Canada's Nuclear Regulator

Environmental Protection Review Report:
Blind River Refinery

October 2023

Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

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REVISION HISTORY

The following table identifies the revision history of this document.

Revision number	Change	Summary of changes	Date
000	Initial release	N/A	April 2021
001	Revision 1	Correction of errata in section 2.1, which previously stated that no federal EA had been carried out when the facility was first proposed and constructed. Correction of errata in section 3.2.4.1, which previously stated that radiation emitted at the BRR facility was due to radiological substances deposited on the ground from historical operations.	March 2022
002	Revision 2	Formatting revised to meet new accessibility requirements.	October 2023

Executive summary

The Canadian Nuclear Safety Commission (CNSC) conducts Environmental Protection Reviews (EPR) for all 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, are met through other oversight activities.

This EPR Report was written by CNSC staff for the Commission, Indigenous peoples and the public as a stand-alone document, describing the scientific and evidence-based findings from CNSC staff's review of Cameco Corporation's (Cameco) environmental protection measures. Under Cameco's current operating licence, FFOL 3632.00/2022, Cameco is permitted to process natural uranium concentrates (also known as yellowcake), natural uranium bearing materials and natural uranium metal into natural uranium trioxide (UO_3) at its Blind River Refinery facility in Blind River, Ontario. UO_3, an intermediate product of the nuclear fuel cycle, is shipped to facilities like Cameco's Port Hope Conversion Facility in Port Hope, Ontario for further processing.

CNSC staff's EPR Report focuses on items that are of Indigenous, public, and regulatory interest such as potential environmental releases from normal operations and decommissioning activities, as well as risk of radiological and hazardous substances to the receiving environment, valued ecosystem components and species at risk.

This EPR Report includes CNSC staff's assessment of documents submitted by the licensee from 2015 to 2020, such as, but not limited to, the following:

- the results of Cameco's environmental monitoring, as reported in Annual compliance monitoring and Operational performance reports
- Cameco's 2016 Environmental risk assessment for the Cameco Blind River Refinery
- Cameco's 2020 Review of the environmental risk assessment for the Blind River Refinery
- Cameco's Preliminary Decommissioning Plan (PDP)
- the results of CNSC's Independent Environmental Monitoring Program (IEMP)
- the results from other environmental monitoring programs and/or health studies (e.g. completed by other levels of government) in proximity to Cameco's Blind River Refinery

Based on CNSC staff's assessment and evaluation of Cameco's documentation and data, CNSC staff conclude that the potential risks from radiological and hazardous releases to the atmospheric, terrestrial, aquatic, geological, hydrogeological and human environments are negligible. The potential risks to the environment from these releases are not distinguishable from natural background and the potential risk to humans is similar to health outcomes in the general public. CNSC staff also conclude that Cameco 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 Cameco's environmental protection programs, through ongoing licensing and compliance activities and reviews.

The information provided in this EPR Report summarizes CNSC staff's conclusions that may inform and support staff recommendations to the Commission in future licensing and regulatory decisions. CNSC staff's conclusions do not represent the Commissions conclusions, which can be informed not only by CNSC staff and the licensee, but also Indigenous peoples and their knowledge, the public, and any interventions heard during public hearings on licensing matters.

Cameco makes many summary documents, including reports containing environmental data, available on their website. References used throughout this document are available upon request and requests can be sent to cnsc.ea-ee.ccsn@canada.ca.

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1.0 Introduction

1.1 Purpose

The Canadian Nuclear Safety Commission (CNSC) conducts Environmental Protection Reviews (EPR) for all 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. An EPR is a science-based environmental technical assessment conducted by CNSC staff to support these requirements as set out in the NSCA. 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. EPRs are typically conducted every 5 years and are based on a licensee's environmental protection program and documentation submitted by licensees as per regulatory reporting requirements.

The purpose of this EPR is to report the outcome of CNSC staff's review of Cameco Corporation's (Cameco) Blind River Refinery (BRR) environmental protection (EP) activities and environmental compliance activities conducted under the NSCA. This review serves to assess whether the environment and health of persons are protected from Cameco's operations at the BRR facility.

This EPR Report presents information pertaining to the protection of the environment and human health. No decision is made on the EPR itself, but CNSC staff's conclusions may inform and support future recommendations to the Commission in future licensing and regulatory decision making. CNSC staff's conclusions do not represent the Commission's conclusions, which can be informed not only by CNSC staff and the licensee, but also Indigenous peoples and their knowledge, the public, and any interventions heard during public hearings on licensing matters. The information is intended to inform Indigenous peoples, members of the public and any regulatory decisions being sought from the Commission at the time of licensing decisions. EPR Reports are prepared to thoroughly document CNSC staff's assessment relating to a licensee's EP measures and are published online for information and transparency for any interested party. Publishing EPR Reports online, separately from the documents drafted during the licensing process, allows interested Indigenous peoples and members of the public additional time to review EP related information.

This EPR Report is based on information submitted by Cameco, compliance and technical assessment activities completed by the CNSC staff from 2015 to 2019, independent sampling and verification activities by CNSC staff, as well as the following:

- regulatory oversight (section 2.0)
- CNSC staff's review of the Cameco's Preliminary Decommissioning Plan (PDP) [1] (section 2.2)
- CNSC staff's review of Cameco's Annual Compliance Monitoring and Operational Performance Reports (ACMOPR) [2-6]
- the 2016 Environmental Risk Assessment (ERA) for the Cameco Blind River Refinery (2016 ERA) [7] (section 3.2)
- the 2020 Review of the Environmental Risk Assessment for the Blind River Refinery (2020 review of the ERA) [8] (section 3.2)

- Independent Environmental Monitoring Program (IEMP) results (section 4.0)
- health studies with relevance to the BRR facility (section 5.0)
- other environmental monitoring programs in proximity to the BRR site (section 6.0)

A review has been conducted for all environmental components related to the licenced facility, however only a selection of topics related to environmental protection are presented in detail in this report. These topics were selected based on those that have historically been of interest to Indigenous peoples, members of the public and the Commission.

This EPR Report focuses on topics related to the environmental performance of the facility including emissions (atmospheric releases) and effluents (liquid releases) to the environment, the potential transfer of contaminants of potential concern (COPC) through key environmental pathways and associated potential exposures and/or effects on valued ecosystem components including human and non-human biota. The focus is on radiological and hazardous substances associated with activities undertaken at the BRR facility, with additional information provided on other topics of Indigenous, public and/or regulatory interest such as greenhouse gas (GHG) emissions. CNSC staff also present information on relevant regional environmental or health monitoring, or studies conducted by the CNSC (e.g., IEMP) or other governmental organizations.

1.2 Facility overview

This section of the report provides general information on the BRR site. This includes 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 regulatory oversight activities.

1.2.1 Site description

Cameco owns and operates the BRR facility in northern Ontario on the northern shore of Lake Huron, between Sudbury and Sault Ste. Marie (see figure 1.1). The facility is located on a Cameco owned property of approximately 257 hectares of land, with approximately 11 hectares fenced-in licensed area in which the BRR facility's operations are carried out. Cameco also has a lease with the Town of Blind River for approximately 194 hectares just east of their existing property, seen in figure 1.2. Figure 1.2 also provides a more detailed view of the property and areas around the BRR facility, including the golf course less than 1 km to the northwest, the nearest communities of the Mississauga First Nation (MFN), approximately 1 km to the north, and the Town of Blind River, approximately 3 km to the east. Figure 1.3 shows an aerial overview. The surrounding area is predominantly forested land and wetlands, with few residences in the direct vicinity to the east and west, outside of the communities to the north and the east [7].

Figure 1.1. Overview map of the region where the BRR facility is located [7]

Figure 1.2. Map of BRR facility and the surrounding area [7]

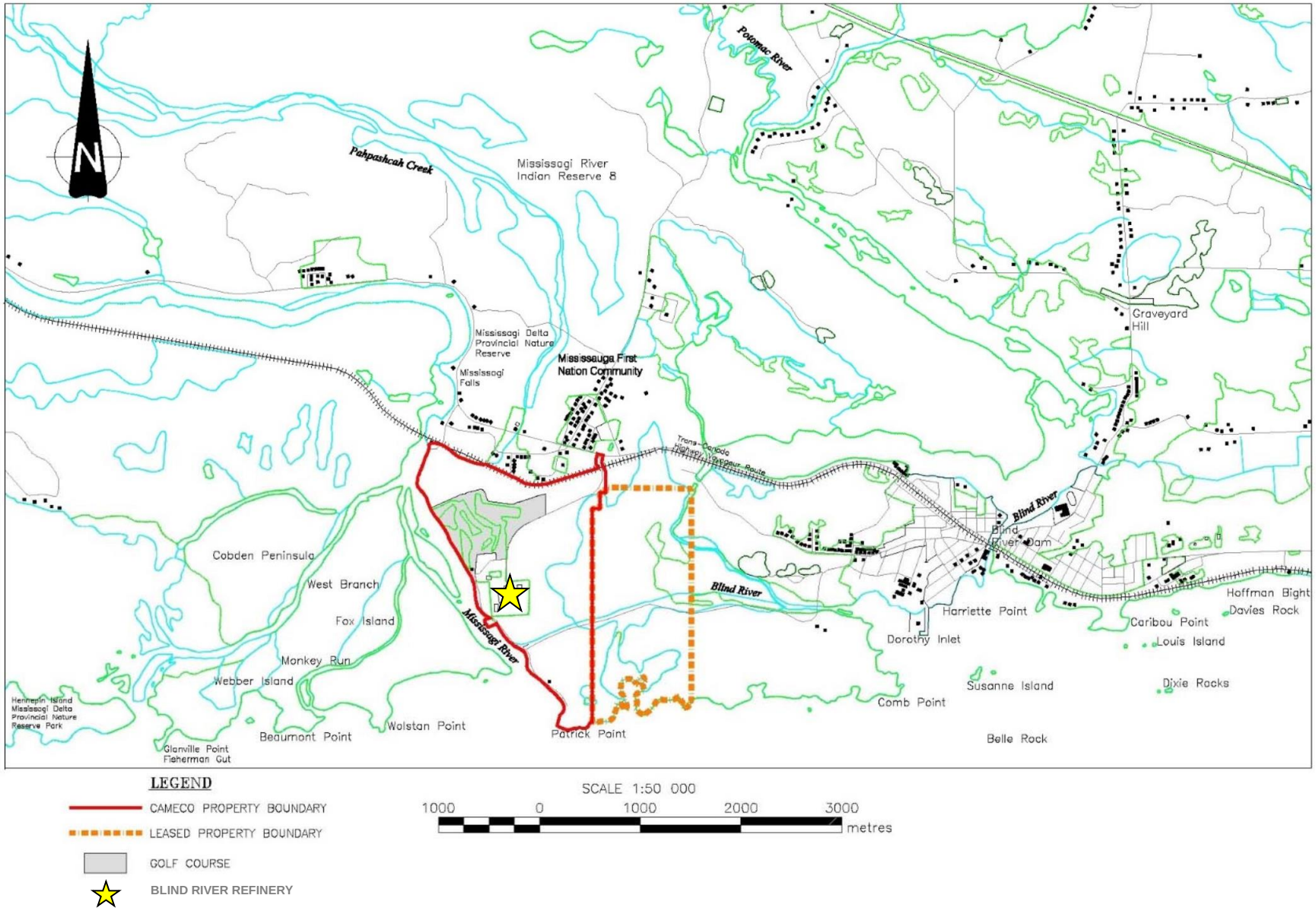


Figure 1.3. Aerial overview of the BRR facility and surrounding area [7]

1.2.2 Facility Operations

The BRR facility first began commercial operations in 1983 [9]. Cameco is permitted to process natural uranium concentrates (also known as yellowcake), along with small quantities of scrap natural uranium bearing materials such as uranium dioxide (UO_2) and natural uranium metal, into uranium trioxide (UO_3) at the BRR facility. The processing production of UO_3 is carried out in a series of steps involving the digestion of the uranium in nitric acid and purification by solvent extraction, followed by evaporation and de-nitration of the purified uranium [1]. UO_3, an intermediate product of the nuclear fuel cycle, is collected in shipping totes (shown in figure 1.4) and then primarily shipped to Cameco's Port Hope Conversion Facility (PHCF) in Port Hope, Ontario for further processing [7]. Cameco also prepares and ships UO_3 to other customers in the world.

