Canada's Nuclear Regulator

CNSC CCSN

# Environmental Protection Review Report:
# **Port Hope Area Initiative**

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**Environmental Protection Review Report: Port Hope Area Initiative**


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# Revision history

The following table identifies the revision history of this document.

| Revision number | Change | Summary of changes | Date |
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| 000 | Initial release | N/A | October 2022 |
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# Table of contents

## List of tables



## List of figures

# Executive summary

The Canadian Nuclear Safety Commission (CNSC) conducts environmental protection reviews (EPRs) for all nuclear facilities with potential project–environmental interactions, in accordance with its mandate under the Nuclear Safety and Control Act (NSCA) to ensure the protection of the environment and the health of persons. An EPR is a science-based environmental technical assessment conducted by CNSC staff. The fulfillment of other aspects of the CNSC's mandate, such as regulating safety and security, is met through other oversight activities.

This EPR report was written by CNSC staff as a standalone document describing the scientific and evidence-based findings from CNSC staff's review of Canadian Nuclear Laboratories' (CNL's) environmental protection measures for the Port Hope Area Initiative (PHAI) located in the municipalities of Port Hope and Clarington, Ontario. Under its multiple current licences comprising the PHAI, CNL is permitted to perform cleanup activities of historic low-level radioactive waste contamination and place it in long-term waste management facilities located in Clarington and Port Hope. These licences are:

- the waste nuclear substance licence WNSL-W1-2310.02/2022, for the Port Hope Long-Term Low-Level Radioactive Waste Management Project
- the waste nuclear substance licence WNSL-W1-2311.00/2022, for the Port Granby Long-Term Low-Level Radioactive Waste Management Project
- the waste nuclear substance licence WNSL-W1-182.0/2022, for the Pine Street Extension Temporary Storage Site
- the waste nuclear substance licence WNSL-W1-344-1.8/ind., for the Port Hope Radioactive Waste Management Facility

The PHAI also lies within the traditional territory of the Wendat, Anishinabek Nation, and the territory covered by the Williams Treaties with Michi Saagiig and Chippewa Nations. CNSC staff's EPR report focuses on items that are of Indigenous, public and regulatory interest, such as potential environmental releases from normal operations, as well as risk of radiological and hazardous (non-radiological) substances to the receiving environment.

This report includes CNSC staff's assessment of documents submitted by the licensee from 2012 to 2021, such as, but not limited to, the following:

- regulatory oversight activities
- the results of CNL's environmental monitoring, as reported in annual compliance monitoring reports
- Independent Environmental Monitoring Program (IEMP) results
- health studies with relevance to the PHAI sites
- the results from other environmental monitoring programs in proximity to the PHAI sites

Based on their assessment and evaluation of CNL's documentation and data, CNSC staff found that the potential risks from radiological and hazardous releases to the atmospheric, terrestrial, aquatic and human environments are negligible and tend to be similar to natural background. Further, the potential risks to human health are not impacted by the PHAI activities and are indistinguishable from health outcomes found in the general public. CNSC staff have also found that CNL continues to implement and maintain effective environmental protection measures to adequately protect the environment and the health of persons. CNSC staff will continue to verify CNL's environmental protection programs through ongoing licensing and compliance activities.

The information provided in this EPR report summarizes CNSC staff's findings that may inform and support staff recommendations to the Commission in future licensing and regulatory decisions. CNSC staff's findings do not represent the Commission's conclusions. The Commission's decision making will be informed by submissions from CNSC staff, the licensee, Indigenous Nations and communities, and the public, and through any interventions heard during public hearings on licensing matters.

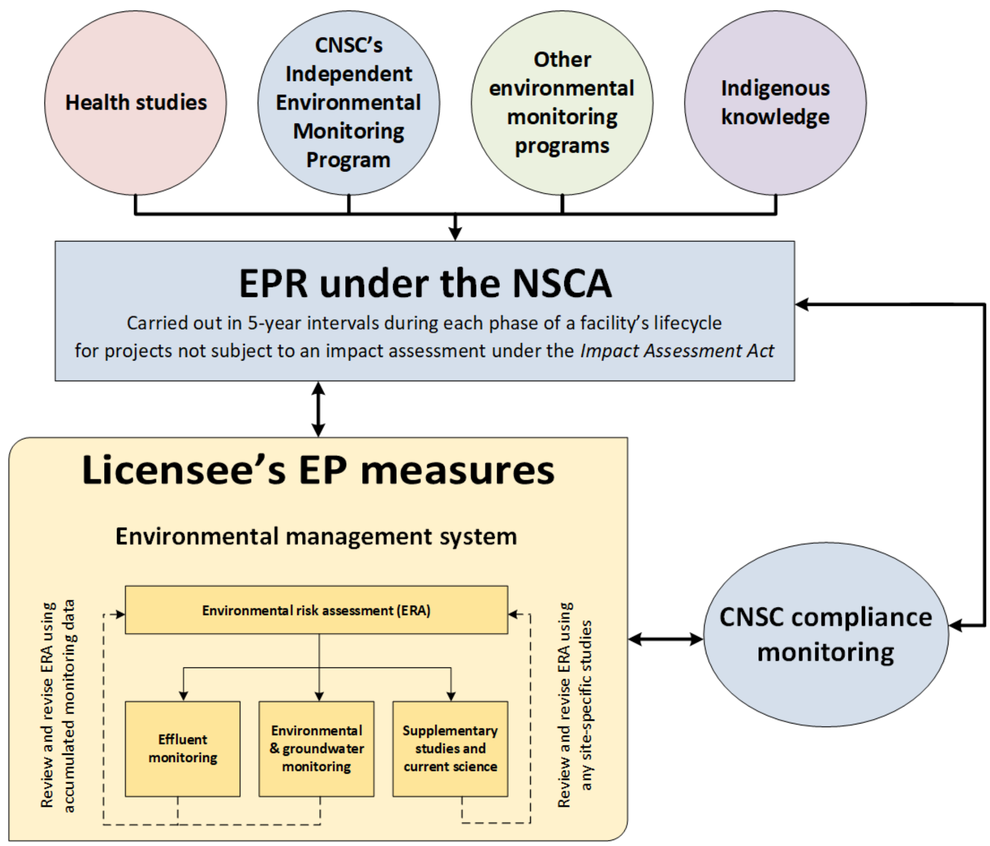
For more information on CNL's PHAI, visit the CNSC's web page and CNL's web page. References used throughout this document are available upon request and requests can be sent to ea-ee@cnsc-ccsn.gc.ca.

# 1.0 Introduction

## 1.1 Purpose

The Canadian Nuclear Safety Commission (CNSC) conducts environmental protection reviews (EPRs) for all nuclear facilities with potential interactions with the environment, in accordance with its mandate under the *Nuclear Safety and Control Act* (NSCA). CNSC staff assess the environmental and health effects of nuclear facilities and/or activities at every phase of a facility's lifecycle. As shown in figure 1.1, an EPR is a science-based environmental technical assessment conducted by CNSC staff to support the CNSC's mandate for the protection of the environment and human health as set out in the NSCA. As per the CNSC's Indigenous Knowledge Policy Framework the CNSC recognizes the importance of considering and including Indigenous knowledge in all aspects of the CNSC's regulatory processes, including in environmental protection assessments. CNSC staff are committed to working directly with Indigenous Nations and communities and knowledge holders on integrating their knowledge, values, land use information and perspectives in the CNSC's EPRs where appropriate and when shared with the licensee and CNSC. The fulfillment of other aspects of the CNSC's mandate, such as safety and security, are met through other regulatory oversight activities and are outside the scope of this report. Each EPR is typically conducted every 5 years and is informed by the outcomes of the licensee's environmental protection (EP) program and documentation submitted by that licensee, as per regulatory reporting requirements.

**Figure 1.1: EPR framework**



The purpose of this EPR report is to report the outcome of CNSC staff's assessment of Canadian Nuclear Laboratories' (CNL's) EP and environmental compliance activities for the Port Hope Area Initiative (PHAI). This review serves to assess whether CNL's environmental protection measures for the PHAI adequately protect the environment and health of persons.

No decision is made on the EPR itself. CNSC staff's findings may inform and support recommendations to the Commission in future licensing and regulatory decision making, as well as inform CNSC staff's future compliance and verification activities. CNSC staff's findings do not represent the Commission's conclusion. The Commission's conclusions and decisions are informed by information submitted by CNSC staff, the licensee, Indigenous Nations and communities, and the public, and through any interventions heard during public hearings on licensing matters. The information in this EPR report is also intended to inform Indigenous peoples, members of the public and interested stakeholders.

EPR reports are posted online for information and transparency to allow interested Indigenous peoples and members of the public additional time to review EP-related information ahead of any licensing hearings or Commission decisions.

This EPR report is based on information submitted by CNL, compliance and technical assessment activities completed by CNSC staff from 2012 to 2021, and the following:

- regulatory oversight activities (section 2.0)
- the results of CNL's environmental monitoring, as reported in annual compliance monitoring reports for Port Hope [1] [2] [3] [4] [5] [6] [7] [8] [9] [10]and Port Granby [11] [12] [13] [14] [15] [16] [17] [18] [19] [20]
- Independent Environmental Monitoring Program (IEMP) results (section 4.0)
- health studies with relevance to the PHAI (section 5.0)
- other environmental monitoring programs in proximity to the PHAI sites (section 6.0)

This EPR report focuses on topics related to the environmental performance of the facility, including liquid (effluent) releases to the environment, the potential transfer of contaminants of potential concern (COPCs) through key environmental pathways and associated potential exposures and/or effects on valued components (VCs), including human and non-human biota. VCs refer to environmental biophysical or human features that may be impacted by a project. The value of a component relates not only to its role in the ecosystem, but also to the value people place on it (e.g., it may have scientific, social, cultural, economic, historical, archaeological or aesthetic importance). The focus of this EPR report is on radiological and hazardous substances associated with activities undertaken at the PHAI sites, with additional information provided on other topics of Indigenous, public and/or regulatory interest. CNSC staff also present information on relevant regional environmental or health monitoring, including studies conducted by the CNSC (e.g., IEMP) or other governmental organizations. These topics were selected based on those that have historically been of interest to Indigenous peoples, members of the public and the Commission.

## 1.2 Facility overview

This section of the report provides general information on the CNL's site, including a description of the site location and a basic history of site activities and licensing. This information is intended to provide context for later sections of this report, which discuss completed and ongoing environmental and regulatory oversight activities.

### 1.2.1 Site description

The PHAI is a remediation project with sites located within the traditional territory of the Wendat, Anishinabek Nation, and the territory covered by the Williams Treaties with Michi Saagiig and Chippewa Nations and on the north shore of Lake Ontario in the municipalities of Port Hope and Clarington, Ontario. As the licensee, CNL responsible for carrying out the day-to-day activities on behalf of the Atomic Energy of Canada Limited (AECL), while AECL retains ownership of the lands, assets and liabilities associated with CNL's licences. Figures 1.2 and 1.3 provide detailed aerial views of the 2 main areas for the project, the Port Hope and Port Granby long-term waste management facility (WMF) sites. The surrounding area consists of predominantly urban residential properties and farmland.

**Figure 1.2: Aerial view of the Port Hope long-term waste management facility [21]**

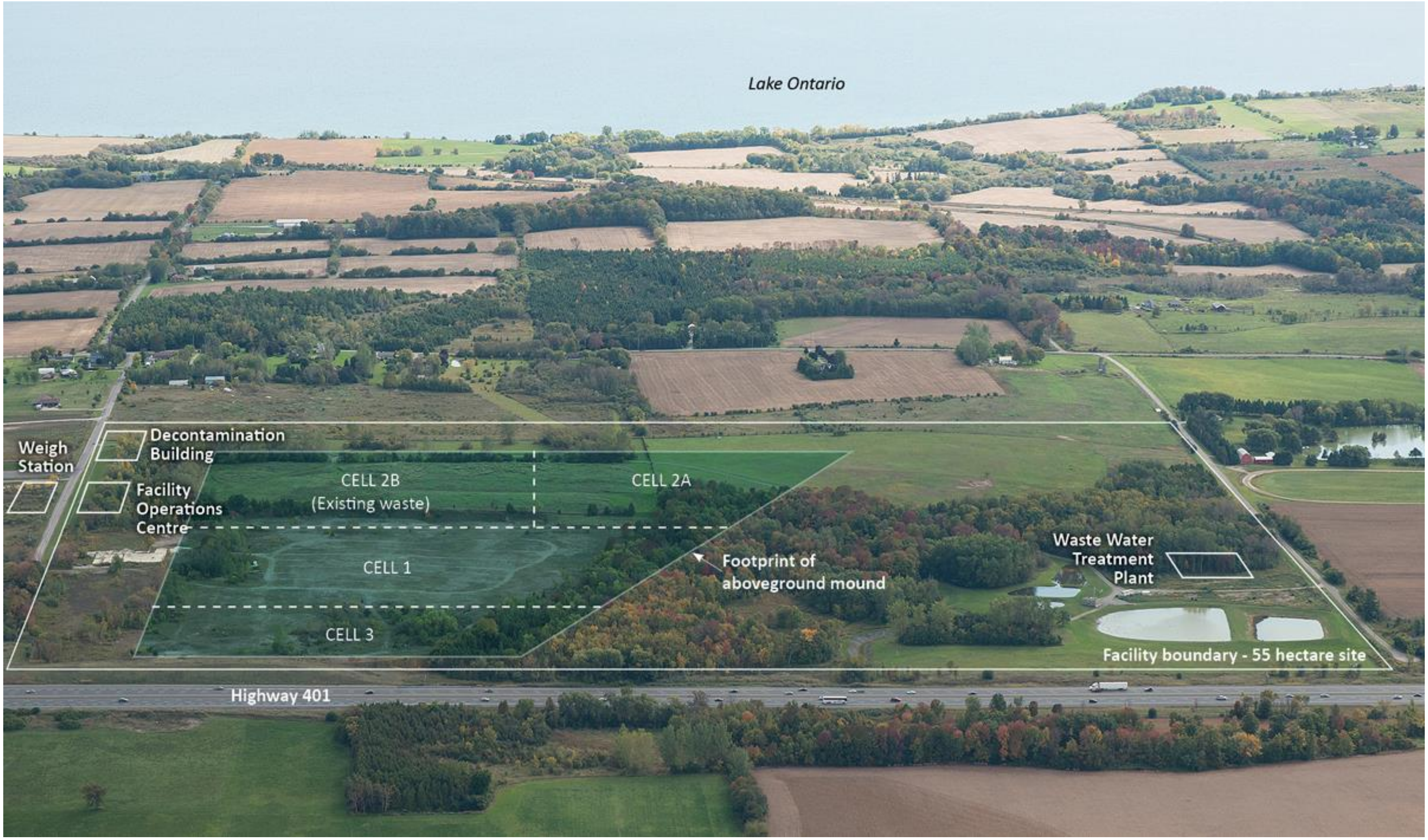


**Figure 1.3: Aerial view of the Port Granby long-term waste management facility [22]**

### 1.2.2 Site history and operations

Port Hope hosted a radium refining facility from 1933 to the 1950's. This facility was owned by a former federal crown corporation known as Eldorado Nuclear Limited. In the 1940's the operation shifted to uranium refining – this activity is still in operation today at the CNSC-licensed Port Hope Conversion Facility, operated by Cameco Corporation. Waste from Eldorado's operations were placed in the Welcome Waste Management Facility, which was eventually closed in 1955, and other locations throughout the urban area. Waste management operations then shifted to Port Granby Residue Area in the mid-1950s [23]. Originally, waste placed in the Welcome WMF consisted of iron and carbonate residues with trace amounts of other metals such as uranium, radium, arsenic, cobalt, copper, nickel, and zinc, and low-grade ore that was rejected from processing. Today the wastes are largely soil type materials that contain elevated levels of uranium, arsenic and radium [24].

In 2001, a legal agreement between the now municipalities of Port Hope and Clarington and the Government of Canada set out the framework for the PHAI and the launch of two environmental assessments (EA) for the clean-up and long-term management of historic low-level radioactive waste (LLRW) identified at major, industrial and small-scale sites within Port Hope and the Port Granby Residue Area. Additional information about the EAs for the two projects is provided in section 2.1.

The PHAI is being carried out as two projects – the Port Hope Project (PHP) and the Port Granby Project (PGP). Each project has three phases, and both are currently in the same phase 2:

1. Pre-Construction Phase – Monitoring intended to supplement or confirm the baseline information used to conduct the EA studies.
2. Construction and Development Phase – Monitoring intended for verification of predicted environmental effects and the effectiveness of mitigation measures during project activities.
3. Maintenance and Monitoring Phase – Monitoring intended to verify that the environmental effects are as predicted by the EA and that the long-term waste management facility (LTWMF) is operating as expected. The duration of this phase will be several hundred years.

**Port Hope Project**

PHP consists of remediating historic low-level radioactive waste at multiple sites in Port Hope and transporting the waste to a new LTWMF, see figure 1.3.

Locations for cleanup range from major sites such as the Highland Drive Landfill and the Port Hope Harbour to smaller scale sites like residential properties. There are also 2 separate licences that are captured under the PHP, the Pine Street Extension, a temporary storage location for contaminated material, and the Port Hope Radioactive WMF. More information on the sites under the PHP can be found here [25].

The PHP LTWMF involves the design and construction of an engineered aboveground mound to isolate the waste by encasing it in multiple layers of natural and specially manufactured materials. These layers are designed to prevent contaminants from entering the environment. The proposed design and location were approved by the CNSC as part of the EA in January 2007. The LTWMF consists of 4 cells that have been constructed in phases. CNL completed the construction of Cell 1 in 2016 and completed the construction of Cell 3, 2A and 2B in December 2021. The initial receipt of wastes began in 2017 following the construction of Cell 1. Following the remediation activities in the Port Hope area, CNL will construct the capping system to encapsulate the waste from the environment. Following the capping of the LTWMF, CNL will begin its Phase 3 activities which involve long term maintenance and monitoring.

The LTWMF also includes a waste water treatment plant (WWTP) to treat surface water and groundwater during waste placement in the engineered mound and groundwater and contaminated water from within the mound after it is capped and closed. The two-stage treatment process consists of chemical precipitation and clarification followed by reverse osmosis. The reverse osmosis system removes salts, heavy metals and contaminants such as radium and arsenic by forcing the water under high pressure through a membrane where the contaminants are filtered out. Excess acid in the treated water is removed through filters and the pH level is adjusted before the final treated effluent is discharged into Lake Ontario [26].

**Port Granby Project**

Similar to the PHP, the PGP involves relocating historic low-level radioactive waste from the former Port Granby WMF to a new PGP LTWMF which includes a WWTP and an engineered above-ground mound like the PHP, see figure 1.4. The proposed design and location were approved by the CNSC as part of the EA in August 2009. The PGP LTWMF consists of 2 cells which began receiving waste in 2016. By 2020, CNL completed the transfer of historic LLRW from the Port Granby WMF into the engineered above-ground LTWMF. In total 1,315,061 metric tonnes of LLRW were safely transported to the LTWMF since the remediation started.

The PGP WWTP operates a similar process as the PHP WWTP except phase one uses a bioreactor tank to treat ammonia nitrate, which is a contaminate specific to PGP [27]. Progress continues including final grading, erosion control measures, and the construction of the groundwater collection system at the Port Granby site. These activities are expected to be finalized in the fall of 2022 and then PGP will move into Phase 3, which entails long-term maintenance and monitoring of the site and operation of the WWTP.

Additional information on effluent sampling and monitoring for the PHP and PGP WWTPs can be found in section 3.1.2.

# 2.0 Regulatory oversight

The CNSC regulates nuclear facilities and activities in Canada to protect the environment and the health and safety of persons in a manner that is consistent with applicable legislation and regulations, environmental policies and Canada's international obligations. The CNSC assesses the effects of nuclear facilities and activities on human health and the environment at every phase of a facility's lifecycle. This section of the EPR report discusses the CNSC's regulatory oversight of CNL's EP measures for the PHAI.

To meet the CNSC's regulatory requirements, and according to CNL's licensing basis for the PHAI, CNL is responsible for implementing and maintaining EP measures that identify, control and (where necessary) monitor releases of radiological and hazardous substances, and the effects on human health and the environment. These EP measures must comply with, or have implementation plans in place to comply with, the regulatory requirements found in CNL's licences and associated licence conditions handbooks (LCH). The relevant regulatory requirements for the PHAI are outlined in this section of the report.

## 2.1 Environmental protection reviews and assessments

When the PHAI was initiated in 2001, no federal EA was carried out, as there were no EA requirements stipulated in the federal legislation at the time. Since that time, 2 EAs were completed, for the Port Hope Long-Term Low-Level Radioactive Waste Management Project in 2007 and the Port Granby Long-Term Low-Level Radioactive Waste Management Project in 2009, as noted in table 2.1 below and described further in subsection 2.1.1. These EAs were conducted under the *Canadian Environmental Assessment Act, 1992* (CEAA 1992) [28], predecessor to the *Canadian Environmental Assessment Act, 2012* (CEAA 2012) [29]. In 2019, the *Impact Assessment Act of Canada* (IAA) [30] came into force replacing CEAA 2012. CNL's current activities do not require an impact assessment under the IAA's Physical Activities Regulations. The purpose of any one of these assessments is to identify the possible impacts of a proposed project or activity and to determine whether those effects can be adequately mitigated to protect the environment and the health and safety of persons.

An EPR under the NSCA has not previously been conducted for PHP or PGP, and as such, this report is the first developed for PHAI.

**Table 2.1: Federal environmental assessments completed for the PHAI**

| Project | Applicable EA process and/or legislation | EA start date | EA decision date |
|---|---|---|---|
| Port Hope Long-Term Low-Level Radioactive Waste Management Project | *Canadian Environmental Assessment Act* (1992) | November 21, 2001 | January 24, 2007 |
| Port Granby Long-Term Low-Level Radioactive Waste Management Project | *Canadian Environmental Assessment Act* (1992) | November 21, 2001 | August 19, 2009 |

### 2.1.1 Previous environmental assessments completed under CEAA 1992

The PHAI is a community-based program for the development and implementation of a safe, local long-term management solution for historic low-level radioactive wastes in the Port Hope area, Ontario. The Government of Canada enacted a legal agreement with the municipalities of Port Hope and Clarington in March 29, 2001, to support the PHAI. Natural Resources Canada designated AECL as the proponent of the PHAI. In November 2001, AECL applied to the CNSC to seek approval for 2 long-term low-level radioactive waste management projects (LTWMFs) as part of the PHAI.

**Port Hope Long-Term Low-Level Radioactive Waste Management Project in Port Hope, Ontario**

The PHP EA consisted of the remediation of sites containing LLRW, marginally contaminated soils (MCS) and specified industrial wastes in the Municipality of Port Hope, and the management of wastes in a local LTWMF.

CNSC staff reviewed the application and determined that pursuant to section 5 and 7 of CEAA 1992 [28], a screening EA of this project was required in order for the project to proceed. In addition, an EA screening report was required pursuant to subsection 18(1) of CEAA 1992. The project was also subject to permits and approvals under the NSCA [31] to possess, manage and store a waste nuclear substance. An EA screening report [32] was prepared in accordance with the requirements of CEAA 1992.

Following the Commission's consideration of the EA screening report in 2006, public concerns expressed about the project, and CNSC staff recommendations, the Commission rendered its decision on the EA [33]. In its decision, the Commission stated that, taking into account implementation of mitigation measures identified in the EA screening report, the project was not likely to cause significant adverse environmental effects and that the Commission would proceed to consider the application for a licence amendment under the provisions of the NSCA [31].

It was determined that a follow-up program to verify the accuracy of the EA, and/or determine the effectiveness of any measures taken to mitigate the adverse environmental effects, was required for this project, and this follow-up program was added as a condition of the licence granted by the CNSC [33].

**Port Granby Long-Term Low-Level Radioactive Waste Management Project in Clarington, Ontario**

The PGP EA assessed the remediation of sites containing LLRW and MCS in the Municipality of Clarington and associated with the existing licensed Port Granby WMF. The waste from remediation efforts would be transferred to the LTWMF.

