2001).

Consequently, there is no overlap of effects from previous activities at the WL site (i.e., effects from the WMA) and changes to groundwater quality from the Project. Potential for cumulative effects with surface water quality and human health are considered in Section 8.3.3.2 Surface Water Quality and Section 8.3.6.1 A detailed safety analysis still needs to be completed for the ISD of the WMA trenches. It is expected that this analysis will capture the potential changes to groundwater quality and surface water loadings to the Winnipeg River from not remediating the trenches in combination with the predictions for the Project.

8.3.3 Surface Water Environment

Potential for cumulative effects on surface water is considered at the regional scale, specifically within the surface water RSA.

8.3.3.1 Hydrology

As described in Section 6.4.1, there are no RFDs expected in the surface water RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). Results of the Comprehensive Study Report (see Section 6.3.3 of AECL 2001) indicated that alterations of surface water flow regimes from the decommissioning activities are not expected. The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. The drainage system for the reclaimed WL site will have similar physical characteristics as similar natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. The WL site will be graded to promote drainage from the site to the Winnipeg River. Overall, cumulative effects from the Project in combination with the decommissioning of the remaining infrastructure and support facilities, and reclamation of the affected areas at the WL site are anticipated to have a negligible effect on hydrology.

8.3.3.2 Surface Water Quality

As described in Section 6.4.2, there are no RFDs expected in the RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). Decommissioning and reclamation of the entire WL site, including the Project, may alter drainage rates and flow patterns as current precipitation management is removed. Consequently the discharge volume to Winnipeg River may change, which may alter surface water quality. The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. The drainage system for the reclaimed WL site will have the similar physical characteristics as similar natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. The contribution to site runoff from the Project is expected to be minor relative to the entire decommissioned WL site. Although closure of the WL site may slightly alter the drainage rates and flow patterns and discharge volume to the Winnipeg River; the changes are expected to be within the natural range of variation. As such, changes to discharge volume to from the closure of the WL site, including the Project, are predicted to have a negligible effect on the surface water quality in Winnipeg River.

Results of the Comprehensive Study Report (see Section 6.3.3 of AECL 2001) indicated residual effects on surface water, particularly the Winnipeg River, are related to discharges from the Active Liquid Waste Treatment

Centre and the sewage lagoon. These discharges, currently well below applicable standards, will gradually diminish to almost zero following decommissioning. Re-suspension of contaminated sediments is also not expected to lead to a decrease in water quality (Section 7.0 AECL 2001).

The Comprehensive Study Report (AECL 2001b) also considered the potential for effects via groundwater quality from the LLW that may be managed in situ in the WMA, and their potential to affect the Winnipeg River (see also Section 8.3.2.2 Hydrogeology). The assessment considered three general exposure pathways: upward migration (with potential contamination of soils and vegetation), near-surface later migration (with potential contamination to local discharge in perimeter and roadside ditches), and downward migration and contamination of the sand and gravel aquifer and subsequently the river). Only the near-surface lateral migration scenario was considered in further detail. With respect to downward migration and release to the river it was determined that the general hydrology of the site limits or eliminates this pathway.

Water concentrations in the ditch were predicted and compared to established guidelines for several of the contaminants in the WMA. Radionuclide modelling in the Comprehensive Study Report (Appendix C of AECL 2001b) indicated that three radionuclides have the potential to exit the WMA through migration over a 200-year period, namely tritium, technetium-99 and carbon-14. Of these three radionuclides only technetium-99 is potentially present in nonzero concentrations in the ditch adjacent to the WMA in as early as 20 years. The carbon-14 and tritium will be lost to the atmosphere, and when this is modelled there is no release of these radionuclides to the perimeter ditch. These predictions were considered further for their potential effect on human health (see Section 6.7.2.5 Human and Ecological Health). With respect to non-radiological contaminants, some exceedances of applicable standards were predicted. Further refinement of the modelling and potential need for selective remediation to remove the hazard was recommended (AECL 2001b).

Consequently, there is no overlap of effects between WR-1 and previous activities at the WL site (i.e., effects from the WMA) and changes to surface water quality in the Winnipeg River. A detailed safety analysis still needs to be completed for the ISD of the WMA trenches. It is expected that this analysis will capture the potential changes to groundwater quality and surface water loadings to the Winnipeg River and site-specific acceptance criteria would be defined in accordance with applicable regulatory requirements.

As part of CNL's licence with the CNSC, environmental monitoring around the WL site will continue for the Project in accordance with the Environmental Assessment Follow-up Program. Follow-up monitoring during the post-closure phase will continue to verify effect predictions and to provide information for use in adaptive management to address potential unforeseen effects. Consequently, changes to surface water quality from the closure of the WL site, are predicted to be negligible.

8.3.4 Aquatic Environment

As described in Section 6.5, there are no RFDs expected in the RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). Potential effects from the Project on the aquatic environment that may overlap spatially with decommissioning activities include activities resulting in changes to surface water quality, sediment quality and hydrology.

The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. The drainage system for the reclaimed WL site will have similar physical characteristics as similar natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. The contribution to site runoff from the Project is expected to be minor relative to the

entire decommissioned WL site. Similar to the decommissioning plan for the Project, the WL site will be graded to promote drainage to the Winnipeg River. Although closure of the WL site may slightly alter the drainage rates and flow patterns and discharge volume to the Winnipeg River; the changes are expected to be within the natural range of variation. As such, changes to hydrology from the closure of the WL site, including the Project, are predicted to have a negligible effect on the maintenance of self-sustaining and ecologically effective fish populations, including species-at-risk.

Results of the Comprehensive Study Report indicated that the potential effects to aquatic biota is also related to changes in surface water quality in the Winnipeg River from the presence of contaminated river sediments. No decrease in water quality is expected and effluent emissions to the Winnipeg River are expected to decline to virtually zero following decommissioning (see Section 7.0 of AECL 2001). Re-suspension of contaminated sediments is also not expected to lead to a decrease in water quality. Consequently, changes to surface water quality from the closure of the WL site, are predicted to have a negligible effect on the maintenance of self-sustaining and ecologically effective fish populations, including species-at-risk.

8.3.5 Terrestrial Environment

Potential for cumulative effects on the terrestrial environment is considered at the regional scale, specifically within the terrestrial RSA. As described in Section 6.6, there are no RFDs expected in the terrestrial RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the land use and landscape of the day. Results of the Comprehensive Study Report (see Section 6.3.5 of AECL 2001), indicated that no effects were identified for terrestrial biota as natural vegetation will re-establish following completion of decommissioning and reclamation activities. Airborne emissions from decommissioning activities are likely to be less than in the past and no effect from this exposure pathway is expected (see Section 6.3.5 of AECL 2001).

Overall, cumulative effects from the Project in combination with the decommissioning of the remaining infrastructure and support facilities, and reclamation of the affected areas at the WL site are anticipated to positively affect the terrestrial environment. Once existing infrastructure is removed and the RSA is reclaimed the level of anthropogenic disturbance within RSA will be reduced, benefiting the terrestrial environment of the RSA. In addition, follow-up monitoring will be completed during the post-closure phase to confirm radionuclide concentrations in surface water quality and will verify the anticipated low effects (or lack thereof) and provide information for use in adaptive management to address potential unforeseen effects. Because cumulative effects from the Project in combination with the decommissioning and reclamation of the affected areas at the WL site are anticipated to be positive, an RFD Case is not presented as part of this assessment.

8.3.6 Human and Ecological Health

Potential for cumulative effects on the human and ecological is considered at the regional scale, specifically within the human and ecological health RSA, as represented by a number of receptor locations (see Figure 6.7.1-1).

8.3.6.1 Human Health

As described in Section 6.7.1, there are no RFDs expected in the RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). Results of the Comprehensive Study Report (see Section 6.3.8 of AECL 2001) indicated that no public health threats were predicted from the decommissioning and reclamation activities for the WL site. Releases are well

within regulatory limits for the protection of human health and regular monitoring provides that any aberrations are detected immediately. Current effects from the existing WL facilities and operations are considered part of the Base Case (i.e., existing conditions).

The Comprehensive Study Report (AECL 2001) also considered the potential for effects via groundwater quality from the LLW that may be managed in situ in the WMA, and their potential to affect the Winnipeg River and human health (see also Section 8.3.3.2 Surface Water Quality). The assessment considered three general exposure pathways: upward migration (with potential contamination of soils and vegetation), near-surface later migration (with potential contamination to local discharge in perimeter and roadside ditches), and downward migration and contamination of the sand and gravel aquifer and subsequently the river). Only the near-surface lateral migration scenario was considered in further detail. With respect to downward migration and release to the river it was determined that the general hydrology of the site limits or eliminates this pathway.

Water concentrations in the ditch were predicted and compared to established guidelines for several of the contaminants in the WMA. Radionuclide modelling in the Comprehensive Study Report (Appendix C of AECL 2001) indicated that three radionuclides have the potential to exit the WMA through migration over a 200-year period, namely tritium, technetium-99 and carbon-14. Of these three radionuclides only technetium-99 is potentially present in nonzero concentrations in the ditch adjacent to the WMA in as early as 20 years. The carbon-14 and tritium will be lost to the atmosphere, and when this is modelled there is no release of these radionuclides to the perimeter ditch. The preliminary exposure assessment for radiological contamination of the ditch resulted in a dose of 0.16 mSv/a at the predicted peak concentration of technetium-99.

With respect to non-radiological contaminants, some exceedances of applicable standards were predicted. Further refinement of the modelling and potential need for selective remediation to remove the hazard was recommended (AECL 2001). Organic contaminants were also considered; it was concluded that the remaining concentrations of the solvents and DDT are very small and unlikely to present a residual hazard.

Consequently, there is no overlap of effects between WR-1 and previous activities at the WL site (i.e., effects from the WMA) and changes to surface water quality in the Winnipeg River. A detailed safety analysis still needs to be completed for the ISD of the WMA trenches. It is expected that this analysis will capture the potential changes to groundwater quality and surface water loadings to the Winnipeg River and site-specific acceptance criteria would be defined in accordance with applicable regulatory requirements. CNL would be required to meet the applicable regulatory requirements at that time. As such, an RFD Case is not presented as part of this assessment.

8.3.6.2 Ecological Health

As described in Section 6.7.2, there are no RFDs expected in the RSA other than the continued decommissioning of the remaining WL facilities, as the Comprehensive Study Report (AECL 2001). Results of the Comprehensive Study Report (see Section 6.3.3 of AECL 2001) indicated that no decrease in water quality is expected and effluent emissions to the Winnipeg River are expected to decline following decommissioning. Results of the assessment concluded that no effect on aquatic species is expected as doses were below the limit at which no effects on aquatic populations is expected (see Section 6.3.6 of AECL 2001). Current effects from the existing WL facilities and operations are considered part of the Base Case (i.e., existing conditions). Consequently, cumulative effects of the Base Case and the potential effects from the Project are evaluated in the Application Case. As such, an RFD Case is not presented as part of this assessment.

8.3.7 Land and Resource Use

Cumulative effects on land and resource use were considered at the regional scale (i.e., the RSA), which corresponds to the Local Government District (LGD) of Pinawa in its entirety and the stretch of the Winnipeg River from the WL site downstream to the northern boundary of the Town of Lac du Bonnet (i.e., to capture recreational use of the Winnipeg River by residents of Lac du Bonnet). As described in Section 6.8, there are no RFDs expected in the RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). Results of the Comprehensive Study Report (see Section 6.3.9 of AECL 2001) identified residual effects land and resource use through as a result of the long-term land use restrictions. Land and resource use activities have persisted adjacent to the site, including uses of the Winnipeg River. It is expected that all activities and land uses adjacent to the site will be able to continue in the future with the Project as the Project will have no effect on land tenure or usage beyond the WL site boundaries.

Future use of the WL site will depend on the ability of AECL to release parts of the site for unrestricted use upon completion of the Project. CNL is developing appropriate criteria for site remediation and clean-up activities of the WL site. In general, affected areas will be remediated to meet the WL preliminary soil cleanup and the non-radiological and radiological clearance and release criteria in accordance with the target end state of the associated land-use category. However, some lands will have restrictions of the future use and/or development of the land to ensure there are no adverse effects to the safety assessment and modelling assumptions associated with the ISD of infrastructure and facilities, such as the WR-1 and the Waste Management Area. These areas will require ongoing controls including Institutional Control, access restrictions, and performance monitoring. However, the amount of land associated with all of these areas is negligible relative to the size of the WL site that will have unrestricted land use.

The Local Government District of Pinawa has expressed a desire to develop economic activity at the Whiteshell Labs site to offset lost jobs due to closure of the site. The Whiteshell Laboratories Community Regeneration Partnership is evaluating business opportunties, including new industries that could be located on site. This is a potential outcome for the WL site and will require agreement by AECL as the land owner, and potentiallly the Province of Manitoba. As noted in Section 6.9.6.1.2 Application Case Results, the previous decommissioning plan assumed that radioactive wastes would eventually be removed and placed in permanent disposal facilities with the assumption that a national disposal facility for low-level radioactive waste would be available by 2025 and a national disposal facility for medium-level waste operational by 2050 (CNSC 2002). Under the original decommissioning plan, a smaller percentage of the site (the WMA) would have had restricted access than with the Project; however, the area with anticipated restricted access under the Project is still small when compared with the remainder of the WL site. The communities had assumed that this would provide them with the ability to recruit a new industry (and associated employment) to the WL site. Although the Project will result in long-term institutional controls for a small portion of the WL site, the remaining land is safe and appropriate for other use. This may include transfer of the land to other parties following engagement with stakeholders, Aboriginal groups and the public. Future uses/zoning have not been determined, but it is assumed that the land will meet Canadian Council of Ministers of the Environment (CCME) land use criteria.

The Project in combination with the decommissioning and reclamation of the WL site is also anticipated to contribute to positive effects the environment, which will indirectly positively affect land and resource use within the RSA (e.g., less industrial activity that could affect outdoor recreation, hunting, fishing, trapping, and plant and berry gathering). Consequently, cumulative effects from the Project in combination with the decommissioning of

the remaining infrastructure and support facilities, and reclamation of the affected areas at the WL site are anticipated to be negligible.

8.3.8 Socio-economic Environment

As described in Section 6.9, the following two projects are identified as overlapping with the socio-economic RSA.

- **Manitoba-Minnesota Transmission Project** is a 213 km-long international powerline in southeastern Manitoba. After circling the south side of Winnipeg, the transmission line would track east-west south of Provincial Trunk Highway (PTH) 15 until just after Anola, where it would beginning tracking south south-east to the Canada-US border near Piney. The Manitoba-Minnesota Transmission Project includes construction of the line, modifications to three existing stations and operations. Construction would begin in summer 2017 until the in-service date, summer 2020 (Manitoba Hydro 2015).
- **Energy East Pipeline** is 4,500 km crude oil pipeline system from an oil supply complex in Alberta to an existing oil refining and marine terminal facility near Saint John, New Brunswick. The pipeline segment crossing southern Manitoba is a converted mainline and a series of pump stations. Construction is expected to begin in 2018 with the earliest in-service dates scheduled for the fourth quarter of 2021 (TransCanada Pipelines Ltd and Energy East Pipeline Ltd 2016).

While the Manitoba-Minnesota Transmission Project and Energy East Pipeline are located in the socio-economic RSA, their locations suggest that there is no overlap with the residual effects of the Project. Consequently, there is no RFD case assessed for the socio-economic assessment.

As described in Section 6.9, the effects of current and future decommissioning activities for the WL site are included in the Base Case. As described in the Comprehensive Study Report (AECL 2001), the original decommissioning approach for the WL site proposed three phases that would ultimately lead to final decommissioning activities being completed over a 60 year period (i.e., 2061). Therefore, cumulative effects of the decommissioning approach for the WL site and the Project are evaluated as part of the Application Case.

8.4 Summary

The Project is located in a rural area and no RFDs are expected to overlap spatially or temporally with the Project other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). While the Manitoba-Minnesota Transmission Project and Energy East Pipeline are located in the socio-economic RSA, their locations suggest that there is no overlap with the residual effects of the Project. Cumulative effects for the RFD Case were identified for air quality, hydrogeology, hydrology, surface water quality, and land and resource use (Table 8.4-1).

Results of the Comprehensive Study Report (AECL 2001) indicated that closure of the WL site may slightly alter existing conditions; however, effects were predicted to be within applicable guidelines (e.g., air quality, human and ecological health) or negligible (e.g., hydrology, hydrogeology, land and resource use). The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the land use and landscape of the day. Therefore, decommissioning of remaining WL structures is also anticipated to result in positive effects for many VCs (e.g., geology, terrestrial environment, and land and resource use).

Table 8.4-1: Summary of Cumulative Effects for Valued Components

Valued Compound	Contributing Project Activity	Phase the Project Effect Occurs in	Cumulative Effect	Proposed Mitigation[a]
Air Quality	Closure activities for the Project will overlap with decommissioning of the remaining infrastructure and support facilities at the WL site as per the existing decommissioning licence.	Closure Phase	Cumulative effects from the Project in combination with the decommissioning of the remaining infrastructure and support facilities, and reclamation of the affected areas at the WL site are anticipated to be negligible.	■ Use of dust control measure (e.g., containment and suppression) to control generation of airborne emissions and nuisance dust. ■ Curtailment of activities during periods of adverse meteorological conditions (e.g., during periods of high winds). ■ Maintenance of on-site access routes. ■ Continued implementation of the Environmental Assessment Follow-up Program for the WL site.

Table 8.4-1: Summary of Cumulative Effects for Valued Components

Valued Compound	Contributing Project Activity	Phase the Project Effect Occurs in	Cumulative Effect	Proposed Mitigation[a]
Hydrogeology	Decommissioning and reclamation of the entire WL site, including the Project, may alter groundwater quantity.	Closure Phase	Cumulative effects from the Project in combination with the decommissioning of the remaining infrastructure and support facilities, and reclamation of the affected areas at the WL site are anticipated to have a negligible effect on groundwater quantity.	■ The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. ■ The drainage system for the reclaimed WL site will have similar physical characteristics as similar natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. ■ The WL site will be graded to promote drainage from the site to the Winnipeg River.

Table 8.4-1: Summary of Cumulative Effects for Valued Components

Valued Compound	Contributing Project Activity	Phase the Project Effect Occurs in	Cumulative Effect	Proposed Mitigation[a]
Hydrology	Decommissioning and reclamation of the entire WL site, including the Project, may alter drainage rates and flow patterns, and consequently the discharge volume to Winnipeg River.	Closure Phase	Changes to discharge volume to from the closure of the WL site, including the Project, are predicted to have a negligible effect on the surface water quality in Winnipeg River.	■ The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. ■ The drainage system for the reclaimed WL site will have the similar physical characteristics as similar natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. ■ The WL site will be graded to promote drainage from the site to the Winnipeg River.

Table 8.4-1: Summary of Cumulative Effects for Valued Components

Valued Compound	Contributing Project Activity	Phase the Project Effect Occurs in	Cumulative Effect	Proposed Mitigation[a]
Surface Water Quality	Decommissioning and reclamation of the entire WL site, including the Project, may alter drainage rates and flow patterns as current precipitation management is removed. Consequently the discharge volume to Winnipeg River may change, which may alter surface water quality.	Closure Phase	Changes to drainage rates and flow patterns volume to from the closure of the WL site, including the Project, are predicted to have a negligible effect on the surface water quality in Winnipeg River.	■ The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. ■ The drainage system for the reclaimed WL site will have similar physical characteristics as similar natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. ■ The WR-1 site will be graded to promote drainage from the site to the Winnipeg River.

Table 8.4-1: Summary of Cumulative Effects for Valued Components

Valued Compound	Contributing Project Activity	Phase the Project Effect Occurs in	Cumulative Effect	Proposed Mitigation[a]
Fish and Fish Habitat	Release of chemical and radiological contaminants in the long-term during the post-closure phase from the previous activities completed at the WL site.	Post-closure Phase	Release of chemical and radiological contaminants in the long-term during the post-closure phase from the previous activities completed at the WL site are predicted to have a negligible effect on fish and fish habitat, including species-at-risk.	■ As part of CNL's licence with the CNSC, environmental monitoring around the WL site will continue for the Project. ■ Follow-up monitoring as part of the Environmental Assessment Follow-up Program during the post-closure phase will continue to verify effect predictions and to provide information for use in adaptive management to address potential unforeseen effects.