Figure 1.4. Shipping totes used to transfer UO_3 from the BRR facility [10]

On-site incinerator

There is an onsite incinerator to burn radioactively contaminated combustible materials that cannot be disposed of or recycled from the BRR facility, and other Cameco facilities such as the PHCF and Cameco Fuel Manufacturing. The contaminated incinerator ash is blended with product containing recyclable amounts of uranium produced at the BRR facility, and then transported in drums off-site to a uranium mill in the United States to recover the uranium [7]. A variety of pollution control equipment including bag houses, scrubbers and activated carbon beds are used at the BRR facility to control and reduce emissions to air. The incinerator is regulated both by the CNSC and also Ontario's Ministry of the Environment, Conservation, and Parks (MECP) through an environmental compliance approval (ECA).

Liquid effluent treatment system

The BRR facility has a liquid effluent treatment system to process effluent generated from its operations. The majority of effluent water is comprised of condensed water from the nitric acid concentrators and, to a lesser extent, water from lab sink drains, the chlorine circuit scrubber, the powerhouse, and a small amount of treated effluent wastewater from the on-site sewage treatment plant (STP). Treated effluent is then transferred to 3 process lagoons:

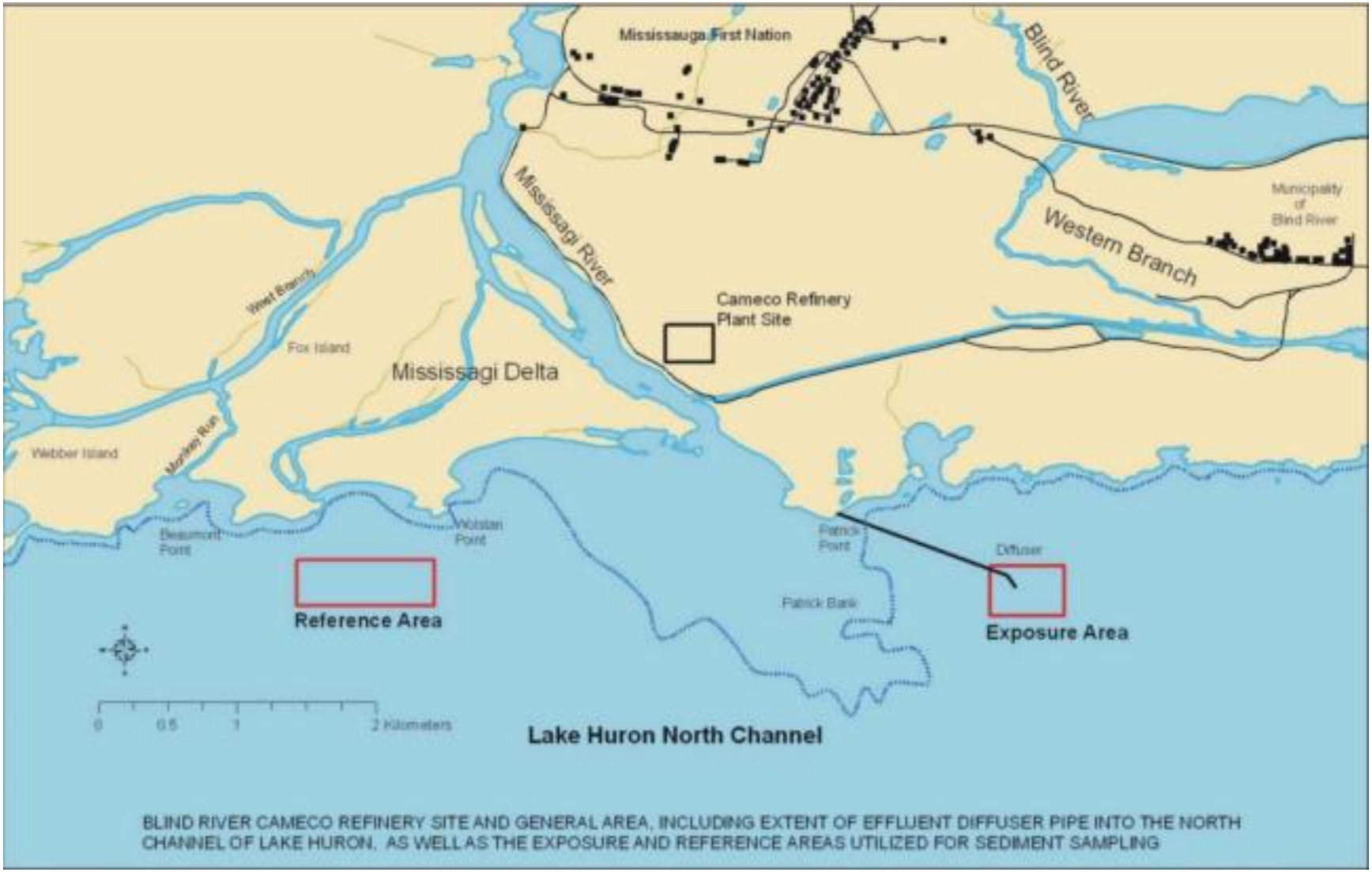
- the Effluent and the Monitor Lagoons are the largest with a capacity of 2,400 m^3 each, and are the primary lagoons which collect the treated effluent
- the Treatment Lagoon, with a capacity of 1,100 m^3, is used primarily as an overflow lagoon for stormwater and occasionally for collecting process water

The facility also maintains a Stormwater Lagoon, with a capacity of 1,100 m^3, which collects stormwater, runoff and snow melt. In preparation for discharge, water from the stormwater lagoon is transferred to 1 of the 3 process lagoons, depending on the capacity of lagoons at the time. Stormwater cannot be discharged directly to Lake Huron without first being transferred to a process lagoon for storage and analysis.

Once a process lagoon is ready to be discharged, it is isolated and a sample is collected. The sampling results are reviewed and compared to the release limits and action levels. If the results are confirmed to be below the release criteria, the drain valve is opened and the lagoon is drained by gravity into a sump below the effluent pumphouse building, which subsequently pumps the discharge to the Lake Huron North Channel through a diffuser, shown in figure 1.5. This process ensures that the release limits will be met. A complete discharge takes approximately 24 hours, over several batch releases, and is conducted every 2 to 3 days, with the exception of shutdown periods, which typically occurs in July and August. If sampling results are above an action level (AL), the effluent will be treated in the field or recycled back to the circuit until the release criteria are met.

The bottom of the Effluent, Monitor and Treatment Lagoons are covered with a plastic liner to inhibit algae growth. All 3 of the lagoons are cleaned approximately 2 to 3 times per year depending on algae growth and accumulation of other debris. The Stormwater Lagoon also has a plastic liner but has an overlying layer of sand, gravel and clay, which prevents cleaning and allows for the growth of aquatic vegetation similar to natural occurrences [7].

Figure 1.5. BRR Discharge location of treated effluent water [7]



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 Canadian acts and regulations, environmental policies and with Canada's international obligations. The CNSC assesses the environmental and health effects of nuclear facilities and activities at every phase of its lifecycle. This section of the EPR Report discusses the CNSC's regulatory oversight of EP measures at Cameco's BRR facility.

To meet the CNSC's regulatory requirements, Cameco is responsible for implementing and maintaining EP measures that identify, control and (where necessary) monitor releases of radiological and hazardous substances and effects on human health and the environment, from the BRR facility. These EP measures must comply with, or have implementation plans in place to comply with, the regulatory requirements found in Cameco's licence and Licence Condition Handbook. The regulatory requirements for Cameco's BRR facility are outlined in this section of the report.

2.1 Environmental protection reviews and assessments

EPR reports are produced as part of the ongoing, lifecycle EP framework under the NSCA and its regulations. The information is published to provide greater transparency for Indigenous people and the public. The report may be used by CNSC staff to support its recommendations to the Commission for licensing and other regulatory decision making.

Depending on the scope and impact of Cameco's project, other legislation such as the *Impact Assessment Act of Canada* [11] or the former *Canadian Environmental Assessment Act, 2012* (CEAA 2012) [12] and the *Canadian Environmental Assessment Act* (CEAA) [13] may require, or have required, an impact or environmental assessment (EA).

The following section provides information on any past federal EAs completed with respect to activities at the BRR facility. When the BRR facility was first constructed and began operations, no federal EA was carried out, as there were no EA requirements stipulated in either federal guidelines or federal legislation at the time.

2.1.1 Previous EAs completed under the Canadian Environmental Assessment Act

Proposed modification to the operation of the Blind River Refinery incinerator

In the fall of 2004, Cameco submitted a letter of intent and project description, proposing to modify the operation of the BRR incinerator to upgrade the capacity of the incinerator to handle contaminated combustible by-products from Cameco's operations at the BRR facility and the PHCF. The proposal also included pollution control equipment and on-line monitoring equipment to enable the BRR incinerator to handle the increased loading of material and meet provincial emission requirements. Lastly, Cameco also proposed to install an oil injection system to allow for the incineration of contaminated uranium-bearing waste oil.

CNSC staff reviewed the application and determined that pursuant to subsection 18(1) of the CEAA, a screening EA of the project would be required before a decision from the Commission

could be made pursuant to the NSCA, and a screening report was prepared in accordance with the requirements of CEAA [14].

Following the Commission's consideration of the screening report in 2006 and CNSC staff's recommendations for Cameco's licence amendment application [15], the Commission rendered its decision on the EA stating that, upon taking into account implementation of appropriate mitigation measures and public input, that the project, as proposed, would not likely cause significant adverse environmental effects [16].

No additional follow-up program requirements were identified as apart of the EA or Commission decision.

Proposed production increase at the Blind River Refinery

In the spring of 2005, Cameco submitted a letter of intent and project description with the proposal to amend its licence to authorize an increase in the annual production capacity at the BRR facility from 18,000 tonnes of UO_3 to 24,000 tonnes of UO_3.

CNSC staff reviewed the application and determined that pursuant to subsection 18(1) of the CEAA, a screening EA of the project would be required before a decision from the Commission could be made pursuant to the NSCA, and a screening report was prepared in accordance with the requirements of CEAA [17].

Following the Commission's consideration of the screening report in the fall of 2008, the Commission rendered its decision on the EA stating that, upon taking into account implementation of appropriate mitigation measures, and indigenous and public input, that the project, as proposed, would not likely cause significant adverse environmental effects [18].

No additional follow-up program requirements were identified as apart of the EA or Commission decision.

To date, the Cameco has not required the increased production capacity at the BRR facility.