CNSC staff reviewed the application and determined that pursuant to section 5 and 7 of CEAA 1992 [28], a screening EA of this project was required in order for the project to proceed. In addition, an EA screening report was required pursuant to subsection 18(1) of CEAA 1992. The project was also subject to permits and approvals under the NSCA [31] to possess, manage and store a waste nuclear substance. An EA screening report was prepared in accordance with the requirements of CEAA 1992 [34].

Following the Commission's consideration of the EA screening report in 2009, public concerns expressed about the project, and CNSC staff recommendations, the Commission rendered its decision on the EA [35]. In its decision, the Commission stated that, taking into account implementation of mitigation measures identified in the EA screening report, the project was not likely to cause significant adverse environmental effects and that the Commission would proceed to consider the application for a licence amendment under the provisions of the NSCA [31].

It was determined that a follow-up program to verify the accuracy of the EA, and/or determine the effectiveness of any measures taken to mitigate the adverse environmental effects, was required for this project, and this follow-up program was added as a condition of the licence granted by the CNSC [36].

### 2.1.2 Current environmental assessments follow-up programs

EA follow-up programs are designed to validate the predicted environmental effects and the effectiveness of mitigation measures. The CNSC ensures that EA follow-up programs that are within the CNSC's mandate are incorporated into licensing and compliance activities.

**Port Hope Long-Term Low-Level Radioactive Waste Management Project in Port Hope, Ontario**

In 2009, to fulfill the requirements of the EA for the Port Hope LTWMF [33], AECL submitted an EA follow-up program to the CNSC [37]. Appendix A of this EPR report lists all activities included in the EA follow-up program.

CNL, on AECL's behalf, continues to inform the CNSC of the status and results of EA follow-up program activities through annual compliance reports ([1] – [9]). Some activities have met the established EA objectives and are therefore completed, while other activities are still ongoing (see appendix A). Many of the activities have been integrated into the Port Hope Environmental and Bio-physical Monitoring Plan [38] (see section 2.2) to be continued as CNL's routine monitoring. CNSC staff continue to review the detailed monitoring activities pertaining to the EA follow-up program to ensure that objectives are being met.

**Port Granby Long-Term Low-Level Radioactive Waste Management Project in Port Hope, Ontario**

In 2009, to fulfill the requirements of the EA for the PGP [36], AECL submitted an EA follow-up program to the CNSC [39]. This program integrated any active EA follow-up program activities identified in the 2007 EA. Appendix B of this EPR report lists all activities included in the EA follow-up program.

CNL, on AECL's behalf, continues to inform the CNSC of the status and results of EA follow-up program activities through annual compliance reports ([11] – [20]). Some activities have met the established EA objectives and are therefore completed, while other activities are still ongoing (see appendix B). Many of the activities have been integrated into the Port Granby's Environmental and Bio-physical Monitoring Plan [40] (see section 2.2) to be continued as CNL's routine monitoring. CNSC staff continue to review the detailed monitoring activities pertaining to the EA follow-up program to ensure that objectives are being met.

## 2.2 Environmental regulatory framework and protection measures

The CNSC has a comprehensive EP regulatory framework which includes both radiological and hazardous substances; physical stressors (such as noise); and the protection of people and of the environment. Public dose is considered under the EP framework, from a radiation protection standpoint. The focus of this section of the EPR report is on the EP regulatory framework and the status of CNL's environmental protection program (EPP) for the PHAI. The results derived from this EPP are detailed in section 3.0 of this report.

The EPP at CNL's PHAI sites was designed and implemented in accordance with the principles of REGDOC-2.9.1, Environmental Protection: Environmental Principles, Assessments and Protection Measures (2014) [41], as well as the environmental protection standard of the CSA Group listed below. The EPP includes effluent release limits, action levels (ALs) and public dose modelling. CNL's PHP EPP meets the latest version of REGDOC 2.9.1, Environmental Protection: Environmental Principles, Assessments and Protection Measures (2020) [42] and the latest draft of the REGDOC-2.9.2 Controlling Releases to the Environment [43]. The implementation status for these items for the PHP is shown in table 2.2 and for PGP in table 2.2 below.

**Table 2.2: Status of EP measures to implement regulatory documents and standards at PHP**

| Regulatory document or standard | Status |
|---|---|
| CNSC REGDOC-2.9.1, Environmental Principles, Assessments and Protection Measures, version 1.2 (2020) [42] | Implemented/ September 2020 |
| CNSC REGDOC-2.9.2 Controlling Releases to the Environment (Under Development) [43] | Implemented/ March 2021 |

**Table 2.3: Status of EP measures to implement regulatory documents and standards at the PGP**

| Regulatory document or standard | Status |
|---|---|
| CNSC REGDOC-2.9.1, Environmental Principles, Assessments and Protection Measures, version 1.2 (2020) [42] | Implemented/ December 2021 |
| CNSC REGDOC-2.9.2, Controlling Releases to the Environment (under development) [43] | Implemented/ December 2021 |
| CSA N288.8-17, Establishing and Implementing Action Levels to Control Releases to the Environment from Nuclear Facilities [44] | Implemented/ December 2021 |

CNSC staff confirm that CNL has implemented programs according to the relevant EP regulatory documents or standards.

Licensees are also required to regularly report on the results of their EPPs. Reporting requirements are specified in REGDOC-3.1.3, Reporting Requirements for Waste Nuclear Substance Licensees, Class II Nuclear Facilities and Users of Prescribed Equipment, Nuclear Substances and Radiation Devices [45], the *Radiation Protection Regulations* [46] (e.g., for ALs or dose limit exceedances), the licensees' approved programs and manuals, or the LCHs [47] [48].

CNL is required to submit PGP and PHP annual compliance monitoring reports. These reports are reviewed by CNSC staff for compliance and verification, as well as trending. Summaries of CNL's PGP and PHP annual compliance monitoring reports are available via the PHAI's public documents page on its website [49].

CNSC staff regularly report on the licensee's performance to the Commission regarding activities conducted at the PHAI sites, including operational issues that could result in potential releases to the environment. Regulatory oversight reports (RORs) are a standard mechanism for updating Indigenous peoples, the public and the Commission on the operation and regulatory performance of licensed facilities. RORs are available on the CNSC website [50].

### 2.2.1 Environmental protection measures

To meet the CNSC's regulatory requirements under REGDOC-2.9.1 [42], CNL is responsible for implementing and maintaining EP measures that identify, control and monitor releases of radioactive and hazardous substances, and the effects on human health and the environment from the PHAI sites. EP measures are an important component of the overall requirement of licensees to make adequate provision to protect the environment and the health of persons.

This, and the following subsections, provide a summary of CNL's EPP for the PHP and PGP and the status of each specific EP measure, relative to the requirements or guidance outlined in the latest regulatory document or CSA Group standard. Section 3.0 of this EPR report summarizes the results of these programs or measures against relevant regulatory limits and environmental quality objectives or guidelines and, where applicable, discusses any interesting trends.

CNL is not required to implement an environmental management system that conforms to International Standards Organization Standard 14001:2015, Environmental Management Systems [51] for the PHP and PGP, as both sites are not Class I facilities according to the NSCA [31]. However, CNL has developed and implemented an EPP [52], which includes the following components in accordance with licence conditions [47] [48] (with corresponding subsections discussed in this EPR report), to align with the requirements and guidance as outlined in REGDOC-2.9.1 [42]:

- Effluent and emissions control and monitoring
    - Effluent release limits
    - Liquid effluent monitoring
- Environmental monitoring program (EMP)
    - Ambient air monitoring
    - Soil monitoring
    - Surface water monitoring
    - Groundwater monitoring
    - Gamma monitoring

### 2.2.2 Environmental risk assessment

The environmental risk assessment (ERA) that a licensee conducts is a systematic process to identify, quantify and characterize the risk from contaminants and physical stressors in the environment to human and non-human (biological) receptors. As the PHP and PGP sites are not Class I nuclear facilities, CNL does not require an ERA according to the criteria of CSA N288.6-12 [53]. However, CNL performs EA follow-up monitoring to confirm that the environmental effects of the projects are consistent with the predictions of the EA, and to perform environmental monitoring as per conditions of the waste nuclear substance licences [54] [55] [56] [57].

### 2.2.3 Effluent and emissions control and monitoring

Controls on environmental releases are established to provide protection to the environment and to respect the principles of sustainable development and pollution prevention. The effluent and emissions prevention and control measures are established based on industry best practices, the application of optimization (e.g., in design) and as low as reasonably achievable principles, the Canadian Council of Ministers of the Environment (CCME) guidelines, and findings of the past EAs.

CNL's EPP [52] was reviewed and approved by CNSC staff and the EPP was revised in April 2022 [58]. It contains site-specific effluent operating limits and AL to control radiological and hazardous effluents and emissions. The effluent release limits are CNSC-licensed limits in place to ensure that the PHP and PGP continue to operate within their licensing basis. In addition, the PHP and PGP have established ALs to serve as an early warning of potential loss of control to prevent exceedances of the effluent release limits exceedances, in accordance with PHP licence condition 2.10 [47] and PGP licence condition 7.1 [48].

The PGP's effluent monitoring programs have been reviewed and approved by CNSC staff and are in compliance with REGDOC-2.9.1 [42] and the relevant standards. CNL will revise the PHP EPP accordingly during the upcoming licence period to address any changes in the PHP and PGP programs associated with the implementation of the most recent version of REGDOC-2.9.1 (2020) [42].

Based on compliance and technical assessment activities, CNSC staff have concluded that the effluent monitoring programs currently in place for the PGP and PHP continue to protect human health and the environment.

### 2.2.4 Environmental monitoring program

The CNSC requires licensees to design and implement an EMP that is specific to the monitoring and assessment requirements of the licensed facility and its surrounding environment. The program is required to:

- measure contaminants in the environmental media surrounding the facility or site
- determine the effects, if any, of the facility or site operations on people and the environment
- serve as a secondary support to emission monitoring programs to demonstrate the effectiveness of emission controls

More specifically, the program must gather the necessary environmental data to calculate public dose and demonstrate compliance with the public dose limit (1 millisievert (mSv) per year). The program design must also address the potential environmental interactions identified at the PHP and PGP sites. Radium-226, uranium and arsenic are the main contaminants of interest at the PHP and PGP, although other hazardous substances and radionuclides are included within monitoring activities associated with liquid discharges. CNL's EMP for the PHP and PGP consists of the following components:

- particulates in ambient air monitoring

- soil monitoring
- surface water monitoring
- groundwater monitoring
- gamma monitoring
- sediment monitoring
- noise monitoring

CNL submits the environmental and biophysical monitoring plans for the PHP and PGP sites. These plans provide details on the effluent and environmental monitoring activities for each project during the Pre-Construction, Construction and Development and post-construction (Maintenance and Monitoring) Phases. The most recent submission was in March 2018, which included all of the above monitoring requirements [38] [40] [59]. CNSC staff reviewed and accepted the revisions in 2018 and 2019 for the PHP and PGP, respectively. CNL submits environmental monitoring results to the CNSC through annual compliance reports for CNSC staff to review. If environmental effects from the projects are found to differ significantly from EA predictions, CNL must re-evaluate and adjust mitigation measures to ensure successful completion of the project without significant adverse effects on the environment.

CNL will be required to maintain its EMP to be in compliance with REGDOC-2.9.1 [42] and relevant standards.

Based on compliance activities and technical assessments, CNSC staff have determined that CNL is in compliance with REGDOC-2.9.1 and continues to implement and maintain an effective EMP for the PHP and PGP that adequately protects the environment and the health of persons.

# 3.0 Status of the environment

This section provides a summary of the status of the environment around the PHP and PGP. It starts with a description of the radiological and hazardous (non-radiological) releases to the environment (section 3.1), followed by a description of the environment surrounding the PHP and PGP and an assessment of any potential effects to the different components of the environment as a result of exposure to these contaminants (section 3.2).

It should be noted that CNSC staff regularly review the environmental components through annual reporting requirements and compliance verification activities, as detailed in other areas of this report. This information is reported to the Commission in the sections on environmental protection in licensing CMDs and annual RORs. The annual compliance reports submitted by CNL for the PHP and PGP ([1] - [20]) are made publicly available via the PHAI's public documents page on its website [49].

## 3.1 Releases to the environment

Radioactive and hazardous substances that have the potential to cause an adverse effect to ecological or human receptors are identified as COPCs. Once COPCs are emitted from a facility or licensed site, they are considered a release to the environment. The ways they get to the different receptors considered by the EA are called exposure pathways. Figure 3.1 below illustrates a conceptual model of the environment around a generic nuclear waste mangement facility to show the relationship between releases (airborne emissions or waterborne effluent) and human and ecological receptors or exposure pathways. This graphic is meant to provide an overall conceptual model of the releases, exposure pathways and receptors for the PHP and PGP, and thus should not be interpreted as a complete depiction of the PHP and PGP sites and their surrounding environments. The specific releases and COPCs associated with the PHP and PGP sites are explained in detail in the following subsections.

**Figure 3.1. Conceptual model of the PHAI sites**

### 3.1.1 Licensed release limits

The PHP and PGP have licensed release limits, to control effluent releases to the environment. CNSC staff requested that CNL establish exposure-based release limits (EBRLs) at identified release points for the PHP and PGP [60]. EBRLs result in a release limit that is based on the objective of ensuring that releases to the receiving environment stay below certain levels, or within endpoint parameters, to meet desired human health or environmental quality criteria in the areas of radiotoxicity, chemical toxicity, and protection of aquatic life. In general, liquid and air EBRLs are established for contaminants that require control as part of a screening level assessment. The lowest and limiting endpoint parameter is selected when calculating the EBRLs. The principle applied is the protection of human health and the most sensitive fresh-water aquatic receptors. When calculating the EBRLs, existing federal or provincial guidelines are also identified and used.

Under the NSCA, the operating licences for PHP and PGP include licence limits for radium-226, pH and total suspended solids (TSS), which CNSC staff have adopted from the *Metal and Diamond Mining Effluent Regulations* (MDMER) [61].

CNL submitted its proposed EBRLs in 2018 and 2020 for the PGP [62] and PHP [63] WWTPs, respectively. CNSC staff reviewed and approved the proposed EBRLs, which were submitted by CNL for PGP and PHP in 2018 [62] and 2020 [63], respectively. These EBRLs were harmonized with the MDMER [61] (where applicable, i.e. radium-226, pH and TSS) and with technology-based release limits that are protective of the environment.

### 3.1.2 Waterborne effluent

CNL controls and monitors liquid (waterborne) effluent from the PHP and PGP to the environment under its implementation of the EPP/EMP and includes monitoring of radiological and hazardous releases.

CNL monitors primary COPCs of uranium, radium-226 and pH, and secondary COPCs in effluent released from the PHP and PGP WWTPs. The effluent discharge is typically sampled on a flow-proportional basis with the use of automated samplers. Sample types and techniques are specified in accordance with methods and protocols approved by the Ontario Ministry of the Environment, Conservation and Parks (MECP). The PHP and PGP each have 1 discharge location in Lake Ontario. Treated effluent at each location is released using an outfall pipe and diffuser. The diffusers are designed to ensure a minimum 100-fold dilution at the point of entry into the lake under normal conditions.

Tables 3.1 to 3.4 summarize the concentrations of liquid effluent discharged to Lake Ontario for PHP and PGP, respectively, before dilution occurs at the end of the pipe, over a ten-year period from 2012 to 2021. In addition to licence limits, the PHP and PGP have established liquid effluent ALs, which are used to prevent exceedances of licence limits. Exceedances of these limits and ALs are reported to the CNSC, documented and investigated, and appropriate corrective action are taken where warranted.

Before 2017, there were limited release limits for both the PHP and PGP's water treatment plants (WTP). The design objectives and AL were developed by CNL for the new PHP WWTP in December 2017 [64], which were put in place for after CNSC staff reviewed and approved them in March 2018 [65], until the design objectives were turned into release limits in April 2020 [63].

The AL and release limits were put into place for the new PGP WWTP in August 2017 [66] and April 2018 [67], respectively. During heavy rainfall events in 2017, 2018, and 2019, CNL restarted the water treatment buildings to treat excess contaminated water, in accordance with CNL's water contingency plan, to avoid a release of untreated water to the environment. The water treatment buildings has not been used since 2020.

**Table 3.1: PHP WTP annual treated liquid effluent releases from 2012 – 2016 [1]–[5]**

| COPC, Unit | Concentration | 2012 | 2013 | 2014 | 2015 | 2016 | Licence Limits (Monthly Mean) |
|---|---|---|---|---|---|---|---|
| Ra-226 (Bq/L) | Annual Avg | 0.075 | 0.050 | 0.049 | 0.034 | 0.028 | 0.37 |
| Ra-226 (Bq/L) | Maximum | 0.105 | 0.078 | 0.066 | 0.049 | 0.081 | 0.37 |
| As (µg/L) | Annual Avg | 17.0 | 12.0 | 7.6 | 7.7 | 13 | 500 |
| As (µg/L) | Maximum | 53.0 | 38.2 | 19.5 | 21.3 | 52 | 500 |
| pH | Annual Avg | 7.51 | 7.51 | 7.6 | 7.71 | 7.64 | 6-9 |
| pH | Minimum / Maximum | >7.07, <7.89 | >6.91, <7.82 | >7.33, <7.87 | >6.97, <8.02 | >7.19, <7.90 | 6-9 |

**Table 3.2: PHP WWTP annual treated liquid effluent releases from 2017–2021 [6]–[10]**

| COPC, Unit | Concentration | 2017 | 2018 | 2019 | 2020 | 2021 | 2017 - 2020 Interim Limits (Monthly Mean)[1] | 2021 to Present Licence Limits (Monthly Mean)[2] |
|---|---|---|---|---|---|---|---|---|
| Ra-226 (Bq/L) | Annual Avg | 0.005 | 0.005 | 0.005 | 0.006 | 0.005 | 0.37 | 0.37 |
| Ra-226 (Bq/L) | Maximum | 0.005 | 0.005 | 0.005 | 0.008 | 0.005 | 0.37 | 0.37 |
| As (µg/L) | Annual Avg | 1.9 | 10.6 | 1.2 | 1.4 | 11.7 | 41 | 150 |
| As (µg/L) | Maximum | 6.5 | 38.0 | 2.0 | 6.8 | 29.9 | 41 | 150 |
| pH | Annual Avg | 7.39 | 7.68 | 7.81 | 7.58 | 7.59 | 6 - 9 | 6 - 9 |
| pH | Minimum / Maximum | >7.08, <7.58 | >7.12, <7.83 | >7.56, <7.93 | >7.28, <7.90 | >7.36, <7.88 | 6 - 9 | 6 - 9 |
| Acute Toxicity | Pass / Fail | Pass | Pass | Pass | Pass | Pass | Cannot be toxic | Cannot be toxic |
| Acute Toxicity | Maximum | N/A | N/A | N/A | N/A | N/A | Cannot be toxic | Cannot be toxic |
| U (µg/L) | Annual Avg | 0.7 | 4.6 | 1.2 | 1.4 | 1.5 | 150 | 150 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| U (µg/L) | Maximum | 1.5 | 11.0 | 2.3 | 2.8 | 2.5 | 150 | 150 |
| TSS (mg/L) | Annual Avg | 1 | 1 | 1 | 1 | 1 | 15 | 15 |
| TSS (mg/L) | Maximum | 1 | 1 | 1 | 1 | 2 | 15 | 15 |
| Al (µg/L) | Annual Avg | 6.1 | 5.9 | 5.3 | 2.7 | 1.2 | 660 | 110 |
| Al (µg/L) | Maximum | 13.0 | 8.0 | 6.0 | 5.4 | 2.0 | 660 | 110 |
| B (µg/L) | Annual Avg | 20 | 30 | 34 | N/A | N/A | 1820 | - |
| B (µg/L) | Maximum | 26 | 53 | 47 | N/A | N/A | 1820 | - |
| Cu (µg/L) | Annual Avg | 1.0 | 1.0 | 1.1 | 1.4 | 1.3 | 15 | 15 |
| Cu (µg/L) | Maximum | 1.0 | 1.0 | 2.5 | 1.90 | 2.1 | 15 | 15 |
| Pb (µg/L) | Annual Avg | 0.5 | 0.5 | 0.5 | 0.4 | 0.5 | 22.8 | 23 |
| Pb (µg/L) | Maximum | 0.5 | 0.5 | 0.5 | 0.6 | 0.7 | 22.8 | 23 |
| Zn (µg/L) | Annual Avg | 5.0 | 5.0 | 5.0 | 2.9 | 1.4 | 110 | 210 |
| Zn (µg/L) | Maximum | 5.0 | 5.0 | 5.0 | 2.9 | 2.5 | 110 | 210 |

[1] Interim Licence limits for PHP new WWTP, used since 2017 to April 2020
[2] Licence limits PHP new WWTP used since April 2020

**Table 3.3: PGP WTP annual treated liquid effluent releases from 2012 – 2016 [11]–[15]**

| COPC, Unit | Concentration | 2012 | 2013 | 2014 | 2015 | 2016 | Licence Limits (Monthly Mean) |
|---|---|---|---|---|---|---|---|
| Ra-226 (Bq/L) | Annual Avg | 0.058 | 0.057 | 0.072 | 0.172 | 0.005 | 0.37 |
| Ra-226 (Bq/L) | Maximum | 0.065 | 0.084 | 0.145 | 0.230 | 0.190 | 0.37 |
| pH | Annual Avg | 7.68 | 7.80 | 7.74 | 7.87 | 7.70 | 6 - 9 |
| pH | Minimum / Maximum | >7.49, <7.89 | >7.22, <7.91 | >7.65, <7.86 | >7.60, <8.14 | >7.56, <8.58 | 6 - 9 |

**Table 3.4: PGP WWTP annual treated liquid effluent releases from 2017 – 2021 [16]–[20]**

| COPC, Unit | Concentration | 2017 | 2018 | 2019 | 2020 | 2021 | 2017 Interim Limits | 2018 to Present Licence Limits |
|---|---|---|---|---|---|---|---|---|

| | | | | | | | (Monthly Mean)[1] | (Monthly mean)[2] |
|---|---|---|---|---|---|---|---|---|
| Ra-226 (Bq/L) | Annual Avg | 0.009 | 0.005 | 0.008 | 0.006 | 0.005 | 0.37 | 0.37 |
| Ra-226 (Bq/L) | Maximum | 0.051 | 0.008 | 0.038 | 0.008 | 0.005 | 0.37 | 0.37 |
| As (µg/L) | Annual Avg | 4.1 | 12.3 | 9.3 | 6.8 | 8.7 | 41 | 100 |
| As (µg/L) | Maximum | 8.5 | 35.5 | 39.1 | 15.6 | 24 | 41 | 100 |
| pH | Annual Avg | 7.45 | 7.46 | 7.68 | 7.64 | 7.49 | 6 – 9.5 | 6 – 9.5 |
| pH | Minimum / Maximum | >7.01, <7.57 | >5.91, <7.85 | >7.35, <7.94 | >7.37, <7.98 | >7.3, <7.74 | 6 – 9.5 | 6 – 9.5 |
| Acute Toxicity | Pass / Fail | PASS | PASS | PASS | PASS | PASS | Cannot be toxic | Cannot be toxic |
| Acute Toxicity | Maximum | N/A | N/A | N/A | N/A | N/A | Cannot be toxic | Cannot be toxic |
| U (µg/L) | Annual Avg | 7.5 | 7.3 | 10.4 | 3.9 | 1.2 | 150 | 100 |
| U (µg/L) | Maximum | 15.5 | 17.5 | 55.8 | 8.8 | 2.7 | 150 | 100 |
| TSS (mg/L) | Annual Avg | 1.0 | 1.0 | 1.0 | 1.5 | 1.1 | 15 | 15 |
| TSS (mg/L) | Maximum | 1 | 1.4 | 1 | 1.5 | 1.3 | 15 | 15 |
| Se (µg/L) | Annual Avg | 2.0 | 2.0 | 2.0 | 2.0 | 0.04 | 10 | 30 |
| Se (µg/L) | Maximum | 2.0 | 2.0 | 2.0 | 2.0 | 0.04 | 10 | 30 |
| Cu (µg/L) | Annual Avg | 1.0 | 1.0 | 1.0 | 0.5 | 0.7 | 24 | 15 |
| Cu (µg/L) | Maximum | 1.2 | 1.2 | 1.2 | 1.1 | 2.1 | 24 | 15 |
| Mo (µg/L) | Annual Avg | 1.73 | N/A | N/A | N/A | N/A | 730 | - |
| Mo (µg/L) | Maximum | 3.90 | N/A | N/A | N/A | N/A | 730 | - |
| Tl (µg/L) | Annual Avg | 0.05 | 0.05 | 0.05 | 0.05 | 0.005 | 8 | 8 |
| Tl (µg/L) | Maximum | 0.07 | 0.06 | 0.05 | 0.01 | 0.005 | 8 | 8 |
| Cd (µg/L) | Annual Avg | 0.10 | 0.10 | 0.10 | 0.10 | 0.01 | 0.33 | 1 |
| Cd (µg/L) | Maximum | 0.10 | 0.10 | 0.10 | 0.10 | 0.01 | 0.33 | 1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| V (µg/L) | Annual Avg | 0.51 | 0.62 | 0.64 | 0.26 | 0.24 | 42 | 40 |
| V (µg/L) | Maximum | 0.57 | 1.06 | 1.55 | 0.40 | 0.90 | 42 | 40 |
| P (mg/L) | Annual Avg | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.10 | 0.35 |
| P (mg/L) | Maximum | 0.02 | 0.02 | 0.04 | 0.03 | 0.05 | 0.10 | 0.35 |
| Nitrite (mg/L) | Annual Avg | 0.02 | 0.11 | 0.09 | 0.07 | 0.12 | 0.6 | 1.5 |
| Nitrite (mg/L) | Maximum | 0.02 | 0.26 | 0.25 | 0.16 | 0.30 | 0.6 | 1.5 |
| Nitrate (mg/L) | Annual Avg | 3.30 | 2.94 | 1.58 | 0.44 | 0.10 | 127.8 | 75 |
| Nitrate (mg/L) | Maximum | 5.74 | 8.94 | 3.35 | 1.92 | 0.10 | 127.8 | 75 |
| Ammonia (mg/L) | Annual Avg | 0.11 | 0.10 | 0.13 | 0.16 | 0.18 | 2.9 | 5.75 |
| Ammonia (mg/L) | Maximum | 0.60 | 0.27 | 0.34 | 0.73 | 0.30 | 2.9 | 5.75 |
| Co (µg/L) | Annual Avg | 0.50 | 0.50 | 0.57 | 0.52 | 0.52 | 9 | 5 |
| Co (µg/L) | Maximum | 0.50 | 0.55 | 1.24 | 1.30 | 2.30 | 9 | 5 |

[1] Interim Licence limits for PGP NEW WWTP, used in 2017

[2] Licence limits for PGP NEW WWTP, used since 2018.