Table 8.4-1: Summary of Cumulative Effects for Valued Components

Valued Compound	Contributing Project Activity	Phase the Project Effect Occurs in	Cumulative Effect	Proposed Mitigation[a]
Land and Resource Use – Land Tenure	Decommissioning and reclamation of the entire WL site, including the Project, may change the future land tenure and uses of the WL site.	Post-closure Phase	Cumulative effects from the Project in combination with the decommissioning of the remaining infrastructure and support facilities, and reclamation of the affected areas at the WL site are anticipated to be negligible.	■ The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. ■ Affected areas will be remediated to meet the WL preliminary soil cleanup and the non-radiological and radiological clearance and release criteria in accordance with the target end state of the associated land-use category.

Note:
[a] Some mitigation efforts are within the scope of the Project, and others are as identified for other projects (e.g., as identified in the Comprehensive Study Report)

9.0 SUMMARY OF SIGNIFICANCE OF RESIDUAL EFFECTS

9.1 Introduction and Approach

The following assessments were completed to evaluate the biophysical and human environment effects of the Project and to satisfy the requirements of the review being undertaken under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012):

- Section 6.2 Atmospheric Environment;
- Section 6.3 Geological and Hydrogeological Environment;
- Section 6.4 Surface Water Environment;
- Section 6.5 Aquatic Environment;
- Section 6.6 Terrestrial Environment;
- Section 6.7 Human Health;
- Section 6.8 Land and Resource Use; and
- Section 6.9 Socio-economic Environment.

The decommissioning approach for the Whiteshell Laboratories (WL) site as described in the Comprehensive Study Report was to remove all facilities entirely from the WL site with the exception of low level waste trenches in the Waste Management Area, which may be managed through on-site in situ disposal (AECL 2001). Canadian Nuclear Laboratories (CNL) is proposing a revised approach to the Whiteshell Reactor (WR-1 decommissioning that includes partial dismantling and demolition, along with passive, permanent disposal of the below-grade portions of the facility. The disposal approach is referred to as In Situ Decommissioning (ISD). ISD is a proven nuclear decommissioning approach that increases worker safety, provides protection of the environment and the public, reduces interim storage and multiple handling, enables permanent nuclear liability reduction and utilizes less resources. ISD is the safest technique, dramatically reducing the risk to workers compared to dismantling, and providing long-term safety to the public and the environment. Rather than dismantling, packaging and transporting the structure, the below-grade reactor systems, structure and associated radiological and non-radiological hazards are proposed to be permanently disposed in situ. The above-grade structures will be demolished and removed using traditional demolition methods. During decommissioning, consideration will be given to place some equipment from the heat transport system that is currently located on the ground-level reactor floor to a below-grade position for incorporation in the disposal system. An engineered cover will then be constructed over the below-grade structure.

The Project activities are limited to ISD of the WR-1 Building (i.e., the Project). Other decommissioning activities for the WL site, documented in the Comprehensive Study Report, are assumed to be unmodified. Removal of the east annex and service wings of the WR-1 Complex were assessed as part of the Comprehensive Study Report and are covered under the CNL's existing decommissioning licence for the WL site (Licence No. NRTEDL-W5-

8.04/2018). Activities required to prepare for ISD, such as isolation of the WR-1 Building and targeted remediation of hazardous materials, are also covered under CNL's existing decommissioning licence for the WL site.

The closure phase for the Project includes preparation for ISD, grouting of below-grade structures and systems, removal of above-grade WR-1 Reactor structures and systems, installation of the engineered cover over the grouted below-grade structures, final site restoration, and preparation for Institutional Control. Closure activities last from 2019 to 2024. The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. The Institutional Control period includes implementation of active controls throughout 2024 to 2124 (i.e., 100 years) and passive controls through 2024 to 2324. During active Institutional Control, long-term performance monitoring and maintenance activities will continue through to 2124 to demonstrate compliance with the safety case assumptions. The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions). Post-institutional Control occurs after year 2324 and continues indefinitely.

A residual adverse environmental effect is an adverse environmental effect of a project that remains, or is predicted to remain, after mitigation measures have been implemented (the Agency 2015), and therefore, are the expected consequences of the project for the selected valued components (VCs). Interactions (linkages) between Project components or activities and the corresponding potential effects on VCs are identified by a pathway or screening analysis that is used to focus the assessment on those interactions of greatest importance or that are likely to result in residual effects on a VC (see Section 6.1.5 for a more detailed description of the pathway analysis). For some interactions, there are proven effective mitigation or Best Management Practices that would eliminate or reduce the potential effect to a negligible level. Interactions determined to have no linkage to a VC (i.e., mitigation eliminates the potential effect) or those that are predicted to result in a negligible residual effect (i.e., secondary pathway), are not expected to result in environmentally significant effects to a VC, individually or cumulatively. As such, these interactions are not advanced for further assessment. Interactions that require further analysis to determine the environmental significance of the residual effect on a VC (i.e., primary pathways) are advanced to the residual effects analysis step (see Section 6.1.6 for a detailed description). A matrix table is included in Appendix 6.1-1 summarizing project interactions for each VC that are determined to be no linkage, secondary, or primary, after consideration of environmental design features and mitigation.

The residual effects analysis is based on the Project 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 Project, as well as previous, existing and reasonably foreseeable developments. The residual effects analysis is completed for the Application Case and the Reasonably Foreseeable Developments (RFD) Case. This Application Case scenario represents predictions of the cumulative effects of the existing environment combined with the effects that may result from the Project. The RFD Case scenario includes the Application Case plus additional reasonably foreseeable developments in the region that have been approved, but not yet constructed, and those that have not yet been approved. Developments and activities that are currently under application review, have officially entered a regulatory application process were considered reasonably foreseeable.

The residual effects classification of primary pathways provide the foundation for determining the significance of incremental and cumulative effects from the Project and other existing, approved, and reasonably foreseeable developments on VC. The purpose of the residual effects classification is to describe the residual incremental and cumulative adverse effects from the WR-1 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. Effects are classified using the following criteria, which follows the *Generic Environmental Impact Statement Guidelines* provided by the Canadian Nuclear Safety Commission (CNSC 2016) and the Agency's 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 2015). The residual effects classification is then used to make significance determinations.

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 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.

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 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. Duration is often categorized as short-term, medium-term, and long-term.

Reversibility – After removal of the Project activity or stressor, reversibility is the likelihood that the 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 Project). 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 intent of the environmental assessment is to predict if the Project is likely to cause a significant adverse (i.e., negative) effect on the environment or to cause public concern. Only residual effects that are adverse are considered in the determination of significance under CEAA 2012 (the Agency 2015). Consequently, neutral and positive residual effects are reported; however, they are not assessed for significance.

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. 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). 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. The significance of effects from the Project on VCs is evaluated by linking changes in measurement indicators to effects on the assessment endpoints.

All VCs have measurement indicators, but not every VC has an assessment endpoint. For example, VCs such as geology, hydrogeology and surface water are considered as measurement indicators for other VCs, and do not have an assessment endpoint (i.e., may be referred to as pathway or intermediate components). Valued components with no assessment endpoint are still analyzed for Project-specific and cumulative (if applicable) changes in measurement indicators. 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. The classification of this change and determination of significance of the residual effect would be completed for those VCs with assessment endpoints (see Section 6.1.2 and Figures 6.1.2-1 and 6.1.2-2 for additional detail on the approach).

The evaluation of significance for 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 Project and other developments on an assessment endpoint. The following is a summary of some of the key factors considered in the determination of significance on VCs (see Section 5.1.8.2 for additional detail on the approach for determination of significance):

- Results from the residual effects classification of primary pathways and associated predicted changes in measurement indicators.
- 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 might be either significant or not significant, the assessment conservatively identified the effect as significant and provided additional follow-up actions to reduce uncertainty.

9.2 Summary of the Significance of Residual Effects

9.2.1 Atmospheric Environment

9.2.1.1 Air Quality

Air quality was selected as a VC as there is a potential for the Project activities to release air emissions that could affect the local air quality. The assessment endpoint for air quality is performance against the criteria and thresholds for protection of human health and the environment. The assessment of air quality focused on predicting changes in the concentrations of selected non-radiological indicator compounds. These compounds are generally accepted as indicative in changing air quality, and for which relevant air quality criteria exist.

The assessment of effects of the Project on air quality involves two steps, namely the calculation of emission rates, which include the implementation of mitigation, and use of dispersion modelling to predict the resulting concentrations of indicator compounds. During the Application Case, Project activities will result in emissions associated with the operation of vehicles and equipment, as well as material handling emissions from the demolition and grouting and temporary batch mixing plant. Examples of mitigation practices implemented to limit predicted residual effects to air quality include:

- implementation of CNL's Environmental Protection Program (CNL 2017) and Procedure for Management and Monitoring of Emissions (CNL 2013), which includes operational control monitoring, air verification monitoring and environmental monitoring;
- on-site vehicles and equipment engines will meet a minimum of Tier 3 emission standards, where possible, and be maintained in good working order;
- limit idling of vehicles on-site and limit speed on roads; and,
- use of enclosure for raw material handling.

The predicted residual effects air quality were estimated to increase because of the Project. Fugitive dust from paved roads is the largest contributor to suspended particulate matter emissions (Section 6.2.1). Material handling from demolition is the largest contributor to particles nominally smaller than 10 µm in diameter emissions. Non-road equipment exhaust emissions are the largest contributors to particles nominally smaller than 2.5 µm in diameter and oxides of nitrogen (as nitrogen dioxide) emissions. Finally, the largest contributor to sulphur dioxide and carbon monoxide emissions is fuel combustion for emergency power generators.

For an effect to be deemed significant, the effect on an indicator compound must be adverse (negative in direction), exceed relevant guideline/standard (high in magnitude), extend beyond the local study area, but contained within the regional study area (regional in geographic extent) and reversible following completion of the Project phases (long term in duration). The direction is negative for all indicator compounds as there are emissions during the Application Case. However, the magnitude of changes to indicator compound emissions are predicted to be low to moderate as the predicted concentrations of each indicator compound from the Application Case are below their relevant guideline/standard. The predicted effects are limited to the Regional Study Area, and therefore the geographic extent of changes to all indicator compounds is regional for the Application Case. Although there are planned stages for the closure phase, emissions of indicator compounds will be lower; therefore the duration of effect is conservatively considered to be short-term. Criteria air contaminants will be emitted continuously or near-continuously during the Application Case, and therefore the frequency of effect is frequent. The likelihood of emissions from the Project changing indicator compound concentrations for the Application Case phases is high.

Based on the low to moderate magnitude, the limited geographical extent of the effect and the medium-term duration, the overall residual adverse effect of the Application Case on air quality is determined to be not significant (Section 6.2.1). The Procedure for Management and Monitoring of Emissions (AECL 2013) for CNL outlines the key management practices that limit air quality emissions effects. In addition, air quality monitoring activities for the Project will be incorporated into the Environmental Assessment Follow-up Program for WR-1 to verify effects, confirm effectiveness of mitigation, provide information for use in adaptive management, and demonstrate compliance with regulatory requirements.

9.2.1.2 Greenhouse Gases

Climate change was selected as a VC for the greenhouse gas (GHG) assessment as there is a potential for the Project activities to release GHG emissions that could contribute incrementally to climate change. The mechanism by which the Project has the potential to contribute to global climate change is by the addition of GHG emissions. Greenhouse gasses refer to a group of gases that build up in the atmosphere and have the potential to contribute incrementally to climate change. The assessment endpoint for climate change is comparison to provincial and national totals. The measurement indicators considered in the climate change assessment include changes in concentrations of the GHG emissions.

Examples of mitigation practices implemented to limit GHGs include:

- implementation of CNL's Environmental Protection program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring and environmental monitoring;
- on-site vehicles and equipment engines will be maintained in good working order; and,
- limit idling of vehicles on-site.

No primary pathways are identified for the GHG assessment (Section 6.2.2). Project activities will result in GHG emissions associated with the operation of vehicles and equipment during the closure phase, the GHG emissions are estimated to be less than 1% increase in total provincial GHG emissions and less than 0.01% increase in total national GHG emissions. Based on the comparison between the estimated annual emission to both the federal and provincial greenhouse gas emissions, the Project will result in minor releases of GHG emissions, but is predicted to have a negligible effect on climate change. Subsequently, there is no further residual effects classification and determination of significance.

9.2.2 Geology and Hydrogeology

9.2.2.1 Geology

Geology, which includes bedrock, soils and geomorphology, is recognized as an important component of the environment that may be affected by the Project and changes to geology could, in turn, lead to effects on other VCs selected for assessment. Acknowledging that changes to geology are considered to be 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). As such, the geology assessment does not include the assessment of the significance; rather, results of the analysis of changes in measurement indicators for geology are provided to other disciplines for inclusion in their assessment.

Potential effects on geology are limited to changes in soil quantity and quality as a result of construction of temporary supporting infrastructure (e.g., batch mixing plant for preparation of grout) for the Project, and changes

to soil quality from air emissions and leakage from the ISD reactor facility into the groundwater (Section 6.3.1). Mitigation and environmental design features implemented for the Project are well-understood and include existing practices at the WL site. In addition, performance monitoring will be completed throughout the post-closure phase (i.e., active Institutional Control period) to confirm that the final cover is functioning as intended. Consequently, no residual effects on geology are predicted as a result of the Project. As such, there is no further residual effects classification and determination of significance.

9.2.2.2 Hydrogeology

Hydrogeology is recognized as an important component of the environment that may be affected by the Project and changes to hydrogeology could, in turn, lead to effects on other VCs selected for assessment. Acknowledging that changes to hydrogeology are considered to be important aspects of the natural and human environment, hydrogeology is referred to as an intermediate component. As such, the hydrogeology assessment does not include the assessment of significance; rather, Results of the analysis of changes in measurement indicators for hydrogeology are provided to other disciplines for inclusion in their assessment.

Based on the Comprehensive Study Report (AECL 2001), it was determined that the likelihood of contaminant transport beyond the Waste Management Area was very low and no effects on groundwater were anticipated from in situ disposal of the trenches; therefore, no overlap with the Project is expected. Changes to groundwater quality from the Project due to the release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time was identified as having a residual effect on the hydrogeological environment. Environmental design features and mitigation implemented to reduce residual effects on groundwater quality include:

- installation of a multi-component final cover system to mitigate moisture infiltration into the ISD reactor facility;
- removal of the service area and infilling in these areas with compact soil;
- sealing of open conduits in the building foundation;
- grouting the interior portion of the building (containing the remaining components of WR-1) to ground surface elevation; and
- monitoring performance throughout the active post-closure phase for the Project to confirm that the cover and grout is functioning as intended, and to confirm modelling predictions.

Groundwater flow and solute transport modelling was completed to provide screening level solute mass loadings during the post-closure phase (Section 6.3.2). The Winnipeg River was identified by the post-decommissioning groundwater flow model as the principal receptor of groundwater discharge from the geological pathway. Results of the groundwater flow modelling indicate that the mean advective groundwater travel times to the Winnipeg River were estimated to be on the order of 100 years. The peak total activity level estimated from the simulations occurs after approximately 70 years and is principally related to the migration of tritium from the WR-1 Reactor. Due to dispersion, the finite amount of tritium in the source (grout) and the half-life associated with tritium (approximately 12 years) its peak arrival occurs earlier than the mean advective groundwater travel time. Mass flux rates from 53 radiological parameters, and 29 non-radiological elements were simulated in the groundwater flow and transport modelling and passed to other disciplines (i.e., see Section 9.2.3.2 Surface Water Quality, Section 9.2.6 Human and Ecological Health).

CNL will implement an Environmental Assessment Follow-up Program for the WR-1 to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented.

A post-decommissioning monitoring program will also be developed that will provide the sampling and analysis objectives and procedures for sampling and testing the groundwater quality in the vicinity of the WR-1 Building, compliant with CSA N288.7-15.

9.2.3 Surface Water Environment

9.2.3.1 Hydrology

Hydrology, which includes surface water flow and drainage direction, is recognized as an important component of the environment that may be affected by the 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 (i.e., it does not have an assessment endpoint). As such, the hydrology assessment does not include the assessment of the significance; rather, results of the analysis of changes in measurement indicators for hydrology are provided to other disciplines for inclusion in their assessment.

The assessment of potential pathways of effects determined there are no primary pathways that would lead to residual effects on hydrology (Section 6.4.1). The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. Following the completion of closure activities, the WL site and final cover will be graded to promote drainage from the site to the Winnipeg River. Run-off control for the cover is designed to limit erosion and infiltration of water into the grouted structure. This is achieved by sloping the cover surface to maintain a slope toward the edges, and the collection of water by the existing surface water management systems at the WL Site. Although the installation of the final cover at the WR-1 Building is expected to slightly alter the drainage rates and flow patterns and discharge volume to the Winnipeg River; the changes are expected to be within the natural range of variation. As such, effects to hydrology from the installation of the cover at closure is predicted to have a negligible effect on hydrology relative to existing conditions. CNL will implement an Environmental Assessment Follow-up Program for WR-1 to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented.

9.2.3.2 Surface Water Quality

Surface water quality was selected as a VC as humans and the environment depend on the quality. Measurement indicators include estimated concentrations of surface water parameters in the Winnipeg River. Acknowledging that changes to surface water quality are considered to be 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). As such, the surface water quality assessment does not include the assessment of the significance; rather, results of the analysis of changes in measurement indicators for surface water quality are provided to other disciplines for inclusion in their assessment.

During the post-closure phase there is a potential that groundwater could come into contact with materials from the reactor and migrate to the Winnipeg River. As such, the residual effects of groundwater seepage to the Winnipeg River on surface water and sediment quality was assessed. The assessment of effects of the Project on surface water quality involves two steps, namely the calculation of groundwater release rates and use of a dispersion model to predict concentrations of surface water parameters.

The predicted maximum radionuclide concentrations in surface water at both the Nearfield and the Farm A Intake on the Winnipeg River are orders of magnitude lower than groundwater concentrations. Predicted maximum non-radionuclide concentrations in surface water are driven by current river concentrations and some parameters exceed surface water guidelines (Section 6.4.2). Predicted sediment concentrations of radionuclides are lower than their respective Nuclear Substance and Radiation Devices Regulation Clearance Levels. Predicted sediment concentrations of non-radionuclides are driven by current river concentrations and exceed available sediment guidelines (Section 6.4.2).

CNL will implement an Environmental Assessment Follow-up Program for WR-1 to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. CNL's current environmental monitoring program includes collecting water samples at one location upstream and three locations at varying distances downstream of the WL site. Surficial sediment is also collected at two locations upstream, at the outfall, and nine locations downstream. In addition, CNSC has committed to collecting cores in depositional areas in 2026, 2046, and 2066 at Sylvia Lake and upstream and downstream of the waterbody Lac du Bonnet. It is proposed that these same monitoring locations be used to support the WR-1 Environmental Assessment Follow-up Program, coordinating with the existing program, where practical. Follow-up monitoring during the post-closure phase is necessary to confirm predicted concentrations in surface water and sediment in the Winnipeg River and to provide information for use in adaptive management to address potential unforeseen effects.

9.2.4 Aquatic Environment

For the aquatic environment, fish and fish habitat was selected as a VC. The assessment endpoint for the aquatic environment is the maintenance of self-sustaining and ecologically effective fish populations. Fish habitat, benthic macroinvertebrate community structure, fish community structure, and fish flesh radiochemistry were selected as the measurement indicators for the aquatic environment VCs.

Potential effects on the aquatic environment in the Winnipeg River are related to transport of site runoff, changes in drainage rates and flow patterns, air emissions, and seepage of contaminants from the ISD reactor facility to the groundwater in the long-term (Section 6.5). Mitigation and environmental design features implemented for the Project are well-understood and include existing practices at the WL site. Following completion of closure activities, the Project site and final cover will be graded to promote drainage to the Winnipeg River, and performance monitoring will be completed throughout the post-closure phase (i.e., during the active Institutional Control period) to confirm that the final cover is functioning as intended. During the closure and post-closure phases, there are no exceedances of the 9.6 mGy/d radiation benchmark for aquatic biota in the Winnipeg River. All predicted doses are well below these levels. Therefore, it is unlikely there would be significant adverse effects on either aquatic populations or communities as a result of radionuclide releases from closure activities or in the long-term during the post-closure phase (Section 6.5).

Overall, the assessment of potential pathways of effects determined there are no primary pathways that would lead to residual effects on aquatic environment VCs. As such, there is no further residual effects classification and determination of significance.