2.2 Planned End State

The following sub-section provides high level information with respect to the end state of the BRR facility and site following decommissioning activities to provide a narrative of how the project/environmental interactions will change over time. Information in this section is informed by Cameco's PDP for the BRR facility.

The CNSC requires that planning for decommissioning take place throughout the lifecycle of a nuclear facility or for the duration of the licensed activity. Planning for decommissioning is an integral part of the lifecycle planning of a facility and it is an ongoing process. A PDP is developed during the facility lifecycle stages preceding the decommissioning stage. The PDP is progressively updated, where needed, to reflect the appropriate level of detail required for the respective licensed activities. Prior to the decommissioning stage, a detailed decommissioning plan is developed to support an application for a licence to decommission.

The PDP documents the decommissioning strategy and end-state objectives; the major decontamination, dismantling and remediation steps, the approximate quantities and types of waste generated, an overview of the principal hazards and protection strategies, and an estimate of cost. The PDP is developed for planning purposes only, it is not meant to be implemented and does not provide sufficient details for the assessment of environmental impact during

decommissioning. This information is required to be submitted at a later date in support of an application for a licence to decommission. As a full lifecycle regulator, the CNSC will continue to carry out regulatory oversight until the planned end state is achieved and the facility is released from the CNSC regulatory control.

The decommissioning strategy and end state objectives for the BRR facility are documented in the 2017 *Blind River Refinery Preliminary Decommissioning Plan* [1].

Cameco's preliminary decommissioning strategy for the BRR facility is for prompt removal and dismantlement of the facility's buildings, equipment and contaminated soils, once regulatory approvals for decommissioning are obtained. To the extent possible, radioactive and hazardous waste from operations will be removed from the site and sent to an authorized waste management facility for disposal, Cameco is currently removing operational radioactive and hazardous waste on a regular basis under their waste management program. Some process equipment and building materials will require decontamination and some site remediation will be required to bring the site back to a state similar to its natural state.

Cameco submitted a revised version of the BRR facility PDP in September 2020 and at the time of publishing this report, CNSC staff are reviewing the submission and will provide the assessment as part of the licensing CMD-21-H9 in August 2021.

2.3 Environmental regulatory framework and protection measures

The CNSC has a comprehensive EP regulatory framework which includes both radiological and hazardous substances, physical stressors (e.g., noise), the protection of Indigenous peoples and the public, and the environment. Public dose is considered under the EP framework, as well as from a radiation protection standpoint. Human exposure is a result of interaction with the environment (i.e., the public are a part of the environment). The focus of this subsection of the EPR Report is on the EP regulatory framework and the status of Cameco's environmental protection program (EPP) for the BRR facility. The results derived from this EPP are detailed in section 3.0 of this report.

The EPP at Cameco's BRR facility was designed and implemented in accordance with REGDOC 2.9.1-2013 *Environmental Protection: Policies, Programs and Procedures* [19], as well as the environmental protection Canadian Standards Association (CSA) standards that are listed below. The EPP includes Derived Release Limits and public dose modelling. Cameco is required to update its EPP to meet the latest version of REGDOC 2.9.1-2017 *Environmental Protection: Environmental Principles, Assessments and Protection Measures* [20] and the current versions of the associated CSA standards. The implementation status for these items is shown in table 2.1 below.

Table 2.1: Status of Cameco's BRR Environmental Protection Measures to Implement Regulatory Documents and Standards

Regulatory document or standard	Status
CNSC Regulatory Document REGDOC 2.9.1 *Environmental Protection: Policies, Programs and Procedures* (2013) [19]	Implemented
CSA Standard N288.1-14, *Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities* [21]	Implemented

Regulatory document or standard	Status
CSA Standard N288.4-10, *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [22]	Implemented
CSA Standard N288.5-11, *Effluent Monitoring Program at Class I Nuclear Facilities and Uranium Mines and Mills* [23]	Implemented
CSA Standard N288.6-12, *Environmental Risk Assessment at Class I Nuclear Facilities and Uranium Mines and Mills* [24]	Implemented
CSA Standard N288.7-15, *Groundwater Protection Programs at Class 1 Nuclear Facilities and Uranium Mines and Mills* [25]	February 2022
CSA Standard N288.8-17, *Establishing and Implementing Action Levels to Control Releases to the Environment from Nuclear Facilities* [26]	Implemented
CNSC Regulatory Document REGDOC 2.9.1, *Environmental Principles, Assessments and Protection Measures, version 1.1* (2017) [20]	February 2022

CNSC staff confirm that Cameco has either implemented programs according to the relevant EP regulatory documents or standards, or has implementation plans in place. Cameco has committed to a schedule, such that its programs will be designed and implemented, according to REGDOC-2.9.1-2017 [20] and the full range of associated CSA standards before the next licensing hearing.

In addition, licensees are required to regularly report on the results of their EPPs. Reporting requirements are specified within the *Radiation Protection Regulations* [26], such as AL or dose limit exceedances, the licensees' approved programs and manuals, or as specified within the Licence Condition Handbook [28].

Cameco is required to submit Annual Compliance Monitoring and Operational Performance Report (ACMOPRs). These annual reports are reviewed by CNSC staff as part of compliance verification activities and to monitor trending. Cameco's ACMOPRs are available on the BRR facility website (external)[29].

CNSC staff regularly report on the licensee performance to the Commission for activities conducted at the BRR facility. Regulatory Oversight Reports (RORs) are the CNSC's standard mechanism for annually updating Indigenous peoples, the public and the Commission on the operation and regulatory performance of licensed facilities. RORs are published online to the CNSC website and are available here [30].

2.3.1 Environmental protection measures

To meet CNSC's regulatory requirements under REGDOC-2.9.1-2013 [19], Cameco is responsible for implementing and maintaining EP measures that identify, control and monitor releases of radioactive and hazardous substances and effects on human health and the environment, from the BRR facility. EP measures are an important component of the overall requirement of licensees to make adequate provision to protect the environment and health of persons.

This, and the following sub-sections, provide a brief summary of the Cameco's EPP for the BRR facility and the status of each specific EP measure, relative to the requirements or guidance outlined in the latest regulatory document or CSA standard. Section 3.0 of this EPR Report summarizes the results of these programs/measures against relevant regulatory limits and environmental quality objectives/guidelines, and discusses, where applicable, any interesting trends.

Cameco is required to implement an Environmental Management System (EMS) that conforms to REGDOC-2.9.1-2013, and submit an EPP. Cameco's EPP includes the following components to meet the requirements and guidance as outlined in REGDOC-2.9.1-2013 [19]:

- EMS
- ERA
- Effluent Emissions Control and Monitoring:
    - derivation of DRLs and Facility Licence Operating Limits (FLOLs)
    - air emissions and liquid effluent monitoring
- Environmental Monitoring Program (EMP):
    - ambient air monitoring, soil monitoring, surface water monitoring, groundwater monitoring and gamma monitoring

2.3.2 Environmental management system

An EMS refers to the management of an organization's environmental policies, programs and procedures in a comprehensive, systematic, planned and documented manner. It includes the organizational structure as well as, planning and resources to develop, implement and maintain a policy for EP. An EMS requires facilities to continuously improve their environmental protection program. This includes periodic updates to the ERA which would drive improvements to a facility's effluent and environmental monitoring programs. The EMS serves as a management tool to integrate all of a licensee's EP measures in a documented, managed and auditable process, in order to:

- identify and manage non-compliances and corrective actions within the activities, through internal and external inspections and audits
- summarize and report the performance of these activities both internally (licensee management) and externally (Indigenous peoples, the public, and the Commission)
- train personnel involved in these activities
- ensure the availability of resources (i.e., qualified personnel, organizational infrastructure, technology and financial resources)
- define and delegate roles, responsibilities and authorities essential to effective management

Cameco established and implemented an EMS for the BRR facility in accordance with REGDOC-2.9.1-2013 [19], and is also registered and certified under CAN/CSA ISO-14001-2015 *Environmental Management Systems – Requirements with Guidance for Use* [31]. CNSC staff review Cameco's annual internal audits, management reviews, and environmental objectives to ensure compliance with REGDOC-2.9.1-2013 [19]. While formal ISO certification is not solely considered by the CNSC as meeting the requirements of REGDOC-2.9.1 [19, 20], the results of these third-party audits are reviewed by CNSC staff, as part of the compliance program.

The EMS at the BRR facility effectively documents how EP programs, systems and practices are used to meet the requirements laid out in the applicable regulatory documents as required by the facility operating licence. CNSC staff conclude that environmental effects from facility operations have been adequately considered and evaluated in their respective licensed activities.

Cameco continues to maintain their EMS to improve environmental performance at the BRR facility.

2.3.3 Environmental risk assessment

An environmental risk assessment (ERA) of nuclear facilities is a systematic process used by licensees to identify, quantify and characterize the risk posed by contaminants and physical stressors in the environment on human and other biological receptors, including the magnitude and extent of the potential effects associated with a facility. The ERA serves as the basis for the development of site specific effluent limits and controls, and EMPs. The results of these programs in turn inform and refine future revisions of the facility-specific or site specific ERA.

In 2016, Cameco submitted an ERA to the CNSC, for the BRR facility. A revised ERA, which is publicly available on Cameco's website here (external) [32], was submitted in 2017 to address CNSC staff's comments [7]. The ERA included an Ecological Risk Assessment and a Human Health Risk Assessment (HHRA) for radiological and non-radiological (hazardous) contaminants and physical stressors. CNSC staff reviewed Cameco's ERA and found it to be in accordance with CSA standard N288.6-12 *Environmental risk assessment at Class I nuclear facilities and uranium mines and mills* [24].

In 2020, Cameco submitted a *Review of the Environmental Risk Assessment for the Blind River Refinery* [8] in accordance with requirements set out in the CSA standard N288.6-12 *Environmental risk assessment at Class I nuclear facilities and uranium mines and mills* [24] to review and revise their ERA every 5 years. The 2020 review of the ERA was submitted 1 year early to support Cameco's licence renewal application for the BRR facility. CNSC staff agree with Cameco's conclusions that no changes to licensed operations or scientific knowledge and that no new risks have emerged since the 2016 ERA was completed [33]. CNSC staff found the 2020 review of the ERA to be acceptable and that the update addressed staff's technical comments and recommendations on the 2016 ERA.

Cameco's conclusions of the 2016 and 2020 review of the ERA are summarized in table 2.2. Effects to ecological and human health due to releases of COPCs to the air and water from the BRR facility were found to be negligible.

Table 2.2: Conclusions of the 2016 ERA and 2020 review of the ERA conducted by Cameco for the BRR facility [7]

Type of risk	Members of the public	Aquatic and terrestrial environment
Radiological	No adverse impacts expected from radiological COPCs released from the BRR facility.	No adverse impacts expected from radiological COPCs released from the BRR facility.
Non-radiological	No adverse impacts expected from non-radiological COPCs released from the BRR facility.	No adverse impacts expected from non-radiological COPCs released from the BRR facility.
Physical stressors	No adverse impacts expected to human health expected from noise at the BRR facility.	No physical stressors associated with the operation of the BRR facility were found to be relevant for assessment.

2.3.4 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 practice; the application of optimization (e.g., in design) and As Low As Reasonably Achievable (ALARA) principles; the Canadian Council of Ministers of the Environment (CCME) and MECP guidelines; and results of the licensee's ERAs.