#### 3.1.2.1 Findings

CNSC staff have found that CNL's reported liquid effluent discharged to Lake Ontario from the PHP and PGP remained below the CNSC's approved licence limits throughout the reported period (2012 to 2021).

CNSC staff are satisfied that CNL continues to provide adequate protection to the people and the environment from effluent it discharges to Lake Ontario from the PHP and PGP.

## 3.2 Environmental effects assessment

This section presents an overview of the assessment of predicted effects from licensed activities on the environment and the health of persons. CNL performs environmental effects monitoring to ensure that all reasonable precautions have been taken to protect the environment. This monitoring also determines if the effects on environmental aspects of the project are as predicted in the EA, confirms whether the mitigation measures implemented are effective, and determines if new mitigation strategies are required. In addition to environmental effects monitoring, CNL also performs performance/operational monitoring, to ensure integrity of the LTWMF, and compliance monitoring, to ensure compliance with licence requirements and regulations (e.g., effluent monitoring from the WWTP as described in section 3.1.2). This section of the report focuses on environmental effects monitoring between 2015 and 2020, inclusively. To inform this section of the report, CNSC staff reviewed CNL's EA predictions [68] [69] and environmental monitoring plans [38] [40] [59], along with CNL's monitoring results presented in its annual reports [1]–[18].

While CNSC staff conducted a review for all environmental components, only a selection of components is presented in detail in the following subsections. The environmental components were selected based on licensing requirements; some were also included because they have historically been of interest to the Commission, Indigenous peoples and the public.

The Port Hope Environmental and Biophysical Monitoring Plan [38], the Port Granby Project Environmental and Biophysical Monitoring Plan [40], and the Port Hope Licensed Sites Environmental Programs Specifications [59] provide the details of the environmental monitoring activities required throughout the projects. These plans include the EA follow-up monitoring undertaken in the biophysical environment during the implementation of the projects. CNL submitted these plans for the PHP and PGP sites in March 2018, revisions to which were reviewed and accepted by CNSC staff in 2018 and 2019, respectively. These plans will continue to apply as the sites move into their respective Maintenance and Monitoring Phases. It is important to distinguish that the monitoring requirements for the environmental effects may be different in each of the 3 project phases for the Port Hope and Port Granby projects:

1. Pre-Construction Phase – Monitoring intended to supplement or confirm the baseline information used to conduct the EA studies.

2. Construction and Development Phase – Monitoring intended for verification of predicted environmental effects and the effectiveness of mitigation measures during project activities.

3. Maintenance and Monitoring Phase – Monitoring intended to verify that the environmental effects are as predicted by the EA and that the LTWMF is operating as expected. The duration of this phase will be several hundred years.

The PHP LTWMF project is currently in phase 2 (the Construction and Development Phase). Therefore, only monitoring relevant to this phase is discussed in the following sections. Many offsite locations for the PHP have not started remediation work; therefore, they are not the focus of this report. The PGP is nearing completion of phase 2; therefore, discussion around the monitoring requirements moving into phase 3 (the Maintenance and Monitoring Phase) is discussed in the following sections.

### 3.2.1 Port Hope Project

#### 3.2.1.1 Port Hope offsite locations

A number of offsite activities require remediation as part of the PHP (including sites under the Waste Nuclear Substance Licence – Pine Street Extension Temporary Storage Site (WNSL-W1-182.1/2021) [56] and the Waste Nuclear Substance Licence – Port Hope Radioactive WMF (WNSL-W1-344-1.8/ind) [57]). These offsite locations vary from small consolidation sites, small-scale sites (e.g., Port Hope residential properties), to large-scale sites with greater volumes of LLRW (e.g., Port Hope Harbour and Highland Drive Landfill Area).

Some of the environmental subcomponents monitored at offsite locations during the remediation projects include:

- the atmospheric environment (e.g., non radiological air quality, radiological air quality, noise, odour)
- the aquatic environment (e.g., both radiological and non-radiological surface water and sediment quality)
- the terrestrial environment (e.g., soil quality)
- the hydrogeological environment (e.g., both radiological and non-radiological groundwater and drainage water quality, groundwater flow)

The measured concentrations are compared to predictions made during the EA and applicable federal and provincial guidelines.

Many of the Port Hope offsite locations have not been remediated yet. Each site requiring remediation undergoes detailed planning prior to any construction activities. Due to the nature of these offsite locations and the fact that many have not undergone remediation at the time of this report, monitoring results are not discussed in detail.

**Findings**

Based on the review of CNL's results of the monitoring program for the PHP's offsite locations, CNSC staff have found that the environment surrounding the sites remains within EA predictions and that offsite locations will continue to be remediated to improve conditions in the future.

### 3.2.1.2 Port Hope Harbour

CNL began mechanical dredging of the Port Hope Harbour in 2019 and is required to execute the EA follow-up monitoring for the harbour as outlined in its monitoring plan [38]. Prior to any dredging activities, CNL performed a fish-out, by electrode fishing, of the inner harbour area. Fish-out activities are reported to the DFO, Environment Climate Change Canada, and the CNSC. The follow-up monitoring program for the Port Hope Harbour includes quarterly surface water sampling at three locations to track water quality in the Ganaraska River and in the harbour confluence (see figure 3.2). Sampling is conducted for a suite of parameters before, during and after (only if required) the dredging of the Port Hope Harbour. The surface water monitoring is designed to verify that there is no effect on downstream water quality during dredging activities. The results are compared to the Canadian Water Quality Guidelines for Protection of Aquatic Life (CCME) [70] and Provincial Water Quality Objectives (PWQO) [71]. CNL's monitoring plan also requires weekly monitoring at two other locations (PHH-1 and PHH-2) during dredging activities to verify that there are no unexpected water quality effects on the confluence area [38].

EA predictions [68] state that concentrations of radium-226 and uranium may increase in the area between the harbour and the Ganaraska River during dredging of the harbour but should remain below PWQO. There were no exceedances of water quality guidelines for uranium at the 3 harbour monitoring locations in the 2015–2020 reporting period prior to the commencement of dredging activities (see table 3.5). CNL began mechanical dredging of the Port Hope Harbour in 2019 and shortly after observed uranium and other metals at concentrations above PWQO guidelines in the harbour near the dredging site. CNL's environmental plan [38] has a requirement that concentrations of waste-related parameters above PWQO [71] in the confluence area be investigated and mitigated if appropriate. As these elevated concentrations were not predicted in the EA and are above water quality guidelines, CNL has increased the number of monitoring sampling points and frequency of monitoring, initiated routine toxicity testing, performed additional modelling, and is examining potential mitigation measures to ensure the protection of the environment. CNL plans to dredge the harbour sediment down to bedrock or hard till. Once contaminated sediment is removed from the harbour, water quality is predicted to significantly improve over time.

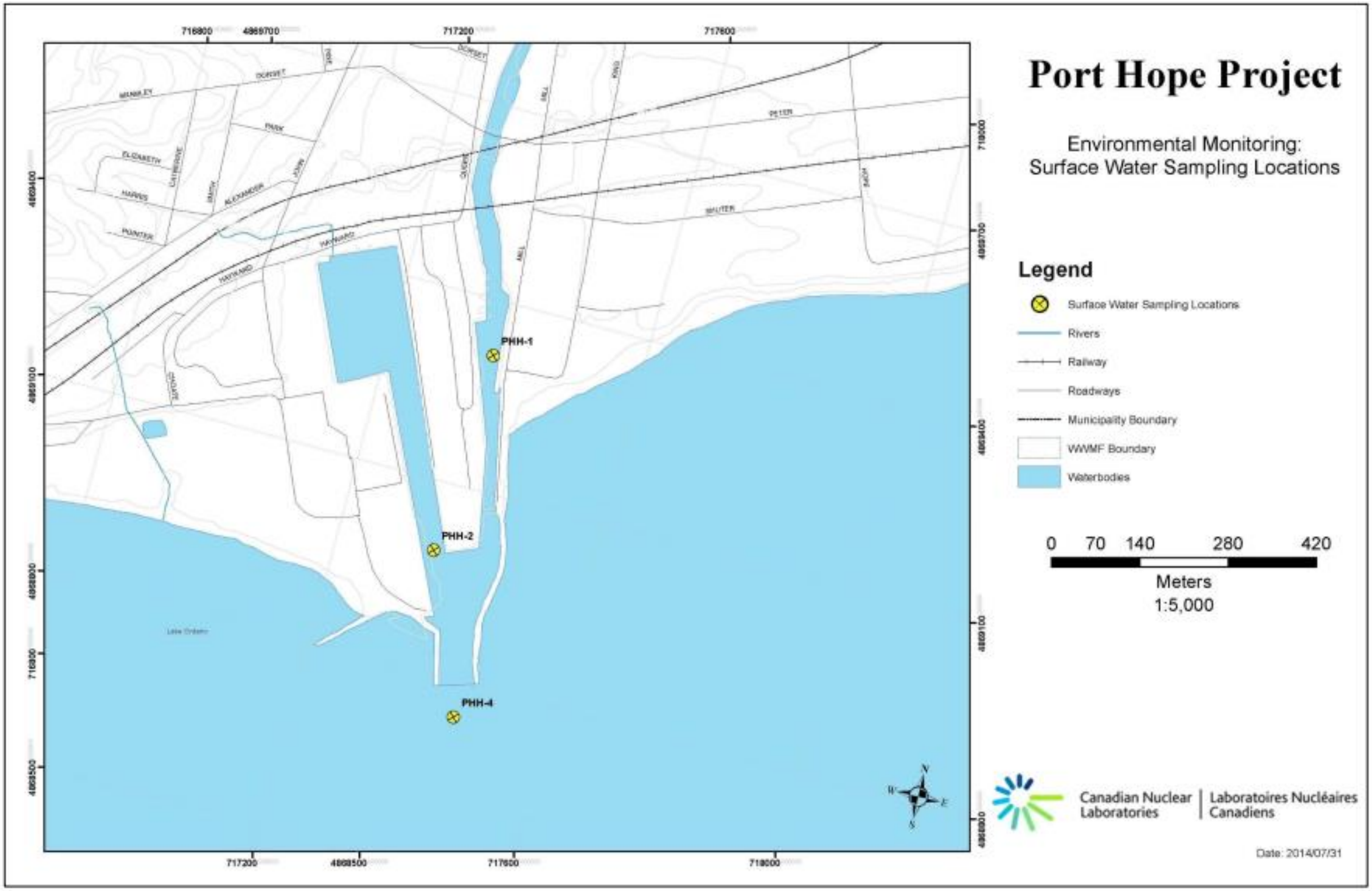
**Table 3.5: Annual average concentrations of uranium in Port Hope Harbour for EA follow up surface water monitoring locations**

| Location | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Limits |
|---|---|---|---|---|---|---|---|
| PHH-1 | 0.8 | 0.8 | 0.75 | 0.84 | 0.74 | 0.78 | PWQO: 5 µg/L [71] |
| PHH-2 | 2.1 | 1.8 | 3.8 | 2.7 | 2.3 | 1.67 | PWQO: 5 µg/L [71] |
| PHH-4 | 1.0 | 0.7 | 0.35 | 0.62 | 0.45 | 0.40 | PWQO: 5 µg/L [71] |

**Findings**

Based on the review of CNL's EA and the results of the surface water monitoring program for the Port Hope Harbour, CNSC are satisfied that surface water quality remains at levels protective of human health and that the environment. Although there have been some exceedances of guidelines for contaminates due to the Port Hope Harbour dredging activities, they have been followed up on appropriately and water quality will continue to improve once the dredging activities are completed.

**Figure 3.2: Surface water sampling locations for the construction and development phase of the Port Hope Project [38]**



#### 3.2.1.3 Port Hope LTWMF

Environmental monitoring is carried out by CNL to ensure the waste remains isolated from the environment, and that there are no impacts on the environment during placement of the waste. The main environmental monitoring measures are taken for air, surface water, soil and groundwater.

The assessment below focuses on the monitoring results for the PHP LTWMF during the Construction and Development Phase (phase 2).

**Atmospheric environment**

CNL is required to characterize the ambient air quality around the PHP LTWMF during the Construction and Development Phase to ensure the project is not impacting the environment. The EA follow-up monitoring activities include monitoring of air quality (radiological and non-radiological parameters) and noise. There will be very limited potential for airborne non-radiological contaminants caused by project activities when the project moves to the Maintenance and Monitoring Phase. Therefore, only radon monitoring will continue to occur at the LTWMF area past phase 2. Discussion below focuses only on the current phase of the PHP, phase 2.

**Ambient Air Quality**

Air quality monitoring addresses concentrations of suspended particulate that could be caused by PHP LTWMF project activities. Management of air quality uses a hierarchical approach starting with observation of visible dust. Personnel trained in the evaluation of visible dust are onsite during construction activities to evaluate the need for improved dust control. During periods of visible dust and to assist trained observers, portable real-time dust monitors are used to take readings at downwind locations along the property line. A PHAI dust administrative control level of 100 $\mu g/m^3$ total suspended particulate (TSP) and PHAI dust AL of 120 $\mu g/m^3$ TSP averaged over 15 minutes at the site perimeter is outlined for the real-time dust monitoring at the work sites, as per CNL's Dust Management and Requirements Plan [72]. These are internal levels and not required to be reported to external regulators. However, exceeding these levels does trigger actions. These levels are set to ensure that, over the long term, levels of airborne metals remain below Ontario's Ambient Air Quality Criteria (AAQC) [73], which are desirable concentrations of a contaminant in air, based on protection against adverse effects on health or the environment. An independent dust monitoring program (IDMP) is also carried out in addition to that conducted by the prime contractor and CNL. The IDMP is designed to monitor dust at the perimeter of PHAI work sites and is not controlled by the prime contractor or CNL. Continuous monitoring occurs during the work hours, and results are reported on a 15-minute interval. An exceedance of the 15-minute interval dust AL triggers an immediate response by CNL and the prime contractor to initiative corrective action to reduce dust levels.

In addition, both TSP and $PM_{2.5}$ (fine particulate matter) are measured using high-volume (Hi-Vol) air samplers operating at 4 locations (figure 3.3), which must be analyzed in an accredited laboratory. The locations monitored include Welcome South, Welcome Northwest, Welcome Weather Station and 192 Toronto Road. Monitoring occurs daily (24-hour sample) on days when dust-generating construction activities are taking place. As per CNL's Dust Management and Requirements Plan [72], the TSP filter results are assessed against an overriding limit of 120 $\mu g/m^3$ averaged over 24 hours which is adopted from Ontario's Ambient Air Quality

Criteria. An exceedance of this overriding limit triggers internal actions. Any TSP filter exceeding 100 µg/m$^3$, or the highest TSP sample measured during the week (if none are above 100 µg/m$^3$), is also analyzed for metals from each monitoring location. For $PM_{2.5}$, in 2012, the CCME adopted the Air Quality Management System as a new comprehensive approach to managing air issues [74]. Prior to that, the monitoring results for $PM_{2.5}$ 98th percentile were compared to the 2000 Canadian Air Quality Standards for Fine Particulate Matter value of 30 µg/m$^3$. In 2020, a value of 27 µg/m$^3$ was published by CCME for $PM_{2.5}$.

Radiological air quality measurements include TSP, long-lived alpha activity (LLA) and radon. Levels of radionuclides are measured on the same TSP filters selected for metals analysis. Radionuclide analysis is carried out for natural uranium, natural thorium, thorium-230, thorium-232, radium-226 and lead-210. LLA is also measured daily at the perimeter locations generally downwind of remedial activities. The LLA results are reviewed daily to provide early indication of any unexpected or unusual levels of airborne radioactivity. Radon monitors are located along the perimeter fenceline of the LTWMF. Comparison of the baseline levels with the levels measured during the Construction and Development Phase and Maintenance and Monitoring Phase determines the levels associated with project activities.

As per the PHAI Radiation Protection Plan [75], a value of 0.5 Bq/m$^3$ averaged over the time period the sample was acquired has been adopted as the investigative threshold for LLA in air measurements taken at work sites. The PHAI Radiation Protection Plan also established a limit of incremental average radon levels of 150 Bq/m$^3$ for the PHP LTWMF during phase 2 activities. An exceedance at any of the monitoring locations triggers a dose assessment to a member of the public for a comparison to the 1mSv/y regulatory dose limit.

**Comparison to EA predictions**

Using air dispersion modelling, the EA studies predicted occasional, albeit infrequent, exceedances of the applicable criterion for TSP of 120 µg/m$^3$ [54] immediately adjacent to the LTWMF. $PM_{2.5}$ was predicted to infrequently exceed the 24-hour Canada-Wide Standard [74] adjacent to the LTWMF. The PHP Screening Report [76] identified that predicted levels of radionuclides would be below Health Canada reference levels [77]. Radon concentrations during the Construction and Development Phase are expected to be no higher than an annual average concentration of 25.3 Bq/m$^3$ at the fenceline of the proposed LTWMF. Since the EA, CNL indicated that the predicted levels had been set to an unachievable level and should be re-evaluated. CNL also noted that during the EA baseline study, different radon monitoring equipment was used for radon measurements, and it is not recommended for comparison to the current monitoring scheme that uses RSSI alpha-track detectors. In a memorandum to the CNSC, CNL defined the radon gas concentration of 150 Bq/m$^3$ as the base concentration and received approval in July 2014. Exceeding this concentration triggers follow-up actions such as ascertaining dose to the public.

Atmospheric monitoring data for TSP from 2015 to 2020 is summarized below (see table 3.6). Between 74 and 259 samples at each location have been collected per year from each high-volume air sampler (TSP and $PM_{2.5}$) for the PHP LTWMF site. The trigger level of 120 µg/m³ for TSP has been exceeded occasionally over the years, as predicted in the EA, and appropriate follow-up actions have been performed. The AAQC for $PM_{2.5}$ of 30 µg/m³ (98th percentile averaged over 3 years) was not exceeded over the monitoring period. There were no exceedances of the AAQC for metals in TSP samples sent for analysis. Radium-226 and thorium-232 occasionally exceeded the EA predicted values for some of the filters over the monitoring period. However, all remained well below the Health Canada reference values [77]. The EA-predicted values were based on modelling $PM_{10}$ concentrations, which was considered a conservative approach.

**Table 3.6: Annual concentrations of TSP in ambient air as measured around the PHP LTWMF**

| Hi-Vol station | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Overriding limit |
|---|---|---|---|---|---|---|---|---|
| PHP LTWMF weather station | Average* (µg/m³) | 14 | 21 | 22 | 23 | 16 | 18 | 120 µg/m³ TSP [47] |
| PHP LTWMF weather station | Maximum (µg/m³) | 56 | 95 | 116 | 104 | 158** | 85 | 120 µg/m³ TSP [47] |
| PHP LTWMF Northwest | Average* (µg/m³) | 14 | 22 | 18 | 26 | 21 | 21 | 120 µg/m³ TSP [47] |
| PHP LTWMF Northwest | Maximum (µg/m³) | 51 | 79 | 73 | 150** | 96 | 179** | 120 µg/m³ TSP [47] |
| PHP LTWMF South | Average* (µg/m³) | 14 | 16 | 14 | 20 | 14 | 15 | 120 µg/m³ TSP [47] |
| PHP LTWMF South | Maximum (µg/m³) | 51 | 85 | 53 | 162** | 85 | 73 | 120 µg/m³ TSP [47] |
| Transportation route, 192 Toronto Road | Average* (µg/m³) | 17 | 27 | 20 | 26 | 18 | 19 | 120 µg/m³ TSP [47] |
| Transportation route, 192 Toronto Road | Maximum (µg/m³) | 69 | 151** | 57 | 119 | 75 | 58 | 120 µg/m³ TSP [47] |

*average presented as geometric mean
**indicates levels exceeding overriding TSP limit of 120 µg/m³ [47].