CNL will implement an Environmental Assessment Follow-up Program for WR-1 to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. As part of CNL's current licence (NRTEDL-W5-8.04/2018), the current Environmental Monitoring Program includes water monitoring and collecting fish flesh at one location upstream and two locations downstream of the WL site

(CNL 2016). Follow-up monitoring for WR-1 will be coordinated with the existing program, where practical. Follow-up monitoring during the post-closure phase to confirm radionuclide concentrations in surface water quality (see Section 9.2.3.2 Surface Water Quality) will also verify the accuracy of environmental effects for the aquatic environment.

9.2.5 Terrestrial Environment

All *Species at Risk Act* (SARA)-listed wildlife species with the potential to occur within the WL property (or with confirmed occurrence records) were considered as potential VCs at the species level, and the chosen species are also useful as indicators for broader species guilds with similar life history traits. Barn swallow were also included despite the lack of SARA-listing, based on their Committee on the Status of Endangered Wildife in Canada ranking and more significant potential pathway for effects through nest destruction associated with the Project. Species with a very low likelihood of occurrence in the Local Study Area (LSA), for which habitat was not present in the Regional Study Area, or for which effects of the Project were unlikely, were excluded as VCs. The VCs assessed for the terrestrial environment included barn swallow, golden-winged warbler, bats, and snapping turtle. The assessment endpoint for the terrestrial environment is the maintenance of self-sustaining and ecologically effective populations. Habitat availability, habitat distribution, and survival and reproduction were selected as the measurement indicators for the terrestrial environment VCs.

Potential effects on the terrestrial environment are related to transport of site runoff, changes in drainage rates and flow patterns, air emissions, and seepage of contaminants from the ISD reactor facility to the groundwater in the long term (Section 6.6). Mitigation and environmental design features implemented for the Project are well-understood and include existing practices at the WL site. The assessment of potential pathways of effects determined there are no primary pathways that would lead to residual effects on VCs (Section 6.6). Surveys during the appropriate season, to be undertaken the year prior to initiation of decommissioning activities, will confirm whether nesting and/or roosting activity is occurring in the WR-1 Building. If evidence of nesting or roosting activity is found, appropriate mitigation measures in the form of deterrents will be implemented, under consultation with Environment and Climate Change Canada, and in accordance with habitat protection provisions and the required permitting process under SARA. The objective of the selected mitigation measures will be to prevent birds and bats from accessing the building during the period when it will be demolished. The potential for road mortality of snapping turtle will be addressed through adaptive management and on-going monitoring and documentation of road mortalities. If road mortality of snapping turtle occurs, additional mitigation will be enacted, as required. During the closure and post-closure phases, there are no exceedances of the 2.4 mGy/d radiation benchmark for terrestrial and riparian biota on or near the WL site. All predicted doses are well below these levels (Section 6.6). Therefore, it is unlikely there would be significant adverse effects on either terrestrial populations or communities as a result of radionuclide releases from closure activities or in the long-term during the post-closure phase. As such, there is no further residual effects classification and determination of significance.

Although no residual effects on terrestrial VCs are predicted, monitoring programs are described as possible proactive mitigation by CNL, and includes consideration of all future decommissioning and building demolition activities that will occur on the WL property. In addition, CNL will continue to implement the Environmental Assessment Follow-up Program for WR-1 as outlined for other environmental components to verify the accuracy of indirect environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented.

9.2.6 Human and Ecological Health

9.2.6.1 Human Health

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 human health VCs and represent the key properties of the VCs that should be protected for future human generations (i.e., incorporates sustainability). The assessment endpoint is the protection of human health. Measurement endpoints represent properties of the environment, that when changed, could result in or contribute to an effect on an assessment endpoint. Measurement endpoints for the human health assessment include changes in air quality, groundwater quality, and surface water quality. 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 benchmarks, and (ii) the degree of conservatism and uncertainty in the analysis.

The receptors for the Human Health Risk Assessment (HHRA) were selected to be appropriate for assessment of both radiological and non-radiological stressors on human health. Off-site members of the public will potentially be exposed to low levels of airborne contaminants from decommissioning of the WR-1 Building. The most-affected off-site members of the public are defined as the “critical group” which include:

- Farm A and F (year-round occupants, with livestock);
- On-site Farm (post-Institutional Control); and
- Harvesters (additional receptor not identified in the Derived Release Limits).

The assessment of effects on human health considered locations where people are known to be present. Two farms were selected for the HHRA as these receptors are the most exposed critical groups for atmospheric and waterborne releases. Harvesters were also selected and represent traditional users of the area who may be exposed through harvesting of country foods. For the post-closure phase, an onsite farm was also considered. Nuclear Energy Workers and workers who lease businesses on-site will be monitored and their doses during closure controlled through CNL’s Radiation Protection Program.

For the closure phase, the relevant contaminants of potential concern (COPCs) are expected to be released via atmospheric releases from the WR-1 Building as reactor systems are dismantled, transported off-site or entombed within the ISD reactor facility. It has been assumed that the WR-1 Building stack is removed During the closure phase; therefore, atmospheric releases are assumed to surface water are not expected because any release from the grouted reactor would occur at ground level.

An environmental transport and pathways model was used to evaluate the transport and effects of contaminants on the local environment including human receptors. The calculated radiological doses for the Project are all below the CNSC public dose limit of 1 millisievert per year (mSv/a), as well as the dose constraint for the Project of 0.25 mSv/ limit, for all human receptors in the candidate critical groups. Since the dose estimates are a small fraction of the public dose limit, no discernable health effects are anticipated due to exposure to radioactive releases from Project activities. For the closure phase, all predicted air concentration for non-radiological COPCs were below their relevant ambient air quality criteria; therefore, no non-radiological COPCs were identified for the closure phase and no health effects are anticipated as a result of airborne effluents from the Project.

The total radiation dose to human receptors during the post-closure phase are below the CNSC public dose limit of 1 mSv/a, as well as the dose constraint for the project of 0.25 mSv/a. Since the dose estimates are a small fraction of the public dose limit, no discernable health effects are anticipated due to exposure of potential critical groups to radioactive releases from the WL site during post-closure.

The doses to human receptors that could be exposed to the non-radiological COPCs (i.e., cadmium and lead) in surface water during post-closure were calculated based on total concentration (background plus Project contribution). Risk was quantified for the human receptor based on the calculation of a hazard quotient (HQ) by dividing the estimated exposure by a toxicity reference value TRV that is known to be protective. Incremental HQs were compared to a benchmark HQ of 0.2, which is consistent with approach taken by Health Canada (2010) in their guidance on human health quantitative risk assessment. The HQs derived for constituents of potential concern were below the protective benchmark for all receptors, with the exception of a toddler harvester, which slightly exceeded the benchmark. If only the project contribution is considered, the HQs are reduced even further and are well below for all receptors (the project contribution to the total is 0.0021% for cadmium and 0.00002% for lead).

Although uncertainties in the assessment exist, conservatism has been included in the modelling so that residual effects are not greater than predicted. The closure activities are well encompassed by existing engineering and administrative controls currently in place at the WL site. Although there are some uncertainties to be defined (e.g., exact quantities of hazardous substances), the existing programs and procedures can be applied to manage these potential hazards. Proven operational programs will be in effect ensuring worker doses are below regulatory criteria and are As Low As Reasonably Achievable.

Overall, residual effects are considered to be not significant for all human health VCs during the closure and post-closure phases. Monitoring and follow-up programs include implementation of CNL's existing Environmental Monitoring Program and the Environmental Assessment Follow-up Program for the Project. These activities will verify effects predictions for human health.

9.2.6.2 Ecological Health

It is generally an impractical task to assess the effect of radiological and non-radiological emissions on every species of biota within a natural ecosystem, and specifically within the ecosystem around the WL site. Therefore, representative organisms are chosen for dose and risk analysis. These organisms are selected because they are known to exist on the site, and are representative of major taxonomic groups or exposure pathways, or have a special importance or value. The assessment of potential effects to ecological 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 ecological health is evaluated based on: (i) the potential magnitude of the response, as indicated by the comparison to benchmarks, and (ii) the degree of conservatism and uncertainty in the analysis.

During closure, the focus is on terrestrial VCs because releases are only expected via atmospheric pathways. During post-closure phase, the focus is on aquatic and riparian VCs, because releases are only expected via groundwater to surface water pathways. An environmental transport and pathways model was used to evaluate the transport and effects of contaminants on the local environment including ecological receptors. Results of the radiological dose assessment for the closure and post-closure phases indicates that doses to ecological health VCs are below their respective benchmark values. In addition, all predicted non-radiological concentrations were

less than their selected guidelines or alternate benchmarks. 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 closure and post-closure phases. Monitoring and follow-up programs include implementation of CNL's existing Environmental Monitoring Program and the Environmental Assessment Follow-up Program developed for the Project. These activities will verify effects predictions for ecological health.

9.2.7 Land and Resource Use

The land and resource use VCs chosen for the Project to reflect identified concerns, professional judgement and/or standard practice in environmental assessment are Land Tenure, Outdoor Recreation and Tourism, Cultural and Archaeological Sites, Traditional Land and Resource Use by Aboriginal People, and the Winnipeg River.

The Project could affect outdoor recreation and tourism activities, and traditional land use through effects to vegetation, fish and wildlife and their habitats, and surface water quality in the Winnipeg River. Changes to these VCs could result from a change in the abundance and distribution of resources, the quality of the resource, and the ability to access the resource including fish, wildlife and vegetation. Any of these changes could subsequently affect the ability and the desire to engage in activities. There are not anticipated to be any threshold exceedances in harvested receptors through atmospheric releases and waterborne dispersion of contaminants (Section 6.8). In addition, the mitigation proposed to limit Project effects on surface water quality, the aquatic environment, the terrestrial environment, human health and ecological health are anticipated to eliminate or limit potential effects to the resources on which recreation and tourism activities and traditional land and resource use are dependent (Section 6.8).

The WL site has been operational since the 1960s, with public access generally restricted for safety and security reasons. Exceptions to this include parcels of the WL site on the west side of the Winnipeg River that have been continuously used for agricultural purposes under agreements with Atomic Energy of Canada Limited (AECL). No outdoor recreation and tourism activities or traditional land and resources uses are permitted on the WL site. Land and resource use activities have persisted adjacent to the site, including uses of the Winnipeg River. It is expected that all activities and land uses adjacent to the site will be able to continue in the future as the Project will have no effect on land tenure or usage beyond the WL site boundaries (Section 6.8).

Canadian Nuclear Laboratories is developing appropriate criteria for site remediation and clean-up activities of the WL site. Under the original decommissioning plan, a smaller percentage of the site (the waste management area) would have had restricted access than with the Project; however, the area with anticipated restricted access under the Project is still small when compared with the remainder of the WL site. Although the Project will result in long-term institutional controls for a small portion of the WL site, the remaining land is safe and appropriate for other use. This may include transfer of the land to other parties following engagement with stakeholders, Aboriginal groups and the public. Future uses/zoning have not been determined, but it is assumed that the land will meet Canadian Council of Ministers of the Environment (CCME) land use criteria. Consequently, the Project is expected to have a negligible effect on land and resource use VCs.

CNL will implement the Environmental Assessment Follow-up Program for WR-1 to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. In addition, to mitigate perceptions related to the suitability for use of the WL site and the lands around it, CNL will support robust communication of environmental monitoring results to confirm the safety of the WL site and help address concerns about future uses.

Although there are currently no archaeological sites located on the WL site, there is a site located approximately 1,700 m south of the WL site (AECL 2001) and the Winnipeg River has been an important travel route throughout history, potentially beginning in the Paleo Indian Period (*ca.* 11,000 – 7,000 years ago). Project activities that could affect cultural and archaeological sites include those activities that could cause ground disturbance of any previously undisturbed area, especially if the undisturbed area is located between the western edge of the WL site's built infrastructure and the Winnipeg River. Decommissioning activities are not expected to include any undisturbed land or areas on the WL site (Section 6.8). If, however, activities require use of undisturbed areas, and in particular any activities in proximity to the Winnipeg River, CNL will have an archaeologist available to monitor Project activities and assess any potential finds. If an unexpected discovery of a heritage resource is made during Project activities, CNL will, in accordance with the *Heritage Resources Act*, cease activities until the Heritage Resources Branch can be consulted on the need to conduct a Heritage Resource Impact Assessment before resuming decommissioning activities (Section 6.8).

The assessment of potential pathways of effects determined there are no primary pathways that would lead to residual effects on land and resource use VCs. As such, there is no further residual effects classification and determination of significance.

9.2.8 Socio-economic Environment

The socio-economic VCs chosen for the Project to reflect identified concerns, professional judgement and/or standard practice in environmental assessment are Employment and Income, Business Opportunities, Government Finances, Community Infrastructure and Services, Community Well-being, and Public Safety. The assessment of potential pathways of effects determined there are no primary pathways that would lead to residual effects on Employment and Income, Business Opportunities, and Public Safety. Primary pathways were determined for Community Well-being through changes to the perceived suitability of and physical access to the WL site for future uses.

When assessing effects of the Project on people, it is inherently challenging as issues may arise from differing perspectives, perceptions and values among different groups of affected individuals or communities. Effects that are considered to be moderate to high in magnitude, combined with being medium to long term in duration, have the potential to be considered as significant irrespective of geographic extent; however the social and economic context, uncertainty of outcomes, and potential for adaptation are also considered in the determination.

The assessment for Community Well-being is qualitative and considers the potential changes in the attractiveness of and possible future uses of the WL site in light of the Project. This may affect overall community plans and goals as they relate to economic development. Information from economic and community development organizations and offices, the Key Person Interview Program, Project public engagement feedback, public feedback provided to the CNSC on the Project description and CNL inputs were considered in the analysis.

The previous decommissioning plan assumed that radioactive wastes, except for those designated to remain in the Waste Management Area and a limited area of radioactive contaminated sediment in the Winnipeg River, would eventually be removed and placed in permanent disposal facilities. However, this is under the assumption that a national disposal facility for low-level radioactive waste would be available by 2025 and a national disposal facility for medium-level waste operational by 2050. Eventually, the overall site would be available for unrestricted use. The permanent presence of the encapsulated WR-1 Building will change the perceived suitability of the WL site for future uses due to the perceived risk associated with the long-lived radiological hazards of the reactor

vessel. In addition, the WL site will now have restricted use in proximity to the encapsulated WR-1 Building over an indefinite period of time associated with institution control.

To reduce the potential effect of these perceived concerns CNL is committed to sharing information with the Partnership to help them develop a feasible socio-economic plan and a development of robust communication plan to convey and confirm the Project's safety. Canadian Nuclear Laboratories is currently working with the communities and rural municipalities in the LSA by funding the activities of the Community Regeneration Partnership to develop a socio-economic plan for the region. The plan is anticipated to support future economic development and subsequently community development. Through this venue, the communities and rural municipalities in the LSA should have the opportunity and expertise available to develop a meaningful and feasible path forward that would help maintain the continued vitality of the communities, especially Pinawa, in the area.

Effects on Community Well-being are expected to be negative in direction, moderate in magnitude, local in geographic extent and medium-term in duration. The Project is anticipated to adversely affect the perceived suitability of the WL site for future business ventures and the ability of local communities to gain access to the WL site for other uses following Institutional Control. Since both effects are localized to the site and since use of and access to the site were objectives primarily of the communities and rural municipalities in the area, the geographic extent is anticipated to be local. While ISD entails encapsulating radioactive material below grade for permanent disposal, good communication is expected to shift perceptions of site suitability before the end of the Institutional Control period (i.e., before Year 2324).

While the Project presents challenges to the future use of the WL site, the Partnership, including CNL, will make efforts to effectively identify and implement a path forward for economic development in the area. In addition, CNL will support robust communication of monitoring results. Members of the Public Liaison Committee are expected to share results with their communities. Canadian Nuclear Laboratories can provide communication support if necessary to help disseminate monitoring results. Canadian Nuclear Laboratories may want to consider other communication methods as well, such as a public website to share monitoring results. While the role of the WL site may change in economic and community development in the local area, development is expected to continue, therefore, there is no significant adverse effect of the Project on Community Well-being.

9.3 Summary

Residual adverse effects were identified for air quality, hydrogeology, surface water quality, human and ecological health, and community well-being (Table 9.3-1). Mitigation and environmental design features implemented for the Project are well-understood and include existing practices at the WL site. CNL will implement an Environmental Assessment Follow-up Program for WR-1 to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented.

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Table 9.3-1: 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.	Closure activities will alter concentrations of indicator compounds, including: ■ use vehicles and equipment that combust fuel and emit indicator compounds; ■ material handling, for grouting and demolition; ■ vehicles travelling on paved roads; and ■ operation of batch mixing plant for grout production.	Closure Phase	■ Stage 1: Preparation for In Situ Decommissioning ■ Stage 2: Grouting of below grade structures and systems ■ Stage 3: Removal of above grade WR-1 Reactor structures and systems	■ Implementation of CNL's Environmental Protection Program and Procedure for Management and Monitoring of Emissions, which includes operational control monitoring, air verification monitoring and environmental monitoring. ■ Implementation of dust management techniques to control dust generated by the Project, consistent with the current Environmental Assessment Follow-up Program. ■ Road watering and chemical dust suppressant when necessary. ■ Removal of accumulations of particulates (e.g., dirt) on road as soon as possible. ■ On-site vehicles and equipment engines will meet Tier 3 emission standards, where possible, and be maintained in good working order. ■ Limit idling of vehicles on-site and speed on roads. ■ Use of enclosure for raw material handling.	Not Significant	Not applicable
Physical Environment	Hydrogeology	Intermediate component (i.e., it does not have an assessment endpoint).	Release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time may cause changes in groundwater quality.	Post-closure Phase	Long-term performance during the post-closure phase	■ Installation of a multi-component final cover system to mitigate moisture infiltration into the ISD reactor facility and hence limit release of solutes into the groundwater. ■ The planned decommissioning of the WR-1 Building presently involves: ▪ removal the service area and infilling in these areas with compact soil; ▪ sealing of open conduits in the building foundation; and ▪ grouting the interior portion of the building (containing the remaining components of WR-1) to ground surface elevation. ■ Performance monitoring will be completed throughout the post-closure phase for the Project to confirm that the cover and grout is functioning as intended, and to confirm modelling predictions.	Significance is not determined as VC does not have an assessment endpoint.	Significance is not determined as VC does not have an assessment endpoint.

Table 9.3-1: 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	Surface Water Quality	Intermediate component (i.e., it does not have an assessment endpoint).	Release of chemical and radiological contaminants in the long-term during the post closure phase from the Project, which can surface water and sediment quality.	Post-closure Phase	Post-closure Performance	■ The planned decommissioning of the WR-1 Building presently involves: ▪ removal the service area and infilling in these areas with compact soil; ▪ sealing of open conduits in the building foundation; and ▪ grouting the interior portion of the building (containing the remaining components of WR-1) to ground surface elevation. ■ As part of CNL's licence with the CNSC, environmental monitoring around the WL site is required and will continue for the Project. ■ Follow-up monitoring during the post-closure phase will be completed to verify effects predictions and to provide information for use in adaptive management to address potential unforeseen effects.	Significance is not determined as VC does not have an assessment endpoint.	Significance is not determined as VC does not have an assessment endpoint.
Socio-economics	Community Well-being	The assessment endpoint considers the continued sustainability and overall well-being of communities in proximity to the Project, with a particular focus on Pinawa.	■ The perceived suitability of the site for future business ventures may change as a result of the presence of long-lived radioactive material as part of ISD. ■ The use of ISD as the decommissioning method for the WR-1 Reactor will change the proportion of the site for unrestricted use.	Closure and Post-closure	ISD of WR-1 Building	■ Continued activities through the Community Regeneration Partnership to help the region develop economically. ■ Communication of environmental monitoring results to confirm the safety of the WL site and lands around it. ■ Final ISD design so that projections of doses to members of the public are well below the average Canadian individual background dose rate. ■ Final ISD design will be done to maximize hazard reduction.	Not significant	Not applicable

CNL = Canadian Nuclear Laboratories; km/hr = kilometres per hour; ISD = in situ decommissioning; CNSC = Canadian Nuclear Safety Commission.

10.0 ASSESSMENT OF EFFECTS OF THE ENVIRONMENT ON THE PROJECT

This section of the Environmental Impact Statement (EIS) discusses the effects of the environment on the Project, in a manner consistent with Section 2(1) (c) of the *Canadian Environmental Assessment Act, 2012* (2012), which defines "environmental effects," in part, as "any change to the Project that may be caused by the environment, whether any such change or effect occurs within or outside Canada." Accordingly, this section focuses on the effects of natural hazards (i.e., extreme weather events, forest fires, and seismic events) and climate change on the 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. Accidents and malfunction scenarios that could be caused by the natural hazards are identified in Section 7.0 (Accidents and Malfunctions), including the estimated likelihoods and consequences to the environment and public and worker safety. Additional information on the mitigation actions is reported elsewhere in the EIS, as referenced. The WR-1 is currently protected by the WR-1 Building, and the building will not be demolished until the grout has cured and the contaminants are isolated and immobilized.