The BRR facility's EPP [34] was reviewed and approved by CNSC staff. It contains site-specific DRLs, FLOLs and ALs to control radiological and hazardous effluents and emissions. The DRLs represent the maximum acceptable level of emitted contaminants from the processes at the BRR facility and are derived from the dose limit for members of the public (i.e., 1 millisievert per year). The FLOLs are CNSC licenced limits in place to ensure that the BRR facility continues to operate within their licensing basis and are considerably lower than the DRLs. In addition, the BRR facility has established internal control measures, or ALs, to serve as an early warning of potential loss of control to prevent FLOL exceedances.

The BRR facility's effluent monitoring program has been reviewed and approved by CNSC staff and is in compliance with REGDOC-2.9.1-2013 [19] and the relevant standards including CSA Standard N288.5-11, *Effluent Monitoring Program at Class I Nuclear Facilities and Uranium Mines and Mills* [23]. Cameco will revise its EPP accordingly during the upcoming licence period to address any changes in their programs associated with REGDOC 2.9.1-2017 [20].

Based on compliance and technical assessment activities, CNSC staff have concluded that the effluent monitoring program currently in place for the BRR facility continues to protect human health and the environment.

2.3.5 Environmental monitoring program

The CNSC requires licensees to design and implement an EMP specific to the monitoring and assessment requirements associated with its facility, and the environment within which the facility is situated. The program is required to:

- measure contaminants in surrounding environmental media of the facility or site
- determine the effects, if any, of the site or facility 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 obtain the necessary environmental data to calculate public dose and demonstrate compliance with the public dose limit (1 mSv per year). The program design must also address the potential environmental interactions identified at the site. Radiation and radionuclides are the major focus at the BRR facility, though hazardous substances are included within monitoring activities associated with liquid discharges and air emissions. The BRR facility EMP consists of uranium in ambient air monitoring, soil monitoring, surface water monitoring, groundwater monitoring, and gamma monitoring.

Cameco is required to maintain its EMP to be in compliance with REGDOC-2.9.1-2013 [19] and the relevant standards including CSA Standard N288.4-10, *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [21]. Cameco will revise its EMP accordingly during the upcoming licence period to address any changes in their programs associated with REGDOC 2.9.1-2017 [20] and CSA standard N288.7-15, *Effluent Monitoring Program at Class I Nuclear Facilities and Uranium Mines and Mills* [25].

Based on compliance activities and technical assessments, CNSC staff have concluded that the EMP currently in place for the BRR facility continues to protect the environment and human health.

2.4 Reporting of airborne emissions under other federal or provincial legislation

A core element of the CNSC requirement for an EMS is the identification of all regulatory requirements applicable to the facility, whether under the NSCA or other federal or provincial legislation. The EMS must ensure that programs are in place to respect these requirements.

2.4.1 Greenhouse gas emissions

There are a range of broadly applicable federal environmental regulations (e.g., petroleum products storage tanks, environmental emergency regulations), including the management of GHG emissions.

Under the federal *Canadian Environmental Protection Act, 1999* [35], Cameco is required to monitor and report on GHG emissions [36] to the MECP as per *Ontario Regulation 390/18: Greenhouse Gas Emissions: Quantification, Reporting, and Verification* [37]. Facilities that emit more than the 10,000 tons of CO_2 equivalent (CO_2e) emission reporting threshold on an annual basis must report its GHG emissions. Cameco's BRR facility has continually been below the GHG emission threshold and is therefore not required to report these numbers to the MECP. If the GHG emission threshold were exceeded, MECP would report the exceedance to Environment and Climate Change Canada (ECCC).

The CNSC maintains a collaborative working relationship with ECCC through a formal Memorandum of Understanding (MOU), which includes a notification protocol. An exceedance of the GHG emission threshold would be included under this notification protocol. This ensures

a coordinated regulatory approach is achieved to meet all federal requirements associated with EP, including GHGs.

2.4.2 Halocarbons

In accordance with the *Federal Halocarbon Regulations, 2003* [38], Cameco is required to provide a semi-annual halocarbon release report to ECCC for the BRR facility. According to ECCC's review of Cameco's documentation, and notification protocol between the CNSC and ECCC, CNSC staff confirm that all releases have been in accordance with the halocarbon regulations.

2.4.3 Other environmental compliance approvals

Cameco also holds an environmental compliance approval for BRR facility for the incinerator operations and a site wide comprehensive ECA which includes the Dust Collection Exhaust Vent (DCEV) and absorber stacks. All 3 of these stacks have continuous monitoring requirements and emission limits in place. Cameco contracts a third-party to prepare annual stack testing reports which are submitted to Ontario's MECP to demonstrate compliance with their ECAs. These reports are also submitted to the CNSC to ensure that the emission data remain within licence limits. Air emissions from the BRR facility throughout the current licensing period have been in compliance with the facility's ECAs and the CNSC's regulatory requirements, and more information can be found in section 3.1.1 of this report.

The Blind River Refinery also has permits and approvals issued by the province of Ontario related to water. The Blind River Refinery has 3 groundwater monitoring wells that operate under an MECP Permit to Take Water. These groundwater monitoring wells provide process water for the refinery. The Blind River Refinery also has 3 process lagoons that operate under 3 different Industrial Sewage Works Certificate of Approvals. These process lagoons store stormwater, treated process liquids, and treated sewage before they are tested and released to the environment. More information can be found in section 3.1.2 of this report

3.0 Status of the environment

The following section of this EPR Report includes summaries of the radiological and hazardous releases from the BRR facility and the potential effects of these releases on the different components of the environment, as well as CNSC staff's assessments of this information. The environment is divided into the following components: atmospheric, aquatic, terrestrial and hydrogeological environments as well as human health.

CNSC staff also 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 as part of the environmental protection safety and control area of licensing CMDs and annual RORs. ACMOPRs submitted by Cameco for the BRR facility are made publicly available and can be viewed here [29].

This section includes a description of the radiological and hazardous releases to the environment (section 3.1), followed by a description of the surrounding environment of the BRR facility and an assessment of any potential effects to human health and the environment, as a result of exposure to these contaminants (section 3.2).

3.1 Releases to the environment

Once COPCs leave a facility or licenced site, they are considered a release to the environment and how they find their way to the different receptors considered by the ERA are called pathways. Figure 3.1 illustrates the different potential pathways and how a release may be received in the environment, either through airborne emissions or waterborne effluent. This graphic is meant to be a generic representation of nuclear processing facilities, it should not be interpreted as a perfect representation of the BRR facility and its surrounding environment. CNSC staff plan to produce facility specific graphics for additional specificity in future EPR reports. The specific releases and COPCs associated with the BRR facility will be explained in detail in the following sections but some differences to note include:

- the BRR facility is not on the banks of the Lake Huron North Channel but is situated adjacent to the Mississagi River
- all exposure pathways are demonstrated similarly by a white semi-transparent swirl however, certain pathways (i.e., resuspension and inhalation, infiltration of soil deposition to groundwater, and the different ingestion types) are secondary pathways of exposure
- the graphic does not depict the BRR facility's water intake from the Mississagi River or groundwater wells as it is not a pathway of exposure
- the BRR facility does not release treated effluent directly from the shore. It is released approximately 500 meters from the shoreline via a diffuse.

Figure 3.1. Exposure pathways graphic of a generic nuclear processing facility

3.1.1 Airborne emissions

The BRR facility controls and monitors airborne emissions to the environment under its EPP. This program is based on CSA N288.5-11, *Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [23] and includes monitoring of both radiological and hazardous emissions.

The majority of stack emissions from the BRR facility are discharged through the absorber stack, the DCEV stack, and the incinerator stack which are all routinely monitored. Isokinetic dust samplers are used in the stacks to collect samples from the stack gas streams for the measurement of uranium and total particulate. The absorber stack also has an on-line analyzer to measure nitrogen oxides (NOx) emissions. Each process area also has its own separate ventilation system where uranium emissions from each of the individual process area ventilation systems are estimated through calculation. Uranium emission estimates from the stacks are routinely verified by third-party sampling, whereas third party sampling of some of the ventilation systems are completed periodically. A variety of pollution control equipment including bag houses, scrubbers and activated carbon beds are used at the facility to control and reduce emissions to air.

Air emissions from the BRR facility are provided in table 3.1 and compared against the FLOLs, or licence limits. In addition to licence limits, the BRR facility has established air emission ALs and internal control levels, which are used to prevent AL exceedances. Exceedances of licence limits and ALs are reported to the CNSC, documented, investigated and appropriate corrective action are taken where warranted. Air emissions of uranium, NOx, and particulate have been consistently several orders of magnitude below licence limits throughout the current licensing period.

Table 3.1: Average air emissions monitoring results and licence limits for the BRR facility (2015-2019) [2-6]

Source	Parameter	Value	2015	2016	2017	2018	2019	Licence limits [28]
DCEV	**Uranium (g/hr)**	**Weekly Average**	0.05	0.05	0.04	0.05	0.05	**100**
Absorber	**Uranium (g/hr)**	**Weekly Average**	0.01	0.01	0.01	0.01	0.01	**100**
	NOx (kg/hr)		2.5	1.6	1.8	2.3	3.3	**56**
Incinerator	**Uranium (g/hr)**	**Daily Average**	<0.01	<0.01	<0.01	<0.01	<0.01	**10**
All Stacks	**Particulate (g/hr)**	**Weekly Average**	6.2	6.4	7.6	9.8	12	**11,000**

The BRR facility's contaminants released to the air have been adequately identified by the BRR facility Emission Summary and Dispersion Modeling (ESDM) Report (uranium, NOx, and particulate matter).

3.1.1.1 Conclusions – Airborne emissions

Based on CNSC staff's review of the results of the BRR facility's EPP, CNSC staff conclude that Cameco's reported air emissions to the environment from the BRR facility have remained

below the CNSC approved licence limits throughout the reported period and continues to provide adequate protection of people and the environment from air emissions.

3.1.2 Waterborne effluent

BRR controls and monitors liquid (waterborne) effluent to the environment under its implementation of the EPP. This program is based on CSA N288.5-11, Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills [23] and includes monitoring of radiological and hazardous releases.

Cameco monitors uranium, nitrate, radium-226, and pH in effluent released from the BRR facility. Liquid effluent from the BRR facility's operations, as well as treated effluent from the onsite STP is collected and transferred to 3 process lagoons. The BRR facility also uses a stormwater lagoon to collect surface water run-off from the paved areas on site. Water from the storm water lagoon is transferred to 1 of the 3 process lagoons, where it is mixed with process effluent prior to being discharged. Once the lagoon has been monitored and is deemed to meet release criteria, the treated effluent is pumped to the North Channel of Lake Huron. 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 MECP approved methods and protocols. Only 1 discharge location in Lake Huron exists and treated effluent is released on a batch basis using an outfall pipe and diffuser. The diffuser is designed to ensure a minimum 100-fold dilution at the point of entry into the lake under normal conditions.

Table 3.2 summarizes the concentrations of liquid effluent discharged to Lake Huron over a 5-year period from 2015 to 2019, before dilution occurs at the end of pipe. In addition to licence limits, the BRR facility has established liquid effluent ALs and internal control levels, which are used to prevent AL exceedances. Exceedances of limits and ALs are reported to the CNSC, documented, investigated and appropriate corrective action are taken where warranted.