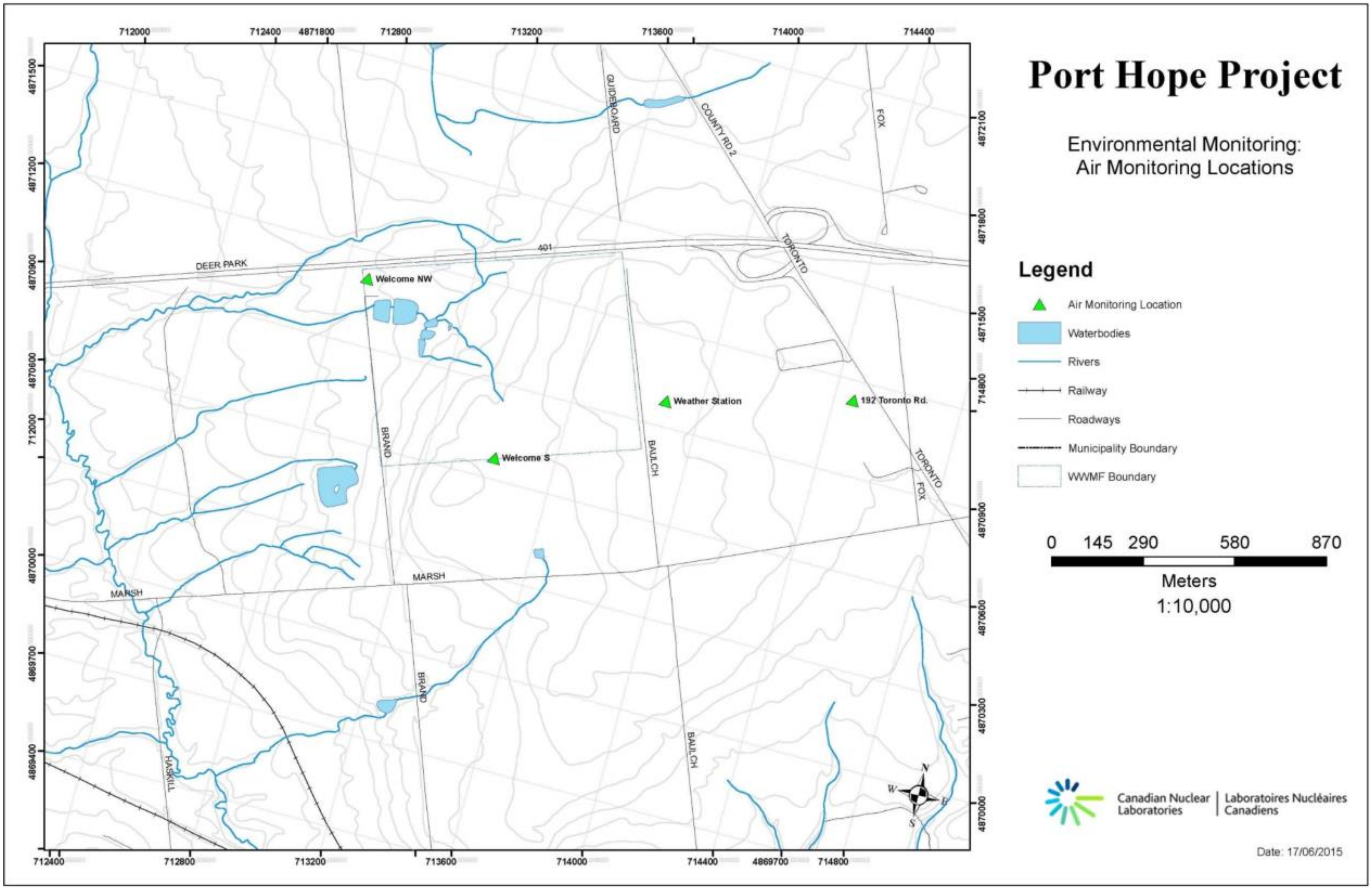
For the independent dust monitoring, in 2019 and 2020, there were 0 confirmed instances when the 15-minute average exceeded the AL. However, in 2015, 2016, 2017 and 2018, there were 10, 65, 37 and 7 instances, respectively, of exceedances that were attributed to site activities at the PHP LTWMF. When exceedances occurred, the contractor used water as a dust suppressant, minimized dust generating activities, and worked to optimize dust-mitigation practices. Although the dust AL was exceeded, there were no exceedances of the TSP limit from the high-volume air samplers located at the perimeter of the controlled area on those days.

Radon measurements are taken monthly at the fenceline as a representative reading of doses to the public. Measurements were often below the reporting AL of 150 $Bq/m^3$. For instance, the average radon measurements ranged between 22 $Bq/m^3$ to 118 $Bq/m^3$ in 2021.

**Findings**

Based on the review of CNL's EA and the results of the atmospheric monitoring program for the PHP LTWMF, CNSC staff have found that airborne emissions from the PHP LTWMF were within the EA predictions, which predicted occasional exceedances of the provincial standards. Exceedances of TSP and dust were followed up on appropriately, and all metals and radionuclides remained within their respective criteria. CNSC staff are satisfied that ambient air quality remains at levels protective of human health and the environment and, therefore, it is unlikely that CNL activities are having a measurable impact on the surrounding atmospheric environment.

**Figure 3.3: Air monitoring locations for the construction and development phase of the Port Hope Project [38]**



**Noise monitoring**

Noise monitoring takes place during the Construction and Development Phase at the PHP LTWMF site to capture potential noise levels from construction activity. Noise monitoring is performed quarterly at several locations around the PHP LTWMF to confirm the accuracy of predictions made during the EA and the effectiveness of mitigation measures.

The guidance level of 70 decibels (dBA) (24-hour weighted average), as per the World Health Organization's Guideline for Community Noise [78], is used for the project, as construction activities are being limited to daytime hours.

**Comparison to EA predictions**

The predicted environmental effect for noise in the EA was an increase in noise levels of 12 dBA for residents adjacent to the LTWMF during construction and development. All noise values from 2015 to 2020 around the PHP LTWMF were below the predicted range of a 12 dBA increase and the World Health Organization's (WHO) guideline of 70 dB over a 24-hour period. The North, South and Central Transportation Routes were also monitored in 2020. Monitoring along the transportation routes showed little to no increase from the baseline monitoring that took place prior to the remedial activities.

**Findings**

Based on the review of CNL's EA and the results of the noise monitoring program for the PHP LTWMF, CNSC staff found that noise from the PHP LTWMF activities is below guidelines and within the EA predictions. Therefore, CNSC staff are satisfied that noise levels remain protective of human health.

**Terrestrial and aquatic environment**

**Soil quality**

The project is expected to have the beneficial effect of improving soil quality at cleanup sites by removing contaminated materials. Potential adverse effects, however, would be expected on soil quality for areas beyond the excavation sites, related to the accumulation of contaminants on surface soil from the airborne transport of soil and dust. Soil quality data is collected for comparison to the existing baseline soil quality data in these areas in order to identify any incremental increases due to dust deposition.

Monitoring in surface soil at the LTWMF site perimeter is carried out annually at 5 locations (see figure 3.4), for both radiological COPCs (e.g., radium-226) and non-radiological COPCs (e.g., uranium, arsenic). A full list of monitored COPCs can be found in CNL's monitoring plan [38]. Soil monitoring results are compared to baseline data and EA predictions [68].

**Comparison to EA predictions**

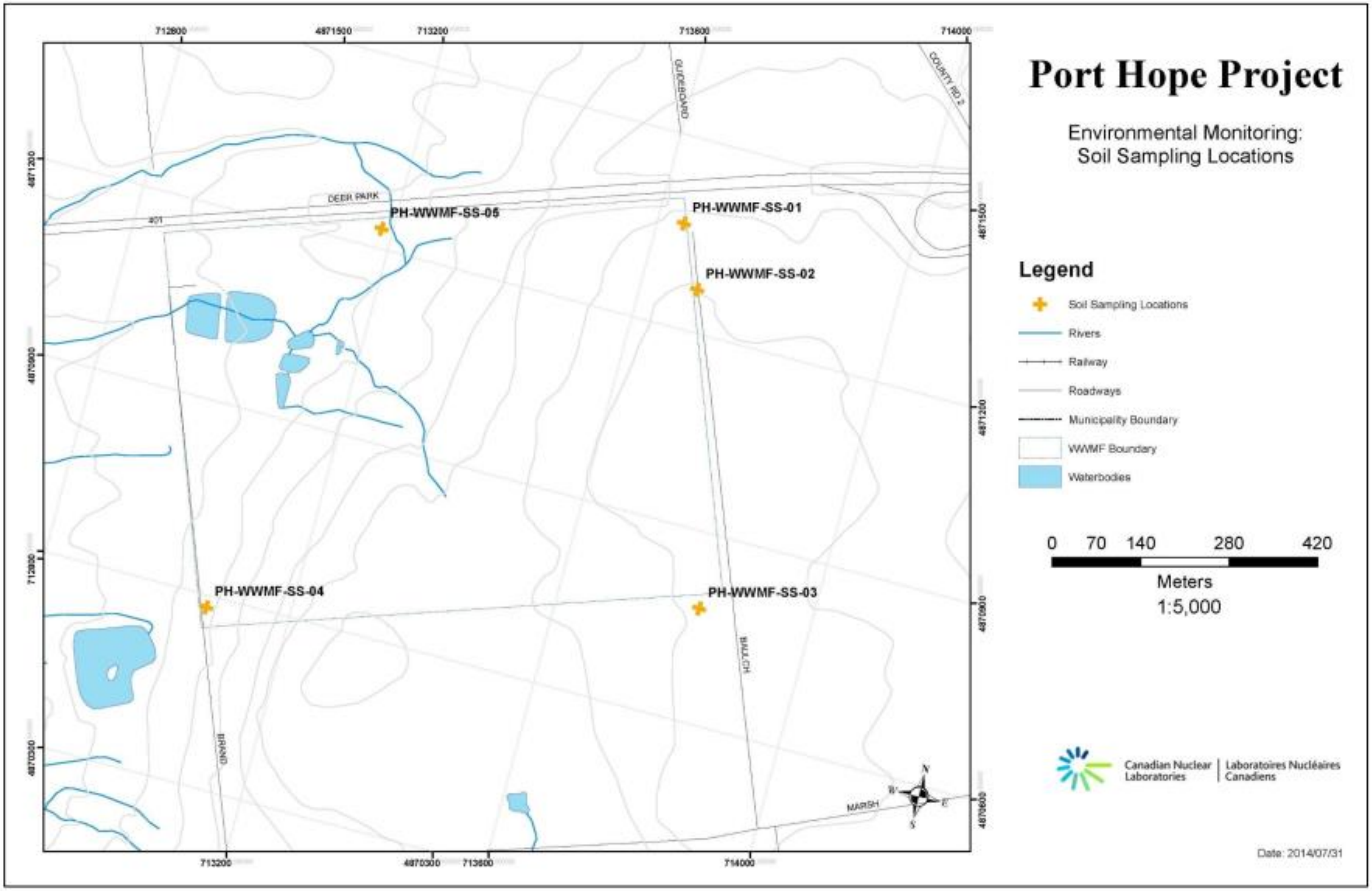
The EA studies predicted mean incremental concentration increases for most radiological contaminants of less than 20% of background at the LTWMF, and the resulting increased amounts were considered not measurable. The exception was thorium-230. Its concentrations were predicted to increase 63% over baseline concentrations assuming no mitigation measures are applied. The mean incremental concentration increases for most non-radiological contaminants at the LTWMF were predicted to be less than 20% of background; these resulting increased amounts were also considered not measurable. The exceptions were arsenic and cobalt. The predicted mean incremental concentration increases for arsenic and cobalt over baseline concentrations at the LTWMF perimeter were 130% (e.g., 4.7 µg/g), and 28% (e.g., 6.67 µg/g), respectively. The predicted concentrations were noted to be well below applicable soil quality guidelines for Ontario [79].

Concentrations of some parameters in soil have been greater than predicted throughout the monitoring period for some locations. For instance, concentrations of arsenic (at location 1 in 2017 and at location 5 from 2015 to 2019) and cobalt (at location 3 in 2018 and 2020) were greater than predicted. Arsenic was also above MECP soil quality guidelines [79] at location 5. This location is an area known to be slightly contaminated with arsenic due to surface water runoff. Therefore, it was concluded that the contamination was not caused by elevated concentrations due to wind-blown dust deposition from construction activities of the LTWMF. The area will be remediated as part of the PHAI cleanup and there are no immediate concerns with this location. Thorium-230 concentrations were also above predictions at some locations. However, this was due to the laboratory detection limit being above the predicted levels.

**Findings**

Based on the review of CNL's EA and the results of the soil monitoring program for the PHP LTWMF, CNSC staff are satisfied that soil quality remains at levels protective of human health and the environment, and that airborne transport of soil and dust from the project is not affecting the soil quality around the site. Areas that exceeded provincial guidelines due to surface water runoff will be remediated as part of the PHAI cleanup.

**Figure 3.4: Soil sampling locations for the construction and development phase of the Port Hope Project [38]**



**Surface water quality**

The EA follow-up activities with respect to surface water quality involve the collection and analyses of surface water samples at locations down-gradient of the PHP LTWMF to:

- verify predicted improvements in surface water
- ensure that discharges are not deleterious to aquatic life
- verify reduction of contaminant loadings due to leachate discharging to Lake Ontario

Decreases in contaminant concentrations are not expected until the waste is remediated. At that point, water quality is expected to improve over the longer term as a result of the cleanup.

Surface water sampling in Brand Creek and in Lake Ontario around the treated leachate discharge are performed on a quarterly basis throughout the Construction and Development Phase. There are 4 sampling locations in Brand Creek and 3 in Lake Ontario (see figure 3.5). The surface water quality of Lake Ontario is sampled at the PHAI diffuser to verify that the water quality in the vicinity of the PHP LTWMF leachate discharge and the associated mixing zone is not affected by PHP LTWMF operations. The mixing zone is approximately 12 m around the diffuser. Sampling is conducted at the diffuser and approximately 20 m east and west of the diffuser. Sampling in Lake Ontario is not always possible due to winter weather or other safety concerns.

Many parameters are analyzed in surface water samples, ranging from general chemistry (e.g., pH, hardness, TSS), total metals (e.g., arsenic, lead, uranium), radionuclides (e.g., radium-226, lead-210, thorium-230), and field-measured parameters (e.g., dissolved oxygen, temperature, turbidity). A full list of parameters can be found in CNL's monitoring plan [38]. However, the key COPCs identified in the EA were arsenic, radium-226 and uranium.

The surface water results are compared to the Canadian Water Quality Guidelines for Protection of Aquatic Life (CCME) [70] and PWQO [71]. CNL must also ensure that the discharge is not deleterious to the aquatic environment (fish) at the point of discharge; and appropriate monitoring must be employed to confirm this.

**Comparison to EA predictions**

The EA predicted that during the Construction and Development Phase, changes in water quality in Brand Creek would be small. Loadings to Brand Creek were expected to increase slightly (less than 1%). The EA predicted loadings to Lake Ontario via pipeline from the LTWMF would increase by 12%. Water quality is expected to improve over the longer term because of the cleanup.

Results from quarterly samples in Brand Creek were generally consistent from 2015 to 2020, suggesting that construction of the PHP LTWMF is not having an adverse effect on the surface water quality in Brand Creek. There have been occasional exceedances of the PWQO [71] over the monitoring period for some parameters. For instance, an increase in uranium concentrations was observed in a tributary of Brand Creek (sample location BC-T) relative to the other locations in monitoring years 2017 to 2020. This tributary is fed mainly by Clark's Ditch, which receives surface water runoff from the PHP LTWMF. Exceedances for uranium had been observed in previous years, prior to the construction of the PHP LTWMF, suggesting historical contamination as the cause. The water quality of this tributary is expected to improve over time as remediation progresses. Criteria for iron, chloride and phosphorus were also exceeded at both downstream and upstream locations in Brand Creek over the monitoring period. This suggests that an offsite source may be responsible for these elevated levels, as it is typical for agricultural/urban watersheds in the region to exceed these limits. It is suspected that the elevated chloride concentration may be due to road salt as Highway 401 is located just to the north of the PHP LTWMF.

In the Lake Ontario samples, there were no exceedances of the PWQOs [71] or Canadian Water Quality guidelines (CWQG) [70], except for fluoride (which had only slight elevations over the monitoring years), cadmium and selenium in 2017 (due to detection limits being elevated above the CWQGs), and uranium in 2018 (see table 3.7 for uranium results from 2015 to 2020). Elevated fluoride concentrations are typical for the nearshore zone of the lake in this region, and results were well under the Ontario drinking water quality standard of 1.5 mg/L [80]. In 2018, there was an exceedance of uranium at the Lake Ontario diffuser location. In 2018, CNL operated the water treatment buildings (in addition to the newly engineered WWTP as described in section 3.1.2) to increase the treatment capacity required for the Collection Pond expansion activities. However, the results for the sampling locations around the diffuser did not show elevated results for uranium; this suggests no impact past the mixing zone. Other monitoring results are generally consistent with the monitoring data for the past few years, suggesting that PHAI operations are not having an adverse effect on Lake Ontario water quality.

**Table 3.7: Annual average concentrations of uranium in the Lake Ontario surface water sampling locations, in µg/L**

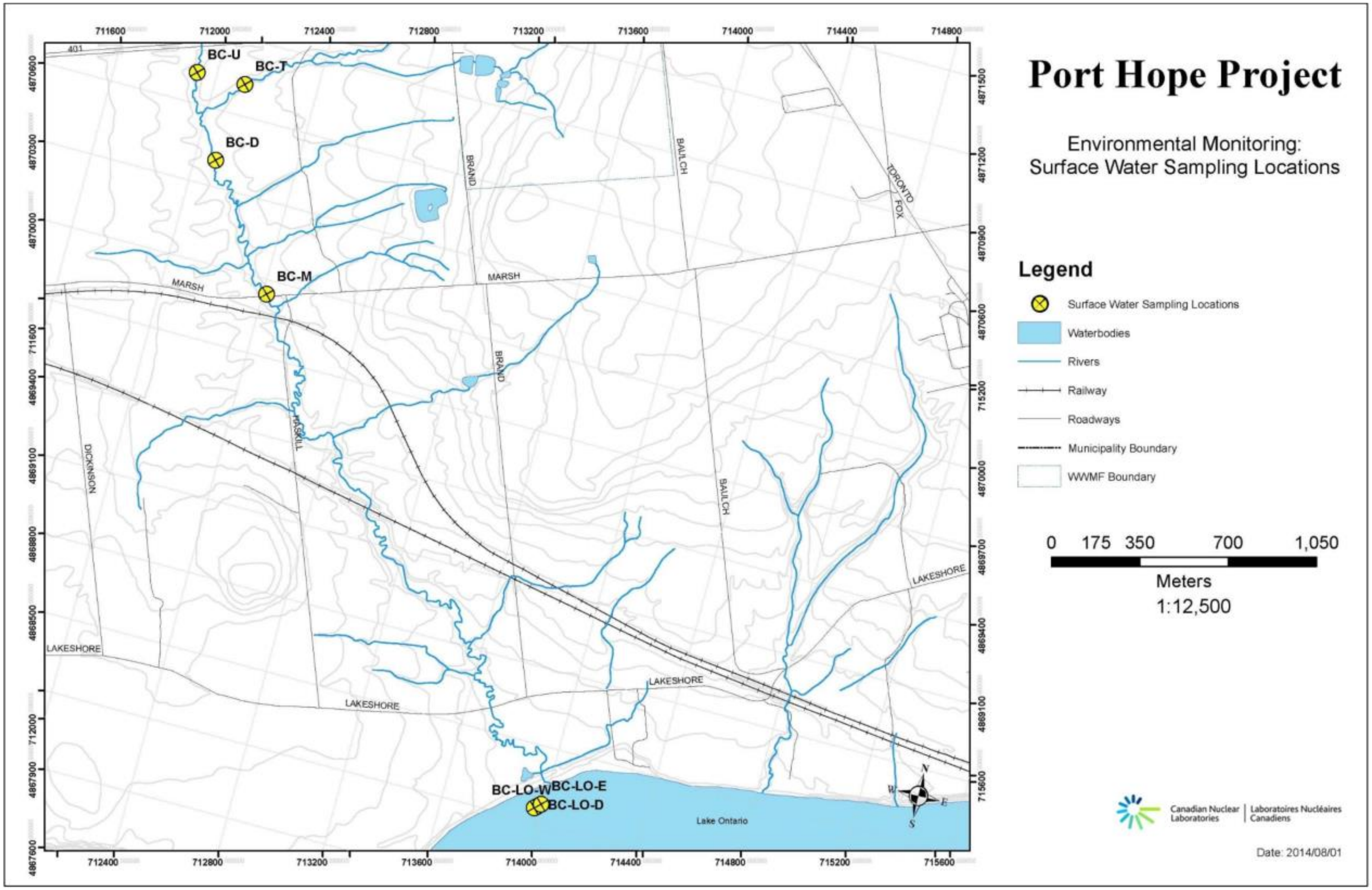
| Location | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Limits |
|---|---|---|---|---|---|---|---|
| BC-LO-D | 2.71 | 0.36 | 0.35 | 9.69* | 0.38 | 0.35 | PWQO: 5 µg/L [71] |
| BC-LO-E | 0.42 | 0.45 | 0.36 | 0.54 | 0.38 | 0.38 | PWQO: 5 µg/L [71] |
| BC-LO-W | 1.36 | 0.35 | 0.36 | 0.33 | 0.38 | 0.35 | PWQO: 5 µg/L [71] |

* indicates an exceedance of applicable guideline.

### Findings

Based on the review of CNL's EA and the results of the surface water monitoring program for PHP LTWMF, CNSC staff found that water quality from the PHP LTWMF activities is often below guidelines and within the EA predictions, which predicted increased loadings during phase 2. CNSC are satisfied that surface water quality remains at levels protective of human health and that the environment and expect water quality will continue to improve once the project is completed.

**Figure 3.5: Surface water sampling locations for the construction and development phase of the Port Hope Project [38]**



**Sediment quality**

In the Brand Creek Watershed, sediment sampling was undertaken during the Pre-Construction Phase, to supplement existing baseline information, in areas below the remediation zone where expected discharge to the aquatic environment had the potential to influence sediment quality. This serves as a point of comparison for future sediment concentrations. Sediment sampling will not take place in the Construction and Development Phase. Sediment sampling in the Monitoring and Maintenance Phase will only be required if upset releases of suspended solids have occurred, or if water quality objectives have been frequently exceeded over the Construction and Development Phase (i.e., 25% of quarterly samples). As this section of the report focuses on phase 2, sediment monitoring is not discussed further for the PHP LTWMF Brand Creek Watershed.

**Findings**

CNSC will review Brand Creek Watershed sediment sampling results in the Monitoring and Maintenance Phase if required as per the criteria above.

**Hydrogeological environment**

The PHP LTWMF site, including the Welcome WMF, is located in the Iroquois Plain physiographic region, south of the Oak Ridges Moraine and the former glacial Lake Iroquois shoreline. This is primarily a glaciolacustrine clay and sand plain that extends south to Lake Ontario. The surficial geology consists of glacial lake deposits either of sand and gravel or of silt and clay.

Groundwater in the region generally flows south, mimicking the ground surface and the top of bedrock trends. Aquifers are found in both the overburden and the bedrock, with both near-surface and deeper overburden aquifers in zones of sand and gravel. At the PHP LTWMF site, horizontal groundwater flow occurs in 3 separate hydro-stratigraphic units. All groundwater ultimately discharges into Lake Ontario.

The construction of the LTWMF reduces the infiltration to groundwater over the footprint of the facility and causes a localized change in the groundwater level, flow rate and direction [76]. The low-permeability cover and liner system of the LTWMF causes the volume of water collected as surface runoff to be much greater than during baseline conditions. On the other hand, it reduces the volume of contaminated drainage and groundwater that requires collection in the groundwater/drainage water collection and treatment system.

**Comparison to EA predictions**

Groundwater levels were measured quarterly from 2015 to 2020 [4]–[9]. The average groundwater levels in monitoring wells were generally stable over this period.

Groundwater samples were collected from the following wells (see figure 3.6 for the monitoring well locations) and analyzed for contaminants twice annually from 2015 to 2020 [4]–[9]:

- In 2015 and 2016, of the 22 monitoring wells around the Welcome WMF, 20 wells were suitable for monitoring.
- From 2017 to 2020, of the 22 (26 in 2019 and 2020) monitoring wells around the PHP LTWMF, 20 (21 in 2020) wells were suitable for monitoring.

The results were compared against water quality criteria for potable groundwater conditions listed in the Port Hope Screening Report [76]. This is a conservative approach, as water is not potable onsite. In addition, results were compared to Ontario's groundwater standards [79].

Barium concentrations at a monitoring well, WC-MW3A-11R, were found to exceed the criterion identified in the Port Hope Screening Report from 2015 to 2020 ([4] – [9]). There were no exceedances of the Ontario groundwater standards, specifically table 3, in this period. Exceedances are the result of the effects of the previous Welcome WMF, which does not have a complete engineered liner or cover system in place. Monitoring of the groundwater conditions will continue throughout the phases of the project, and improvements to groundwater quality are expected to occur as the Welcome WMF is remediated and through natural attenuation.