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. 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 10.4.4 Climate Change.

10.1.1 Temperature Fluctuations

Temperature fluctuations and the effects of freezethaw cycles will be considered in the design of the engineered cover, as natural freezethaw cycles could damage the components of the WR-1 ISD structure. The engineered cover will be designed to protect the components of the WR-1 ISD structure from the effects of freeze-thaw cycles. To prevent freezing, the engineered cover system design may include granular/soil materials of sufficient thickness above key cover components required to ensure containment. The design of the engineered cover system will limit damage from freeze-thaw cycles. Meteorological records will be reviewed annually to confirm that the cover performance is not overloaded during the active Institutional Control period. This will be included in the Environmental Assessment Follow-up Program.

10.1.2 Extreme Rainfall Events, Snowmelts and Flooding

Extreme rain could result in an increase in surface water runoff and subsequently, erosion of the engineered cover, soil mobilization and migration of contamination from the ISD waste. During decommissioning, extreme rainfall events could also result in worker safety issues, such as slippery surfaces, reduce visibility, and increased electrical hazards. Consequences of potential extreme precipitation event, such as a power outage, are encompassed by Canadian Nuclear Laboratories (CNL's) Emergency Preparedness Program (Section 7.3.5).

The end-state plan for the Whiteshell Laboratories (WL) site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. The drainage system for the reclaimed WL site will have the similar

physical characteristics as similar natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. Extreme rainfall and snowmelt events could also lead to soil erosion on the engineered cover. The engineered cover system will be designed to cover the entire surface of the decommissioned WR-1 Building and will be graded to promote drainage from the site to the Winnipeg River, similar to the rest of the WL site. The engineered cover is also designed to limit water infiltration, to direct any infiltration water away from the grouted structure, and to resist degradation by surface geologic processes and biotic activity (e.g., deters intrusion by burrowing animals).

Flooding of the WL site due to a rise in the Winnipeg River is remote and has been previously evaluated. A failure of the Seven Sisters Dam, which is upstream of the WL site, is considered a bounding scenario for a potential rise in river levels due to extreme rainfall. There has never been a failure of a hydroelectric dam in Canada (AECL 2001). A rise in river level in response to ice jams or extreme precipitation events is considered an unlikely event (1 in 100 years [refer to Section 7.1.2]) based on historical occurrence data, for the assessment still considered a credible event. Further, Manitoba Hydro has contingency plans for comprehensive notification, warning, and response systems in case an emergency condition is detected.

Flood levels of the river at the WL site following a failure of the Seven Sisters Dam were previously estimated to take 1.5 hours to reach a peak at 7 metres (m) above normal water levels (see Section 6.5 in AECL 2001). This is below the level of the WR-1 Building, as such a flooding incident of this magnitude would not flood the WR-1 site; it would affect the shoreline of the Winnipeg River adjacent to the WL site, but it would not flood the WL site. The assessment concluded that there was potential for the Pumphouse to be flooded during an extreme event. The risk from flooding, therefore, is considered of low probability and of low consequence (i.e., negligible physical or biological effects [Section 7.1.2]). Consequences of potential flooding, such as a power outage, are encompassed by CNL's Emergency Preparedness Program (Section 7.3.5).

Heavy downpours and runoff could increase the probability of a vehicle accident, as a result of reduced visibility and poor road conditions. During extreme rain events, activities will be carried out in accordance with the existing Occupational Safety and Health Program and Environmental Protection Program to ensure risks are managed. Further, suspension of decommissioning activities would be executed during extreme rainfall when necessary to limit associated risks.

10.1.3 Heavy Snowfall

Severe snowstorms are primarily a concern related to worker safety during the closure phase and throughout the institutional control period where workers will be occasionally present for environmental and performance monitoring. These activities are already encompassed by CNL's Emergency Preparedness Program. Severe snowstorms could affect vehicle operation at the site because of reduced traction and visibility and 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. Consequences of potential heavy snowfalls, such as a power outage, are also encompassed by CNL's Emergency Preparedness Program.

10.1.4 Tornado/Extreme Wind

Tornadoes are recognized as a hazard to the facilities on the WL site, including the Project. As reported in Section 6.5: The Effects of the Environment on Decommissioning Activities in the Comprehensive Study Report (CSR), between 1868 and 1990 at least 75 tornadoes or tornado groups have occurred in Manitoba with two of

these tornadoes passing near the WL site in 1978 (AECL 2001, Section 6.5). Between 1980 and 2009 there were 283 confirmed tornadoes in Manitoba, two of which passed within 10 km of the WL site (2005 at Lac du Bonnet and 2007 at Seven Sisters Falls). Based on the most recent 30 year period of data available (1980 to 2009), the frequency for a tornado strike on the property is estimated to be 5.4×10^{5} per year and a return period of 2×10^{5} years (Cheng et al 2013). There is, therefore, a low probability of a tornado affecting the WL site (Section 7.1.2). There is concern that climate change will increase the frequency and severity of summer storms, including tornadoes, hail storms, and lightning events (Peterson et al 2008). While it appears that these storms have already become more frequent (comparing the 1868 to 1990 and 1980 to 2009 data), reporting of tornadoes has increased significantly with increasing population density, resulting in a higher reporting rate than was previously possible (Government of Canada 2015). It is therefore uncertain, at this time, if the perceived increase in reported tornadoes is due to increased storm frequency or due to improved detection and reporting. These summer storms are treated as moderately probably events and encompassed by CNL's Emergency Preparedness Program, including extreme storms.

High winds, atmospheric pressure changes, and wind induced missiles have the potential to cause structural damage and/or failure of infrastructure. In 2005, the 1995 National Building Code of Canada (NBCC) was updated to include provisions so that basic structural resilience under low end tornadic loads in areas of Canada defined as "tornado prone," (NBCC 2005) and Environment Canada has recently compiled an updated 30-year national tornado database (Cheng et al 2013).

Severe winds or tornadoes are primarily a concern related to worker safety during the closure phase and throughout the institutional control period when workers will occasionally be present for environmental and performance monitoring. During closure, hazards include the spread of contamination if the building is damaged. Activities will be conducted in accordance with CNL's Radiation Protection Program. It is unlikely that a tornado would have any impact on the ISD cover system but could damage the intrusion control infrastructure (e.g., fencing). These activities are already encompassed by CNL's Emergency Preparedness Program. The risks associated with severe winds or tornadoes are managed through the management practices described above. Consequences of potential tornadoes, such as a power outage, are encompassed by CNL's Emergency Preparedness Program.

10.2 Forest Fires

The Project is located in an area that is primarily under treed cover (approximately 83% of the terrestrial RSA), representing a potential fire hazard. Historical data for the 1980 to 2015 period (the most recent period for which data are available (Natural Resources Canada 2017) indicate that southern Manitoba is generally at lower risk of forest fires than more northerly parts of the province. During closure, an effective response to fires will be facilitated through CNL's Emergency Preparedness Program and the Fire Protection Program. The onsite risks associated with wildfires would (e.g., low visibility due to smoke) during closure; therefore, continue to be managed through existing procedures during closure and design criteria in the long-term. Based on regional conditions and historical data, the probability of such an event has been assessed as unlikely, and there is minimal treed cover in the immediate vicinity of the WR-1 Building.

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 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. Consequences of a fire, such as a power outage and system failure, are encompassed by CNL's Emergency Preparedness Program and evaluated previously in this document in Section 7.3.5.

10.3 Seismic Events

Major earthquakes (i.e., seismic events) are related to movements at tectonic plate boundaries. The province of Manitoba is the least earthquake-prone area in Canada (AECL 2001). Seismic activity in the prairie region south of 60 degree north (°N) is predominantly confined to southern Saskatchewan in a zone that continues into Montana (AECL 2001). Furthermore, the Canadian Nuclear Fuel Waste Management Program studied seismic stability in Northwest Ontario and Eastern Manitoba and found, based on a detection level of 2.5 on the Richter scale that the WL site and the southern two-thirds of Manitoba are aseismic (Wetmiller et al. 1996). The conclusion was based on data collected by the Geological Survey of Canada and the AECL through the operation of a network of seven seismograph stations in eastern Manitoba and northern Ontario from 1982 to 1995.

Detailed information on earthquakes that have occurred in Canada is contained in publications of Earthquakes Canada of Natural Resources Canada and their predecessor organizations. A seismic zoning map for Canada has been developed on the basis of these studies and is used in the NBCC (National Research Council of Canada, "National Building Code of Canada 2010", Supply and Services Canada, Ottawa, 2010). The NBCC placed the WL site (and all of Manitoba) within a Seismic Zone 0, a zone that has a probability of less than 0.01 per year for exceeding a horizontal ground acceleration of 0.01 g, where g is acceleration due to gravity. The probability of earthquake damage from such low ground acceleration approaches zero, and therefore, the NBCC-assigned horizontal design ground acceleration for Zone 0 is also zero.

10.4 Climate Change

Changes in the global and regional climate could affect the Project during the closure and post-closure phases. The Canadian Nuclear Safety Commission (CNSC) 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 2017). As such, an effect assessment of climate change was completed that follows the guidance provided by the Federal Provincial Territorial Committee on Climate Change and Environmental Assessment (FPTCCCEA). 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 that the changes over the 20th 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 degrees Celsius (°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 that 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 (Environment Canada 2016). 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 southern and central Prairies of Canada will experience more of a warming trend 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 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 near the Project footprint. In general, the current climate normals- and trends indicate a current 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 show increasing trends for all seasons (Climate Change Assessment for WR-1 In Situ Decommissioning [Golder 2017a]).

An analysis of the Pinawa Whiteshell Nuclear Research Establishment (WNRE; Climate ID 5032162; ECCC 2016) climate station data was completed illustrating:

- increasing trend in total precipitation;
- increasing trend in spring total precipitation;
- increasing trend in summer total precipitation;
- increasing trend in winter total precipitation;
- increasing trend in total rainfall;
- increasing trend in the number of days with greater than 20 mm of rainfall; and
- increasing trend in average fall temperatures.

10.4.2.2 Future Climate Conditions

Future climate projections were derived using General Circulation Models (GCM) for two time periods, the Mid Term (2041 through 2070) represents near the beginning of the post-closure phase (2024 onwards) and the Far Term (2070 through 2100) represents the continuation of the post-closure phase (Climate Change Assessment for WR-1 In Situ Decommissioning; [Golder 2017a]). Climate projects were also considered for the Long Term (2100 through 3000) described using publicly available literature Golder 2017a).

The model projected means for the Mid Term and Far Term are greater than the observed climate normal for both temperature and precipitation (Tables 10.4.2-1 and 10.4.2-2 of Golder 2017a). The projected temperatures will continue to increase for both the Mid Term and Far Term periods. The projected changes in precipitation also show an increase for both the Mid Term and Far Term, although the monthly amounts will be similar to the current climate.

Table 10.4.2-1: Model Projected Mean and Climate Normal for Project for the Mid Term (2041 – 2070)

Period	Temperature (°C)			Precipitation (mm)		
	Climate Normal	Projected Mean	Difference	Climate Normal	Projected Mean	Difference
Annual	2.8	5.2	2.4	588.6	633.7	45.2
Spring	2.9	4.6	1.7	117.1	128.4	11.3
Summer	17.9	19.9	2.0	261.3	266.5	5.2
Fall	4.5	7.6	3.1	144.1	150.5	6.4
Winter	-14.5	-11.7	2.8	66.1	76.9	10.8

Table 10.4.2-2: Model Projected Mean and Climate Normal for Project for the Far Term (2071 – 2100)

Period	Temperature (°C)			Precipitation (mm)		
	Climate Normal	Projected Mean	Difference	Climate Normal	Projected Mean	Difference
Annual	2.8	6.0	3.2	588.6	647.1	58.6
Spring	2.9	5.5	2.5	117.1	132.3	15.2
Summer	17.9	20.8	2.8	261.3	268.3	7.0
Fall	4.5	8.4	3.9	144.1	152.7	8.6
Winter	-14.5	-10.8	3.6	66.1	79.8	13.7

For the Long Term, based on Representative Concentration Pathways (RCPs) 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 (Table 10.4.2-3 of Golder 2017a). 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°C 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
	Climate Normal	Climate Normal
Current Climate Normal (1981 – 2010)	2.8	588.60 mm
Mid Term Projected Change (2041 – 2070)[a]	2.4	45.2 mm
Far Term Projected Change (2071 – 2100)[a]	3.2	58.6 mm
Long Term Projected Changes (2101 – 3000)[b]	0.6 to 7.8[b]	1 to 3%/°C[c]

a) Please note that projected changes represent changes above the current climate (1981 – 2010) for the Project region.
b) Please note that these projected changes represent the changes above the reference period of 1986 – 2005 and are global values. Project-specific information is not available.
c) Absolute change not provided by literature. Projected change in precipitation is dependent on the projected warming experienced.

10.4.3 Climate Change Effects on the Project

Climate change may result in shifts in the frequency and/or intensity of the extreme weather events and forest fires. As such, the Project design features and mitigation, management and monitoring practices are also included to consider the potential effects from climate change. 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. The drainage system for the reclaimed WL site will have the same physical characteristics as similar natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. A multi-component engineered cover system will be designed over the entire surface of the decommissioned WR-1 Building, which will be graded to promote positive drainage from the site to the Winnipeg River, similar to the rest of the WL site. 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 GCMs for the Project indicate that snowfall is increasing.

Climate change has the potential to greatly influence our country'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 Project; however, the probability of forest fires increase with dry conditions, as well as lightning strike probability, and a forest fire could affect the Project infrastructure and workers' safety (during closure and posts-closure).

During the closure phase and active Institutional Control period of the post-closure phase, monitoring will be incorporated into the adaptation management 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.

Changes in temperature and precipitation, as well as frequency or magnitude of extreme events and erosion will be tracked through the existing Environmental Assessment Follow-up Program for the WL site to inform the need for adaptive management. Meteorological data will be collected on an annual basis to track local changes to hydrogeological and climatological processes during the active Institutional Control period. This will be included in the Environmental Assessment Follow-up Program. Examples of adaptive management to be integrated into post-closure planning could be as a result of:

- changes to temperature and precipitation affecting hydrology, and subsequently hydrogeology (i.e., changes in water table) and surface geology (i.e., erosion);
- changes to temperature and precipitation affecting the vegetation used in the rehabilitation of the site; or
- climate changes (e.g., increased erosion rates) affecting the engineered cover system design.

10.5 Glaciation

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; Clark et al. 2009). 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). Global warming, however, is anticipated to elongate the interglacial period and postpone the next glacial event by tens of thousands of years. The global warming projected until the year 3000 (0.6 to 7.8 °C over 1000 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) (Section 10.4). This corresponds to a higher rate of increase in atmospheric carbon dioxide ($C0_2$) concentration than observed in previous periods (Clark et al. 2003, Berger et al. 2003). Coupling of climate change models and glaciation models predicts a relatively long interglacial period of about 55,000 years (Berger et al 2003) to 100,000 (Peltier 2011). It is thought that if concentrations of greenhouse gases remain similar to present the next glacial event is not likely to occur before 100,000 years after present and the glacial retreat occurring 55,000 years after that. Taking into account projected increase in greenhouse gases, it is thought the next glacial event may never occur. However, projections for atmospheric concentrations beyond 3,000 years let alone 100,000 after present are uncertain. Therefore the potential for a glacial event should not be discounted.

The assessment does not try to predict the future, rather it aims to provide meaningful illustration of future conditions to inform the Project design. During glaciation, following glacial advance, it could be expected that the groundwater flow within the geological surround could be hindered and the infiltration of water into the WR-1 ISD structure limited. Thus limiting the migration of contaminants from the WR-1 ISD structure into the geosphere. However, this cannot be predicted with a high degree of certainty. What can be predicted with a high degree of certainty is that there would be no human receptors present during this period as the environment would not be able to sustain a human population. It is anticipated that a thick sheet of ice will have covered the majority of North America and northern Europe and Asia and will persist for tens of thousands of years.

As the current climate trend will likely delay the interglacial period until 100,000 years after present, the scenario of human inhabitants returning to the area after the glacial retreat would be projected to occur 140,000 years from present. The worst-case scenario is assumed with the glacial advance having completely removed the engineered cover and excised the WR-1 ISD structure (i.e., glacial erosion), and glacial retreat having dispersed the ISD material within the surface environment. It is recognized that glaciation radically alters the geography (e.g., forming drumlins). As the sheet of ice expands the accumulation of snow and ice crushes and abrades both surface rock and bedrock and erosional landforms result (e.g., u-shaped valleys). When the ice sheet retreats it leaves behind the crushed rock picked up during the advance creating depositional landforms (e.g., eskers). Examples of possible changes include the occurrence of a river being significantly altered during advancement, or during retreat deposited material damning a river bed, or large chunks of ice being left behind to form glacial lakes or ponds (i.e., kettle lakes). Predicting what the environment will look like after glacial retreat, along with predicting the life styles and living conditions of the human inhabitants of Manitoba after the cessation of an ice age, 140,000 years from now, is fraught with uncertainty. An appropriate level of conservatism must be incorporated to account for these uncertainties.

People living on or near the reactor contents, 140,000 years from now, would be expected to receive radiation exposure through the dominant pathways of:

- inhalation or ingestion of radioactive material; and/or
- direct external gamma radiation exposure.

The formation of a glacial lake over the ISD structure was not identified as the conservative assessment case, as this would limit the critical pathways for exposure (i.e., inhalation, ingestion, and direct contact). The assessment case assumes that the ISD material is excised and spread within the surface environment, and that 140,000 years from present, receptors consistent with the population present today would become established (i.e., consistent habits and exposure pathways).

Currently the total mass of radioactive waste within WR-1 has been estimated at 880 Megagrams (Mg) (CNL 2017). This includes the reactor core, the biological shield, the primary heat transport (PHT) system and the various other radioactive systems that comprise WR-1. By the time the glacier retreats, only a few long-lived radionuclides will remain in the waste. The long-lived activation products will generally be found within the reactor core (which accounts for 99% of the original source term) and the biological shield, while the remaining long-lived activation products will be distributed within the PHT and some of the ancillary circuits. All of these components will be encased within the concrete foundation and grout that will fill major void spaces during decommissioning.

After closure (i.e., WR-1 Building sumps turned off and water table allowed to equilibrate), the WR-1 ISD structure will be located below the level of groundwater in the area. It is expected that there will be substantial oxidation of the metals in the process system after being immersed in groundwater for 100,000 years prior to the glaciation event. Following the hypothetical excision of the waste during glaciation retreat (140,000 years), the remnants of the WR-1 systems and components would not be expected to maintain structural integrity. Rather the metals and the remaining radioactivity would be distributed as an undefined mass, mixed with the gravel and soil normally associated with glacial deposits.

The assumed exposure of the ISD waste to the surface was evaluated to determine potential risk to human and non-human biota. The glaciation scenario considers the radioactivity remaining in the WR-1 ISD structure after 140,000 years, the assume time of the end of the next glaciation event and the return to a temperate climate.

Further detail on the glaciation analysis is provided in Section 2.3.5.2.6 of the Decommissioning Safety Assessment Report (CNL 2017). A comparison with CNSC Unconditional Clearance Levels is provided in Section 10.5.1. Furthermore, a comparison with natural analogues is provided in Section 10.5.2 as an additional line of reasoning.

10.5.1 Comparison with Unconditional Clearance Levels

Following cessation of pumping from the sumps in the WR-1 Building, and the encapsulation of WR-1 within a grout block, groundwater elevations will recover to a new equilibrium elevation and the remaining components of the reactor will be situated below the water table (Golder 2017b). It is anticipated that the WR-1 ISD structure will eventually deteriorate over time allowing the release of the solutes contained in the biological shield, PHT, and reactor components to the interior of the grouted structure, and eventually to the geological pathway. As mentioned earlier, 99% of the source term is found in the long-lived activation products contained in the reactor core components. The metal reactor components will gradually corrode over time, allowing the release of solutes contained to the grouted WR-1 ISD structure.

The solutes released from the biological shield, PHT, and reactor components will migrate through the WR-1 ISD structure via diffusion and advection and will subsequently be released through the geological pathways and then to the downstream environment. This leaching, transport and release is evaluated as part of the Normal Evolution Scenario (see Section 6 Environmental Effects of the EIS).