Table 3.2: Concentrations in liquid effluent for the BRR facility (2015-2019) [2-6]

Parameter	Value	2015	2016	2017	2018	2019	Licence limits
Uranium (mg/L)	**Average**	0.02	0.01	0.01	0.01	0.01	**2[1]**
Nitrate (mg/L)	**Average**	13	11	14	20	21	**1000[1]**
Radium-226 (Bq/L)	**Average**	<0.01	0.01	0.01	0.01	0.01	**1[1]**
pH	**Daily Min.**	7.2	7.3	7.3	7.3	7.2	**6 ≤ 9.5**
	Daily Max.	8.4	8.6	8.2	8.5	8.4	

[1]Limit based on the monthly average of weekly composite samples
[2] Limit based on daily discharge sample, and because it is pH, concentration values should be higher than licence limit

3.1.2.1 Conclusions – Waterborne effluent

CNSC staff conclude that Cameco's reported liquid effluent to Lake Huron from the BRR facility remained below the CNSC approved licence limits and has met regulatory requirements during the reported period and continues to provide adequate protection of people and the environment from effluent released to Lake Huron.

3.1.3 Release Limits

The BRR facility has DRLs and FLOLs, or licence limits, to control releases to the environment. As discussed in section 2.3.4, the DRLs are based on the most-exposed person receiving a radiological dose of 1 mSv per year from radiological releases at the BRR facility during normal operations. The BRR facility established FLOLs as a regulatory control measure which are based on the DRLs, but set at a much lower level.

CNSC staff requested that Cameco establish Exposure Based Release Limits (EBRLs) at identified release points at the BRR facility. EBRLs create a release limit that is based on the objective of ensuring that releases to the receiving environment stay below certain levels, or endpoint parameters, in order 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 would be 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 protection of human health and the most sensitive fresh-water aquatic receptors is applied and the identification and use of existing federal or provincial guidelines are selected when calculating the EBRLs. Cameco submitted their proposed EBRLs in September 2020 and at the time of publishing this report, CNSC staff are reviewing the submission.

3.2 Environmental effects assessment

Cameco submitted an ERA for the BRR facility in 2016 [7] and the 2020 review of the ERA [8]. The purpose of the ERA is to analyze the potential risk that airborne and waterborne releases may pose to the various components that make up the surrounding environment. A summary of Cameco's current ERA for the BRR facility is provided in section 2.3.3. A description of the releases of radiological and hazardous COPCs from the BRR facility is included in section 3.1 along with CNSC staff's conclusions on regulatory release limits. Cameco's ERA for the BRR facility, along with annual compliance monitoring reports submitted by Cameco, were reviewed and assessed by CNSC staff to inform this section of the EPR Report.

The following sub-sections discuss the effects of Cameco's environmental releases due to licenced activities at the BRR facility in relation to its environmental interactions, based on the results of both environmental monitoring and modelling, and CNSC staff's conclusions on whether Cameco has and will continue to protect the environment and human health.

The assessment of predicted effects of the licenced activities was carried out in a stepwise manner as follows:

- identifying potential environmental and health effects
- determining whether the environment and health of persons are protected

A review was conducted for all environmental components, but only a selection of topics are presented in detail in this section. These components were selected based on licensing requirements, as well as those that have historically been of interest to, Indigenous peoples, the public and the Commission.

3.2.1 Atmospheric environment

An assessment of the atmospheric environment requires Cameco to characterize both the meteorological conditions and the ambient air quality at the BRR facility site. Meteorological

conditions such as temperature, wind speed, wind direction and precipitation are monitored in order to assess the extent of the atmospheric dispersion of contaminants emitted to the atmosphere, the rates of contaminant deposition, and to determine predominant wind directions which are used to identify critical receptor locations from the air pathway. Meteorological data was gathered from the Killarney automated meteorological station and the Gore Bay station between the years of 2011 to 2015 and compared with a 30 year period between 1971 and 2000.

Ambient air monitoring is used to confirm that ambient air quality, as a result of atmospheric emissions from the operation of the facility due to operations, remain at levels protective of the environment and human health.

Assessment of potential effects

The atmospheric environment was assessed in the ERA by using air dispersion modeling, based on emissions data from the facility, to predict air deposition. None of the contaminants assessed exceeded applicable screening criteria, and the ERA therefore did not indicate a requirement for follow-up monitoring of air emissions. However, the atmospheric monitoring program described below is in place to support the BRR facility operations in the event of an upset condition, to support validation of existing air dispersion models and to support updates to the ERA.

As part of Cameco's EPP, a suspended particulate monitoring program is implemented using high volume air samplers (Hi-Vols). The Hi-Vols are placed at 5 locations around the facility and in the community, to confirm the effectiveness of emission abatement systems and to monitor the impact of the facility on the environment. There are 2 on site and 3 off site Hi-Vol locations. The off site locations are the golf course, hydro yard, and in the Town of Blind River. The Hi-Vols operate continuously during operations and collect parameters with applicable regulatory performance criteria, such as total particulate and uranium. The filters are changed bi-weekly and are weighted before and after being placed in the field to determine particulate emissions and then analyzed for uranium to determine uranium emissions. Over the 5-year period from 2015 to 2019, the results from these monitoring locations show that uranium in air, measured as suspended particulate, has consistently remained very low as summarized in table 3.4. The highest annual average concentration (among the sampling stations) of uranium in ambient air measured around the facility was 0.0042 $\mu g/m^3$, well below the MECP's standard for uranium in ambient air of 0.03 $\mu g/m^3$, based on an annual average [39].

Table 3.3: Annual concentrations of uranium (µg/m³) in ambient air as measured around the BRR facility [2-6]

Hi-Vol Station		2015	2016	2017	2018	2019	Ontario standard [39]
Golf Course	**Average**	0.0002	0.0001	0.0002	0.0002	0.0004	**0.03**
Golf Course	**Maximum**	0.0003	0.0003	0.0005	0.0005	0.0008	
South East Yard	**Average**	0.0007	0.0007	0.0005	0.0008	0.0008	
South East Yard	**Maximum**	0.0015	0.0016	0.0016	0.0020	0.0019	
East Yard	**Average**	0.0031	0.0039	0.0017	0.0022	0.0040	
East Yard	**Maximum**	0.0111	0.0192	0.0070	0.0064	0.0105	
Hydro Yard	**Average**	0.0001	0.0001	0.0002	0.0002	0.0002	
Hydro Yard	**Maximum**	0.0003	0.0002	0.0005	0.0005	0.0004	
Town of Blind River	**Average**	0.0001	0.0001	0.0002	0.0002	0.0002	
Town of Blind River	**Maximum**	0.0003	0.0002	0.0005	0.0005	0.0007	

3.2.1.1 Conclusion – Effects on atmospheric environment

Based on CNSC staff's review of the annual EMP data during the current licencing period and the ERA results for the BRR facility, CNSC staff conclude that atmospheric emissions of uranium attributable to operations of the BRR facility remain significantly below the provincial standard and, therefore, ambient air quality consistently remains at levels protective of human health and the environment.

3.2.2 Terrestrial and aquatic environment

An assessment of potential effects on non-human biota at the BRR facility and the surrounding area consists of characterizing local habitat and species (including consideration of federal and provincial species at risk) and assessing the possibility of their exposure to radiological and hazardous substances, as well as physical stressors that may be disruptive to ecological receptors.

Habitat and non-human biota

The adjacent areas surrounding the BRR facility are predominantly naturalized forested area, with forested lowland, or bog, to the east, a golf course just to the north/northwest of the facility site, and the Mississagi River to the west/southwest before it meets the Lake Huron Northern Channel to the south.

In the 2008 EA study conducted on the proposed increased production capacity for the BRR facility [17], there were no species with statuses of concern identified within the surrounding area, and the 2016 ERA for the BRR facility did not identify any listed species. The 2020 review of the ERA did identify the Blanding's turtles as a species at risk, listed as "threatened" both

federally and provincially. The Blanding's turtles can potentially be in the area of the BRR facility; however, based on Cameco's 2016 ERA conclusions, impacts to any SAR species is unlikely.

Cameco has identified that a thorough identification and description of both federally and provincially listed species potentially present at the BRR site should occur. CNSC staff expect this review will be done through the next ERA revision, as required.

Habitat and non-human biota - Terrestrial environment

There are no natural features within the BRR facility site, however there are surrounding lands that are of importance:

- Mississagi Bay Shoreline Marsh – extensive 75 ha area of shallow and deep shoreline marshes along the coast of the North Channel.
- Mississagi Delta Provincial Park and Nature Reserve – protects 2395 ha of sand delta at the mouth of the Mississagi River. It is located within a few kilometres west of the Refinery.
- Marsh Bay Wetland, Island 9 – provincially significant coastal wetland complex.

A total of 12 amphibian and 10 reptile species can potentially be found in the local area, which extends approximately 4 to 5km beyond the property boundary in every direction and includes the Town of Blind River. Spring peeper and green frog are the most common aquatic amphibians and the painted turtle and garter snake are the most common reptiles. As many as 206 bird species may use the habitat types found in the surroundings, including the wetlands, Mississagi River and Blind River. Seventeen mammal species have been sighted in the regional area, which is extends from Iron Bridge in the west, Elliot Lake to the north, and Serpent River in the east.

Habitat and non-human biota - Aquatic environment

Water bodies that may be affected by the operation of the BRR facility include:

- the southern section of Mississagi River and delta
- the southern section of Blind River, western branch
- the shallow offshore area of the North Channel (known as the Blind River Bank)

The Mississagi River drains into the North Channel on the western boundary of the land on which Cameco currently operates the BRR facility. The river is approximately 150 m from the BRR facility site.

Waters of the North Channel in the vicinity of the BRR facility are commercially fished for lake whitefish, lake trout, walleye, yellow perch, lake sturgeon and northern pike, and to a lesser degree lake herring, round whitefish and channel catfish.

Trapping and gill-netting activities adjacent to the BRR facility yielded species of sport and commercial fish at the following areas:

- 6 species in the Mississagi River delta (walleye, yellow perch, white sucker, rock bass, smallmouth bass and brown bullhead)

- 10 species in Blind River and delta (brown bullhead, yellow perch, trout perch, walleye, rock bass, northern pike, white sucker, channel catfish, smallmouth bass and burbot)
- 13 species in the North Channel (white sucker, yellow perch, walleye, alewife, rainbow smelt, lake whitefish, northern pike, burbot, cisco, brown bullhead, rock bass, smallmouth bass and lake sturgeon)

The Mississagi River is important walleye habitat and is recreationally fished for that species. Walleye spawn in both the Mississagi and Blind Rivers.

Aquatic birds in the vicinity of the BRR facility include mallard, hooded merganser, bald eagle and double crested cormorant. Amphibians known to be present on site include spring peeper and green frogs [17].

Soil monitoring

Cameco collects soil samples at the 0 to 5 cm depth each year in order to monitor uranium concentrations in surface soil. The samples are obtained to monitor long-term effects of air emissions on soil quality due to deposition of airborne uranium on soil in the vicinity of the BRR facility. The 2019 soil monitoring results remained consistent with the respective concentrations detected in previous years, as shown in table 3.4. The maximum uranium soil concentrations measured near the facility in the period from 2015 to 2019 were slightly above Ontario's natural background levels (up to 2.5 µg/g) [40] but below 23 µg/g, which is the most restrictive soil quality guideline set by the CCME for uranium (for residential and parkland land use) [41]. These data demonstrate that current BRR operations do not contribute to accumulation of uranium in surrounding soil, and that no adverse consequences to relevant human and environmental receptors are expected.