Before construction of the PHP LTWMF, all impacted drainage water at the PHP LTWMF site was collected in the drainage collection system and treated onsite at the old water treatment building, prior to discharge via pipeline to Lake Ontario. Drainage water quality in the western portion of the site represents groundwater discharge that exhibits impacts related to the presence of the Welcome WMF burial area. According to the screening report [68], before construction of the PHP LTWMF, the concentrations of aluminum, antimony, arsenic, cadmium, chromium, cobalt, copper, iron, lead, nickel, phosphorous, silver, thallium, uranium, vanadium, zinc, uranium and radium-226 commonly exceeded the PWQO [71].

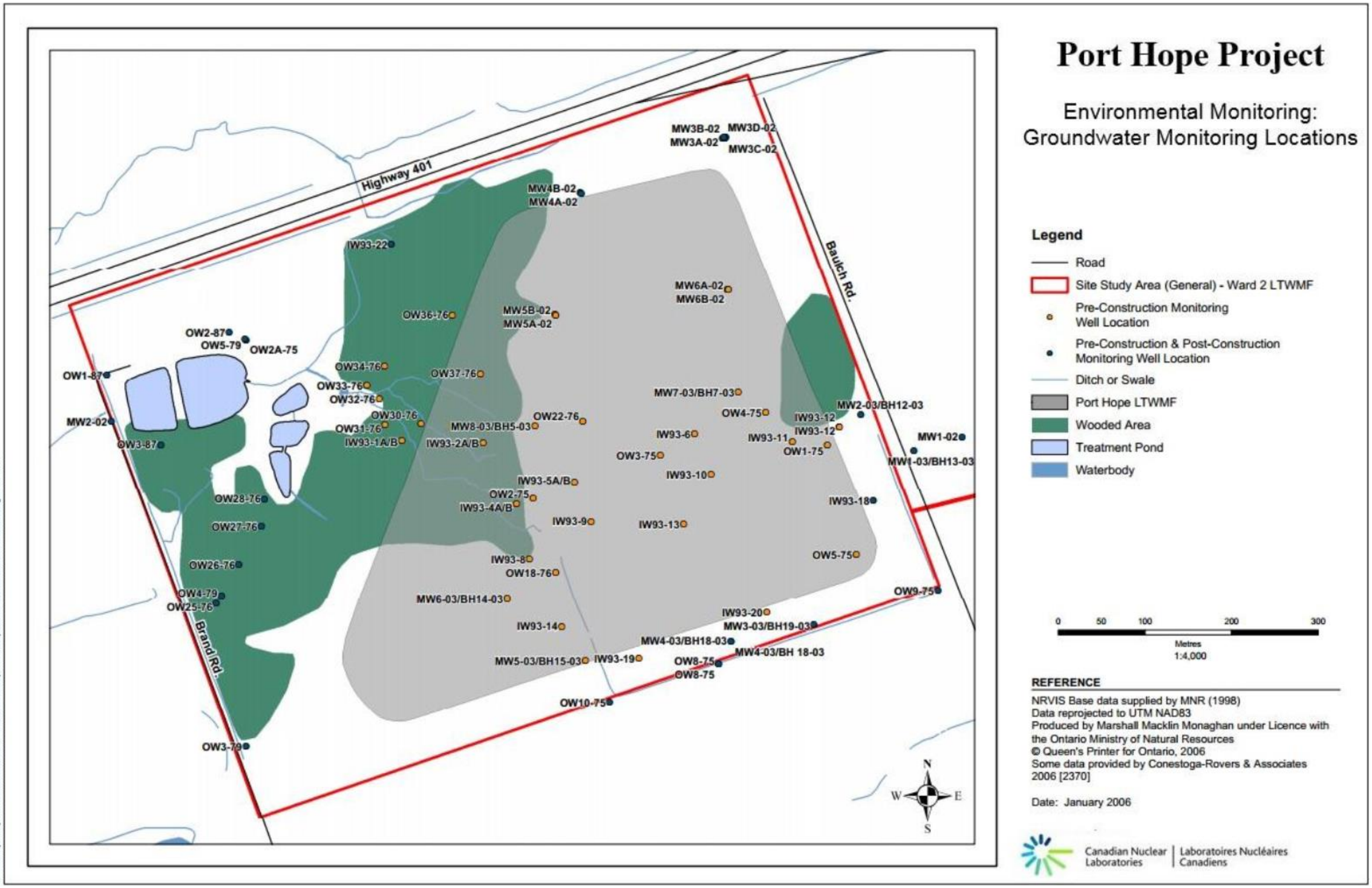
The drainage (i.e., leachate appearing as groundwater seepage) from the Welcome WMF mound (from 2015 to 2016) and the PHP LTWMF mound (from 2017 to 2020) collected in the treatment ponds was sampled twice every year. Slight fluctuations in water quality have been observed over the years. Changes in drainage water quality and volume are expected to occur after remediation work commences. Drainage water onsite is treated prior to release to the environment.

The use of wells and groundwater for water supply in Port Hope is limited mainly to the rural areas. From 2015 to 2020, CNL voluntarily sampled domestic wells on residential properties (ranging from 6 to 16 properties) near the WWMF and analyzed the samples for arsenic, radium-226, uranium and nitrate concentrations as well as for pH. All results were below the Ontario Drinking Water Standards for 2015 to 2020 ([4] – [9]), except in 2015 when nitrate concentration from 1 well exceeded the standard. The source of the elevated nitrate was assumed to be the fertilizers used in the farm fields in the area surrounding the well. Residents have been notified in writing about the results.

**Findings**

Based on the review of CNL's EA and the results of the groundwater monitoring program for the PHP LTWMF, CNSC staff have found that groundwater quality from the PHP LTWMF activities is often below guidelines and within the EA predictions. CNSC are satisfied that groundwater quality remains at levels protective of human health and the environment and that groundwater quality will continue to improve once the project is completed.

**Figure 3.6: Groundwater monitoring locations for the Port Hope LTWMF [38]**



**Human environment**

An assessment of the human environment at the PHP LTWMF site consists of identifying representative persons located within or in proximity to the site and determining whether they could be exposed to radiological or hazardous COPCs, such as by breathing the air, being on the land, drinking and swimming in surface water, and eating plants, fish and wildlife from the area. Representative persons are those individuals who, because of their location and habits, are likely to receive the highest exposures to radiological or hazardous substances from a particular source and therefore potentially have their health harmed by these exposures. In general, human receptors may be exposed to contaminants through 4 primary routes: dermal (i.e., skin), inhalation, incidental ingestion (e.g., soil) and ingestion of food and water.

The EA [68] reviewed the project works and activities to determine the potential of each to interact with the existing human health and safety components of the environment. Each interaction was evaluated to identify if it would result in a measurable change to the environment. Residents in the rural areas adjacent to the LTWMF during construction and development were determined to be the most exposed individuals for potential radiological and hazardous contaminant exposures.

**Exposure to radiological substances**

The *Radiation Protection Regulations* [46] prescribe radiation dose limits to protect workers and the public from exposure to radiation from licensed activities. Doses are either monitored by direct measurement or by estimates of the quantities and concentrations of any nuclear substance released as a result of the licensed activities. The annual effective dose limit for a member of the public is 1 mSv per year.

At the PHP LTWMF, dose to the public is determined through calculation of exposures based on fenceline thermoluminescent dosimeters (TLDs) and radon monitors around the PHP LTWMF and takes into account estimated time spent in proximity to these fences daily. The TLDs are strategically placed along the PHP LTWMF fenceline to account for any dose to members of the public. In the EA, the highest predicted radiation dose to the public as a result of the PHP was 0.25 mSv/y for an infant who is a Ward 2 resident adjacent to the LTWMF during the Construction and Development Phase. This dose is 25% of the public dose limit of 1 mSv/y.

Results from monthly and quarterly deployment of environmental radon monitors and TLDs confirm that public doses from 2012 to 2021 were significantly less than the annual public dose limit (see table 3.8).

**Table 3.8: Estimated annual public doses PHP LTWMF**

| Percentage of the public dose limit | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Public dose limit (µSv) | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| 1,000 | 9% (90.3 µSv/a) | 10% (99.8 µSv/a) | 9% (87.1 µSv/a) | 10% (93.52 µSv/a) | 1% (11.95 µSv/a), | 1% (4.5 µSv/a) | 3% (27.5 µSv/a) | 3.6% (36 µSv/a) | 3.3% (33 µSv /a) | 2.3% (23 µSv/a) |

**Exposure to hazardous substances**

In the EA [68], each of the PHP LTWMF works and activities was reviewed to consider its potential to interact with human health. Air quality was considered in the evaluation for potential effects. Dispersion modelling indicated that there would be measurable changes in the concentrations of TSP, $PM_{10}$, and $PM_{2.5}$ at all residential locations, and that the predicted concentrations would exceed the applicable criteria at adjacent residential locations for $PM_{10}$, as well as at the LTWMF fenceline and residential locations adjacent to the remediation site for $PM_{2.5}$. Air quality modelling also predicted a measurable increase in concentrations of nitrogen oxides ($NO_2$) that would exceed MECP criteria at Wards 1 and 2 adjacent residential locations, and at the LTWMF fenceline. Even with the proposed mitigation measures, it was predicted that $PM_{10}$, $PM_{2.5}$ and $NO_2$ would exceed their 24-hour AAQC [73]. It was concluded there would be no residual effects given most exceedances were eliminated in models that consider plume depletion. The EA follow-up monitoring includes monitoring for TSP and $PM_{2.5}$ to ensure levels remain protective of human health.

**Findings**

Estimated radiological doses to the public have remained well below the public dose limit of 1 mSv per year, indicating that radiological releases from the PHP LTWMF pose a negligible risk to human health (i.e., potential risk to humans is similar to health outcomes in the general public).

With respect to hazardous substances, CNSC staff's review indicated that hazardous releases from the PHP LTWMF pose a negligible risk to human health (i.e., potential risk to humans is similar to health outcomes in the general public).

Based on assessments conducted for the PHP LTWMF, including the review of the annual reports, as well as quarterly and annual environmental monitoring data, CNSC staff have found that impacts to the human environment from radiological and hazardous substances released from the PHP are negligible, and they are satisfied that people living and working near the facility remain protected.

### 3.2.2 Port Granby Project

The PGP involves the design and construction of an engineered above-ground mound to isolate the waste by encasing it in multiple layers of natural and specially manufactured materials. These layers are designed to prevent contaminants from entering the environment. The proposed design and location were approved by the Commission as part of the EA. The PGP LTWMF consists of 2 cells that have been constructed in phases. CNL completed the construction of the cells and commenced waste emplacement in 2016. In 2020, CNL completed the transfer of historic LLRW from the Port Granby WMF into the engineered above-ground LTWMF. In total, 1,315,061 metric tonnes of LLRW were safely transported to the LTWMF from the start of the remediation until the transfer was completed. Progress continues including final grading, erosion control measures, and the construction of the groundwater collection system at the Port Granby site. These activities are expected to be finalized in the fall of 2022. Environmental monitoring is carried out by CNL to ensure the waste remains isolated from the environment. The main environmental monitoring measurements are taken for air, surface water, soil, and groundwater.

By removing the source of contamination from the site, groundwater improvements are expected over time, which will reduce the environmental impact on Lake Ontario. The PGP site will remain in a maintenance and monitoring period for the foreseeable future. CNSC staff will continue their regulatory oversight of the PGP to ensure the protection of the public and environment. The assessment below focuses on the monitoring results from the Construction and Development Phase for the PGP.

#### 3.2.2.1 Port Granby LTWMF

**Atmospheric environment**

CNL is required to characterize the ambient air quality around the PGP (PGP WMF and PGP LTWMF) during the Construction and Development Phase to ensure the project is not impacting the environment. The EA follow-up monitoring activities as described in CNL's monitoring plan for the PGP [40] include monitoring of air quality (radiological and non-radiological parameters) and noise. Air quality monitoring is required primarily during the Construction and Development Phase. However, radon monitoring at the boundary of the LTWMF will extend into the Maintenance and Monitoring Phase.

**Ambient air quality**

Air quality monitoring addresses concentrations of suspended particulate that could be caused by PGP project activities. Management of air quality uses a hierarchical approach starting with observation of visible dust. Personnel trained in the evaluation of visible dust are onsite during construction activities to evaluate the need for improved dust control. During periods of visible dust and to assist trained observers, portable real-time dust monitors are used to take readings at downwind locations along the property line. A PHAI dust administrative control level of 100 µg/m$^3$ total dust particulate (TSP) and PHAI dust AL of 120 µg/m$^3$ TSP averaged over 15 minutes at the site perimeter is outlined for the real-time dust monitoring at the work sites, as per CNL's Dust Management and Requirements Plan [72]. These are internal levels and not required to be reported to external regulators. However, exceeding these levels does trigger actions. These levels are set to ensure that, over the long term, airborne metals levels remain below Ontario's AAQC [73], which are desirable concentrations of a contaminant in air, based on protection against adverse effects on health or the environment. An IDMP is also carried out in addition to that conducted by the prime contractor and CNL. The IDMP designed to monitor dust at the perimeter of PHAI work sites and is not controlled by the prime contractor or CNL. Continuous monitoring occurs during the work hours, and results are reported on a 15-minute interval. An exceedance of the 15-minute interval dust AL triggers an immediate response by CNL and the prime contractor to initiate corrective action to reduce dust levels.

In addition, both TSP and $PM_{2.5}$ (fine particulate matter) are measured using Hi-Vol air samplers operating at 2 locations (see figure 3.7), which must be analyzed in an accredited laboratory. Samplers are located outside the fenceline at the northwestern boundary of the LTWMF, one east of the LTWMF and one south of the LTWMF, and generally allow an evaluation of "upwind" and "downwind" concentrations. Mini-Vol portable air samplers (for both TSP and $PM_{2.5}$) are at the PGP Northwest location as an alternative to high-volume air samplers due to the lack of a power source at that location; the Mini-Vol samplers allow measurements upwind of the Port Granby hamlet. As per CNL's Dust Management and Requirements Plan [72], the TSP filters results are assessed against an overriding limit of 120 µg/m$^3$ averaged over 24 hours. This limit is adopted from Ontario's AAQC. An exceedance of this overriding limit triggers internal actions. Any TSP filter exceeding 100 µg/m$^3$, or the highest TSP sample measured during the week (if none are above 100 µg/m$^3$), is also analyzed for metals from each monitoring location. For $PM_{2.5}$, in 2012, the Canadian Council of Ministers of the Environment (CCME) adopted the Air Quality Management System as a new comprehensive approach to managing air issues [74]. Prior to that, the monitoring results for $PM_{2.5}$ 98th percentile were compared to the 2000 Canadian Air Quality Standards for Fine Particulate Matter value of 30 µg/m$^3$. In 2020, a value of 27 µg/m$^3$ was published by CCME for fine particulate matter ($PM_{2.5}$).

Radiological air quality measurements include TSP, LLA, and radon. Levels of radionuclides are measured on the same TSP filters selected for metals analysis. Radionuclide analysis is carried out for natural uranium, natural thorium, thorium-230, thorium-232, radium-226 and lead-210. LLA is also measured daily at the perimeter locations generally downwind of remedial activities. The LLA results are reviewed daily to provide early indication of any unexpected or unusual levels of airborne radioactivity. Radon monitors are located along the perimeter of the LTWMF as well as at a distance from the LTWMF. Comparison of the baseline levels with the levels measured during the Construction and Development Phase and Maintenance and Monitoring Phase determines the levels associated with project activities.

As per the PHAI Radiation Protection Plan [75], a value of 0.5 Bq/m$^3$, averaged over the time period the sample was acquired, has been adopted as the investigative threshold for LLA in air measurements taken at work sites. The PHAI Radiation Protection Plan also established a limit of incremental average radon levels of 150 Bq/m$^3$ for the PHP LTWMF during phase 2 activities.

**Comparison to EA predictions**

The EA studies predicted TSP to be within Ontario's AAQC annual average of 60 µg/m$^3$ and the 24-hour AAQC of 120 µg/m [73]$^3$. For $PM_{2.5}$ particulate emissions, the Canada-Wide Standard of 30 µg/m$^3$ is not expected to be exceeded at any receptor site, except for occasional slight exceedances along the very edge of the existing PGP WMF property boundary. The concentrations of particulate-bound metals are also predicted to be below 24-hour AAQC limits [73].

Likely effects on radiological air quality were assessed using an air dispersion model in the EA, and it was identified that predicted levels of radionuclides would be below Health Canada reference levels. The highest annual average predicted radon concentration was 5.1 Bq/m$^3$. Since the EA, CNL indicated that the predicted levels in the EA were set to an unachievable level and should be re-evaluated. CNL also noted that during the baseline study, different radon monitoring equipment was used for radon measurements and that it is not recommended for comparison to the current monitoring scheme which uses RSSI alpha-track detectors. In a memorandum to the CNSC, CNL defined the radon gas concentration of 150 Bq/m$^3$ as the base concentration and received approval in July 2014. Exceeding this concentration triggers follow-up actions such as ascertaining of dose to the public.

Atmospheric monitoring data for TSP from 2015 to 2020 is summarized below (see table 3.9). Between 68 and 248 samples at each location have been collected per year from each high-volume air sampler (TSP and $PM_{2.5}$) for the PGP site. The overriding limit of 120 µg/m$^3$ for TSP has been exceeded occasionally over the years. For instance, the TSP limit was exceeded from 2016 to 2020, with the highest number of exceedances representing 8% of total samples (e.g., in 2016 at the PGP Northwest location during a period of very dry and hot weather conditions).

Exceedances were attributed to a mixture of both onsite and offsite activities based on wind directions and dust exceedances observed by independent real-time dust monitoring. Appropriate follow-up actions were performed. The AAQC for $PM_{2.5}$ of 30 µg/m$^3$ (98th percentile averaged over 3 years) was exceeded occasionally over the monitoring period, as predicted in the EA. There was 1 exceedance of the AAQC [73] for iron in 2016 and for nickel in 2020. However, these exceedances were attributed to offsite activities. All radionuclides remained well below the Health Canada reference values. As the Construction and Development Phase is coming to an end at the PGP (as of 2022), particulate exceedances due to site activities are no longer expected.

For the independent dust monitoring, there were occasional exceedances of the 15-minute average AL of 120 µg/m$^3$ [72]. When exceedances occurred, the contractor used water as a dust suppressant, minimized dust-generating activities and worked to optimize dust mitigation practices. Although the dust AL was exceeded, there were no exceedances of the AAQC for metals or the Health Canada reference levels from the high-volume air samplers located at the perimeter of the controlled area on those days.

Radon measurements are taken monthly at the fenceline for a total of 7 locations at the PGP LTWMF and PGP WMF as a representative reading of doses to the public. Measurements were below the reporting AL of 150 Bq/m. For instance, the average radon measurement was 111 Bq/m$^3$ in 2020.

**Findings**

Based on the review of CNL's EA and the results of the atmospheric monitoring program for the PGP, CNSC staff have found that airborne emissions from the PGP often remained below the provincial standards and within the EA predictions; therefore, they are satisfied that ambient air quality remained at levels protective of human health and the environment. Exceedances due to the project activities of TSP and dust were followed up on appropriately, and all metals and radionuclides remained below their respective criteria. As the PGP is moving into the Maintenance and Monitoring Phase, the risks for atmospheric contamination during construction and development are no longer present and exceedances are not expected moving forward.

**Table 3.9: Annual concentrations of TSP in ambient air as measured around the PGP LTWMF facility**

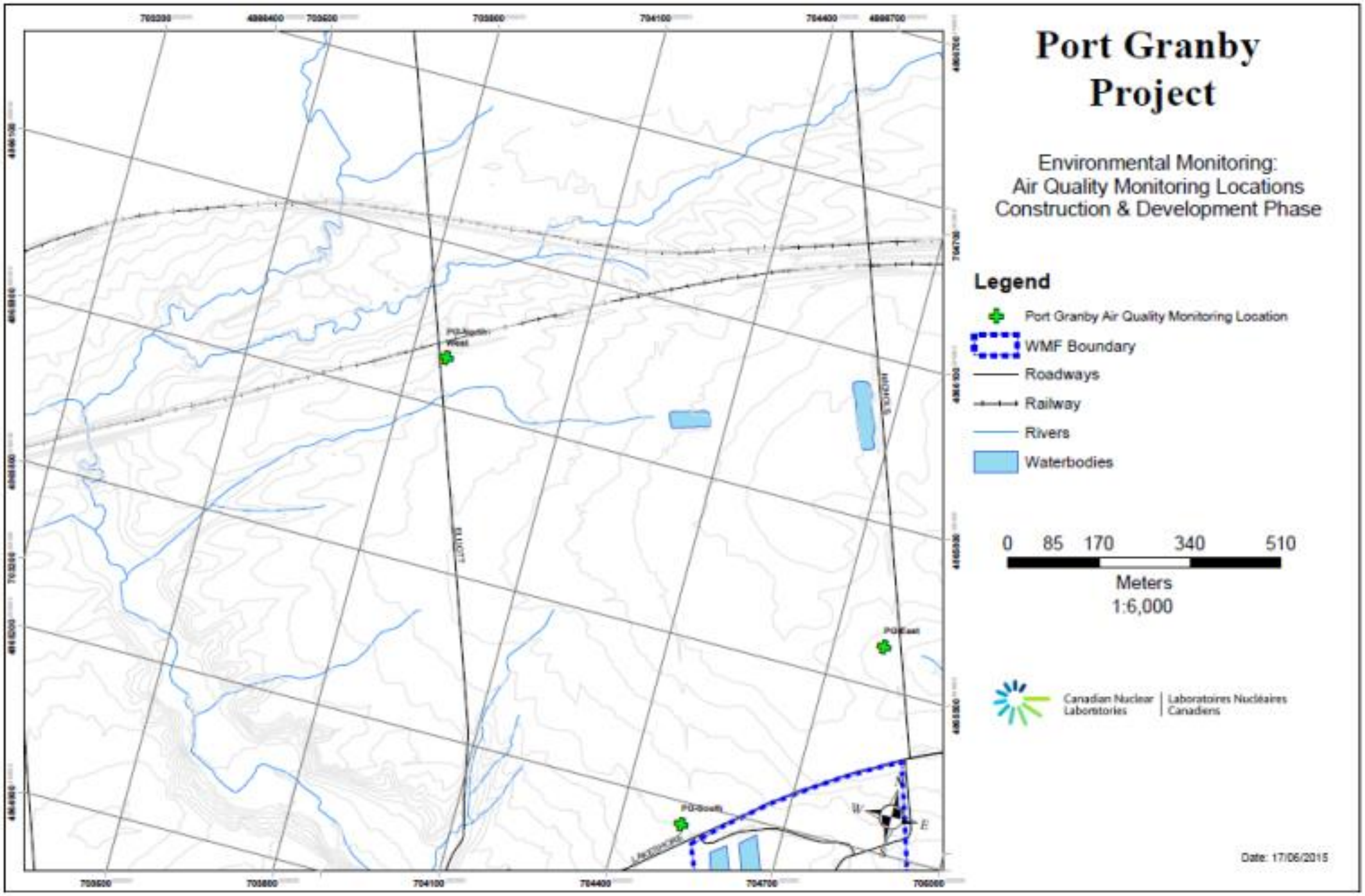
| Hi-Vol station | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Overriding limits |
|---|---|---|---|---|---|---|---|---|
| PGP South | Average* (µg/m$^3$) | 12 | 20 | 16 | 22 | 17 | 18 | 120 µg/m$^3$ TSP [48] |
| PGP South | Maximum (µg/m$^3$) | 47 | 166** | 170** | 223** | 161** | 184** | 120 µg/m$^3$ TSP [48] |
| PGP East | Average* (µg/m$^3$) | 12 | 20 | 16 | 20 | 15 | 16 | 120 µg/m$^3$ TSP [48] |
| PGP East | Maximum (µg/m$^3$) | 48 | 259** | 179** | 157** | 71 | 56 | 120 µg/m$^3$ TSP [48] |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PGP Northwest | Average* (µg/m$^3$) | NA | 23 | 16 | 17 | 17 | 14 | 120 µg/m$^3$ TSP [48] |
| PGP Northwest | Maximum (µg/m$^3$) | NA | 1392** | 91 | 120 | 106 | 271** | 120 µg/m$^3$ TSP [48] |

*average presented as geometric mean

**indicate above overriding TSP limit of 120 µg/m$^3$ [48]

**Figure 3.7: Air quality monitoring locations for the construction and development phase of the Port Granby Project [40]**



**Noise monitoring**

Noise monitoring takes place at 9 locations during the Construction and Development Phase, to capture potential noise levels from construction activity at locations surrounding the PGP WMF and PGP LTWMF. Continuous sound measurements using an integrated sound measurement meter are undertaken seasonally, 4 times per year, for 3 days in each season during anticipated times of peak construction activity. No noise monitoring will take place in the Maintenance and Monitoring Phase as there are no sources of noise associated with the PGP in this phase.