Table 10.5.1-1 shows the calculated radioactivity remaining after being subjected to groundwater leaching for 140,000 years (Golder 2017b). The corrosion process can be expected to affect the mass of the process equipment remaining in place but much of the corroded equipment will still be in place after 140,000 years (Golder 2017b). The dose calculations in Table 10.5.1-1 assume the remaining radioactivity is mixed with the 880 Mg of non-radioactive corroded WR-1 components. The predicted activity concentration for the long-lived radionuclides are then compared to CNSC clearance levels.

The CNSC has established Unconditional Clearance Levels (or concentrations) at which a person may safely abandon or dispose of a radioactive substance. The Unrestricted Clearance Levels may be found in Schedule 2 of the CNSC Nuclear Substances and Radiation Devices Regulations (CNSC 2015). These Unrestricted Clearance Levels correspond to a probable exposure of 10 μSv/a to a resident member of the public residing in the vicinity and include consideration of doses from the inhalation and ingestion of radioactive materials and from external gamma radiation. As described in the Nuclear Substances and Radiation Devices Regulations, where a number of different radionuclides are present, one must calculate the quotient obtained by dividing the activity concentration for each radionuclide by the Unconditional Clearance Level for that radionuclide and sum the fractional quotients thus obtained. The evaluation is provided in Table 10.5.1-1.

Table 10.5.1-1: Comparison of Radioactivity Remaining with CNSC Unrestricted Clearance Levels Assuming Leaching of Radioactivity from WR-1 ISD Structure in Groundwater

Radionuclide	Total Initial Activity (Bq)	Activity Remaining after 140,000 years (Bq)	Fraction remaining after 140,000 Years	Specific Radioactivity (Bq/g)	CNSC Unconditional Clearance Level (Bq/g)	Fraction of Unconditional Clearance Level (%)
C-14	2.99E+12	7.17E-01	0.00000%	8.1E-10	**1**	0.000%
Ca-41	1.40E+08	2.12E-10	0.00000%	2.4E-19	1	0.000%
Cl-36	4.20E+03	8.22E-11	0.00000%	9.3E-20	1	0.000%
Nb-94	3.00E+12	1.59E+05	0.00001%	1.8E-04	0.1	0.181%
Ni-59	8.30E+12	1.95E+07	0.00024%	2.2E-02	100	0.022%
Tc-99	1.30E+08	4.95E+02	0.00038%	5.6E-07	1	0.000%
I-129	2.80E+05	1.56E+00	0.00056%	1.8E-09	0.01	0.000%
Np-237	6.70E+06	4.03E+01	0.00060%	4.6E-08	1	0.000%
Pu-239	6.36E+09	7.13E+02	0.00001%	8.1E-07	0.1	0.001%
U-235	1.60E+06	1.14E+01	0.00071%	1.3E-08	1	0.000%
U-238	1.22E+07	7.63E+01	0.00063%	8.7E-08	1	0.000%
U-234	1.22E+07	2.93E+01	0.00024%	3.3E-08	1	0.000%
					Total	**0.204%**

As presented in Table 10.5.1-1, the total remaining activity concentration is 0.2% of the CNSC Unconditional Clearance Level. This corresponds to an annual probable dose of 0.02 μSv for persons living near or on the wastes 140,000 years from now. Hence, under this scenario, the dispersal of the wastes in the WR-1 ISD structure after the next glaciation cycle is anticipated to lead to a trivial radiation exposure to future inhabitants of the area.

10.5.2 Comparison with Natural Analogues

Many naturally occurring ore bodies contain elevated concentrations of radionuclides. These existing ore bodies provide a point of comparison for evaluating the potential health risks to human and non-human biota of ISD material becoming dispersed within the surface environment. Surficial uranium deposits are formed at or within a few metres of the surface; therefore, these naturally occurring deposits can be used as analogues for qualitative estimation of the potential impacts of the waste in the WR-1 ISD structure becoming exposed to the surface environment 100,000 years from now.

There are a number of near-surface uranium deposits located in Canada, including:

- British Columbia – Prairie Flats, Sinking Pond, Stinkhole Prospect, North Wow Flat;
- Manitoba – Kasmere Lake;
- New Brunswick – Oromocto Lake, Whooper Swamp;

- Nova Scotia – TA Bog; and
- Yukon – Partridge Lake (IAEA 1984).

Generally, these near-surface uranium deposits were deposited after the last ice age (Jones 1990), therefore, they are relatively young. The naturally occurring radionuclides within the deposits have very long radioactive decay times. Therefore, these deposits have not been in place long enough to generate longer half-life radioactive daughter products (Tixier and Beckie 2001). In other words, there are relatively no short-lived radionuclides present, and the long-term potential hazard from the WR-1 ISD structure 140,000 years from now will be similar in terms of specific radioactivity to these surficial uranium deposits that naturally exist today.

By the time the glacier retreat occurs, the radioactivity content in the vicinity of WR-1 will have decayed to levels less than what is typical for surficial uranium deposits in Canada (CNL 2017). This includes the progeny of long-lived uranium and thorium isotopes. Radiological consequences to a hypothetical exposure group settling in the vicinity of the WL site area after the glacial retreat will therefore be bound by the current levels of exposure to members of the public living in the vicinity of surficial uranium deposits. In 2007, the CCME concluded that environmental levels of radionuclides at several locations containing subsurface uranium deposits met regulatory guidelines for the protection of the health of human and non-human biota, and that “no adverse impacts are expected.” Experience has shown that a sound knowledge of the potential radiological impacts associated with the presence of these natural deposits has generally resulted in no measurable impact on human health (CCME 2007).

10.5.3 Conclusion

Calculation of the remaining radioactivity (i.e., hazard) present at the time of glacial retreat took the corrosion of the WR-1 process equipment and the leaching of the radioactivity into account. This calculation yields an annual dose of 0.02 μSv for persons residing on or adjacent to the radioactive wastes 140,000 years from now. Such a trivial dose is well below any level that could constitute a health concern. Finally, the remaining radioactivity in the WR-1 ISD structure is comparable to natural analogues (i.e., surficial uranium deposits) shown to have no adverse impacts.

To ensure long-term safety of the public and the environment, during closure and Institutional Control the performance of the WR-1 ISD structure will be verified. This required management action is consistent with the safety management and monitoring system that would be in place during closure and Institutional Control.

10.6 Summary of 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 Project components and activities.

Table 10.6-1: Environmental Factors That Can Affect the Project and Associated Mitigation

Project Component or Activity	Factors	Mitigation
Multi-component Engineered cover	Rain, extreme events	Extreme rainfall and snowmelt events could lead to soil erosion on the engineered cover. The multi-component engineered cover system will be designed over the entire surface of the decommissioned WR-1 Building and will be constructed to promote positive drainage from the site to the Winnipeg River, similar to the rest of the WL site. The engineered cover is also designed to minimize water infiltration, to direct infiltration away from the grouted structure, and to resist degradation by surface geologic processes and biotic activity (e.g., deter intrusion by burrowing of animals). The design of the engineered cover system will limit damage from freeze-thaw cycles. Meteorological records will be reviewed annually to confirm that the cover performance is not overloaded during the active Institutional Control period. This will be included in the Environmental Assessment Follow-up Program.
Decommissioning Activities	Extreme events, forest fires	Implementation of CNL's Emergency Preparedness Program and the Fire Protection Program will mitigate the consequences of a forest fire and other extreme events (e.g., storms, extreme rainfall and snow).
Long-term Performance Monitoring	Temperature and precipitation, extreme events	Changes in temperature and precipitation, as well as frequency or magnitude of extreme events and erosion will be tracked through the Environmental Assessment Follow-up Program to inform the need for adaptive management. Meteorological data will be collected on an annual basis to track local changes to hydrogeological and climatological processes during the active Institutional Control period. This will be included in the Environmental Assessment Follow-up Program

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11.0 SUMMARY OF MONITORING AND FOLLOW-UP PROGRAMS

In the discipline assessments undertaken in Section 6.0 (Environmental Effects) of the Environmental Impact Statement (EIS), Canadian Nuclear Laboratories (CNL) has proposed monitoring and follow-up to be undertaken during the closure and post-closure stages of the Project. These programs will serve to address the uncertainties associated with the effects predictions and the performance of mitigation, verify the effects predictions, and identify any unanticipated effects and provide for the implementation of adaptive management to limit these effects.

CNL will implement an Environmental Assessment Follow-up Program for the In Situ Decommissioning of WR-1 at the Whiteshell Laboratories Site (the Project) to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. Follow-up and monitoring programs proposed for the Project will be carefully integrated with the existing Environmental Assessment Follow-up Program for the WL site (being implemented under Licence No. NRTEDL-W5-8.04/2018), as well as ongoing monitoring and management plans. Wherever possible, existing programs will be adapted to meet the objectives of monitoring the predictions made by the environmental assessment for the Project. Once the WL site has been decommissioned, monitoring to support the areas of Institutional Control will continue, as well as any other requirements identified in the Environmental Assessment Follow-Up program. A summary of the proposed environmental assessment monitoring and follow-up programs for the Project discussed in each discipline-specific study in Sections 6.2 thru 6.9 of the EIS is presented in Table 11.0-1.

The follow-up monitoring plan presented in the section is conceptual in nature and provides a preliminary description of the activities and the framework for monitoring proposed for the Project. The follow-up monitoring program will be further detailed as the project design is finalized, which may influence the nature, frequency and locations of monitoring. In addition, input from regulatory agencies, First Nation and Métis communities, and the public will be considered. The detailed follow-up monitoring plan 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 measures. These plans will also be prepared consistent with relevant CSA N288 Standards, where applicable.

Existing compliance and monitoring programs for the WL site are listed below:

- 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; and
- Whiteshell Laboratories Environmental Assessment Follow-up Program.

CNL 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. The development and implementation of mitigations identified for the Project and housed in the monitoring and follow-up programs are tracked in relevant management plans, with roles and responsibilities clearly defined in each plan. Monitoring and follow-up programs will be carried out throughout all phases of the Project. The following phases were identified for the Project.

- **Closure Phase**: Preparation and implementation of ISD includes preparation for ISD, grouting of below-grade structures and systems, removal of above-grade WR-1 structures and systems, installation of the engineered cap and environmental controls and final site restoration. These activities last from 2019 to 2024. During the closure phase, CNL will be responsible for implementing the commitments made in the Environmental Assessment Follow-up Program.
- **Post-closure Phase:** The post-closure phase has two discrete periods: Institutional Control and Post-institutional Control. The Institutional Control period includes implementation of both active and passive control throughout 2024 to 2324 (i.e., 300 years). During active Institutional Control, long-term performance monitoring and maintenance activities will continue through to 2124 to demonstrate compliance with the safety case assumptions. The passive Institutional Control period includes passive controls such as access restrictions (e.g., physical barriers/fencing, signage, and land title instruments/deed restrictions) and will continue through 2024 to 2324. Post-institutional Control occurs after year 2324 and continues indefinitely.

As the proponent of the project, CNL will be responsible for implementing and managing the proposed follow-up monitoring program. The responsible owner of the site (the Government of Canada through AECL), will be responsible for the provision of funds for the follow-up monitoring program.

11.1 Data Management

The development and implementation of mitigations identified for the 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 Management System. The Environmental Management System is registered within the requirements of the International Organization for Standardization 14001:2004 standard (ISO 2004). The Environmental Management System includes compliance and improvement systems to evaluate areas for improvement or trending. It will continue to be implemented for the Project construction and operations and will be updated, as needed, as part of an annual management review process.

The development and implementation of all mitigations identified for the Project and housed in the monitoring and follow up programs are tracked in relevant plans. CNL's approach to adaptive management is defined in each plan. As site conditions and monitoring dictate, or as new technology emerges, 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 plan.

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. Where the need for revised mitigations is identified they will be developed and implemented.

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 on issues and opportunities related to the Project, including the monitoring and follow-up program, with First Nation and Métis peoples and communities of interest as part of the Public Information Plan and the Aboriginal Engagement Report (CNL 2017). CNL will continually evaluate both the process and the outcome of the ongoing engagement and communication activities to address and manage issues as they arise.

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Table 11.0-1: Environmental Assessment Monitoring and Follow-up Programs Proposed for the Project

EIS Section	Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Section 6.2 Atmospheric Environment	Air Quality	Closure activities will result in fugitive dust emissions	■ Verify that the following mitigation measures are being incorporated as planned, and are effective. ■ Verify predictions are within air quality criteria. ■ Demonstrate compliance with regulatory requirements.	■ Application of aggregate to unpaved roads – a record will be kept of the date of each application of aggregate to unpaved roads. ■ Dust Control on Roads – a record will be maintained of dust control treatment for roads. ■ 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 measures will be recommended. Environmental conditions will be recorded.	■ Throughout the closure phase	Captured through the implementation of CNL's Procedure for Management and Monitoring of Emissions, which includes operational control monitoring and verification monitoring.
	Greenhouse Gases	Closure activities will result in increased greenhouse gas 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 Project.	■ Annual estimations and GHG reporting, as required during the closure phase	Captured through the implementation of CNL's Procedure for Management and Monitoring of Emissions, which includes operational control monitoring and verification monitoring.
Section 6.3 Geological and Hydrogeological Environment	Geology	Monitoring and follow-up programs are not identified as there are no predicted residual effects to geology.				
	Hydrogeology	Changes to groundwater quality from the release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time during post-closure phases.	■ Verify effects predictions on groundwater from the Project. ■ Verify the effectiveness of mitigation.	■ Water elevation measurements to determine groundwater flow direction and gradients ■ Sampling to confirm groundwater quality to detect potential releases of constituents from the ISD reactor facility ■ Initial sampling frequency will likely be twice per year (spring and fall).	■ Groundwater monitoring will continue through closure and post-closure. The number of parameters and locations may change based annual review of monitoring data.	Project groundwater monitoring will be integrated into the overall CNL Groundwater Monitoring Program, and will be compliant with CSA N288.7-15.
	Hydrology	Monitoring and follow-up programs are not identified as there are no predicted residual effects to hydrology.				
	Surface Water Quality	Changes to surface water quality from the release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time during the post-closure phases.	■ Environmental monitoring – Verify effects predictions related to surface water quality.	■ Monitor the quality of water in the Winnipeg River to evaluate whether the quality of the water is affected by the ISD reactor facility ■ Monitor the quality of water in on-site ditches to verify the hydrogeological model	■ Water quality monitoring will continue through closure phase and post-closure phase (i.e., during the active Institutional Control period). 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, and will be compliant with CSA N288.4-10.
Section 6.5 Aquatic Environment	Fish and Fish Habitat	Monitoring and follow-up programs are not identified as there are no predicted residual effects to fish and fish habitat. However, as part of CNL's current licence (NRTEDL-W5-8.04/2018) with the CNSC, CNL will continue to implement the Environmental Assessment Follow-up Program for the WL site to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. The current program includes water quality monitoring and collecting fish tissues at one location upstream and two locations downstream of the WL site. Follow-up monitoring during the post-closure phase to confirm radionuclide concentrations in surface water quality will also verify the accuracy of environmental effects for the aquatic environment.				

Table 11.0-1: Environmental Assessment Monitoring and Follow-up Programs Proposed for the Project

EIS Section	Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Section 6.6 Terrestrial Environment	Barn swallow	Closure and Post-Closure: If barn swallow are confirmed to be using WR-1 as habitat through pre-disturbance surveys, there will be incremental contribution of the Project and all future decommissioning activities to the loss of potential nesting habitat in the RSA. There is predicted to be negligible effects on barn swallow, if determined to be nesting in the WR-1 building, through the implementation of habitat compensation.	■ Offset the incremental contribution of the Project and all future decommissioning activity to the loss of potential nesting habitat in the RSA using compensatory nesting habitat. ■ Determine number of individuals using compensatory nesting habitat on an annual basis.	■ If barn swallow are confirmed to be using WR-1 as habitat, installation of a compensatory barn swallow nest structure, including nest cups for nest placement, is recommended as an alternative habitat for nesting barn swallow. Installation of barn swallow nest habitat in a suitable location in the RSA will offset the incremental contribution of all decommissioning activities to be undertaken at the WL site to the loss of potential nesting habitat in the RSA. ■ Suitable locations include areas within 1 km of any currently used nesting habitat, but far enough away from other buildings that will be demolished in the future (to avoid colonization on those structures), and adjacent to open foraging areas and aquatic habitat with mud for nest building. Final site selection will be at the discretion of CNL biologists. ■ Effectiveness monitoring will be conducted to determine if the compensatory nest habitat is being used. ■ This compensation model and follow-up monitoring duration is consistent with what has been designed by the Ontario Ministry of Natural Resources and Forestry. Barn swallow are designated as “Threatened” on the Ontario *Endangered Species Act*’s Species at Risk in Ontario list. An equivalent protocol has not been developed for Manitoba (barn swallow are not currently designated on the provincial ESEA).	■ Annually for three years following installation.	Integrated into CNL’s Environmental Protection Program

Table 11.0-1: Environmental Assessment Monitoring and Follow-up Programs Proposed for the Project

EIS Section	Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Section 6.6 Terrestrial Environment	Bats	Closure and Post-Closure: If bats are confirmed to be using WR-1 as habitat through pre-disturbance surveys, incremental contribution of the Project and all future decommissioning activity to the loss of potential anthropogenic maternity roosting habitat in the RSA. There is predicted to be negligible effects on bats, if determined to be roosting in the WR-1 building, through the implementation of habitat compensation.	■ Offset the incremental contribution of the Project and all future decommissioning activity to the loss of potential anthropogenic maternity roosting habitat across the RSA. ■ Install bat boxes and determine number of individuals and species using bat boxes on an annual basis.	■ Inherent uncertainty on the current status of bat populations overlapping the RSA and uncertainty regarding the amount and relative importance of anthropogenic maternity roost habitat that will be lost as a result of the Project and future removal of remaining anthropogenic structures is the main rationale for installing bat boxes. ■ In consultation with CNL biologists on other CNL sites to be decommissioned in the future, and in consideration of future losses of anthropogenic structures that may provide roosting habitat at the WL site, offsetting in the form of eight bat boxes is recommended. ■ Criteria for appropriate siting will include: 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 waterbodies (i.e., Winnipeg River) and wetlands are high priority locations, because these forest types do not currently provide high quality tree 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. ■ Effectiveness monitoring will be conducted to determine if boxes are being used.	■ Bat boxes should remain in place throughout the Closure Phase at minimum. Monitoring should take place annually for three years.	Integrated into CNL's Environmental Protection Program

Table 11.0-1: Environmental Assessment Monitoring and Follow-up Programs Proposed for the Project

EIS Section	Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Section 6.6 Terrestrial Environment	Snapping turtle	Closure: Negligible effect on snapping turtles regarding vehicle collisions was identified. However, CNL will implement a follow-up monitoring program to address the uncertainty regarding the effectiveness of proposed mitigation for protecting snapping turtle populations	■ Track turtle mortality and use information for adaptive management.	■ Despite the current mitigation in place (speed limits and wildlife awareness training of staff), the additional protection to turtles provided by installation of new turtle crossing signs and silt fencing as access barriers at the three most likely turtle crossings on Ara Mooradian Way, and the lack of road mortality recorded for snapping turtle to-date, there is the potential for project-related mortality of turtles to occur in the future. Any road mortality or injury of snapping turtle (or other reptile species) will be reported and data will be compiled in a database that can be used to inform adaptive management for the site. ■ If, after mitigation and operational measures are shown to be ineffective (i.e., driver awareness training and speed limits, installation of signage at the three stream crossing locations on Ara Mooradian Way with the highest likelihood of turtle crossings), and any mortality of snapping turtle occurs, further mitigation in the form of comprehensive assessments of high-risk road crossing locations, potential upgrade of existing crossing culverts to turtle passage enabled design, and the potential need to install permanent fencing on either side of the roadway to funnel turtles into the passage culvert and prevent road access will be considered.	■ On-going reporting and monitoring should take place annually over the active decommissioning period (until the start of Institutional Control).	■ Integrated into CNL's Environmental Protection Program ■ Continuation of WL staff reporting of incidental wildlife observations
Section 6.7 Human and Ecological Health	Human health Ecological health	Closure activities will result in the release of airborne effluent from the WR-1 Building which could affect human and ecological health. Release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time during the post-closure phase may cause changes in groundwater quality which could migrate towards the Winnipeg River and affect receptors along the Winnipeg River.	■ Verify mitigation measures are effective.	■ Monitoring for air quality as noted above (i.e., for dust). ■ Verification monitoring for tritium in air (post venting through WR1 stack). ■ Groundwater monitoring surrounding the ISD reactor facility, as noted above. ■ Surface water quality monitoring in the Winnipeg River, as noted above.	■ Dust monitoring would be initiated during the closure phase. ■ Groundwater and surface water quality monitoring would be on-going during closure and post-closure. The need for and duration of monitoring will be reviewed based annual review of monitoring data.	Integrated into the CNL Effluent Verification and Environmental Monitoring Programs and will be compliant with CSA N288.7-15 and CSA N288.4-10.
Section 6.8 Land and Resource Use	■ Monitoring and follow-up programs are not specifically identified for land and resource use; rather, monitoring for environmental pathways noted above (i.e., for air quality, water quality and groundwater quality) will be implemented to verify effects predictions for land and resource use. ■ CNL will continue to engage with local communities, municipalities, and First Nation and Métis communities during the Closure and Post-closure phases.					