Table 3.4: Soil monitoring results of uranium concentrations (µg/g) at the BRR facility (0–5 cm depth) [2-6]

Parameter	2015	2016	2017	2018	2019	CCME guidelines [41]
Average uranium concentration within 1,000 m	3.8	1.5	1.6	2.0	2.1	**23**
Average uranium concentration outside 1,000 m	1.4	0.5	0.6	0.7	1.0	
Maximum uranium concentration	9.7	2.9	2.8	3.7	3.8	

Assessment of potential effects on non-human biota

The assessment of potential effects on non-human biota near BRR is provided in the 2016 ERA report [7]. This ERA was completed to fully conform with requirements of CSA N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [24]. The most recent 2020 review of the ERA fulfilled the requirements under the CSA N288.6-12 [24] to review and update the ERA and to support the BRR licence renewal application. The 2020 review demonstrated that no new risks have emerged since the 2016 ERA and, therefore, ecological risks attributable to BRR operations are negligible.

A total of 23 ecological receptors were selected for the assessment based on knowledge of the BRR site and surrounding environment, relevant environmental studies field observations, and accessibility of the environmental media. The receptors listed in table 3.5 reflect a variety of diets/feeding habits, cover a variety of trophic levels, and are representative of the potential species present in the area.

Table 3.5: Ecological receptors identified for the 2016 ERA for the BRR facility [7]

Aquatic receptors	Terrestrial receptors
Forage/Benthic Fish	Earthworms
Predator/Pelagic Fish	Grass
Benthic Invertebrates	Berries
Macrophytes	Pine
Mallard	Grouse (Herbivore)
Scaup	American Robin (Omnivore)
Hooded Merganser	Barred Owl (Carnivore)
Cormorant (Piscivore)	Bald Eagle (Piscivore)
Northern Leopard Frog	Deer
Beaver	Red Fox
n/a	Black Bear
n/a	Meadow Vole
n/a	Coyote

An assessment of potential radiological effects is based on comparison of the estimated radiation dose received by each ecological receptor from key radiological stressors through all applicable pathways (i.e., external and internal exposure due to radionuclides in air, soil, water, sediment, and gamma radiation) to the recommended benchmark values (dose limits to non-human biota).

Based on the 2014 environmental data measurements from thermoluminescent dosimeters (TLD), maximum potential external exposure of the ecological receptors to gamma radiation at the boundary of the facility was estimated to be 1.6 µGy/h (for comparison, the respective 2019 maximum level is 1.0 µGy/h). This level of exposure is below the most conservative screening criterion for non-human biota of 10 µGy/h and therefore below the values known to cause adverse effects.

The overall radiation dose (including all internal and external doses form all exposure pathways) were significantly below the radiological dose benchmarks recommended in CSA 288.6-12 [24] – 100 µGy/h for terrestrial receptors and 400 µGy/h for aquatic non-human biota. This indicates no potential for adverse effects and no need for further (detailed) assessment.

The 2016 ERA [7] assessed the potential effects of several hazardous substances (specifically uranium, ammonia and tributyl phosphate (TBP)) on terrestrial and aquatic receptors. The estimated risks for terrestrial and aquatic receptors based on maximum concentrations of

uranium in each environmental media were below the respective benchmark values [24]. Ammonia was screened out as a COPC because the maximum concentrations in surface water were less than the CCME Water Quality Guidelines for the Protection of Aquatic Life [42]. As reflected in the 2020 review of the ERA, ammonia has been eliminated from the BRR facility refining process and is no longer included as a COPC for assessment [8].

The maximum measured concentration of TBP at the point of discharge (diffuser) was 0.42 mg/L. This concentration would be diluted further where it would be not be detected downstream in the North Channel. Therefore, exposure of aquatic receptors to TBP in surface water would be well below the lowest predicted no-effect concentration of 0.82 mg/L for fish, and pose negligible risk to aquatic organisms.

In the 2020 review of the ERA, Cameco indicated the TBP detection limit had been lowered from 0.6 mg/L to 0.13mg/L. New reporting confirmed that the maximum measured concentrations of TBP at the diffuser of 0.42 mg/L, were below the no-effect concentrations derived by the European Chemicals Agency [43].

3.2.2.1 Conclusion – Effects on terrestrial and aquatic environment

Based on CNSC staff's review of the results of the EMP for the BRR facility and the assessment of potential radiological dose to ecological receptors conducted within the respective ERAs, CNSC staff confirm that non-human biota and soil quality remain protected from radiological exposures due to releases from the BRR site.

Based on CNSC staff's review of Cameco's 2020 review of the ERA, CNSC staff confirm that the risk to aquatic organisms from the BRR is negligible and releases of hazardous substances from the BRR facility are not expected to result in adverse impacts to non-human biota.

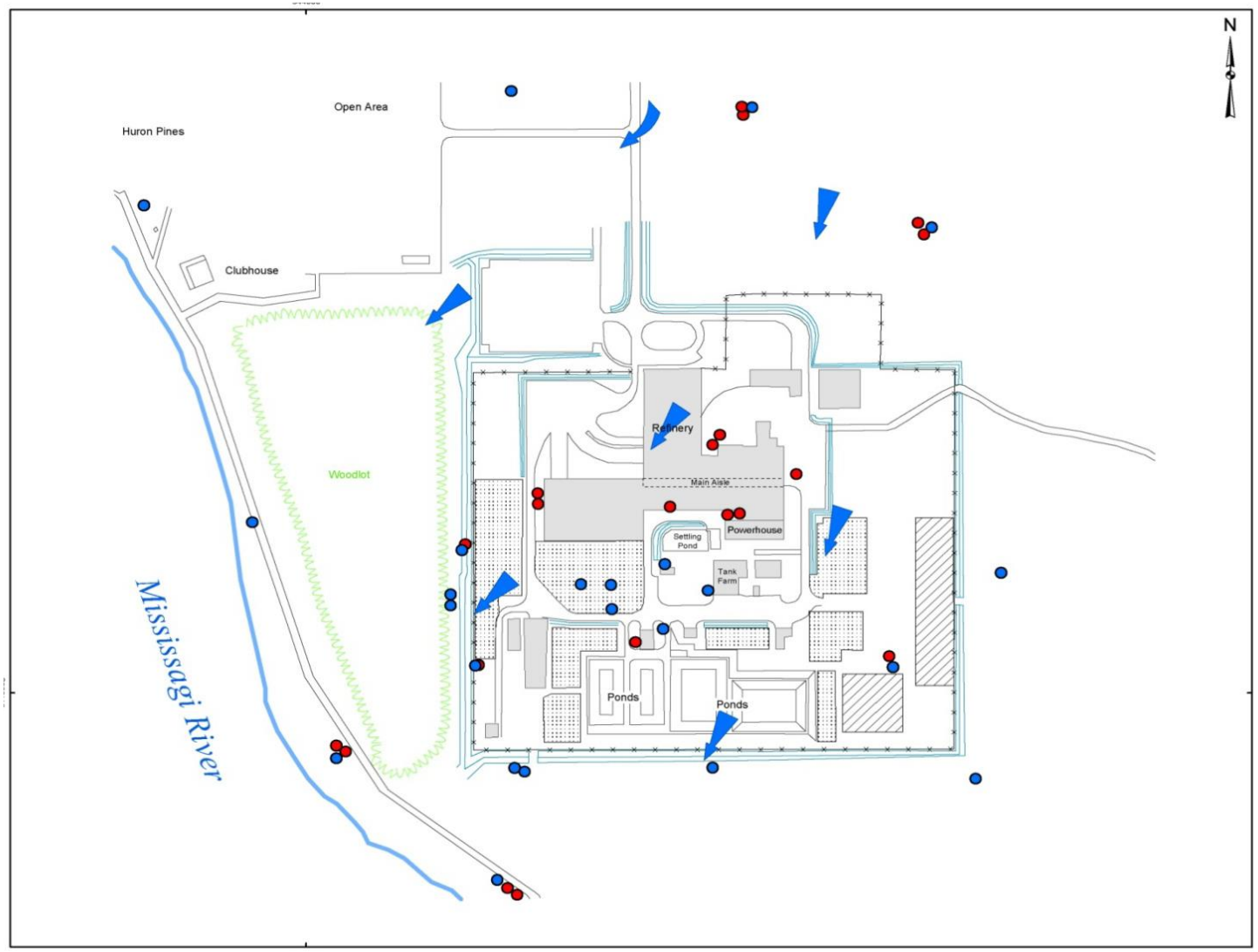
3.2.3 Hydrogeological environment

An assessment of the hydrogeological environment at the BRR site consists of identifying potential sources of groundwater contamination on the site, determining the extent of contamination, if any, which could lead to an exposure pathway human and/or non-human receptors, and determining the significance of any exposure from this pathway. Additionally, the hydrogeological assessment confirms whether control measures in place continue to remain effective in protecting the environment.

In the area of the BRR facility, the native overburden deposits is generally overlaid by fill materials consisting of various proportions of sand and gravel (having a thickness of between approximately 0.9 and 2.5 metres). Bedrock in the area of the main facility consists of grey/green, medium to coarse grained diabase.

Groundwater flows from north-east towards Mississagi River in the south-west, as shown in figure 3.2.

Figure 3.2. Groundwater Flow Directions and Monitoring Well Locations at BRR Facility[1] [6]



[1]Historical monitoring wells are in blue and monitoring wells drilled since 2012 are in red

Assessment of potential effects

Groundwater is monitored through 35 monitoring wells: 14 wells located within the perimeter of the BRR facility and 21 wells outside of it. The well depths vary from 3.66 m in the overburden to 14.9 m in the bedrock.

Monitoring results of uranium in groundwater are presented in table 3.6 and show that they have remained below Health Canada's *Guidelines for Canadian Drinking Water Quality* (GCDWQ) (20 µg/L) [44] and the MECP s*oil, ground water and sediment standards for use under under Part XV.1 of the Environmental Protection Act* (20 µg/L) [40] in the last 5 years; except for in 2018 when there was 1 groundwater monitoring well, in which the maximum concentrations slightly exceeded the GCDWQ. The uranium exceedance was not related to any current operations at the BRR facility but was related to historical contamination in the vicinity of 1 of the monitoring wells, which is located in an area that was used as a temporary storage of empty uranium concentrate drums over 10 years ago. Cameco intends to continue to sample and monitor results from this monitoring well and others, and will take additional action if necessary. Currently, the nearest downstream monitoring well have consistently reported uranium concentrations as less than the detection limit of 0.7 µg/L [45]. It is important to note that groundwater in the area is not used for drinking water purposes and that the Health Canada GCDWQ is used as a conservative comparative measure.

Table 3.6: Uranium concentrations from groundwater monitoring results at the BRR facility [2-6]

Parameter	Units	Value	2015	2016	2017	2018	2019	GCDWQ [44]	MECP [40]
Uranium	**µg/L**	**Average**	1.7	1.3	1.2	2.3	2.0	**20**	**20**
Uranium	**µg/L**	**Maximum**	18.5	14.0	11.0	27.0	14.0	**20**	**20**

3.2.3.1 Conclusion – Effects on hydrogeological environment

CNSC staff review the hydrogeological conditions and variations through monitoring results reported in Cameco's annual compliance reports. Based on CNSC staff's assessments of Cameco's monitoring results, CNSC staff conclude that there are no adverse impacts to the groundwater from the BRR facility and that Cameco continues to protect the environment and human health.

3.2.4 Human environment

An assessment of the human environment at the BRR site consists of identifying representative persons located in proximity to the site, and whether the aforementioned environmental pathways will have an impact on these persons. 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. Indigenous peoples and the public, and residents working at the Huron Pines Golf clubhouse were determined to be the most exposed individuals for potential radiological exposures [2-6].