The guidance level of 70 decibels (dBA) (24-hour weighted average), as per the WHO Guideline for Community Noise [78], is used for the project, as construction activities are being limited to daytime hours.

**Comparison to EA predictions**

The EA studies predicted the worst-case hourly noise levels at maximum zones of influence to be 56 dBA at the PGP WMF and PGP LTWMF. There has been a general increase in noise levels unrelated to the project since the initial 2004 EA due to an increase in road and train traffic. Therefore, CNL has proposed that data from 2015 provides a better baseline as there was no outdoor construction in 2015. Baseline values from 2015 occasionally exceeded the 70 dBA WHO guideline [78]. Noise values since 2015 have been comparable to the 2015 baseline values.

**Findings**

Based on the review of CNL's EA and the results of the noise monitoring program for the PGP, CNSC staff found that noise levels from the PGP activities are comparable to baseline levels and, therefore, that noise remains at levels protective of human health.

**Terrestrial and aquatic environment**

**Soil quality**

The project is expected to have the beneficial effect of improving soil quality at cleanup sites through the removal of contaminated materials. Potential adverse effects would be expected on soil quality for areas beyond the excavation sites related to the accumulation of contaminants on surface soil from the airborne transport of soil and dust. Soil quality data is collected for comparison to the existing baseline soil quality data in these areas in order to identify any incremental increases. Soil monitoring around the site perimeters will be continued for a year following completion of remedial activities to demonstrate that any accumulation of soil contaminants that may have been observed over the Construction and Development Phase has ceased.

**Comparison to EA predictions**

Monitoring in surface soil at the PGP site perimeter is carried out annually at 5 locations: 4 at the LTWMF perimeter and 1 at the PGP WMF perimeter (see figure 3.8), for both radiological COPCs (e.g., radium-226) and hazardous COPCs (e.g., arsenic, uranium). A full list of monitored COPCs can be found in CNL's monitoring plan [40]. Soil monitoring results are compared to baseline values [48] and EA predictions.

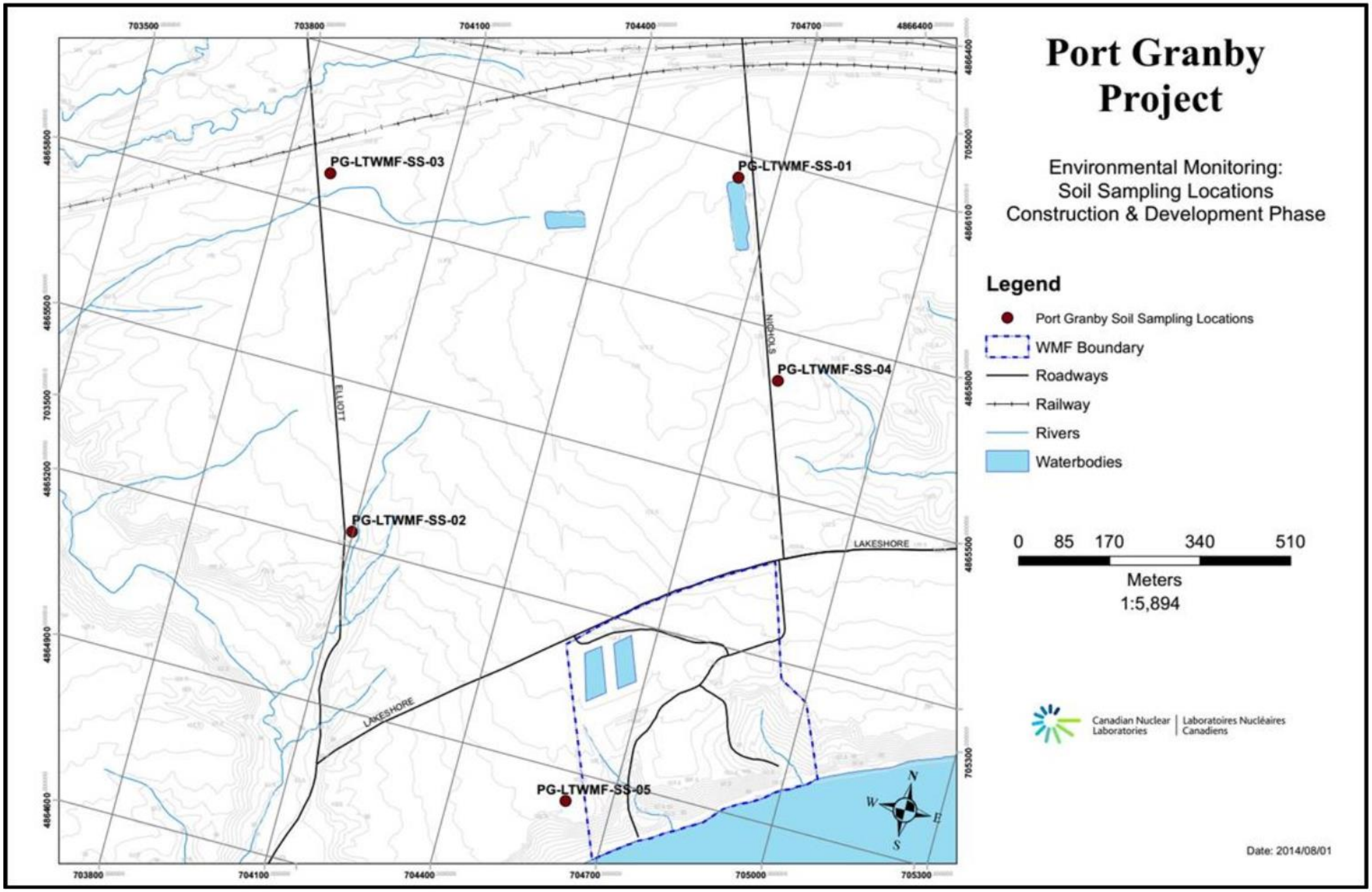
The EA studies predicted that the largest mean incremental concentrations of most radiological contaminants will be less than 20% of background at remediation sites. The exception is thorium-230, which is expected to increase 38% over baseline levels during the construction and development phase of the project. In 2021, soil concentrations of thorium-230 have remained consistent with baseline data.

Concentrations of all parameters are comparable to previous years' concentrations, indicating PGP activities are not having an adverse impact on soil quality from airborne transport of radiological and hazardous substances.

**Findings**

Based on the review of CNL's EA and the results of the soil monitoring program for the PGP, CNSC staff have found that soil surrounding the PGP activities is below the guidelines and within the EA predictions. Therefore, soil quality remains at levels protective of human health and the environment, and airborne transport of soil and dust from the project is not affecting the soil quality around the site. As the PGP is almost transitioned to phase 3 (as of 2022), impacts on soil due to project activities are not expected, moving forward.

**Figure 3.8: Soil sampling locations for the construction and development phase of the Port Granby Project [40]**



**Surface water quality**

The EA follow-up activities with respect to surface water quality involve the collection and analyses of surface water samples at locations down-gradient of the PGP to:

- verify predicted improvements in surface water
- ensure that discharges are not deleterious to aquatic life
- verify reduction of contaminant loadings due to leachate discharging to Lake Ontario

Decreases in contaminant concentrations are not expected until the waste is remediated. At that point, water quality is expected to improve over the longer term as a result of the cleanup. Surface water sampling in Port Granby Creek and in Lake Ontario will be continued for a period of at least a year following completion of phase 2.

Surface water sampling in Port Granby Creek, a tributary of Port Granby Creek, and in Lake Ontario around the treated effluent discharge, is sampled quarterly throughout the Construction and Development Phase. There are 7 sampling locations: 2 in Port Granby Creek, 2 within the Port Granby Creek Tributary (flow permitting), and 3 in Lake Ontario (see figure 3.9). Lake Ontario samples include 1 sample near/at the diffuser in Lake Ontario, 1 sample 20 m west of the diffuser location and 1 sample 20 m east of the diffuser location. Many parameters are analyzed in surface water samples, ranging from general chemistry (e.g., hardness, TSS), total metals (e.g., arsenic, lead, uranium), radionuclides (e.g., radium-226, lead-210, thorium-230), and field-measured parameters (e.g., dissolved oxygen, temperature, turbidity). A full list of parameters can be found in CNL's monitoring plan [40].

The surface water results are compared to CCME [70] and PWQO [71]. CNL must also ensure that the discharge is not deleterious to the aquatic environment (fish) at the point of discharge; and appropriate monitoring must be employed to confirm this.

**Comparison to EA predictions**

The EA predicted that the removal of contaminated material at the existing PGP WMF site would result in a short-term increase in contaminant concentrations during the Construction and Development Phase. However, levels were not predicted to exceed criteria and overall the removal would provide a long-term improvement to down-gradient surface water quality. Concentrations of arsenic and uranium in the treated leachate plume in Lake Ontario were predicted to increase by approximately 70% due to an increased volume of leachate arising from collection and treatment of waste contact water during excavation. Concentrations are predicted to approach, but not exceed, chronic toxicity effect levels for aquatic invertebrates; concentrations are also not predicted to exceed effect levels for fish. Loadings to Port Granby Creek were predicted to increase slightly (6% or less). Water quality over the longer term is expected to return to baseline in Port Granby Creek and will be improved relative to baseline in Lake Ontario near the treated effluent discharge.

Results from quarterly samples in Port Granby Creek were generally consistent from 2015 to 2020, suggesting that construction of the PGP is not having an adverse effect on Port Granby Creek water quality. There have been occasional exceedances of the PWQO [71] over the monitoring period for some parameters. For instance, the PWQOs [71] and the CWQGs [71] [70] for iron were exceeded at the upstream locations in Port Granby Creek in January 2020. An offsite source is likely responsible for the elevated level as streams in the local study area exceeded water quality guidelines for fluoride and iron during the baseline monitoring. Such exceedances are typical for agricultural/urban watersheds in the region, and iron is not a key COPC associated with the PGP. In the Lake Ontario samples, there were no exceedances of the PWQOs [71] or CWQGs [70], except for fluoride (which had only slight elevations over the monitoring years). Elevated fluoride concentrations are typical for the nearshore zone of the lake in this region and results were well under the Ontario drinking water quality standard of 1.5 mg/L [80]. Other monitoring results are generally consistent with the monitoring data for the past few years, suggesting that PGP operations are not having an adverse effect on Lake Ontario water quality.

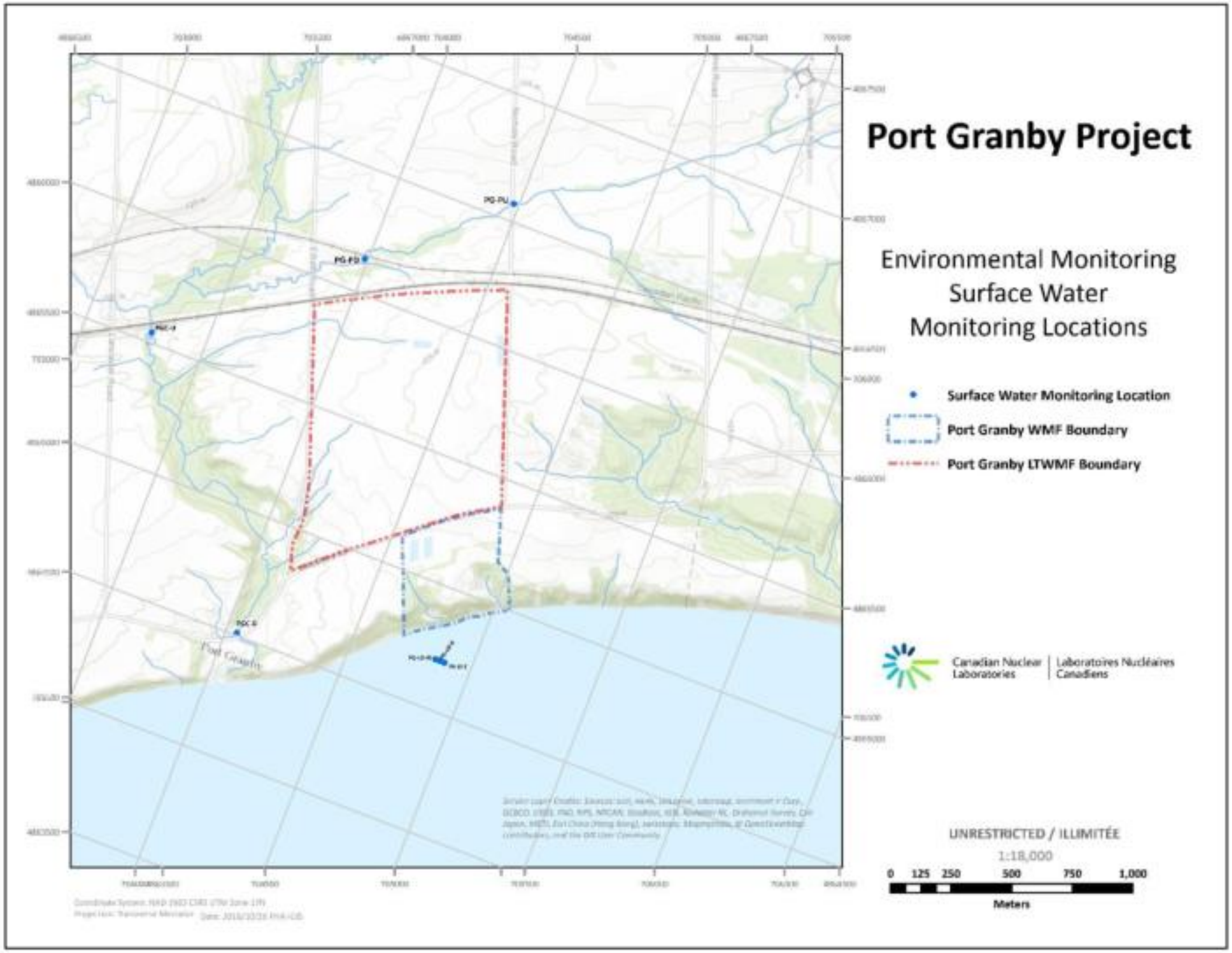
**Table 3.10: Annual average concentrations of uranium in the Lake Ontario average surface water monitoring locations, in µg/L**

| Location | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Limits | |
|---|---|---|---|---|---|---|---|---|
| PG-LO-D | 0.40 | 0.36 | 0.35 | 0.37 | 0.36 | 0.33 | PWQO: 5 µg/L [71] | CWQG: 15 µg/L [70] |
| PG-LO-E | 0.39 | 0.36 | 0.36 | 0.37 | 0.35 | 0.34 | PWQO: 5 µg/L [71] | CWQG: 15 µg/L [70] |
| PG-LO-W | 0.40 | 0.36 | 0.35 | 0.38 | 0.35 | 0.33 | PWQO: 5 µg/L [71] | CWQG: 15 µg/L [70] |

**Findings**

Based on the review of CNL's EA and the results of the surface water monitoring program for the PGP, CNSC staff found that water quality from the PGP activities is below guidelines and within the EA predictions and, therefore, surface water quality remains at levels protective of human health and the environment (see table 3.10). Water quality will continue to improve as the PG WMF has been remediated.

**Figure 3.9: Surface water monitoring locations for the construction and development phase of the Port Granby Project [40]**



**Sediment quality**

For the Port Granby Creek, no EA follow-up sediment quality monitoring during the Construction and Development Phase is required, unless receiving water quality monitoring suggests the possibility of sediment quality impairment. In that case, sediment monitoring would focus on depositional areas. If upset releases of suspended solids occur during the Construction and Development Phase, then biannual sediment sampling will take place during the first year of the Maintenance and Monitoring Phase of the PGP.

For Lake Ontario, during the Construction and Development Phase sediment quality samples are collected in the spring and fall in two locations along the Lake Ontario shoreline in the vicinity of the East and West Gorge and analyzed for radium-226, thorium-230, thorium-232, lead-210, and metals.

Arsenic has often exceeded the applicable provincial and federal sediment quality guidelines and several effect-based benchmarks at 2 locations with the exception of 2016, which was below guidelines and benchmarks. These results are likely due to natural sediment susceptibility to erosion which may lead to the brief deposition of near shore sediments with elevated levels of metals and radionuclides in Lake Ontario after every storm event. Sediment quality is expected to improve once remediation of the PGP site is complete. Monitoring will continue throughout the construction and development phase to evaluate the efficacy of mitigation measures intended to control off-site migration of contaminated wastes during excavation.

**Findings**

Based on the review of CNL's EA and the results of the sediment monitoring program for Lake Ontario at the PGP, CNSC staff have found that sediment quality was below guidelines for most parameters measured. CNSC staff are satisfied that sediment quality remains at levels protective of human health and the environment and sediment quality is expected to improve once remediation of the PGP site is complete.

**Hydrogeological environment**

**Geology and groundwater environment**

The Port Granby site (PGP LTWMF and PGP WMF) is located in the Lake Iroquois Plain physiographic region, south of the Oak Ridges Moraine and the former glacial Lake Iroquois shoreline. This is primarily a glaciolacustrine clay and sand plain that extends south to Lake Ontario. The surficial geology in the area around the site is primarily sand and gravel, with sandy silt to sand till glacial deposits. The main surface water features include Lake Ontario, as well as the Port Granby Creek and East Granby Creek.

Groundwater in the region generally flows south toward Lake Ontario, mimicking the ground surface topography and the top of bedrock trends. Aquifers are found in both the overburden (including sand and gravel) and the bedrock. The local shallow groundwater flow in the area north of Lakeshore road follows a west-to-east pattern towards Port Granby Creek, whereas flow in the area south of Lakeshore Road is in a more north-to-south pattern. All groundwater ultimately discharges into Lake Ontario.

### Groundwater quality

Of the 39 groundwater wells to be monitored as part of the biophysical effects management program, 37 wells were suitable for monitoring in 2015 (see figure 3.10 for monitoring well locations). The groundwater wells were sampled on a quarterly basis in 2015. On the site of the PGP WMF, the groundwater quality is expected to be improved significantly once waste removal is completed.

Of the 39 groundwater wells to be monitored as part of the PGP Environmental and Biophysical Monitoring Plan [40], 4 have not been located on the PGP WMF since 2013, 3 were decommissioned in April 2016 due to the construction of the PGP LTWMF, and 11 located on the PGP WMF site have not been sampled since the remediation on the site commenced in 2016 due to ongoing construction and inaccessibility. The remaining 21 wells located around the PGP LTWMF were sampled on a quarterly basis from 2016 to 2020.

The sampling results (quarterly measurement and annual average) of the 21 wells for 2015 to 2020 were compared against the Water Quality Criteria for Potable Groundwater Conditions tabled in the PGP Screening Report [34], which is conservative since onsite water is not potable. In addition, results were compared to the EA predictions [69] and Ontario's groundwater standards [79]. Overall, sampling results for key COPCs have been consistently below the limits since 2015.

### Drainage water quality

Drainage water is defined as runoff water and water contained within ditches (which may include groundwater discharging to a ditch) that does not support aquatic resources.

At the PGP LTWMF, drainage water samples were collected from 2 locations (PG-SW1 and PG-SW2) from 2015 to 2020. It should be noted that PGSW2/DP2-02 was not sampled from 2016 to 2020 as the existing pond had been removed as part of the site preparation work for the PGP LTWMF. The results of the sampling were compared against the PWQOs [71] and the CWQGs [70] and indicated that fluoride exceeded the CWQG at PG-SW1/DP1-02 from 2018 to 2020, and phosphorus exceeded CWQG from 2015 to 2020. However, exceedances had been observed in previous years for fluoride and phosphorus in drainage water prior to emplacement of the waste, and as such are not likely related to the operation of the facility. The rural nature of the site and the associated farming activities would likely contribute to the elevated phosphorus levels in the pond.

### Operational groundwater monitoring

Operational wells on the PGP WMF were used to detect any migration of contaminants from the PGP WMF via the groundwater pathway. Twelve of 17 available observation wells were sampled in October 2015. Each groundwater sample was analyzed for concentrations of radium-226, arsenic, uranium, fluoride, nitrate and ammonium. The elevated concentration of the contaminants in groundwater is a result of the existing PGP WMF, which does not have an engineered liner or cover system in place. These elevated levels are expected to decline following the remediation. The operational groundwater wells were decommissioned in 2016 as they were located within or adjacent to the PGP WMF excavation areas. The re-installation of these wells will be evaluated in the Maintenance and Monitoring Phase after the remediation and final grading of the sites are complete.

### Groundwater seepage monitoring (bluff)

Bluff seepage to Lake Ontario is occurring along the midpoint of the bluffs below the PGP WMF. This seepage, consisting of shallow groundwater flow from a till layer, is estimated at the rate of 51,100 $m^3$ per year [69]. A sampling program of typical seepage water from the south bluffs was initiated in 2010 at the request of the CNSC.

Seepage from the south bluffs is sampled quarterly from 3 locations (PG-S-1, PG-S-2, and PG-S-3) along the Lake Ontario bluffs between the East George and West George (see figure 3.10), accessibility and other conditions permitting. Sampling from PG-S-3 was not conducted in October 2020 due to limitations from accessibility and will be ceased in the future.

The sampling results [19] during the monitoring period indicates that the sampled contaminant concentrations fluctuate over time and that some contaminants have been decreasing since 2015. There are elevated levels of fluoride, arsenic, uranium and nitrates that are above Ontario's PWQO [71] and/or the CWQG [70]. Contaminants being released to Lake Ontario through bluff seepage are expected to decrease over time as the PGP WMF has been remediated. Surface water sampling for bluff seepage will continue for at least a year following completion of the LTWMF. Subsequently, if bluff seepage water quality is at baseline or improved relative to baseline, as expected, then both the sampling frequency analytical parameters will be reduced.