Table 11.0-1: Environmental Assessment Monitoring and Follow-up Programs Proposed for the Project

EIS Section	Valued Component	Project Phase and Potential Effect	Monitoring Program Objective	Conceptual Monitoring Program	Suggested Duration	Implementing Program
Section 6.9 Socio-economics	Government Finances	During the post-closure phase, changes to the overall decommissioning will accelerate changes to the sources of municipal revenue for Pinawa.	■ Verify mitigation measures are effective.	■ CNL will proactively seek, engage, and support meaningful discussion on issues and opportunities related to the Project. ■ CNL will continually evaluate both the process and the outcome of the ongoing 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.	Executed as part of CNL's Public Information Program.
	Community Infrastructure and Services	During the post-closure phase, changes in government finances for the LGD of Pinawa will result in changes to the provision of infrastructure and services by the LGD of Pinawa				
	Community Well-being	The perceived suitability of the site for future business ventures during the post-closure phase may change as a result of the presence of long-lived radioactive material as part of ISD. The use of ISD as the decommissioning method for WR-1 will change the proportion of the site for unrestricted use during the post-closure phase.		■ To reduce the potential effect of these perceived concerns CNL is committed to sharing information with the Partnership to help them develop a feasible socio-economic plan and a development of robust communication plan to convey and confirm the Project's safety. It is assumed that the Public Liaison Committee and the Partnership will continue for the duration of the Project and provide a means through which CNL can disseminate information with the communities and RMs in the LSA and communities and RMs in the LSA can bring their concerns and issues regarding future use and access to the site forward to CNL. Communication efforts will build on the current Environmental Assessment Follow-up Program, which focuses on environmental monitoring, interim storage and end-state support and communications. The public communication component of the Environmental Assessment Follow-up Program is to develop and maintain communication mechanisms during decommissioning that support ongoing communication.		

CNL = Canadian Nuclear Laboratories; km/hr = kilometres per hour; ISD = in situ decommissioning; CNSC = Canadian Nuclear Safety Commission; GHG = greenhouse gases; .

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12.0 CONCLUSIONS

Canadian Nuclear Laboratories (CNL) is performing the decommissioning of the Whiteshell Laboratories (WL) nuclear research facility with the outcome of complete site closure by 2024. CNL is licensed to perform this work under a Canadian Nuclear Safety Commission (CNSC) decommissioning licence. A Comprehensive Study Report (CSR) under the *Canadian Environmental Assessment Act* (1992) was completed for the decommissioning project in 2001.

Enabled by the CSR and the site decommissioning licence, CNL is authorized to decommission Whiteshell Reactor 1 (WR-1) by means of dismantling and demolition. CNL is proposing a revised approach to the WR-1 decommissioning that includes partial dismantling and demolition, along with passive, permanent disposal of the below-grade portions of the facility. The disposal approach is referred to as In Situ Decommissioning (ISD). ISD is a proven nuclear decommissioning approach that increases worker safety, provides protection of the environment and the public, reduces interim storage and multiple handling, enables permanent nuclear liability reduction and utilizes less resources.

In Situ Disposal is a departure from the end-state defined in the Comprehensive Study Report. As a result, the Project qualifies as a designated project under Section 37(b) of the *Regulations Designating Physical Activities* of the *Canadian Environmental Assessment Act, 2012,* related to “the long term management or disposal of irradiated fuel or nuclear waste”. A key element of the regulatory approvals process is the completion of an environmental assessment under the *Canadian Environmental Assessment Act, 2012*, the results of which are documented in this Environmental Impact Statement.

The Environmental Impact Statement includes an analysis of alternatives, a process of public and Aboriginal engagement, studies of baseline conditions, and a description and assessment of Project activities during the Project. The environmental assessment is an iterative project planning process, intended to affirm that proposed activities will not cause significant adverse environmental effects (human and non-human biota). The assessment is completed to demonstrate that proposed activities can be safety completed in compliance with the prescribed protective limits, including radiological doses to workers and members of the public and the releases of radioactive material to the surrounding environment. The environmental assessment considers the closure phase (which includes decommissioning and reclamation) and long-term performance during the post-closure phase of the Project. The Environmental Impact Statement (EIS) also includes an assessment of likely cumulative effects of the Project in combination with other past, present or reasonably foreseeable projects, 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 Project.

In Situ Decommissioning is proposed, which allows CNL to decommission the WR-1 building in a safe, cost effective manner, in a shorter timeframe and without interim storage. In Situ Decommissioning is the safest technique, dramatically reducing the risk to workers compared to dismantling, and providing long-term safety to the public and the environment. Rather than dismantling, packaging and transporting the structure, the below-grade reactor systems, structure and associated radiological and non-radiological hazards are proposed to be permanently disposed in situ. The above-grade structures will be demolished and removed using traditional demolition methods. During decommissioning, consideration will be given to place some equipment from the heat transport system that is currently located on the ground-level reactor floor to a below-grade position for incorporation in the disposal system. An engineered cover will then be constructed over the below-grade structure.

ISD is a permanent, passive decommissioning end state. The In Situ Decommissioning disposal system utilizes multiple barriers to contain the waste, providing time for the radioactive materials to decay to safe levels. The first barrier is the radioactive metals themselves. The vast majority of remaining activity is activated molecules within the metal components of the reactor core, primarily the fuel channels and the calandria. These metals will corrode very slowly inhibiting release of contaminants. The second barrier is the thick (approximately 2 m), concrete bioshield. This heavy concrete barrier surrounds the reactor core, further restricting accessibility to the reactor and inhibiting solute transport. The third barrier is the concrete grout that will fill all major void spaces in the reactor facility surrounding the core. Approximately 10,000 cubic meters of grout will fill all rooms, providing structural prevention of subsidence and further limiting solute transport through the groundwater. The fourth barrier is the reactor building foundation, which is reinforced concrete and sits directly on the bedrock. Another barrier is the cover, which will include a reinforced concrete cap to prevent access, minimize water ingress and further prevent intrusion by plants and animals. The final barrier is the geology of the region, which is rich in clays, creating a slow pace for groundwater movement.

The decommissioning activities for the WR-1 Building proposed as part of the Project and assessed in the Environmental Impact Statement include:

- preparing for ISD including de-energizing the building;
- establishing temporary and supporting infrastructure;
- grouting of below-grade structures and systems;
- removing above-grade structures and systems (excluding the east and south service wings);
- installing an engineered cover over the grouted below-grade structures and systems;
- final site restoration;
- preparing for Institutional Control; and
- Institutional Control (includes both passive and active controls).

This section provides a summary of residual effects predicted to result from the Project that cannot be avoided or fully mitigated through the re-design or relocation of the proposed Project or through Proponent commitments. Determination of significance for the residual effects (where applicable) is provided, and proposed monitoring to verify residual effects predictions for the Project is also summarized.

Overall, the EIS confirms that WR-1 is well suited for this ISD approach because the small reactor core contains the vast majority of remaining activity and it can be isolated below-grade in a permanent, safe way that provides protection of the environment and people, while dramatically reducing the risk to workers compared to dismantling. In addition, institutional controls, including restrictions on land use, and a program for monitoring will be completed to confirm that the ISD performs as predicted during post-closure.

12.1 Atmospheric Environment

12.1.1 Air Quality

Project activities will result in emissions associated with the operation of vehicles and equipment, as well as material handling emissions from the demolition and grouting and temporary batch mixing plant. As described in Section 6.2.1, the predicted residual effects on air quality were estimated to increase because of the Project during the closure phase. Fugitive dust from paved roads is the largest contributor to suspended particulate matter emissions. Material handling from demolition is the largest contributor to particles nominally smaller than 10 µm in diameter (PM_{10}) emissions. Non-road equipment exhaust emissions are the largest contributors to particles nominally smaller than 2.5 µm in diameter ($PM_{2.5}$) and oxides of nitrogen (NO_2) emissions. Finally, the largest contributor to sulphur dioxide (SO_2) and carbon monoxide (CO) emissions is fuel combustion for emergency power generators.

For an effect to be deemed significant, the effect on an indicator compound must be adverse (negative in direction), exceed relevant guideline/standard (high in magnitude), extend beyond the local study area, but contained within the regional study area (regional in geographic extent) and reversible following completion of the Project phases (long term in duration). Mitigation practices will be implemented to limit potential effects to air quality, including CNL's Procedure for Management and Monitoring of Emissions (AECL 2013), which includes operational control monitoring, air verification monitoring and environmental monitoring, and dust management techniques. Result of the assessment indicate that predicted concentrations of each indicator compound from the Application Case are below their relevant guideline/standard Consequently, the residual effects from the Project on air quality was determined to be not significant.

As described in Section 6.2.1, there are no reasonably foreseeable future developments expected in the atmospheric environment Regional Study Area (RSA) other than the decommissioning of the remaining infrastructure and support facilities, and reclamation of affected areas at the WL site, as described in the Comprehensive Study Report (AECL 2001). Results of the air quality assessment completed as part of the Comprehensive Study Report indicated that from time to time nuisance dust will be generated. Mitigation practices will be implemented to limit potential effects to air quality, including dust control measures (e.g., containment and suppression), curtailment of activities during periods of high winds and maintenance of on-site access routes (AECL 2001). Special enclosures to cover large areas may also be required to contain airborne emissions from decommissioning activities in some cases (e.g., decommissioning of the Waste Management Area [WMA]). The evaluation of effects to air quality from decommissioning and reclamation activities for the entire WL site concluded that release of air emissions is negligible; consequently, no significant effects were predicted.

Although the decommissioning strategy has changed for the WR-1, activities related to the decommissioning of the WR-1 are expected to less than previously approved. Consequently, the Project is not anticipated to result in a change in the conclusions of the 2001 Comprehensive Study Report related to air quality (see Section 6.2.1.6.2 Application Case Results for the Project air quality predictions). As such, the Project is not expected to contribute cumulatively to the effects of decommissioning of the remaining infrastructure and support facilities at the WL to cause a significant effect.

12.1.2 Greenhouse Gases

Project activities will result in greenhouse gas (GHG) emissions associated with the operation of vehicles and equipment during the closure phase. The GHG emissions are estimated to be less than 1% increase in total provincial GHG emissions and less than 0.01% increase in total national GHG emissions (Section 6.2.2). Based on the comparison between the estimated annual emission to both the federal and provincial greenhouse gas emissions, the Project will result in minor releases of GHG emissions, but is predicted to have a negligible effect on climate change. The Procedure for Management and Monitoring of Emissions outlines the key management practices to limit GHG emissions. Implementation of CNL's Procedure for Management and Monitoring of Emissions, which includes operational control monitoring, emissions verification monitoring and environmental monitoring, will continue for the Project.

12.2 Geological and Hydrogeological Environment

12.2.1 Geology

Potential effects on geology are limited to changes in soil quantity and quality as a result of construction of temporary supporting infrastructure (e.g., batch mixing plant for preparation of grout) for the Project, and changes to soil quality from air emissions and leakage from the ISD reactor facility into the groundwater (Section 6.3.1). Mitigation and environmental design features implemented for the Project are well-understood and include existing practices at the WL site. In addition, performance monitoring will be completed throughout the post-closure phase (i.e., during the active Institutional Control period) to confirm that the engineered cover and ISD facility are functioning as intended. Consequently, no residual effects on geology are predicted as a result of the Project.

As described in Section 6.3.1, there are no Reasonably Foreseeable Developments (RFDs) expected in the RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). Results of the Comprehensive Study Report indicated that existing effects on soils are limited to contaminated soils within affected lands on the WL site. Affected lands and associated contaminated soils in these lands will be remediated and/or removed during the WL site decommissioning to meet the WL preliminary soil clean up criteria and the non-radiological and radiological clearance and release criteria in accordance with the target end-state of the associated land-use category. The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. Consequently, cumulative effects from the Project in combination with the decommissioning of the remaining infrastructure and support facilities, and reclamation of the affected areas at the WL site are anticipated to positively affect soil.

Monitoring and follow-up programs are not specifically identified for geology; rather, operational monitoring will be implemented to verify effects predictions for geology. For example, visual inspections of the temporary construction areas and surface water management systems will be completed to confirm erosion control practices are effective. In addition, following closure, monitoring will be implemented to confirm long-term performance of the engineered cover and the ISD reactor facility during the active Institutional Control period.

12.2.2 Hydrogeology

Changes to groundwater quality from the release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time was identified as having a residual effect on the hydrogeological environment. Groundwater flow and solute transport modelling was completed to provide screening level solute mass loadings during the post-closure phase (Section 6.3.2). The Winnipeg River was identified by the post-decommissioning groundwater flow model as the principal receptor of groundwater discharge from the geological pathway.

Results of the groundwater flow modelling indicate that the mean advective groundwater travel times to the Winnipeg River were estimated to be on the order of 100 years. The peak total activity level estimated from the simulations occurs after approximately 70 years and is principally related to the migration of tritium from the WR-1 Reactor. Due to dispersion, the finite amount of tritium in the source (grout) and the half-life associated with tritium (approximately 12 years) its peak arrival occurs earlier than the mean advective groundwater travel time. Mass flux rates from 53 radiological parameters, and 29 non-radiological elements were simulated in the groundwater flow and transport model for consideration by other disciplines (i.e., water quality, human and ecological health).

As described in Section 6.3.2, there are no RFDs expected in the RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). Following decommissioning of the building sumps, groundwater levels will rebound to static conditions similar to the local environment. On the main campus of the WL site, groundwater heads indicate downward flow conditions exist. For the Project, as the conditions rebound in during the post-closure phase groundwater will flow downwards through the overburden and westward, ultimately discharging at the Winnipeg River. Consequently, although closure of the WL site and the project may slightly alter the drainage flow patterns to the Winnipeg River for a short period of time; the changes are expected to be within the natural range of variation. Overall, cumulative effects from the Project in combination with the decommissioning of the remaining infrastructure and support facilities, and reclamation of the affected areas at the WL site are anticipated to have a negligible effect on groundwater quantity.

Results in the Comprehensive Study Report (AECL 2001) indicate that for effects to groundwater quality, the main area of concern was the Low-level Waste to be managed in situ in the WMA. The evaluation of contaminant migration from the WMA trenches concluded that the nature of groundwater flow in the area around the WMA limits contaminant migration away from the WMA. There is no downward movement of groundwater flow from the WMA to the underlying permeable sandy zone which has the potential to act as a transmission zone to the Winnipeg River (see Section 6.3.4 of AECL 2001). Consequently, there is no overlap of effects from previous activities at the WL site (i.e., effects from the WMA) and changes to groundwater quality from the Project.

CNL will implement an Environmental Assessment Follow-up Program for the WR-1 to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. A post-decommissioning monitoring program will also be developed that will provide the sampling and analysis objectives and procedures for sampling and testing the groundwater quality in the vicinity of the WR-1 Building, compliant with CSA N288.7-15.

12.3 Surface Water Environment

12.3.1 Hydrology

Following the completion of closure activities, the WL site and final cover will be graded to promote drainage from the site to the Winnipeg River. Run-off control for the cover is designed to limit erosion and infiltration of water into the grouted structure. This is achieved by sloping the cover surface to maintain a slope toward the edges, and the collection of water by the existing surface water management systems at the WL Site. Although the installation of the final cover is expected to slightly alter the drainage rates and flow patterns and discharge volume to the Winnipeg River; the changes are expected to be within the natural range of variation. As such, changes to drainage patterns and flows from the installation of the cover at closure are predicted to have a negligible effect on hydrology relative to existing conditions.

As described in Section 6.4.1, there are no RFDs expected in the surface water RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). Results of the Comprehensive Study Report indicated that alterations of surface water flow regimes from the decommissioning activities are not expected. The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. The drainage system for the reclaimed WL site will have similar physical characteristics as similar natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. The WL site will be graded to promote positive drainage from the site to the Winnipeg River. Overall, cumulative effects from the Project in combination with the decommissioning of the remaining infrastructure and support facilities, and reclamation of the affected areas at the WL site are anticipated to have a negligible effect on hydrology.

12.3.2 Surface Water Quality

Residual effects during the Post-closure phase have the potential to affect surface water quality. Groundwater may come into contact with the WR-1 Building and then flow to the Winnipeg River, resulting in changes to surface water and sediment quality. The assessment of effects of the Project on surface water quality involves two steps, namely the calculation of groundwater release rates and use of a dispersion model to predict concentrations of surface water parameters (Section 6.4.2).

The predicted maximum radionuclide concentrations in surface water at both the Nearfield and the Farm A Intake on the Winnipeg River are orders of magnitude lower than groundwater concentrations. Predicted maximum non-radionuclide concentrations in surface water are driven by current river concentrations and some parameters exceed surface water guidelines. Predicted sediment concentrations of radionuclides are lower than their respective Clearance Levels. Predicted sediment concentrations of non-radionuclides are driven by current river concentrations and exceed available sediment guidelines.

As described in Section 6.4.2, there are no RFDs expected in the RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). Results of the Comprehensive Study Report indicated that potential changes in surface water quality in the Winnipeg River from the presence of contaminated river sediments. No decrease in water quality is expected and effluent emissions to the Winnipeg River are expected to decline to virtually zero following decommissioning. Re-suspension of contaminated sediments is also not expected to lead to a decrease in water quality. Consequently, changes to surface water quality from the closure of the WL site, are predicted to be negligible.

CNL will implement an Environmental Assessment Follow-up Program for WR-1 to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. CNL's current environmental monitoring program includes collecting water samples at one location upstream and three locations at varying distances downstream of the WL site. Surficial sediment is also collected at two locations upstream, at the outfall, and nine locations downstream. In addition, CNSC has committed to collecting cores in depositional areas in 2026, 2046, and 2066 at Sylvia Lake and upstream and downstream of the waterbody Lac du Bonnet. It is proposed that these same monitoring locations be used to support the WR-1 Environmental Assessment Follow-up Program, coordinating with the existing program, where practical. Follow-up monitoring during the post-closure phase is necessary to confirm predicted concentrations in surface water and sediment in the Winnipeg River and to provide information for use in adaptive management to address potential unforeseen effects.

12.4 Aquatic Environment

Potential effects on the aquatic environment in the Winnipeg River are related to transport of site runoff, changes in drainage rates and flow patterns, air emissions, and seepage of contaminants from the ISD reactor facility to the groundwater in the long-term. Mitigation and environmental design features implemented for the Project are well-understood and include existing practices at the WL site. Following completion of closure activities, the Project site and final cover will be graded to promote drainage to the Winnipeg River, and performance monitoring will be completed throughout the post-closure phase to confirm that the final cover is functioning as intended. During the closure and post-closure phases, there are no exceedances of the 9.6 mGy/d radiation benchmark for aquatic biota in the Winnipeg River. All predicted doses are well below these levels. Therefore, it is unlikely there would be significant adverse effects on either aquatic populations or communities as a result of radionuclide releases from closure activities or in the long-term during the post-closure phase. Consequently, changes to surface water quality and hydrology from the Project are predicted to have a negligible effect on the aquatic environment relative to existing conditions.

As described in Section 6.5, there are no RFDs expected in the RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the post-closure land use classification and release criteria to achieve the planned end-states. The drainage system for the reclaimed WL site will have similar physical characteristics as similar natural drainage systems in the general geographic region in terms of dynamic stability, robustness, and longevity. The contribution to site runoff from the Project is expected to be minor relative to the entire decommissioned WL site. Similar to the decommissioning plan for the Project, the WL site will be graded to promote drainage to the Winnipeg River. Although closure of the WL site may slightly alter the drainage rates and flow patterns and discharge volume to the Winnipeg River; the changes are expected to be within the natural range of variation. As such, changes to hydrology from the closure of the WL site, including the Project, are predicted to have a negligible effect on the maintenance of self-sustaining and ecologically effective fish populations, including species-at-risk.