3.2.4.1 Human exposure - Radiological

The CNSC's *Radiation Protection Regulations* [27] prescribe radiation dose limits to protect the public from exposure to radiation as a result of licensed activities. The annual effective dose limit for a member of the public is 1 mSv per year.

The annual doses to residents in vicinity of the BRR facility as well as to employees at nearby worksites, have been calculated based on environmental monitoring data as well as from measurements of airborne and liquid emissions from the facility. The annual dose calculations include 5 groups of residents at the following locations:

- residents of the Lantain subdivision, which is closest to the BRR site
- the MFN community
- residents living on Colonization Rd. east of the facility
- a residence approximately 2 km north east of the facility on the south side of Highway 17
- seasonal employees at the Huron Pines Golf clubhouse located next to the BRR site, as well as for full time employees at the Hydro Yard at approximately 1.3 km to the north north-east of the facility.

These residents are assumed to reside year-round while being exposed to emissions and effluent from the BRR facility, and to gamma radiation from materials on site. They are also assumed to visit the Boom Camp trail recreational area, spending 200 hours per year there. This represents spending approximately 4 hours per week, for the entire year, at this day-use location.

The annual doses to these residents and employees include dose received from external exposure to gamma radiation emitted by material stored on-site at the BRR facility. This is as a result of radiological substances deposited on the ground from historical operations during the period of 1983 to 2009. The annual doses also include dose from inhalation, food consumption, including consumption of local fish and wild game and fowl, inadvertent soil ingestion, drinking water consumption, and external exposure from radiological substances deposited on the ground. Residents include infants, children and adults.

The gamma doses to these residents and employees, spanning the period from 2015 to 2019, are based on environmental monitoring data from optically stimulated luminescence dosimeters surrounding the site boundary and located at 5 Hi-Vol air sampling locations.

During 2019, the maximum annual dose to the most exposed member of the public was calculated to be 5 μSv [6]. The annual dose limit for members of the public, as stipulated in the *Radiation Protection Regulations* [27] is 1000 μSv (1 mSv).

During the period from 2015 to 2019, the dose to the public from BRR remained well below the regulatory limit of 1000 μSv (1 mSv) per year. It can be seen in table 3.8, that annual doses are very low. The doses reported in table 3.7 are those received by the most exposed persons, which are residents working 1,200 hours per year at the golf club. Since this is a seasonal facility, 1,200 hours per year represents working 40 hours per week for 30 weeks per year. Almost all of the dose is due to external gamma exposures from material stored at the BRR facility. Inhalation and ingestion contribute less than 0.01 μSv [6].

Table 3.7: Estimated annual public doses for the BRR facility [2-6]

Gamma dose from TLD at Golf Club (μSv)

Public dose limit (µSv)	2015	2016	2017	2018	2019
1000	5	5	5	5	5

The above calculation method is based on the method used to calculate BRR's DRLs. In 2019, an updated DRL document was submitted to the CNSC. CNSC staff reviewed Cameco's submission and confirmed alignment with CSA N288.1-14 [21]. Further, the ERA for the BRR facility estimated doses to the public using more conservative assumptions and provided an upper bound of 84 µSv per year to residents (less than 10% of the public dose limit) [7]. This is considered a bounding assessment. Through this, Cameco continued to ensure protection of members of the public in proximity to the BRR facility in accordance with the *Radiation Protection Regulations* [27].

3.2.4.2 Human exposure – Hazardous substances

The non-radiological HHRA for the BRR facility encompassed an approach consistent with CSA N288.6-12 [24]. Human receptors assessed included onsite persons (BRR worker), and offsite members of the public such as a resident, a cottager, a golf worker, a hydro worker, and a Boom Camp worker. Based on a preliminary screening of contaminants using CCME and other criteria, the following non-radiological COPCs were assessed: ammonia (in groundwater), uranium, and TBP.

In general, human receptors may be exposed to the contaminants through 4 primary routes: dermal (skin), inhalation, incidental ingestion (e.g., soil), and ingestion of contaminated food and water. Effects on human health were assessed using an approach encompassing a semi-quantitative pathways analysis to determine if there was a likelihood for members of the public to be exposed through air, water or the food chain.

Concentrations of ammonia in the groundwater were low, and owing to its low toxicity and non-carcinogenicity, would pose a negligible risk to human health.

The conservative analysis showed that there were exceedances of the benchmark for TBP in groundwater for resident receptors and in surface water for all other receptors, while uranium levels in soil and groundwater posed a negligible risk. The results for TBP were then raised for further assessment using a more realistic dilution factor of 500 [46]. This approach was reviewed and approved by CNSC staff [47], and it was determined that levels of TBP in the groundwater did not pose a residual risk to the respective receptors. This conclusion was also based on the fact that the groundwater measurement data used in the assessment were from within or adjacent to the BRR facility site and not from residential areas. In addition, it was concluded that risk to humans is unlikely owing to the absence of an exposure route to contaminated water because groundwater is not a source of drinking water and the direction of groundwater flow is away from inhabited area, as shown in figure 3.2.

Similarly, after the initial conservative assessment, it was concluded that levels of TBP in surface water would not pose a residual risk to human health after considering the dilution factor of 500 of TBP released from the effluent lagoons. It is CNSC staff's expectation that Cameco will continue to monitor for levels of TBP in surface water to confirm these findings.

3.2.4.3 Conclusion – Effects on human health

The dose resulting from radiological substances in airborne and liquid emissions as well as from external exposure to gamma radiation from material stored on site has remained constant at 5 µSv per year for the last 5 years. This represents the highest dose to a person living and working near the BRR facility, due to current operations as well as historic releases. The results from table 3.6 and the HHRA for the BRR facility have shown that radiological doses to the public are well below the annual dose limit of 1000 µSv (1 mSv) [27]. It can be concluded that the radiological emissions from the BRR facility poses a negligible risk to human health.

With respect to hazardous substances, the HHRA and CNSC staff's review indicated that operations at BRR posed a negligible risk to human health.

Based on assessments conducted for the BRR facility, including the ERA, annual reports, and annual environmental monitoring data, CNSC staff conclude that impacts to the human environment are negligible and that people living and working near the facility are protected.

3.2.5 Additive cumulative effects

CNSC staff considered the additive cumulative effects of site-specific factors in a risk informed manner within the context of its overall assessment of environmental protection. Additive cumulative effects are 1 type of cumulative effect that the federal guidance document titled *Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012* defines "as the sum of individual effects of 2 or more physical activities" [48]. CNSC staff continually assess additive cumulative effects through the cyclical nature of ERAs, the monitoring data in annual reports, data from regional monitoring programs, the IEMP, and through health studies. For the BRR facility, based on the data assessed thus far and presented in this EPR Report, CNSC staff conclude that no additive cumulative effects are occurring in the surrounding environment.

4.0 CNSC Independent Environmental Monitoring Program

The CNSC has implemented its IEMP to verify that Indigenous peoples, the public, and the environment around licensed nuclear facilities are protected. 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 contaminant substances in those samples. CNSC staff collect the samples and send them to the CNSC's laboratory for testing and analysis.

4.1 IEMP at the BRR facility

CNSC staff conducted IEMP sampling around the BRR facility in 2013, 2014, 2017 and 2018. Staff developed site-specific sampling plans focused on radiological and hazardous contaminants, and based on Cameco's site-wide EMP and CNSC's regulatory experience with the site.

In 2018, for the most recent campaign, CNSC staff collected the following samples in publicly accessible areas outside the perimeter of the BRR facility:

- air (3 locations)
- water (9 locations)
- soil (10 locations)

Collected samples were analyzed by qualified laboratory specialists in the CNSC's laboratory in Ottawa, using appropriate analytical protocols. CNSC staff analyzed the samples for uranium, nitrate and pH.

Figure 4.1 to 4.4 provide an overview of the sampling locations for the 2018 IEMP sampling campaign around the BRR facility. The IEMP results are published on the CNSC website [49].

4.2 Indigenous participation in the IEMP

It is a priority for the CNSC that IEMP sampling reflects Indigenous traditional land use, values and knowledge, where possible.

In advance of the IEMP sampling campaigns at BRR facility, notification emails are sent to all Indigenous groups near the BRR facility, including the Métis Nation of Ontario (MNO) Region 4, Sagamok First Nation (SFN), Thessalon First Nation, Serpent River First Nation and the MFN. The notification letters invited suggestions for sample types and locations, and species of interest or valued components.

In 2018, the CNSC met with the MFN, MNO Region 4, and the SFN. These meetings provided CNSC staff with the opportunity to collaborate with Indigenous groups, to learn about their individual histories and cultures, and to address questions related to the operations at Cameco's BRR facility. The following sections summarizes CNSC staff`s collaboration with the local Indigenous groups during the 2018 sampling campaign.

4.2.1 Sampling with the Mississauga First Nation

Since 2014, CNSC staff have been working with the MFN by holding regular meetings to discuss Cameco's licensing and compliance activities for the BRR facility. CNSC staff

incorporated input from the MFN into the 2018 IEMP sampling plans for the BRR facility, including suggested sampling types and locations around the community (refer to figure 4.1 to e 4.4 for a visual representation).

In 2018, the MFN informed sampling locations for the following locations:

Air

- Binojee Nagdawenjigamik Daycare, 36 Ella Dr (BR17-A02)
- MFN member Residence, 93 MacIver Dr (BR18-A03)

Water

- MFN member Residence, 93 MacIver Dr (BR18-W05))
- Boat launch (Mississagi Chutes) in Mississagi Falls off of Hwy 17 (reference location) (BR30-W11)

Soil

- Playground, Corner of Ella Dr and Village Rd (BR23-S06)
- Red Pine Lodge, 28 Elders Rd (BR24-S07)
- MFN member Residence, 93 MacIver Dr (BR18-S08)
- Baseball diamond by In Motion Fitness Centre, 43 Park Rd (BR26-S09)
- Boat launch (Mississagi Chutes) in Mississagi Falls off of Hwy 17 (reference location) (BR30-S11)