### Residential wells

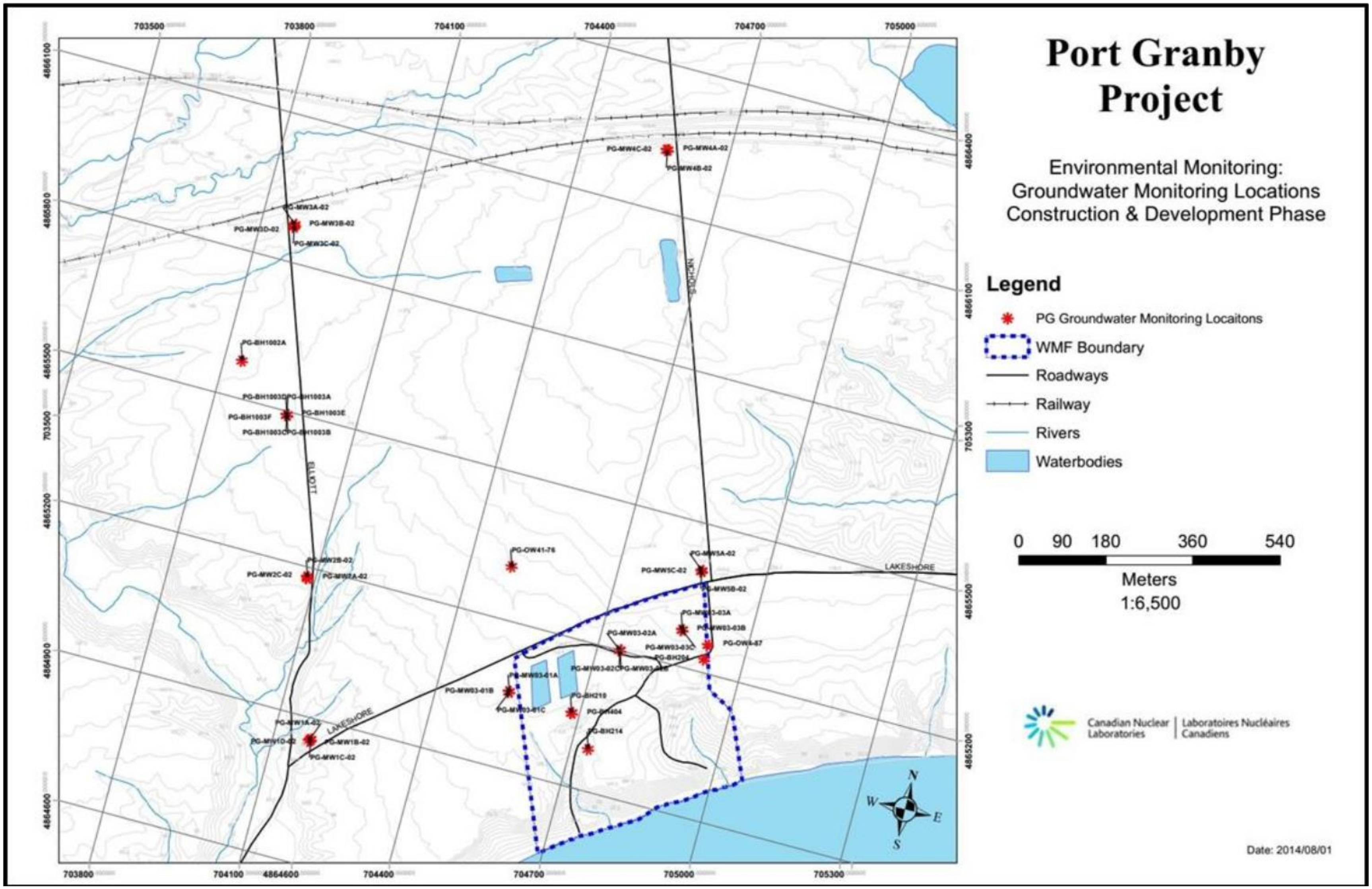
The PGP LTWMF and the WMF site is in the southern portion of the Municipality of Clarington and the south western portion of the Municipality of Port Hope. The majority of residents in this area depend on private wells for their water supply. All of these private wells are located up gradient of the WMF. It is not expected the site would have impact on the residential wells. There are no actively used private water wells in the immediate area of the PGP LTWMF and the PGP WMF [69].

### Geotechnical monitoring program

The contractor and CNL have conducted geotechnical inspections and monitoring (including instrument monitoring and regular visual observations) in order to provide continued assurance that erosion does not threaten the integrity of the waste storage area during the remaining lifetime of the PGP WMF site. Weekly and monthly geotechnical reporting ceased in 2020 as they were no longer required [19].

Some surface sloughing occurred in areas of exposed soil with high water content. Minor sloughing was repaired using rip-rap, silt fencing and/or clean fill as required

**Figure 3.10: Groundwater monitoring locations for the construction and development phase of the Port Granby Project [40]**



## Human environment

An assessment of the human environment at the PGP site consists of identifying representative persons located within or in proximity to the site and determining whether they could be exposed to radiological or hazardous COPCs, such as by breathing the air, being on the land, drinking and swimming in surface water, and eating plants, fish and wildlife from the area. In general, human receptors may be exposed to contaminants through 4 primary routes: dermal (i.e., skin), inhalation, incidental ingestion (e.g., soil) and ingestion of food and water. Representative persons are those individuals who, because of their location and habits, are likely to receive the highest exposures to radiological or hazardous substances from a particular source and therefore potentially have their health harmed by these exposures.

The EA [69] reviewed the project works and activities to determine the potential of each to interact with the existing human health and safety components of the environment. Each interaction was evaluated to identify if it would result in a measurable change to the environment. Residents adjacent to the PGP during construction and development were determined to be the most exposed individuals for potential radiological and hazardous contaminant exposures.

### Exposure to radiological substances

The *Radiation Protection Regulations* [46] prescribe radiation dose limits to protect workers and the public from exposure to radiation from licensed activities. Doses are either monitored by direct measurement or by estimates of the quantities and concentrations of any nuclear substance released as a result of the licensed activities. The annual effective dose limit for a member of the public is 1 mSv per year.

At the PGP, dose to the public is determined through calculation of exposures based on fenceline TLDs and radon monitors around the PGP, as well as accounting for estimated time spent in proximity to these fences daily. The highest predicted radiation dose to the public as a result of the PGP was 0.12 to 0.15 mSv/y (upper bound dietary intakes) for an adjacent resident child and infant. This dose is within 15% of the CNSC public dose limit of 1 mSv/y

Results from monthly and quarterly deployment of environmental radon monitors and TLDs confirm that a public doses from 2012 to 2020 were significantly less than the annual public dose limit (see table 3.11).

**Table 3.11: Estimated annual public doses for the PGP**

| Percentage of public dose limit | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Public dose limit (µSv) | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| 1,000 | 1% (7.2 µSv/a) | 1% (8.4 µSv/a) | 1% (6.6 µSv/a) | <1% (8.4 µSv/a) | <1% (5.43 µSv/a) | <1% (5.71 µSv/a) | 2% (20 µSv/a-) | <4% (39.6 µSv/a) | 2% (20 µSv/a) | 4.1% (41 µSv/a) |

**Exposure to hazardous substances**

In the EA [69], each of the PGP LTWMF works and activities was reviewed to consider its potential to interact with human health. Air quality was considered in the evaluation for potential effects. Dispersion modelling indicated that there would be measurable changes in the concentrations of $PM_{10}$, and $PM_{2.5}$ at all adjacent residential locations. However, air quality modelling also predicts that all 24-hour average concentrations of $PM_{10}$, and $PM_{2.5}$ would be below the established criteria. Similarly, measurable changes in CO, $NO_2$ and $SO_2$ were predicted, but no exceedances of established ambient air quality criteria for any of the parameters at any residential location are expected. The EA predicted that no unacceptable health risks would occur as a result of the project works and activities. However, EA follow-up monitoring includes monitoring for TSP and $PM_{2.5}$ to ensure levels remain protective of human health.

**Findings**

Estimated radiological doses to the public remain well below the annual public dose limit of 1 mSv per year, indicating that radiological releases from the PGP pose a negligible risk to human health (i.e., potential risk to humans is similar to health outcomes in the general public).

With respect to hazardous substances, CNSC staff's findings indicate that hazardous releases from the PGP pose a negligible risk to human health (i.e., potential risk to humans is similar to health outcomes in the general public).

Based on assessments of the PGP, including the review of the annual reports and annual environmental monitoring data, CNSC staff have found that impacts to the human environment from radiological and hazardous substances released from the PGP are negligible, and that people living and working near the facility remain protected. As the PGP is moving into phase 3, potential effects from project activities are expected to decrease.

# 4.0 CNSC Independent Environmental Monitoring Program

The IEMP implemented by the CNSC is meant to add to the body of evidence that Indigenous peoples, the public and the environment around licensed nuclear facilities are protected and that there are no anticipated health impacts. It is separate from, but complementary to the CNSC's ongoing compliance verification program. The IEMP involves taking samples from public areas around the facilities and measuring and analyzing the amount of radiological and hazardous substances in those samples. CNSC staff collect the samples and send them to the CNSC's laboratory in Ottawa for testing and analysis.

## 4.1 IEMP at the PHAI sites

CNSC staff conducted IEMP sampling around the PHAI sites in 2013, 2014, 2017 and 2019. The sampling plan focused on radiological and hazardous contaminants and took into consideration CNL's environmental monitoring program and the CNSC's regulatory knowledge of the site.

In 2019, the most recent campaign, CNSC staff collected the following samples in publicly accessible areas outside the perimeter of the PHAI sites:

- water (15 locations)
- sediment (4 locations)

Samples were analyzed by qualified laboratory specialists in the CNSC's laboratory, using appropriate protocols. CNSC staff measured radionuclides (i.e., radium-226, uranium), hazardous substances (i.e., arsenic, ammonia), phosphorous, pH and total dissolved solids in the collected samples.

Figure 4.1 provides an overview of the sampling locations for the 2019 IEMP sampling campaign around the PHAI sites. The IEMP results were published on the CNSC's PHAI IEMP dashboard [81].

**Figure 4.1: Overview of the 2019 sampling locations [22]**


## 4.2 Indigenous participation in the IEMP

It is a priority for the CNSC that IEMP sampling reflect Indigenous traditional land use, values and knowledge, where possible. In 2019, in advance of the IEMP sampling campaigns at the PHAI sites, notification emails were sent to all Indigenous Nations and communities near Port Hope and Port Granby, inviting suggestions for species of interest, valued components or potential sampling locations where traditional practices and activities may take place.

CNSC staff did not receive any comments specific to the 2019 IEMP at the PHAI sites. The CNSC is committed to engaging with Indigenous Nations and communities and will collaborate with interested Nations and communities for the upcoming campaign, tentatively planned for 2023.

## 4.3 Summary of results

The levels of radium-226, uranium, arsenic, ammonia, phosphorous, pH and total dissolved solids in all the water and sediment samples measured during the 2019 IEMP sampling campaign were below available guidelines and CNSC screening levels and were similar to the range of results from the 2013, 2014 and 2017 IEMP sampling campaigns for the PHAI sites. Results for all PHAI campaigns are published on the CNSC website [81].

The IEMP results add to the body of evidence that Indigenous Nations and communities, the public and the environment in the vicinity of the PHAI sites are protected and that there are no anticipated health impacts from operations at the facilities. These results are consistent with those submitted by CNL and reviewed by the CNSC's environmental protection staff, demonstrating that the licensee's environmental protection program protects the health and safety of people and the environment.

# 5.0 Health studies

The following section draws from the results of regional, national and international health studies, reports and publications to provide further independent verification that the health of people living near or working at CNL's PHAI sites is protected. Various organizations and institutions in Ontario—such as Cancer Care Ontario; Public Health Ontario; the Haliburton, Kawartha, Pine Ridge District Health Unit; and the Durham Region Health Department—monitor the health of local and surrounding populations.

To complement the CNSC's regulatory oversight, CNSC staff continuously work towards strengthening relationships with the various health units and offices. CNSC staff also keep abreast of any new publications and data related to the health of populations living near or working at diverse nuclear facilities. Lastly, CNSC staff, at times, conduct health studies on select populations through their research on the effects of low dose (and low dose-rate) exposures. Select community and Canadian publications are discussed below. Additional information on health studies related to nuclear facilities is available on the CNSC web page on health studies [82].

## 5.1 Population and community health studies and reports

The PHAI sites are situated in Northumberland County, where Port Hope is located, as well as in Durham Region, which encompasses Port Granby and Clarington. Information about these regions is captured by their respective health districts—the Haliburton, Kawartha, Pine Ridge District Health Unit and the Durham Region Health Department—as well as more broadly by the statistics reported by Cancer Care Ontario. It is important to note that Durham Region is largely urban, and health statistics may not be as representative of Port Granby, a rural area within the region.

### 5.1.1 Haliburton, Kawartha, Pine Ridge District Health Unit

The Haliburton, Kawartha, Pine Ridge (HKPR) District Health Unit routinely monitors the prevalence of known risk factors and the health status of residents within the health district. Existing provincial cancer incidence, mortality and risk factor databases are used for disease and risk factor surveillance and health planning.

The most recent community health summary (2020) and profile (2017) examine health outcomes and factors that affected the health of people living in areas serviced by the HKPR District [83] [84]. Reports use data from a variety of sources, including from the Ontario Ministry of Health and Long-term Care, Public Health Ontario, the Canadian Cancer Care Registry, and the Canadian Community Health Survey. The leading causes of mortality in 2015 for the HKPR District and for Ontario were cancers, circulatory diseases (e.g., heart attack, heart disease and stroke) and respiratory diseases (e.g., influenza, pneumonia and chronic obstructive pulmonary disease). The age-standardized mortality rate from overall preventable causes in 2015 in the HKPR District was higher than in Ontario for preventable injury mortality, but not significantly different for preventable cancer mortality. This may reflect limited medical access (e.g., screening) given the rural characteristics of much of the area. While cancer incidence rates were similar to the rates for Ontario from 2012 to 2014, higher lung cancer incidence was observed. This may be due to generally higher smoking rates in the HKPR District compared to Ontario.

### 5.1.2 Durham Region Health Department

The Durham Region Health Department (DRHD) routinely monitors the health status of Durham Region using health indicators and health data from sources such as hospitals and laboratories, among other record-storing facilities and databases.

The DRHD publishes an overview report through the Health Neighbourhood Project [85], which examines information for 50 health neighbourhoods in Durham Region. The report provides a picture of how health varies among communities and includes demographic and health indicators. As expected, due to Durham Region's diverse population, with a mix of urban and rural populations, Durham Region's performance compared to the province of Ontario is better or poorer, depending on the health indicator. For example, Durham Region has a higher prevalence of diabetes and lung disease (including chronic obstructive pulmonary disease) compared to Ontario, whereas life expectancy and reported cancer screening levels are higher than the province of Ontario.

The DRDH has also published community health reports that specifically examined mortality [86] and cancer incidence [87] in Durham Region. The reports use data collected by the Office of the Registrar General, Service Ontario, and from the Ontario Cancer Registry. The leading causes of mortality in Durham Region and in Ontario from 2010 to 2012 were heart disease, lung cancer and dementia, which accounted for close to a third of all deaths. The most common cancers in males were prostate, lung and colorectal, accounting for half of new cancer cases. In females, breast, lung and colorectal cancer made up half of new cancer cases. This is similar to cancer incidence statistics for the general Canadian population [88].

### 5.1.3 Cancer Care Ontario

Cancer Care Ontario, through its Ontario Cancer Profiles [89], provides interactive map-based dashboards that display key public health indicators including cancer incidence, mortality and risk factors. Major risk factors for cancer development include physical inactivity, excess body weight or obesity, smoking, poor diet, and excessive alcohol consumption. Regional statistics are available by public health unit and the Local Health Integration Network (LHIN). The PHAI sites lie within the Central East LHIN, encompassing a large area that includes Northumberland County and Durham Region.

In 2018, the Central East LHIN, the HKPR District Health Unit and the DRHD had similar incidence and mortality rates for all cancers combined compared to Ontario. Incidence rates for lung cancer for both sexes and lung cancer mortality rates in females were higher in the HKPR District Health Unit. From 2015 to 2017, the rates for alcohol consumption and sedentary behaviour were higher for the HKPR District Health Unit and the DRHD than for Ontario. Rates for smoking and excessive body weight were significantly higher for the HKPR District Health Unit.

The Cancer Risk Factors Atlas of Ontario [90] outlines geographic distribution patterns of risk factors related to cancer and other chronic diseases in LHINs. From 2000 to 2014 within the

Central East LHIN, alcohol consumption and excess body weight were higher around the PHAI sites compared to the Ontario average. While the "current" smoking status was similar to Ontario's, the "ever-smoked" status was significantly higher. Inadequate fruit and vegetable consumption was also higher among males in the region compared to Ontario. These findings are supported by an additional report, Cancer Risk Factors in Ontario [91], specific to healthy weights, healthy eating and active living.

### 5.1.4 Findings

The review of health reports is an important component for ensuring that the health of people living near nuclear facilities is protected. The population and community health studies and reports indicate that common mortality causes among the populations surrounding the PHAI sites include circulatory and respiratory diseases, cancers and dementia. This is similar to the rest of Ontario and Canada, where heart disease and cancers are the 2 leading causes of death [92]. Major health risk factors such as smoking, excess body weight, alcohol consumption, physical inactivity, and poor diet may account for the occurrence of these diseases and play a contributing role in disease patterns across the province of Ontario.

## 5.2 Studies of radiation health effects – living near or working at CNL's PHAI sites

Several environmental and epidemiological studies have been conducted to assess the potential contamination effects in the Port Hope community over the last 70 years. The lines of evidence from these studies support each other and reveal that the levels of exposure in local area residents and workers are low, and that there is no evidence of adverse health effects resulting from past and present nuclear operations or activities in the region. These findings are consistent with the international scientific understanding of radiation effects on human health and with other studies examining similar populations worldwide.

### 5.2.1 Understanding health studies and risk assessments conducted in the Port Hope community from the 1950s to the present

In 2009, the CNSC created a synthesis report [93], which identified and summarized the scientific information needed to understand and assess the health effects of the past and present radium and uranium refining and processing activities in Port Hope.

The cancer incidence rates of Port Hope residents have been analyzed over the last 30 years through 5 descriptive ecological epidemiological studies. Overall, cancer incidence in local residents for all cancers combined was comparable with the general population of Ontario and Canada, and other similar communities. The most common types of cancer in Port Hope were lung, colon and rectum, breast and prostate. This is consistent with the rest of the province and the entire country. Port Hope residents, especially women, had a significant excess of lung cancer. This pattern was seen for the whole Northumberland County and is consistent with the known main risk factor of lung cancer (tobacco smoking) within the community. The rate of all childhood cancers was comparable with the general Ontario population, including leukemia.

The 5 descriptive ecological studies also examined the residents' mortality over the last 50 years. The leading causes of death in Port Hope were circulatory disease, cancer and respiratory disease. This finding was consistent with the rest of Ontario and Canada. Port Hope residents had a statistically significant excess of circulatory disease, especially heart disease. This pattern was also seen for the whole Northumberland County and is consistent with the known main risk factors of disease within the community. Mortality from all types of cancer was comparable to that for the general Ontario population. The leading causes of cancer death were cancers of the lung, colon and rectum, breast and prostate, which was consistent with the general trend in the provincial and national population, and with the rates of cancer incidence in Port Hope. All childhood cancer mortality was comparable with that for the general population of Ontario, as was mortality from congenital anomalies (birth defects).

### 5.2.2 Use of a weight of evidence approach to determine the likelihood of adverse effects on human health from the presence of uranium facilities in Port Hope, Ontario

In 2011, CNSC staff used a weight of evidence approach to assess the types and levels of contaminants of concern in the environment and the potential human exposure to these contaminants [94]. Their toxicological and radio-toxicological properties were also assessed to determine their potential health effects. The results of these assessments were further compared to findings of earlier epidemiological studies of Port Hope residents and nuclear industry workers.

The conclusions of this study indicated that levels of exposure to radioactive and non-radiological contaminants in Port Hope are below levels known to cause adverse health effects. Further, epidemiological studies provide no evidence of health effects resulting from past and present activities of the Port Hope nuclear industries. These findings are consistent with ERAs completed for nuclear facilities in Port Hope and results of over 40 epidemiological studies conducted elsewhere on populations living around similar facilities or exposed to similar environmental contaminants.

### 5.2.3 An ecological study of cancer incidence in Port Hope, Ontario from 1992 to 2007

In 2013, CNSC staff studied cancer incidence rates in Port Hope for a 16-year period (1992–2007) for continued periodic cancer incidence surveillance of the community [95]. The cancer incidence in the local community for all cancers combined was similar to that for the Ontario and Canadian population. No statistically significant differences in childhood cancer, leukemia or other radiosensitive cancer incidence were observed when compared to rates for populations of similar socio-economic characteristics. The study indicated that large differences in cancer incidence are not occurring in Port Hope compared to other similar communities and the general population.

### 5.2.4 Mortality (1950–1999) and cancer incidence (1969–1999) of workers in the Port Hope cohort study exposed to a unique combination of radium, uranium and gamma-ray doses

In 2013, CNSC staff conducted a study looking at cancer incidence and mortality among workers exposed to radium, uranium and gamma-ray doses in the Port Hope community [96]. Mortality (1950–1999) and cancer incidence (1969–1999) from exposures to these radiation types were examined in a cohort of workers from the Port Hope radium and uranium refinery and processing plant, which continues to operate today as Cameco Corporation's PHCF. Overall, the study demonstrated that workers had lower mortality and cancer incidence compared with the general Canadian population.

### 5.2.5 Findings

The environmental and epidemiological studies conducted in Port Hope support each other and lead to the conclusion that the low levels of radiological and non-radiological environmental exposures within the Port Hope region resulting from the radium and uranium industry have not caused any adverse effects on human health.

## 5.3 Current scientific understanding of radiation health effects

The current scientific knowledge of the sources, effects and risks of ionizing radiation is reviewed and published by international experts at the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) [97]. This information comes from many population studies, animal and cell studies, and clinical investigations. These studies build the foundation of the knowledge about the relationship between radiation exposure and health effects, such as cancer. This knowledge, in turn, informs the recommendations of the International Commission on Radiological Protection (ICRP) [98], which are focused on the protection of human health.

### 5.3.1 Radiation epidemiology

The epidemiological evidence of radiation-related health effects comes from several main research populations. These populations include the lifespan studies of the atomic bomb survivors [99], people involved in the Chernobyl disaster [100] [101], patients treated with radiotherapy for cancer and non-cancer diseases [102], miners exposed to radon and radon decay products [103] [104], and nuclear energy workers [105] [106] [107] [108].

Two major findings consistent within all these studies are:

- excess risk of cancer increases as radiation dose increases
- statistically significant population effects are typically observed at doses above approximately 100 mSv (either acutely or chronically exposed)

Importantly, the absence of statistically significant data does not indicate the absence of risk. To put these findings into perspective, 100 mSv is much higher than the average Canadian natural background of 1.8 mSv per year, which varies between 1 and 4 mSv/y [109]. Similarly, 100 mSv is much higher than the average doses experienced by workers at the PHP and PGP (less than 1 mSv/y) and the public living nearby (less than 0.04 mSv/y).

### 5.3.2 Radiation exposure and cancer incidence (1990 to 2008) around nuclear power plants in Ontario, Canada (RADICON)

In 2013, the CNSC conducted a study on radiation exposure and cancer incidence around Ontario nuclear power plants. The RADICON study determined radiation doses to members of the public living within 25 kilometres of the Pickering, Darlington and Bruce nuclear power plants, and compared cancer cases of this population with the general population of Ontario from 1990 to 2008 [110].

A main finding of the study was that there was no evidence of childhood leukemia clusters around the 3 Ontario nuclear power plants, and no consistent pattern of cancer across the populations in question. Some types of cancer were higher than expected, but, in other cases, they were lower or no different. Although this study detected variations for all cancers combined and for radiosensitive cancers, the pattern was found to be within the natural variation of cancer in Ontario.

### 5.3.3 International Nuclear Worker Study

The largest and most relevant study on nuclear energy workers is the International Nuclear Worker Study, a multinational cohort study that assessed cancer risk from 1943 to 2005 in 308,297 workers from the nuclear industry in France, the United Kingdom, and the United States [105] [106] [107] [108]. The series of studies provides strong evidence of a linear relationship between radiation exposures and cancer risk. The results are consistent with the current radiation protection system, whereby dose limits are set conservatively, below levels where adverse health effects are expected.

### 5.3.4 Findings

Experts worldwide study radiation health effects to provide objective scientific evidence that support the CNSC's environmental and radiation protection programs for ensuring that workers and members of the public are protected. The current international understanding is that very low exposures of radiation result in very low risks to health, indiscernible from the natural variation of disease. CNSC staff are confident that those living near and working at any nuclear facility in Canada are adequately protected.

## 5.4 Summary of health studies

Reviewing and conducting health studies and reports comprise an important component of ensuring protection of the health of people living near or working at nuclear facilities. CNSC staff have considered the most recent international radiation epidemiology reports and the CNSC's own information and scientific publications, as well as various community, provincial and national-level studies and reports to inform their evaluation of the health of populations living or working near the PHAI sites.