Results of the Comprehensive Study Report indicated that the potential effects to aquatic biota is also related to changes in surface water quality in the Winnipeg River from the presence of contaminated river sediments. No decrease in water quality is expected and effluent emissions to the Winnipeg River are expected to decline to virtually zero following decommissioning. Re-suspension of contaminated sediments is also not expected to lead to a decrease in water quality. Consequently, changes to surface water quality from the closure of the WL site,

are predicted to have a negligible effect on the maintenance of self-sustaining and ecologically effective fish populations, including species-at-risk.

CNL will implement an Environmental Assessment Follow-up Program for WR-1 to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. As part of CNL's current licence (NRTEDL-W5-8.04/2018), the current Environmental Monitoring Program includes water monitoring and collecting fish flesh at one location upstream and two locations downstream of the WL site (CNL 2016). Follow-up monitoring for WR-1 will be coordinated with the existing program, where practical. Follow-up monitoring during the post-closure phase to confirm radionuclide concentrations in surface water quality will also verify the accuracy of environmental effects for the aquatic environment.

12.5 Terrestrial Environment

Potential effects on the terrestrial environment are related to transport of site runoff, changes in drainage rates and flow patterns, air emissions, and seepage of contaminants from the ISD reactor facility to the groundwater in the long-term. Mitigation and environmental design features implemented for the Project are well-understood and include existing practices at the WL site. For example, a Surface Water Management Plan will be implemented to manage site runoff during decommissioning activities. In addition, the Dust Management Plan will provide mitigation to limit the potential for effects on soil quality from fugitive dust generation. Following completion of closure activities, the Project site and final cover will be graded to promote positive drainage to the Winnipeg River, and performance monitoring will be completed throughout the post-closure phase to confirm that the final cover is functioning as intended.

Surveys during the appropriate season, to be undertaken the year prior to initiation of decommissioning activities, will confirm whether nesting and/or roosting activity is occurring in the WR-1 Building. If evidence of nesting or roosting activity is found, appropriate mitigation measures in the form of deterrents will be implemented, under consultation with Environment and Climate Change Canada, and in accordance with habitat protection provisions and the required permitting process under the *Species at Risk Act*. The objective of the selected mitigation measures will be to prevent birds and bats from accessing the building during the period when it will be demolished. The potential for road mortality of snapping turtle will be addressed through adaptive management and on-going monitoring and documentation of road mortalities. If road mortality of snapping turtle occurs, additional mitigation will be enacted, as required. During the closure and post-closure phases, there are no exceedances of the 2.4 mGy/d radiation benchmark for terrestrial and riparian biota on or near the WL site. All predicted doses are well below these levels (Section 6.6). Therefore, it is unlikely there would be significant adverse effects on either terrestrial populations or communities as a result of radionuclide releases from closure activities or in the long-term during the post-closure phase.

Although no residual effects on terrestrial VCs are predicted, monitoring programs are described as possible proactive mitigation by CNL, and includes consideration of all future decommissioning and building demolition activities that will occur on the WL property. In addition, CNL will continue to implement the Environmental Assessment Follow-up Program for WR-1 as outlined for other environmental components to verify the accuracy of indirect environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented.

As described in Section 6.6, there are no RFDs expected in the terrestrial RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001).

The end-state plan for the WL site will be to return lands disturbed by site activities to a condition that is physically stable, safe, and in keeping with the land use and landscape of the day. Results of the Comprehensive Study Report, indicated that no effects were identified for terrestrial biota as natural vegetation will re-establish following completion of decommissioning and reclamation activities. Airborne emissions from decommissioning activities are likely to be less than in the past and no effect from this exposure pathway is expected (AECL 2001). Overall, cumulative effects from the Project in combination with the decommissioning of the remaining infrastructure and support facilities, and reclamation of the affected areas at the WL site are anticipated to positively affect the terrestrial environment. Once existing infrastructure is removed and the RSA is reclaimed the level of anthropogenic disturbance within RSA will be reduced, benefiting the terrestrial environment of the RSA.

12.6 Human and Ecological Health

12.6.1 Human Health Assessment

The receptors for the Human Health Risk Assessment were selected to be appropriate for assessment of both radiological and non-radiological stressors on human health. Off-site members of the public will potentially be exposed to low levels of airborne contaminants from decommissioning of the WR-1 Building. The most-affected off-site members of the public are defined as the “critical group,” which include:

- Farm A and F (year-round occupants, with livestock);
- On-site Farmer (post-Institutional Control only); and
- Harvesters (additional receptor not identified in the derived release limit [DRLs]).

Nuclear Energy Workers and workers who lease businesses on-site will be monitored and their doses during closure controlled through CNL’s Radiation Protection Program.

For the closure phase, the relevant contaminants of potential concern (COPCs) are expected to be released via atmospheric releases from the WR-1 Building as reactor systems are dismantled, transported off-site or encapsulated within the ISD structure. An environmental transport and pathways model was used to evaluate the transport and effects of contaminants on the local environment including human receptors. The calculated radiological doses for the Project are all below the CNSC public dose limit of 1 millisievert per year (mSv/a), as well as the dose constraint for the Project of 0.25 mSv/a limit, for all human receptors in the candidate critical groups. Since the dose estimates are a small fraction of the public dose limit, no discernable health effects are anticipated due to exposure to radioactive releases from Project activities. For the closure phase, all predicted air concentrations for non-radiological COPCs were below their relevant ambient air quality criteria; therefore, no non-radiological COPCs were identified for the closure phase and no health effects are anticipated as a result of airborne effluent from the Project.

The total radiation dose to human receptors during the post-closure phase are below the CNSC public dose limit of 1 mSv/a, as well as the dose constraint for the Project of 0.25 mSv/a. Since the dose estimates are a small fraction of the public dose limit, no discernable health effects are anticipated due to exposure of potential critical groups to radioactive releases from the WL site during post-closure. The dominant contributor to the total dose during post-closure is carbon-14 through ingestion of terrestrial plants and animals, and aquatic animals. The total dose is based on maximum mass loadings for each radionuclide.

The doses to human receptors that could be exposed to the non-radiological COPCs (i.e., cadmium and lead) in surface water during post-closure were calculated based on total concentration (background plus Project contribution). Risk was quantified for the human receptor based on the calculation of a hazard quotient (HQ) by dividing the estimated exposure by a toxicity reference value TRV that is known to be protective. Incremental HQs were compared to a benchmark HQ of 0.2, which is consistent with approach taken by Health Canada (2010) in their guidance on human health quantitative risk assessment. The HQs derived for constituents of potential concern were below the protective benchmark for all receptors, with the exception of a toddler harvester, which slightly exceeded the benchmark. If only the project contribution is considered, the HQs are reduced even further and are well below for all receptors (the project contribution to the total is 0.0021% for cadmium and 0.00002% for lead).

The closure activities are well encompassed by existing engineering and administrative controls currently in place at the WL site. Although there are some uncertainties to be defined (e.g., exact quantities of hazardous substances), the existing programs and procedures can be applied to manage these potential hazards. Proven operational programs will be in effect ensuring worker doses are below regulatory criteria and are as low as reasonably achievable (ALARA). Overall, residual effects are considered to be not significant for all human health valued components (VCs) during the closure and post-closure phases.

As described in Section 6.7.1, there are no RFDs expected in the RSA other than the continued decommissioning of the remaining WL facilities, as described in the Comprehensive Study Report (AECL 2001). Results of the Comprehensive Study Report (AECL 2001) indicated that no public health threats were predicted from the decommissioning and reclamation activities for the WL site. Releases are well within regulatory limits for the protection of human health and regular monitoring provides that any aberrations are detected immediately. Current effects to air and surface water quality from the existing WL facilities and operations are considered part of the existing conditions and are included in the assessment of potential Project effects (see previous paragraph).

Monitoring of environmental media at the WL site and surrounding area will proceed as described in CNL's ongoing Environmental Monitoring Program. This includes sampling and analysis of ambient air, surface water and groundwater, including the Winnipeg River, sediment, vegetation, garden produce, game animals, and fish. The Environmental Monitoring Program includes assessment of dose to members of the public, based on emissions monitoring and measurements in environmental media. Additionally, the dose to workers at Whiteshell Laboratories is monitored and reported to the CNSC annually.

Specific to the Project, CNL proposes monitoring and follow-up to be undertaken during the closure and post-closure stages of the Project. These programs will serve to address the uncertainties associated with the effects predictions and the performance of mitigation, verify the effects predictions, and identify any unanticipated effects and provide for the implementation of adaptive management to limit these effects. Monitoring and follow-up programs include implementation of CNL's existing Environmental Monitoring Program and the Environmental Assessment Follow-up Program developed for the Project. Once the WL site has been decommissioned, monitoring to support the areas of institutional control will continue, as well as any other requirements identified in the Environmental Assessment Follow-up Program.

12.6.2 Ecological Health Assessment

An environmental transport and pathways model was used to evaluate the transport and effects of contaminants on the local environment including ecological receptors. Results of the radiological dose assessment for the closure and post-closure phases indicates that doses to ecological health VCs are below their respective benchmark values. In addition, all predicted non-radiological concentrations were less than their selected guidelines or alternate benchmarks. 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 closure and post-closure phases. Overall, residual effects are considered to be not significant for all ecological health VCs during the closure and post-closure phases.

As described in Section 6.7.2, there are no RFDs expected in the RSA other than the continued decommissioning of the remaining WL facilities, as the Comprehensive Study Report (AECL 2001). Results of the Comprehensive Study Report indicated that no decrease in water quality is expected and effluent emissions to the Winnipeg River are expected to decline following decommissioning. Results of the assessment concluded that no effect on aquatic species is expected as doses were below the limit at which no effects on aquatic populations is expected. Current effects to air and surface water quality from the existing WL facilities and operations are considered part of the existing conditions and are included in the assessment of potential Project effects (see above paragraph).

Monitoring of environmental media at the WL site and surrounding area will proceed as described in CNL's ongoing Environmental Monitoring Program. This includes sampling and analysis of ambient air, surface water and groundwater, including the Winnipeg River, sediment, vegetation, garden produce, game animals, and fish. Monitoring and follow-up programs include implementation of CNL's existing Environmental Monitoring Program and the Environmental Assessment Follow-up Program developed for the Project. In addition, the Environmental Assessment Follow-up Program prepared for the Project will expand on the regulatory requirements of CSA N288.5 for the management of these emissions.

12.7 Land and Resource Use

The Project could affect outdoor recreation and tourism activities, and traditional land use through effects to vegetation, fish and wildlife and their habitats, and surface water quality in the Winnipeg River. Changes to these VCs could result from a change in the abundance and distribution of resources, the quality of the resource, and the ability to access the resource including fish, wildlife and vegetation. Any of these changes could subsequently affect the ability and the desire to engage in activities in the local study area. There are not anticipated to be any threshold exceedances in harvested receptors through atmospheric releases and waterborne dispersion of contaminants. In addition, the mitigation measures proposed to minimize Project effects on surface water quality, the aquatic environment, the terrestrial environment, human health and ecological health are anticipated to eliminate or mitigate any potential adverse effects to the resources on which recreation and tourism activities and traditional land and resource use are dependent.

The WL site has been operational since the 1960s, with public access generally restricted for safety and security reasons. Exceptions to this include parcels of the WL site on the west side of the Winnipeg River that have been continuously used for agricultural purposes under agreements with AECL. No outdoor recreation and tourism activities or traditional land and resources uses are permitted on the WL site. Land and resource use activities have persisted adjacent to the site, including uses of the Winnipeg River. It is expected that all activities and land

uses adjacent to the site will be able to continue in the future with the Project as the Project will have no effect on land tenure or usage beyond the WL site boundaries.

Although a smaller proportion of the WL site will not be available for unrestricted use as was previously anticipated because of the Project, it is still anticipated that the majority of the site will be available. Overall, decommissioning of the WL site will result in an increase in the amount available for future use in the Local Study Area (LSA). Although the Project will result in long-term institutional controls for a small portion of the WL site, the remaining land is safe and appropriate for other use. This may include transfer of the land to other parties following engagement with stakeholders, Aboriginal groups and the public. Future uses/zoning have not been determined, but it is assumed that the land will meet Canadian Council of Ministers of the Environment (CCME) land use criteria.

CNL will implement the Environmental Assessment Follow-up Program for WR-1 to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. In addition, CNL will continue to engage with local communities, municipalities, and First Nation and Métis communities.

Although there are currently no archaeological sites located on the WL site, there is a site located approximately 1,700 m south of the WL site (AECL 2001) and the Winnipeg River has been an important travel route throughout history, potentially beginning in the Paleo Indian Period (*ca.* 11,000 – 7,000 years ago). Project activities that could affect cultural and archaeological sites include those activities that could cause ground disturbance of any previously undisturbed area, especially if the undisturbed area is located between the western edge of the WL site's built infrastructure and the Winnipeg River. Decommissioning activities are not expected to include any undisturbed land or areas on the WL site (Section 6.8). If, however, activities require use of undisturbed areas, and in particular any activities in proximity to the Winnipeg River, CNL will have an archaeologist available to monitor Project activities and assess any potential finds. If an unexpected discovery of a heritage resource is made during Project activities, CNL will, in accordance with the *Heritage Resources Act*, cease activities until the Heritage Resources Branch can be consulted on the need to conduct a Heritage Resource Impact Assessment before resuming decommissioning activities (Section 6.8).

The assessment of potential pathways of effects determined there are no primary pathways that would lead to residual effects on land and resource use VCs. As such, there is no further residual effects classification and determination of significance.

12.8 Socio-Economic Environment

The socio-economic valued components chosen for the Project to reflect identified concerns, professional judgement and/or standard practice in environmental assessment are Employment and Income, Business Opportunities, Government Finances, Community Infrastructure and Services, Community Well-being, and Public Safety. The assessment of potential pathways of effects determined there are no primary pathways that would lead to residual effects on Employment and Income, Business Opportunities, Government Finances, Community Infrastructure and Services, and Public Safety.

As described in Section 6.9, the following two projects are identified as overlapping with the socio-economic RSA.

- **Manitoba-Minnesota Transmission Project** is a 213 km-long international powerline in southeastern Manitoba. After circling the south side of Winnipeg, the transmission line would track east-west south of Provincial Trunk Highway 15 until just after Anola, where it would beginning tracking south south-east to the Canada-US border near Piney. The Manitoba-Minnesota Transmission Project includes construction of the line, modifications to three existing stations and operations. Construction would begin in summer 2017 until the in-service date, summer 2020 (Manitoba Hydro 2015).
- **Energy East Pipeline** is 4,500 km crude oil pipeline system from an oil supply complex in Alberta to an existing oil refining and marine terminal facility near Saint John, New Brunswick. The pipeline segment crossing southern Manitoba is a converted mainline and a series of pump stations. Construction is expected to begin in 2018 with the earliest in-service dates scheduled for the fourth quarter of 2021 (TransCanada Pipelines Ltd and Energy East Pipeline Ltd 2016).

While the Manitoba-Minnesota Transmission Project and Energy East Pipeline are located in the socio-economic RSA, their locations suggest that there is no overlap with the residual effects of the Project. Consequently, cumulative effects from the Project in combination with other reasonably foreseeable developments are anticipated to be negligible.

As described in Section 6.9, the effects of current and future decommissioning activities for the WL site are included in the Base Case. As described in the Comprehensive Study Report (AECL 2001), the original decommissioning approach for the WL site proposed three phases that would ultimately lead final decommissioning activities being completed over a 60 year period (i.e., 2061). Therefore, cumulative effects of the decommissioning approach for the WL site and the Project are evaluated as part of the Application Case.

The assessment for Community Well-being is qualitative and considers the potential changes in the attractiveness of and possible future uses of the WL site in light of the Project. This may affect overall community plans and goals as they relate to economic development.

The previous decommissioning plan assumed that radioactive wastes, except for those designated to remain in the Waste Management Area and a limited area of radioactive contaminated sediment in the Winnipeg River, would eventually be removed and placed in permanent disposal facilities. However, this is under the assumption that a national disposal facility for low-level radioactive waste would be available by 2025 and a national disposal facility for medium-level waste operational by 2050. Eventually, the overall site could be available for unrestricted use. The permanent presence of the encapsulated WR-1 Building will change the perceived suitability of the WL site for future uses due to the perceived risk associated with the long-lived radiological hazards of the reactor vessel. In addition, the WL site will now have restricted use in proximity to the encapsulated WR-1 Building over an indefinite period of time associated with institution control.

To reduce the potential effect of these perceived concerns CNL is committed to sharing information with the Partnership to help them develop a feasible socio-economic plan and a development of robust communication plan to convey and confirm the Project's safety. Canadian Nuclear Laboratories is currently working with the communities and rural municipalities in the LSA by funding the activities of the Community Regeneration Partnership to develop a socio-economic plan for the region. The plan is anticipated to support future economic development and subsequently community development. Through this venue, the communities and rural

municipalities in the LSA should have the opportunity and expertise available to develop a meaningful and feasible path forward that would help maintain the continued vitality of the communities, especially Pinawa, in the area.

Effects on Community Well-being are expected to be negative in direction, moderate in magnitude, local in geographic extent and medium-term in duration. The Project is anticipated to adversely affect the perceived suitability of the WL site for future business ventures and the ability of local communities to gain access to the WL site for other uses following Institutional Control. Since both effects are localized to the site and since use of and access to the site were objectives primarily of the communities and rural municipalities in the area, the geographic extent is anticipated to be local. While ISD entails encapsulating radioactive material below grade for permanent disposal, good communication is expected to shift perceptions of site suitability before the end of the Institutional Control period (i.e., before Year 2324).

While the Project presents challenges to the future use of the WL site, the Partnership, including CNL, will make efforts to effectively identify and implement a path forward for economic development in the area. In addition, CNL will support robust communication of monitoring results. Members of the Public Liaison Committee are expected to share results with their communities. Canadian Nuclear Laboratories can provide communication support if necessary to help disseminate monitoring results. Canadian Nuclear Laboratories may want to consider other communication methods as well, such as a public website to share monitoring results. While the role of the WL site may change in economic and community development in the local area, development is expected to continue, therefore, there is no significant adverse effect of the Project on Community Well-being.

12.9 Accidents and Malfunctions

Accidents or malfunctions could take place either as internally-initiated events (e.g., equipment failures) or externally-initiated events (including natural hazards). A number of accidents and malfunctions were identified for the Project through identifying hazards associated with each of the Project activities, and review of similar projects and guidance documents.

Potential worker accidents and injury may arise from conventional industrial hazards, including working at heights, in confined spaces, and with energized systems, hoisting and rigging systems, and falling objects. Dismantling and demolition of the WR-1 Building, in particular, will involve extensive use of cranes and movement of heavy loads. Failure to isolate all energized systems (e.g., electrical, pressurized) from the building during the building isolation, either through improper isolation or accidental exclusion, may also pose a hazard to workers. The likelihood of an occupational health and safety accident occurring, considering controls and mitigation, is unlikely and an accident resulting in a worker fatality is a rare occurrence. Management systems and safety culture already in effect at the WL site, where regular assessment of safety performance is conducted and lessons learned from experience will continue to be applied during the Project.

Spills and leaks may occur during closure activities, including hydraulic fluid or fuel leaks from vehicles or heavy equipment. In addition, during cutting and perforation of components and structures as part of dismantling, unknown or greater than expected quantities of radioactive and non- radioactive hazardous substances may be encountered. Various ISD activities may involve lifting and moving of large, potentially contaminated materials, which could result in a material handling accident, which could also result in releases or physical hazards. To minimize the potential effects of radiological spills and leaks, all work will be executed following the procedures and practices of CNL's Radiation Protection Program and the Whiteshell Laboratories Emergency Preparedness Program. Monitoring associated with these programs have demonstrated that the controls for the release of

potentially hazardous substances currently in place at the WL site continue to provide substantial protection of the environment in the case of this type of event.

Fires may result by ignition of combustible materials, hot work, equipment malfunction, electrical faults, or lightning strikes. A number of systems and components will require cutting or perforating during reactor systems preparation. The use of saws, grinders, cutting torches, and drills pose a risk of ignition of combustible material. Waste generated from decontamination activities, such as wipes, protective clothing, and high efficiency particulate air filters introduces combustible contaminated material, which could be released to the atmosphere during a fire. Firefighting methods may spread contamination, primarily inside the ISD envelope, but also outside of the envelope (e.g., contamination spread in the 600 and 700 level from sections of the primary heat transport system and ventilation system). Adequate ventilation will be ensured to prevent the build-up of volatile components. Implementation of Whiteshell's Fire Protection/Prevention Program will minimize the potential for a fire and the duration and consequences of a fire.