The population and community health studies and reports indicate that cancer incidence and mortality rates, as well as the prevalence of specific health indicators and risk factors related to cancer, are largely consistent with the population of Ontario. The current understanding of the risks associated with radiation exposures is supported by the publications by international agencies like UNSCEAR and the ICRP, as well as academics and researchers worldwide. Very low exposures of radiation result in very low risks to health, indiscernible from the natural variation of disease.

The health studies and reports presented in this section provide a snapshot of the health of people living near the PHAI sites. Based on the assessed exposure and health data, CNSC staff have not observed and do not expect to observe any adverse health outcomes attributable to the remediation of the PHAI sites.

# 6.0 Other environmental monitoring programs

Several monitoring programs are carried out by other levels or bodies of government and are reviewed by CNSC staff to confirm that the environment and the health of persons around the facility in question are protected. A summary of the findings of these programs is provided below.

## 6.1 National pollutant release inventory

Environment and Climate Change Canada operates the National Pollutant Release Inventory (NPRI) [111], which is Canada's public inventory of pollutant releases, disposals and transfers, tracking over 320 pollutants from over 7,000 facilities across the country. Reporting facilities include factories that manufacture a variety of goods; mines, oil and gas operations; power plants; and sewage treatment plants. Information that is collected includes:

- releases from facilities to air, water or land
- disposals at facilities or other locations
- transfers to other locations for treatment and recycling
- facilities' activities, locations and contacts
- pollution prevention plans and activities [112]

CNSC staff conducted a search of the NPRI database and found that 5 facilities in the Port Hope area, including CNL's Port Hope Radioactive WMF and CNL's Port Granby WMF in Clarington, report to the NPRI. While reviewing the data, CNSC staff did not notice any trends or unusual results. It is also worth noting that radionuclides are not included in the inventory of pollutants in the NPRI database. The CNSC receives radionuclide loadings from the licensees through other means; that is, annual and quarterly reports. This information has been used in this report, but the complete dataset is available for download on the CNSC's Open Government Portal [113].

# 7.0 Findings

This EPR report has focused on items historically of interest to Indigenous, public and regulatory interest, including physical stressors, and airborne and waterborne releases from ongoing operations at the PHAI sites.

CNSC staff's findings from this EPR report may inform and support staff recommendations to the Commission in future licensing and regulatory decision making that pertain to the PHAI sites. These findings are based on CNSC staff's reviews of documents associated with CNL's PHAI, such as those related to the submitted environmental documentation and the conduct of compliance verification activities, including the review of annual and quarterly reports, and onsite inspections. CNSC staff also reviewed the results from various relevant or comparable health studies, and other environmental monitoring programs conducted by other levels of government, to substantiate their findings. CNSC staff also conducted IEMP sampling around the PHAI sites in 2013, 2014, 2017 and 2019.

Based on CNSC staff's assessment of CNL's documentation, CNSC staff have found that the potential risks from physical stressors, as well as from radiological and hazardous releases to the atmospheric, aquatic, terrestrial and human environments from the PHAI sites are negligible. The potential risks to the environment from these releases or stressors are similar to natural background, and the potential risks to human health are indistiguishable from health outcomes in the general public. Therefore, CNSC staff have found that CNL has and will continue to implement and maintain effective environmental protection measures to adequately protect the environment and the health of persons. CNSC staff will continue to verify and ensure that, through ongoing licensing and compliance activities and reviews, the environment and the health of persons are protected.

# Abbreviations

| | |
|---|---|
| AAQC | Ambient Air Quality Criteria |
| AECL | Atomic Energy of Canada Limited |
| AL | action level |
| CCME | Canadian Council of Ministers of the Environment |
| CEAA | *Canadian Environmental Assessment Act* (1992) |
| CEAA 2012 | *Canadian Environmental Assessment Act, 2012* |
| CMD | commission member document |
| CNL | Canadian Nuclear Laboratories |
| CNSC | Canadian Nuclear Safety Commission |
| COPC | contaminant of potential concern |
| CSA | Canadian Standards Association (former name of CSA Group) |
| CWQG | Canadian Water Quality Guidelines |
| dBA | a-weighted decibels |
| EA | environmental assessment |
| EBRL | exposure-based release limits |
| EMP | environmental monitoring program |
| EP | environmental protection |
| EPP | environmental protection program |
| EPR | environmental protection review |
| ERA | environmental risk assessment |
| DRHD | Durham Region Health Department |
| HKPR | Haliburton, Kawartha, Pine Ridge |
| IAA | *Impact Assessment Act of Canada* |
| ICRP | International Commission on Radiological Protection |
| IDMP | independent dust monitoring program |
| IEMP | independent environmental monitoring program |
| LCH | licence conditions handbook |
| LHIN | local health integration network |
| LLA | long-lived alpha |
| LLRW | low-level radioactive waste |
| LTWMF | long-term waste management facility |

| | |
|---|---|
| OMOE | Ontario Ministry of the Environment (Former) |
| NPRI | national pollutant release inventory |
| NSCA | *Nuclear Safety and Control Act* |
| MDMER | *Metal and Diamond Mining Effluent Regulations* |
| MECP | Ministry of the Environment, Conservation and Parks |
| MOU | memorandum of understanding |
| mSv | millisievert |
| PHAI | port hope area initiative |
| PHP | port hope project |
| $PM_{2.5}$ | fine particulate matter |
| PWQO | provincial water quality objectives |
| ROR | regulatory oversight report |
| TLD | thermoluminescent dosimeter |
| TSP | total suspended particulate |
| TSS | total suspended solids |
| UNSCEAR | United Nations Scientific Committee on the Effects of Atomic Radiation |
| VC | valued component |
| WHO | World Health Organization |
| WMF | waste management facility |
| WTP | water treatment plant |
| WWTP | waste water treatment plant |

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# Appendix A – Activities under the current Port Hope EA follow-up program [37]

| Environmental component | Activity and objective(s) | Sampling locations | Parameters |
|---|---|---|---|
| Atmospheric Environment | Air quality will not have residual adverse effects with mitigation measures | Offsite and public receptor locations | AS, Co, $PM_{10}$, $PM_{2.5}$ and $NO_2$ |
| | Odours not to have residual adverse effects with mitigation measures | Highland Drive Landfill and Port Hope Harbour | Odour analysis |
| | Noise impacts will comply with by-laws remaining under 67 dBA | LTWMF, Alexander Ravine and Strachan Street | Noise levels |
| | Radiological effects from Rn gas concentration pathways eliminated | Downwind of LTWMF during construction and development<br>In area immediately surrounding methane gas piping exit vents at Cell 3 of the LTWMF | Rn gas concentrations |
| | Radiological effects from particulate radioactivity will be below Health Canada reference levels | Work sites and haul roads | Ra-226, Th-230, Th-232 and U |
| Aquatic Environment | Sediment quality will not have residual adverse effects after remediation work in Sculthorpe Marsh | Sculthorpe Marsh | Benthic invertebrate and aquatic communities |
| | Radiological effects in surface water quality to have no residual adverse effects with mitigation measures. | Highland Drive, South Creek and Brewery Creek | As and U |
| | | Alexander Creek and the area between harbour and Ganaraska River | U and Ra-226 |
| | | Groundwater and down-gradient surface water in the LTWMF | U |

| Environmental component | Activity and objective(s) | Sampling locations | Parameters |
|---|---|---|---|
| | Surface water quality to experience long-term improvement to down-gradient surface water quality, reduced contaminant loadings to down-gradient streams and no measurable changes to Ganaraska River | Point of discharge, the harbour, Ganaraska River<br>Fish tissue<br>Lake Ontario | Non-radiological contaminan concentrations<br>Mercury and levels of other COPC<br>Contaminant loadings |
| | Sediment qualtiy improves in the harbour and habitat conditions | Harbour | Sediment quality and fish habitat conditions |
| Geology and Groundwater Environment | Soil concentrations of radiological contaminants are expected to have less than 10% of background at remediation sitess and less than 20% of background at the LTWMF | All remediation sites and LTWMF | All radiological contaminant concentrations |
| | Soil concentrations of Th-230 are expected to increase to a maximum predicted concentration of 141.9 Bq/kg | LTWMF perimeter fence and surface soils adjacent | Th-230 |
| | Non-radiological contaminants in soil will not exceed predicted maximum concentrations and will have no residual adverse effects with mitigation measures | Perimeter of the LTWMF | As and Co |
| | Radiological contaminants in groundwater will decline below applicable guidelines within 25 years | Remediated Mill and Alexander Street sites | U |
| | Groundwater volume treated at the LTWMF will have a decrease of approximately 30% and contaminant concentrations to decrease over time | LTWMF groundwater collection system | Volume and concentrations of contaminants |
| | Groundwater and drainage water discharge will reduce by a predicted volume of 44% | LTWMF | Volume of drainage water |
| | Groundwater flow to decrease | Water table beneath and adjacent to the LTWMF | Water table levels |

| Environmental component | Activity and objective(s) | Sampling locations | Parameters |
|---|---|---|---|
| | | Onsite drainage system and Lake Ontario<br>Existing facility | Stream flow and groundwater discharge<br>Groundwater flow and direction |
| | Groundwater will not have changes in quality or quantity during the construction of the LTWMF and COPC will be 1% of PWQO and Ontario Drinking Water Standards criteria | LTWMF | Quality and quantity of groundwater and drainage water |
| | Hydraulic conductivity of the LTWMF liners and covers will not exceed a maximum of $10^{-8}$ cm/s and leachate generated will be 150 $m^3$ | LTWMF | Leakage between liners<br>Settlement of LTWMF cover<br>Infiltration rate of the cover |
| | LTWMF waste volumes and contaminant concentrations to be verified | Excavated waste sites | Volume and contaminant concentrations of excavated waste |
| Terrestrial Environment | Temporary loss of vegetation due to LTWMF site preparation and remediation in Ward 1 and outside the Highland Drive Site<br>Permanent conversion of vegetation communities in the Local Study Area and Site Study Area | Storm water management pond<br>Waterworks site<br>Remediation sites | Verify relocation of storm water management pond<br>Verify development of protection and rehabilitation plans<br>Verify implementation of erosion and sediment control structures; application of dust suppression techniques<br>Verify extent and duration of temporary and permanent vegetation loss/change |

| Environmental component | Activity and objective(s) | Sampling locations | Parameters |
|---|---|---|---|
| | Wildlife corridors and habitat complexes within the Local Study Area will be affected | Local Study Area | Vegetation clearing<br>Nest surveys<br>Structural habitat qualities and variability |
| Sculthorpe Marsh | Should remediation take place, no net loss of wetland function would be ensured | Sculthorpe Marsh | No net loss of wetland functions |
| Human Health and Safety | Workers exposed to non-radiological contaminants will be limited to established weighted average criteria for acute 8-hour exposures | Work sites | Accident rate, compliance to federally legislated health and safety regulations, operational policy |
| | Workers exposed to radiological contaminants for onsite and offsite wastes will receive annual radiation doses between 1.6-2.7 mSv/y; workers dewatering sediment during harbour remediation will receive doses up to 7.6 mSv/y | Onsite and offsite waste work sites and the harbour cleanup site | Radiation doses of workers |
| | Noise levels will range 88 to 96 dBA for workers | Construction areas | Accident rate, compliance to federally legislated health and safety regulations, operational policy |
| | Assuage members of the public's concern regarding non-radiological contaminants throughout the project | Members of the public | Level of satisfaction, communications protocols |
| | Ward 1 adjacent residents will not be exposed to more than 0.16 mSv/y of radiation during remediation | | Radiation doses |
| | During construction and development, residents will not be exposed to more than 0.25 mSv/y | | Radiation doses |
| Socio-economic Environment | Manage relocation of tenants, out-migration of residents and decrease in property values near remediation sites, transportation routes and the LTWMF | Area around remediation sites, transportation routes and the LTWMF | Percentage of out-migration of residents, new and resale housing property values, complaint resolution process and PVP program |

| Environmental component | Activity and objective(s) | Sampling locations | Parameters |
|---|---|---|---|
| | Manage relocation of tenant business operations, short-term disruption of outdoor business operations and farm operations. Increased employment and business activity related to project | Businesses and farms around the project | Business-oriented communication plan, business surveys |
| | Minor impacts due to nuisance effects on outdoor tourism events | Transportation routes and Port Hope Tourism | Traffic levels, project related accidents, tourism rates |
| | Short term disruption of outdoor recreational activities, increased safety risks for educational facilities in close proximity of remediation sites and disruption of traffic and transportation.<br>Project to provide improvements to the harbour, waterfront and natuarl areas | | Mitigation measures, quality of roads and bridges |
| | Adjacent residents may see a decrease in enjoyment of properties | | Public attitudes, omplaints and communications |
| | No impacts to cultural and heritage sites are predicted as there are no known heritage sites | | Discovery and disturbances of heritage or archaeological resources and sites |
| Aboriginal Interests | No likely residual adverse effects anticipated | | |
| Cumulative Effects | Incremental annual average Rn concentrations should be indistinguishable from background from a 2km radius and not measurable beyond 1km | 1km from site<br>2km from site | Radiological constituents of re-suspended dust<br>Rn concentrations |

# Appendix B – Activities under the current Port Granby EA follow-up program [36]

| Environmental component | Activity and objective(s) | Sampling locations | Parameters |
|---|---|---|---|
| Atmospheric Environment | Air quality will not have residual adverse effects with mitigation measures. Anticipated slight exceedances for particulate emissions of $PM_{2.5}$ along the edge of the existing WMF site | Site adjacent to construction activities | TSP, $PM_{10}$, $PM_{2.5}$ |
| | Noise impacts are anticipated to increase by 6-56 dBA at the LTWMF and the existing facility. Nuisance noise will impact local receptors | Receptor locations near the Site Study Area during the Construction and Development Phase | Noise levels and mitigation measures |
| | Radon concentrations may reach 5.1 Bq/$m^3$ during construction and development | | Rn and long-lived alpha |
| | Radiological effects from particulate radioactivity will be below Health Canada reference levels | | Radionuclide levels |
| Aquatic Environment | Improvements in sediment quality due to decreased contaminant transport and mitigation measures for offsite contaminated waste mitigation during excavation | Port Granby Creek<br>Lake Ontario shoreline | Post-cleanup monitoring plan established in case of a sedimentation event or spill<br>Remediation of excavation water after rainfall if necessary |
| | Beneficial long-term improvement to downgradient surface water quality, reduced contaminant loading to down-gradient lake and no measurable changes to Port Granby Creek. | Groundwater, stormwater and drainage water collection and treatment systems, Lake Ontario | Effluent quality performance, toxicity testing, contaminant loadings |
| Geology and Groundwater Environment | Radiological effects in soil quality will have no residual adverse effects with mitigation measures with contaminant concentrations to be less than 20% of background | Two Port Granby WMF sites and 5 other sample sites from EASR | Soil quality |

| Environmental component | Activity and objective(s) | Sampling locations | Parameters |
|---|---|---|---|
| | Soil concentrations of Th-230 are expected to increase by 38% in concentration over baseline during the Construction and Development Phase of the LTWMF | Two Port Granby WMF sites and 5 other sample sites from EASR | Th-230 |
| | Volume of groundwater collected for treatment in the LTWMF site groundwater and drainage water collection system would decrease and contaminant concentrations in groundwater quality will decline over time | Selected monitoring wells, with additional wells near the LTWMF if required | Volume and concentrations of contaminants |
| | Groundwater and drainage water discharge to Port Granby Creek will decrease by 1.6% | Groundwater monitoring wells | Groundwater levels |
| | Groundwater will have no measurable changes in quality or quantity during LTWMF construction | Groundwater and drainage water<br><br>Downgradient of the current WMF and East and West Gorges | Quantity and quality of water<br>Contaminant concentrations, bluff seepage |
| | Groundwater flow to decrease | Water table beneath and adjacent to the LTWMF<br>Onsite drainage system and Lake Ontario | Water table levels<br>Stream flow and groundwater discharge<br>Groundwater flow and direction |
| | Hydraulic conductivity of the LTWMF liners and covers will not exceed a maximum of $10^{-7}$ cm/s; leachate generated will be 100 $m^3$ | LTWMF | Leakage between liners<br>Settlement of LTWMF cover<br>Infiltration rate of the cover |
| | LTWMF waste volumes and contaminant concentrations to be verified | Excavated waste sites | Volume and contaminant concentrations of excavated waste |

| Environmental component | Activity and objective(s) | Sampling locations | Parameters |
|---|---|---|---|
| Terrestrial Environment | Temporary loss of vegetation in the Local Study Area and the Site Study Area<br>Permanent conversion of vegetation communities in the Local Study Area and Site Study Area | Storm water management pond<br>East Gorge<br>Remediation sites | Verify relocation of storm water management pond<br>Verify development of protection and rehabilitation plans<br>Verify implementation of erosion and sediment control structures; application of dust suppression techniques<br>Monitor radiological and non-radiological COPC in surficial soil<br>Verify extent and duration of temporary and permanent vegetation loss/change<br>Structural habitat qualities and variability |
| Human Health and Safety | Workers exposed to non-radiological contaminants are not predicted to have measurable effects on workers health. Construction activities aim to be at a total of 4.6 lost time accidents and 15.3 recordable accidents | Work sites | Accident rate, compliance to federally legislated health and safety regulations, operational policy |
| | Workers exposed to radiological contaminants will receive annual radiation doses between 2.1-7.1 mSv/y; workers will receive doses around 0.1 mSv/y during the Maintenance and Monitoring Phase | | Radiation doses of workers |

| Environmental component | Activity and objective(s) | Sampling locations | Parameters |
|---|---|---|---|
| | Noise levels can reach 93 to 95 dBA within 15 m of the LTWMF and the existing WMF | Construction areas | Accident rate, compliance to federally legislated health and safety regulations, operational policy |
| | Assuage members of the public's concern regarding non-radiological contaminants throughout the project | Members of the public | Level of satisfaction, communications protocols and complaints resolution process |
| | Air quality and noise | Members of the public | Level of satisfaction, communications protocols and complaints resolution process |
| | Members of the public will not be exposed to more than 15% of the CNSC public dose limit of 1 mSv/y | | Radiation doses |
| Socio-economic Environment | Manage relocation of tenants, out-migration of residents and decrease in property values near remediation sites, transportation routes and the LTWMF | Area around remediation sites, transportation routes and the LTWMF | Percentage of out-migration of residents, new and resale housing property values, complaint resolution process and PVP program |
| | Manage relocation of tenant business operations, short-term disruption of outdoor business operations and farm operations. Increased employment and business activity related to project | Businesses and farms around the project | Farmer-oriented communication plan, impacts to farmers and businesses |
| | Minor impacts due to nuisance effects on outdoor tourism events | Transportation routes and Port Hope Tourism | Traffic levels, project related accidents, tourism rates |
| | Short term disruption of outdoor trails and natural areas with disruption of community and recreational activities within the zone of influence for LTWMF and transportation routes | | PVP Program, public perception |
| | Increased safety risks for educational facilities in close proximity of remediation sites and disruption of traffic and transportation. | Transportation routes | Traffic levels, accidents, pavement road quality |

| Environmental component | Activity and objective(s) | Sampling locations | Parameters |
|---|---|---|---|
| | No impacts to cultural and heritage sites are predicted as there are no known heritage sites | | Discovery and disturbances of heritage or archaeological resources and sites |
| Indigenous Interests | Some residual adverse environmental effects on the ability of current and future generations to exercise inherent Indigenous and Treaty rights | | First Nation's concerns and ability to exercise inherent Indigenous and Treaty Rights |
| Cumulative Effects | Incremental annual average Rn concentrations should be indistinguishable from background from a 2km radius and not measurable beyond 2km | 2km from site | Radiological constituents of re-suspended dust<br><br>Rn concentrations |

# Appendix C – Clean-up criteria for inorganic contaminants of potential concern applicable to historic LLRW sites during phase 2 of the PHP [38]

| | Port Hope Sites<br>Residential/Parkland/Institutional<br>Non-radiaoctive based on 2011 former Ontario Ministry of the Environment (OMOE) Generic[2] | Port Hope Sites<br>Industrial/Commercial/Community (with exeception of column C)<br>Non-radioactive based on 2011 OMOE Generic[2] | Welcome WMF and Highland Drive Landfill |
|---|---|---|---|
| Primary COPC | | | |
| $^{226}$Ra (Bq/g) | 0.24 | 0.92 | 0.92 |
| $^{230}$Th (Bq/g) | 1.11 | 4.62 | 4.62 |
| $^{232}$Th (Bq/g) | 0.103 | 0.343 | 0.343 |
| Arsenic (ppm) | 18 (11) | 18 | 40[3,4] |
| Antimony (ppm) | 7.5 | 40 (50) | 40 (50) |
| Cobalt (ppm) | 22 | 80 (100) | 80 (100) |
| Copper (ppm) | 140 (180) | 230 (300) | 230 (300) |
| Nickel (ppm) | 100 (130 | 270 (340) | 270 (340) |
| Uranium (ppm) | 23 | 33 | 76[3] |
| Lead (ppm) | 120 [45] | 120 | 120 |
| Secondary COPC | | | |
| Barium (ppm) | 390 | 670 | 670 |
| Beryllium (ppm) | 4 (5) | 8 (10) | 8 (10) |
| Boron, hot water soluble (ppm) | 1.5 | 2.0 | 2.0 |
| Boron, total (ppm) | 120 | 120 | 120 |

| | Port Hope Sites<br>Residential/Parkland/Institutional<br>Non-radiaoctive based on 2011 former Ontario Ministry of the Environment (OMOE) Generic[2] | Port Hope Sites<br>Industrial/Commercial/Community (with exeception of column C)<br>Non-radioactive based on 2011 OMOE Generic[2] | Welcome WMF and Highland Drive Landfill |
|---|---|---|---|
| Cadmium (ppm) | 1.2 [1] | 1.9 | 1.9 |
| Mercury (ppm) | 0.27 [0.25] (1.8) | 3.9 (20) | 3.9 (20) |
| Molybdenum (ppm) | 6.9 | 40 | 40 |
| Selenium (ppm) | 2.4 | 5.5 | 5.5 |
| Silver (ppm) | 20 (25) | 40 (50) | 40 (50) |
| Vanadium (ppm) | 86 | 86 | 86 |
| Zinc (ppm) | 340 | 340 | 340 |

( ) standard in round brackets applies to medium and fine textured soils

[ ] standard in square brackets represents 2011 OMOE “Table 2” values for agricultural use in potable groundwater situations.

Other values are applicable to residential land uses (where two values are listed or to both residential and agricultural land uses (where only one value is given).

[1] Summation rules apply to 226Ra, 230Th and 232 Th. Criteria used for these COPC represent incremental concentrations above background.

[2] Concentrations higher than criteria listed may be acceptable at depths >1.5m, as well as for special circumstance sites.

[3] Project-specific clean-up criteria [LLRWMO, Port Hope Area Initiative Clean-up Criteria, LLRWMO-01611-TE-1104, Rev 5, 2006 December]

[4] Soils subject to an alternative management strategy, as delineated in Figure A on page 7, are excluded from the Phase 2 clean-up criterion for arsenic.

# Appendix D – Port Granby Project clean-up criteria for inorganic contaminants of potential concern in surface soils [40]

| | Clean-up critieria for PGP |
|---|---|
| Primary COPC | |
| $^{226}$Ra (Bq/g) | 0.92 |
| $^{230Th}$ (Bq/g) | 4.62 |
| $^{232}$Th (Bq/g) | 0.343 |
| Arsenic (ppm) | 40 |
| Antimony (ppm) | 40 |
| Cobalt (ppm) | 80 |
| Copper (ppm) | 225 |
| Fluoride (ppm) | 2000 |
| Lead (ppm) | 1000 |
| Nickel (ppm) | 150 |
| Uranium (ppm) | 76 |
| Secondary COPC | |
| Barium (ppm) | 1500 |
| Beryllium (ppm) | - |
| Boron (ppm) | 2.0 |
| Cadmium (ppm) | 12 |
| Mercury (ppm) | 10 |
| Molybdenum (ppm) | 40 |
| Selenium (ppm) | 2 |
| Silver (ppm) | 40 |
| Vanadium (ppm) | 200 |

**Document availability**

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