Potential events during the long-term performance of the Project were also evaluated. Improper techniques and incorrect grout designs could compromise the integrity of the WR-1 ISD structure. The two main pathways resulting in a localized ISD structure failure include non-conformant grout (e.g., through improper curing), and excessive voids (e.g., localized or larger voids). Effects of a localized ISD structure failure include reduced isolation and reduced immobilization of contaminants. The potential effects during localized ISD structure failure scenario were evaluated and are well below the public dose limit of 1 mSv/y, as well as the WL site dose constraint of 0.25 mSv/y. In addition, all potential non-radiological effects are well below their respective hazard quotients.

Institutional controls will be used when transitioning from the end of decommissioning to the phase of post-closure when no active care and/or monitoring is being conducted. During Institutional Control (approximately 300 years [2024 to 2324] for passive controls and 2024 to 2124 for active controls), mechanisms will be used that are 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 (e.g., deed restrictions), and may also include certain physical controls (e.g., fences and gates). It is conceivable that after Institutional Control when site controls to restrict access are no longer effective, human activity could result in undeliberate intrusion into the ISD site. The specific human activity considered for the human intrusion scenario is exploratory drilling that inadvertently intercepts the ISD structure.

For the occurrence of a human intrusion, the worst-case scenario was evaluated, which encompassed an unsealed borehole into the reactor and improperly disposed of material being left on the ISD site. The total dose to a drill crew member (adult exposed during drilling the borehole) was below the public dose limit of 1 mSv/y, but above the WL site dose constraint of 0.25 mSv/y. It was also considered that trespassers could interact with the site following a human intrusion (assumed to be spending 1 hour a day onsite), dose predictions for this human receptor were above the public dose limit of 1 mSv/y but well below the deterministic effects level or effective whole-body annual dose exposure limit of 20 mSv/y for an inadvertent intrusion scenario. The dominant contributor to the total dose is cobalt-60 through groundshine (i.e., from the material improperly disposed of on-site).

CNL will implement multiple procedures and programs to manage and limit risks to workers and the public. Applicable programs include CNL's Radiation Protection Program, Environmental Protection Program, Waste Management Program, Occupational Safety and Health Program, Emergency Preparedness Program, Management of Non-Radiological Hazardous Chemical Waste and Fire Protection Program. The level of risk posed by the ISD activities is comparable to many other industrial settings for these types of hazards and is acceptable with careful mitigation. The evaluation supports the conclusion that the Project design is protective of humans who are currently or in the future will be living in the vicinity of the site (e.g., industrial use), as well as under unexpected land use conditions (on-site farm).

12.10 Effects of the Environment on the Project

The Effects of the Environment on the Project assessment focuses on the effects of natural hazards (e.g., extreme weather events, forest fires, seismic events) and climate change on the 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.

The engineered cover system will be designed to limit water infiltration, to direct any infiltration water away from the grouted structure, to resist degradation, and will be graded to promote positive drainage from the site to the Winnipeg River, similar to the rest of the WL site. The design of the final cover system will prevent components of the ISD structure from effects of freeze-thaw cycles.

Implementation of CNL's Emergency Preparedness Program and the Fire Protection Program will mitigate the consequences of a forest fire and other extreme events (e.g., storms, extreme rainfall and snow).

Major earthquakes (i.e., seismic events) are related to movements at tectonic plate boundaries. The province of Manitoba is the least earthquake-prone area in Canada. Furthermore, the Canadian Nuclear Fuel Waste Management Program studied seismic stability in Northwest Ontario and Eastern Manitoba and found, based on a detection level of 2.5 on the Richter scale that the WL site and the southern two-thirds of Manitoba are aseismic. The probability of earthquake damage from such low ground acceleration approaches zero in this area.

Changes in temperature and precipitation may affect monitoring, as well as extreme events, and will be accounted for as part of the adaptive management plan. Meteorological data will be collected on an annual basis to track water balance and determine local changes to hydrogeological and climatological processes.

Potential effects on WR-1 as a result of glaciation were also considered to inform the Project design. As a conservative hypothesis, it has been assumed that the glaciation process will deposit the radioactivity somewhere on the surface, thoroughly mixed with the oxidized metals from the WR-1 process systems. The predicted dose is well below regulatory limits.

Based on the use of all of these mitigation approaches, residual risks due directly to environmental events are considered of low probability and low consequence. Accidents and malfunction scenarios that could be caused by the natural hazards are identified in the Accidents and Malfunctions section (Section 7.0).

12.11 Conclusion

This Environmental Impact Statement describes the Project, the existing environmental conditions on the WL site, and assesses the likely effects of the Project on the environment. The Environmental Impact Statement also includes an assessment of likely cumulative effects of the Project in combination with other past, present or reasonably foreseeable projects, as required. It describes the effects for normal conditions and as a result of accidents and malfunctions. The Environmental Impact Statement also describes and assesses the likely effects of the environment on the Project.

Residual adverse effects were identified for air quality, hydrogeology, surface water quality, human and ecological health, and community well-being. Mitigation and environmental design features implemented for the Project are well-understood and include existing practices at the WL site. CNL will implement an Environmental Assessment Follow-up Program for WR-1 to verify the accuracy of environmental effects and determine the effectiveness of mitigation measures that have or are to be implemented. Based on the evaluation, residual adverse effects to air quality, human and ecological health, and community well-bring were assessed to be not significant. There is no determination of significance for hydrogeology and surface water quality as these valued components do not have an assessment endpoint; rather the results of the assessment are considered in the evaluation of significance for other valued components.

Overall, the Environmental Impact Statement confirms that the ISD approach provides a permanent, passive decommissioning end state, and incorporates proven technologies and best industry practices, including documented international experience. ISD is the safest technique, dramatically reducing the risk to workers compared to dismantling, and providing long-term safety to the public and the environment. The Project design has been optimized to remain below the assessment criteria established to be protective of the environment and to demonstrate long-term safety of the workers, the public and the environment. In addition, institutional controls, including restrictions on land use, and a program for monitoring will be implemented.

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14.0 GLOSSARY, ACRONYMS AND UNITS

14.1 Glossary

Table 14.1-1: Glossary Of Terms

Term	Definition
Acceptable Risk	A risk which is so small, whose consequences are so slight, or whose associated benefits (perceived or real) are so great, that persons or groups in society are willing to take or be subjected to that risk.
Activation Product	A radionuclide produced by activation. Often used in distinction from fission products. For example, in decommissioning waste comprising structural materials from a nuclear facility, activation products might typically be found primarily within the matrix of the material, whereas fission products are more likely to be present in the form of contamination on surfaces
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 management approach that involves the monitoring and evaluation of a reclaimed area's performance followed by any necessary actions to achieve the intended performance objectives. Adaptive management also allows information to be fed back into the planning and design process so that future reclaimed areas will meet the intended objectives.
Anthropogenic	Coming from or having been caused by man.
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.
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.
Background Radiation	The dose, dose rate or an observed measure related to the dose or dose rate, attributable to all sources other than the one(s) specified.
Becquerels	The SI (International System) unit of radioactivity, corresponding to one disintegration per second.

Table 14.1-1: Glossary Of Terms

Term	Definition
Best Management Practice	Operating practice that enhances the sustainability of the resource to which the practice relates. Must be practical and economically achievable.
Beta Radiation	The emission of a beta particle from the nucleus of an atom.
Bioavailability	The amount of chemical which is actually available to the target tissues following exposure.
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.
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.
Contamination	(1) Radioactive substances on surfaces, or within solids, liquids or gases (including the human body), where their presence is unintended or undesirable, (2) the presence of such substances in such places or (3) the process giving rise to their presence in such places.
Cooling	A term used to describe the process of allowing radioactivity to decay and the rate of heat generation to decrease as in the case of vitrified HLW and spent fuel.
Corporate Social Responsibility	A business approach that contributes to sustainable development by delivering economic, social and environmental benefits for all stakeholders.
Crown Corporation	Any corporation that is established and regulated by a country's state or government.
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.
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.
Decontamination	The complete or partial removal of contamination by a deliberate physical, chemical or biological process.
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.

Table 14.1-1: Glossary Of Terms

Term	Definition
Diffusion	The movement of atoms or molecules from a region of higher concentration of the diffusing species to regions of lower concentration, due to a concentration gradient
Dismantling	The disassembly and removal of any structure, system or component during decommissioning. Dismantling may be performed immediately after permanent retirement of a nuclear facility or it may be deferred
Drainage Basins	Area draining to a lake, stream, reservoir or other body of water.
Duty To Consult	In Canada, the duty to consult and accommodate with Aboriginal peoples arises when the Crown contemplates actions or decisions that may affect an Aboriginal person's Aboriginal or Treaty rights.
Effluent	Liquid waste or sewage discharged into a river, lake or the sea.
Environmental Assessment	A planning tool used to identify the possible environmental effects of a proposed project and to determine if the adverse effects can be mitigated.
Environmental Impact Statement	A document that provides a detailed review of an environmental assessment and related studies.
Environmental Management System	Refers to the management of an organization's environmental programs in a comprehensive, systematic, planned and documented manner. It includes the organizational structure, planning and resources for developing, implementing and maintaining policy for environmental protection.
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.
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.
Fugitive Dust	Small airborne particulate matter which generally comes from soil. Fugitive dust is suspended in the air by wind action and human activities.
Gamma Radiation	Gamma rays are the most energetic form of electromagnetic radiation, with a very short wavelength of less than one-tenth of a nanometer. Gamma radiation is the product of radioactive atoms.
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.
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.

Table 14.1-1: Glossary Of Terms

Term	Definition
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.
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.
High Level Waste	Includes used nuclear fuel and other wastes (e.g., reprocessing wastes) that have been declared as radioactive waste that generate significant heat via radioactive decay. Used nuclear fuel is associated with penetrating radiation and contains significant quantities of long-lived radionuclides.
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.
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.
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.
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.
Ionizing Radiation	A form of radiation that is capable of adding or removing electrons as it passes through matter (such as air, water, or living tissue).
Lc_{50}	LC50 is the lethal concentration of a toxin that is required to kill 50% of the population.
Low Level Waste	Contains material with radionuclide content above established clearance levels and exemption quantities, but generally has limited amounts of long lived activity. Low-level waste requires isolation and containment for up to a few hundred years.
Metasedimentary	Sediment or sedimentary rock that appears to have been altered by metamorphism.
Mixed Waste	Radioactive waste that also contains hazardous substances.

Table 14.1-1: Glossary Of Terms

Term	Definition
Molybdenum	The chemical element of atomic number 42, a brittle silver-gray metal of the transition series, used in some alloy steels.
Near Surface Disposal Facility	A facility for disposal of radioactive waste located at or within a few tens of 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.
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.
Perfluorocarbons	Organofluorine compounds with the formula CxFy, i.e. they contain only carbon and fluorine.
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.
Radiation Field	Represents the energy lost from the source radiator to space.
Radioactive Decay	The process by which the nucleus of an unstable atom loses energy by emitting radiation, including alpha particles, beta particles, gamma rays, and conversion electrons.
Radioactive Waste	For legal and regulatory purposes, waste that contains or is contaminated with radionuclides at concentrations or activities greater than clearance levels as established by the regulatory body. It should be recognized that this definition is purely for regulatory purposes and that material with activity concentrations equal to or less than clearance levels is radioactive from a physical viewpoint — although the associated radiological hazards are considered negligible.
Radiological	Involving radioactive materials
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.

Table 14.1-1: Glossary Of Terms

Term	Definition
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.
Shielding	A material interposed between a source of radiation and persons, or equipment or other objects, in order to absorb radiation and thereby reduce radiation exposure.
Sievert	The SI unit of absorbed radiation dose in living organisms modified by radiation type and tissue weighting factors. The sievert is the unit of dose measuring the “equivalent dose" and “effective dose". It replaces the classical radiation unit the rem. Multiples of sievert used in practice include millisievert (mSv) and microsievert (µSv).
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).
Stochastic Effects	A term used to group radiation-induced health effects (such as cancer or inheritable diseases) which have a statistical risk. For these diseases, the probability of their occurrence increases proportionally to the radiation dose received: the higher the dose, the higher the probability of occurrence.
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.
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.

Table 14.1-1: Glossary Of Terms

Term	Definition
Valued Component	Refers to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Aboriginal peoples, 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.

14.2 Acronyms

Table 14.2-1: List of Acronyms

Acronym	Definition
AECL	Atomic Energy of Canada Limited
ALARA	as low as reasonably achievable
ALWTC	Active Liquid Waste Treatment Centre
AOO	Anticipated Operational Occurrences
AP	Activation Products
ATRIS	Aboriginal and the Treaty Rights Information System
BBDC	Beausejour Brokenhead Development Corp.
BCI	Bat Conservation International
BMPP	Best Management Practice Plan
BON	Brokenhead Ojibway Nation
BSC	Bird Studies Canada
CAC	Criteria Air Contaminants
CANDU	Canadian Deuterium Uranium
CBC	Canadian Broadcasting Corporation
CCS	coverage count stations
CCSF	Concrete Canister Storage Facility
CDC	Manitoba Conservation Data Centre
CEAA	*Canadian Environmental Assessment Act* (1992)
CEAA 2012	*Canadian Environmental Assessment Act, 2012*
CNL	Canadian Nuclear Laboratories
CNSC	Canadian Nuclear Safety Commission
CO	carbon monoxide
COPC	Contaminants of Potential Concern
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CP	Corrosion Products
CSA	Canadian Standards Association
CSR	Comprehensive Study Report
CWB	Community Well-being Index
D_2O	Heavy water (deuterium oxide)
DDP	Detailed Decommissioning Plan
DEM	Digital Elevation Model
DFO	Fisheries and Oceans Canada
DRL	Derived Release Limits
DSAR	Decommissioning Safety Assessment Report
EAFP	Environmental Assessment Follow-up Program

Table 14.2-1: List of Acronyms

Acronym	Definition
EC	Environment Canada
ECCC	Environment and Climate Change Canada
EcoRA	ecological health risk assessment
EF	Emission factor
EIS	Environmental Impact Statement
EnvP	Environmental Protection
EPA	Environmental Protection Agency
ERA	Ecological Risk Assessment
	Environmental Risk Assessment
ESEA	Manitoba's *Endangered Species and Ecosystems Act*
EVMP	Effluent Verification Monitoring Program
FHA	Fire Hazard Analysis
FP	Fission Products
GHA	Game Hunting Area
GHG	greenhouse gases
GHGRP	Greenhouse Gas Reporting Program
GoCo	Government-owned, Contractor-operated
GS	Generating Station
GTG	GoldSim Technology Group
GWP	Global Warming Potential
HASP	Health and Safety Plan
HBC	Hudson's Bay Company
HEPA	High-efficiency Particulate Arrestance
HHRA	Human Health Risk Assessment
HHV	High Heat Value
HLW	High-level Waste
HQ	hazard quotient
HTO	Tritium Oxide
IAEA	International Atomic Energy Agency
IDF	Intensity Duration-Frequency
ILW	Intermediate-level Waste
INAC	Indigenous and Northern Affairs Canada
INL	Idaho National Laboratory
INPO	Institute of Nuclear Power Operations
IPCC	Intergovernmental Panel on Climate Change
IPS	Independent Protective System
ISBN	International Standard Book Number

Table 14.2-1: List of Acronyms

Acronym	Definition
ISD	In Situ Decommissioning
ISO	International Organization for Standardization
IWS	Integrated Waste Strategy
KGS	KGS Group
KPI	Key Person Interview
LGD	Local Government District
LLW	Low-level Waste
LSA	Local Study Area
MARSAME	Multi-Agency Radiation Survey and Assessment of Materials and Equipment
MAS	Manitoba Archaeological Society
MBBA	Manitoba Breeding Bird Atlas
MBCA	*Migratory Birds Convention Act, 1994*
MLI	Manitoba Land Initiative
MMF	Manitoba Metis Federation
MNR	Ministry of Natural Resources
MOECC	Ontario Ministry of the Environment and Climate Change
MPS	Main Protective System
MTO	Ontario Ministry of Transportation
MTS	Manitoba Telephone Services
MW	Molecular Weight
N/A	not available
NABCIC	North American Bird Conservation Initiative Canada
NHS	National Household Survey
NOC	National Occupational Classification
NO_x	oxides of nitrogen – includes nitrogen dioxide (NO_2)
NPD	Nuclear Power Demonstration
NSCA	*Nuclear Safety and Control Act*
NSDF	Near Surface Disposal Facility
NSRDR	Nuclear Substance and Radiation Devices Regulation
NV	no value
NWMO	Nuclear Waste Management Organization
O. Reg.	Ontario Regulation
OAS	Ontario Archaeological Society
OMNRF	Ontario Ministry of Natural Resources and Forestry
OPEX	Operating Experience
OPG	Ontario Power Generation
OSH	Occupational Safety and Health

Table 14.2-1: List of Acronyms

Acronym	Definition
PCB's	Polychlorinated Biphenyl Compounds
PHT	Primary Heat Transport
PLC	Public Liaison Committee
PM	Particulate matter – PM_{10} is particulate matter 10 micrometres or less in diameter, $PM_{2.5}$ is particulate matter 2.5 micrometres or less in diameter.
POI	Point of Impingement
PPE&C	personal protection equipment and clothing
PR	Provincial Route
PTH	Provincial Trunk Highway
QA	Quality Assurance
RCMP	Royal Canadian Mounted Police
REGDOC	Regulatory Document
RFD	Reasonably Foreseeable Developments
RHA	Regional Health Authority
RM	Rural Municipality
RSA	Regional Study Area
RTAC	Roads and Transportation Association of Canada
SAR	species at risk
SARA	*Species at Risk Act*
SD	Manitoba Sustainable Development
SERDC	Southeast Resource Development Council Corporation
SK MOE	Saskatchewan Ministry of the Environment
SMAGS	Shielded Modular Above-Ground Storage
SO_x	oxides of sulphur – includes sulphur dioxide (SO_2)
SPM	suspended particulate matter
SRS	Savannah River Site
SSA	Site Study Area
SSG	Specific Safety Guide
the Agency	Canadian Environmental Assessment Agency
TRCM	Treaty Relations Commission of Manitoba
TRV	toxicity reference value
TSD	Technical Supporting Document
U.S. EPA	United States Environmental Protection Agency
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USGS	United States Geological Survey

Table 14.2-1: List of Acronyms

Acronym	Definition
UTM	Universal Transverse Mercator
VC	Valued Component
VOCs	Volatile organic compounds
WHO	World Health Organization
WIN	Wabaseemoong Independent Nations
WL	Whiteshell Laboratories
WLCP	Whiteshell Laboratories Closure Project
WLDP	Whiteshell Laboratories Decommissioning Project
WMA	Waste Management Area
WNS	White-nose Syndrome
WR-1	Whiteshell Reactor 1
WRNWWMF	Whitemouth, Reynolds, North Whiteshell Waste Management Facility

14.3 Units

Table 14.3-1: List of Units

Unit	Name
$	dollar
%	percent
°C	degrees Celsius
µg	microgram
µg/m^3	microgram per cubic metre
µm	micrometre
Bq/g	Becquerel per gram
Bq/kg	Becquerel per kilogram
Bq/L	Becquerel per litre
Bq/yr.	Becquerel per year
cm/s	centimetre per second
g	gram
g/s	grams per second
GBq	Gigabecquerel
GJ	gigajoule
h	hour
ha	hectare
Hp	horsepower
hr	hour
kg	kilogram
kg/m^3	kilogram per cubic metre
km	kilometre
km/h	kilometre per hour
km^2	square kilometre
kPa	kilopascal
kWh/m^2/d	kilowatt-hour per square metre per day
L	litre
lb	pound
M	million
m	metre
m/s	metres per second
m/s	metre per second
m/s	metres per second
m^2	square metre
m^3	cubic metre

Table 14.3-1: List of Units

Unit	Name
m^3/s	cubic metres per second
masl	metres above sea level
mbgs	metres below ground surface
Mg	megagram
mg/L	milligrams per litre
mg/m^3	milligrams per cubic metre
mGy/d	milligray per day
min	minute
mm	millimetre
MMBTU	Million British Thermal Units
mSv	millisievert
mSv/a	millisieverts (mSv) per year
MW	megawatt
ppm	parts per million
s	second
scf	standard cubic feet
t	tonne
VKT	vehicle kilometres travelled
VMT	Vehicle Mile Travelled
yr.	year
µSv/a	microsievert per year

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