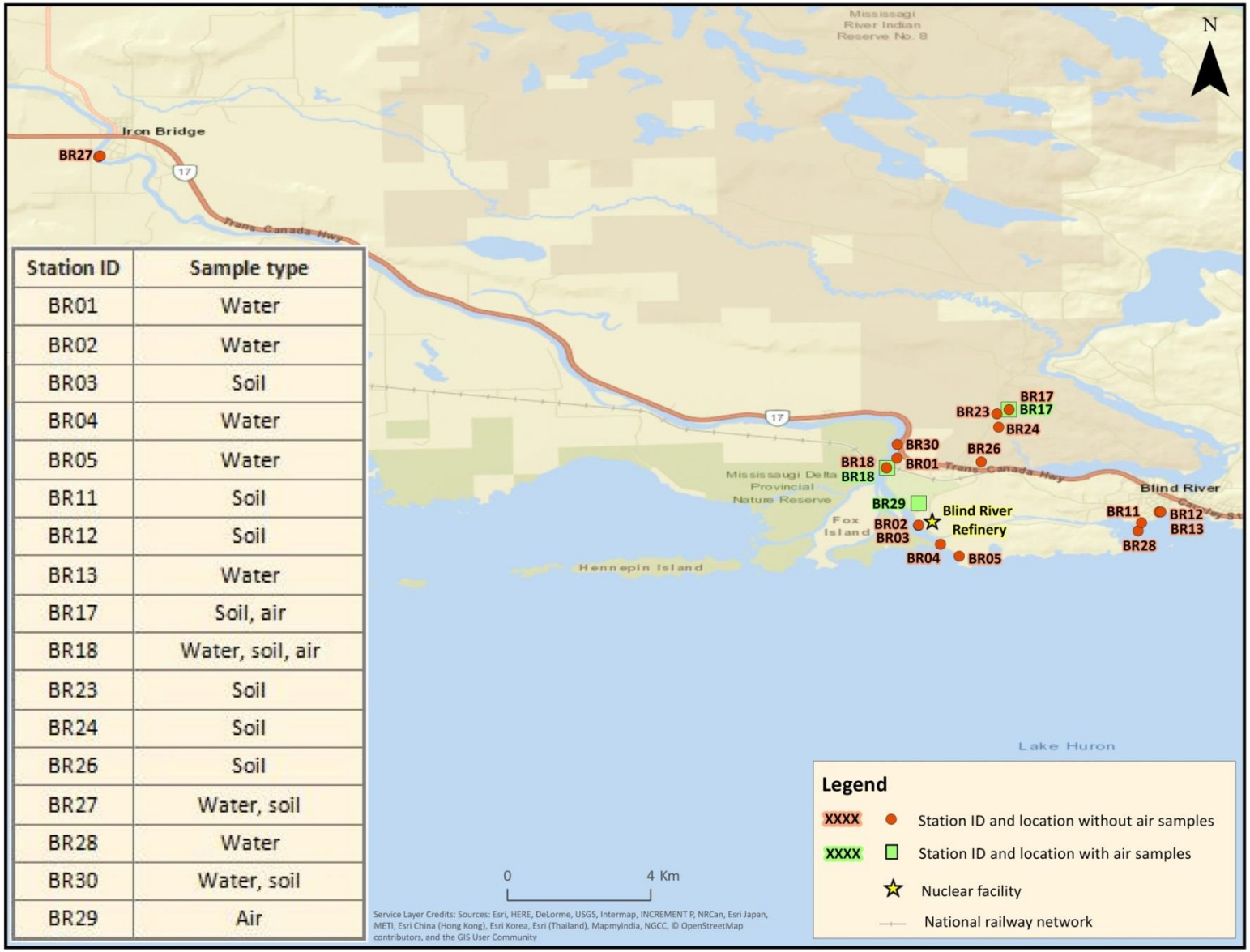
Sampling locations were identified based on what may be of significance for MFN members. BR17 was chosen because it is a full-time daycare, BR18 is an accessible private residence, BR24 is visited frequently, BR26 is used for recreational purposes, and BR30 is publicly accessible. Community members were invited to visit the air sampling station to ask questions and observe how CNSC staff used the equipment [50].

4.3 Summary of results

The levels of uranium, nitrate and pH in all of the samples measured during the 2018 IEMP sampling campaign were below available guidelines and were similar to the range of results from the 2013, 2014 and 2017 IEMP sampling campaigns at BRR. Results for all campaigns are published on the CNSC's website [49].

The IEMP results verify that Indigenous peoples, the public and the environment near the BRR facility are protected. These results are consistent with the results submitted by Cameco and reviewed by CNSC's environmental protection staff, demonstrating that the licensee's EP program protects the health and safety of people and the environment.

Figure 4.1: Location overview of the 2018 sample locations [50]



Station ID	Sample type
BR01	Water
BR02	Water
BR03	Soil
BR04	Water
BR05	Water
BR11	Soil
BR12	Soil
BR13	Water
BR17	Soil, air
BR18	Water, soil, air
BR23	Soil
BR24	Soil
BR26	Soil
BR27	Water, soil
BR28	Water
BR30	Water, soil
BR29	Air

Figure 4.2: Location overview of the 2018 sample locations [50]

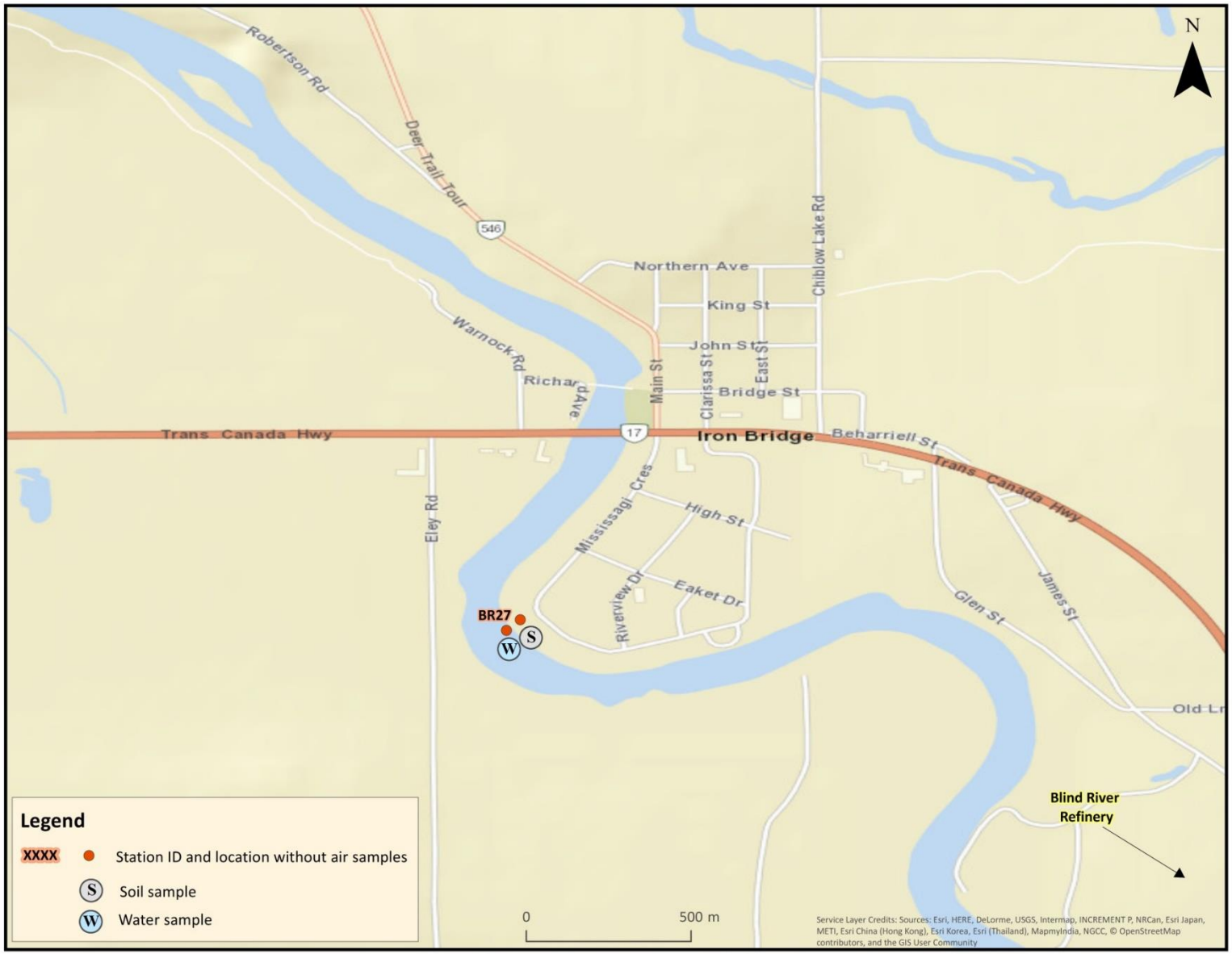


Figure 4.3: Location overview of the 2018 sample locations [50]

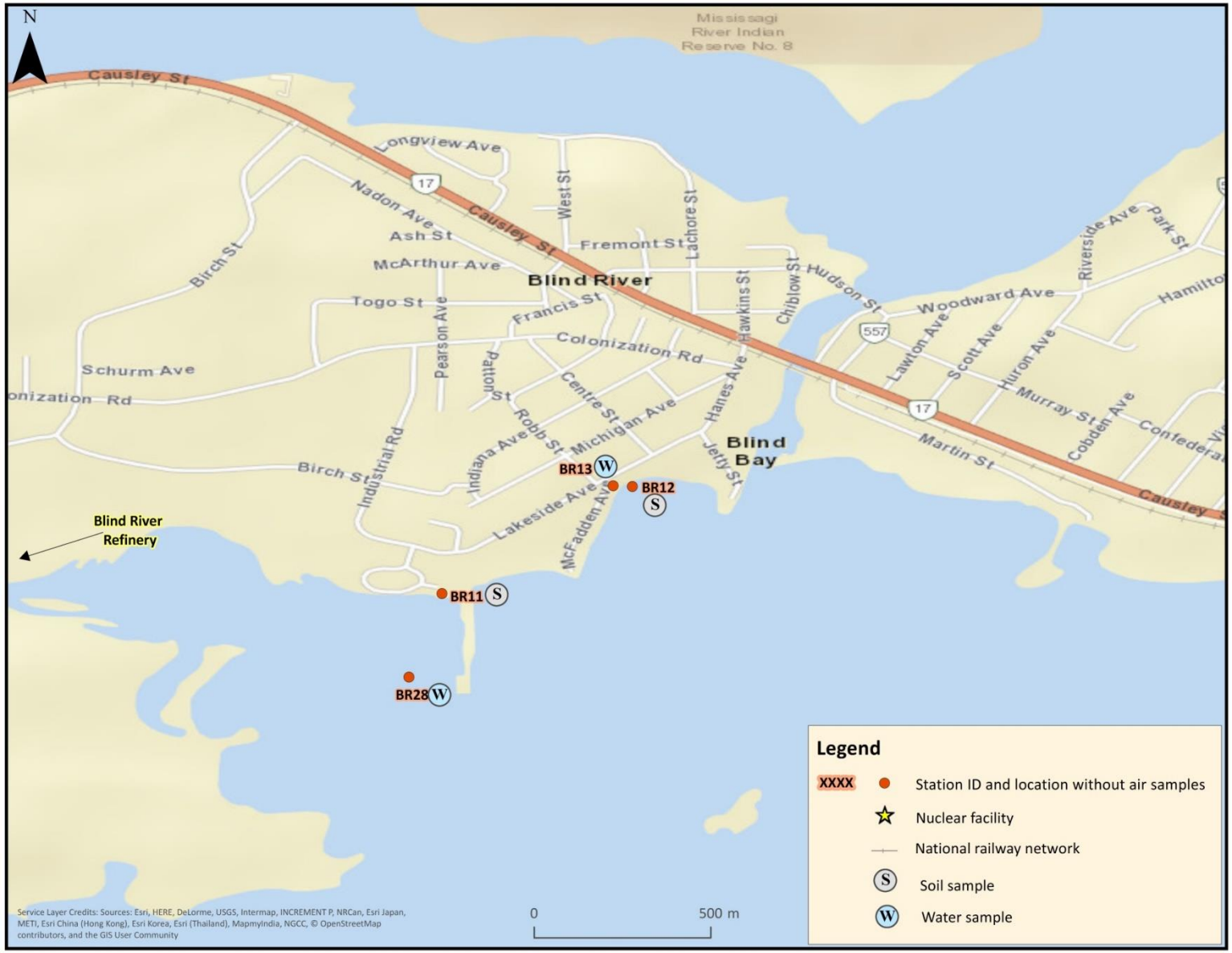
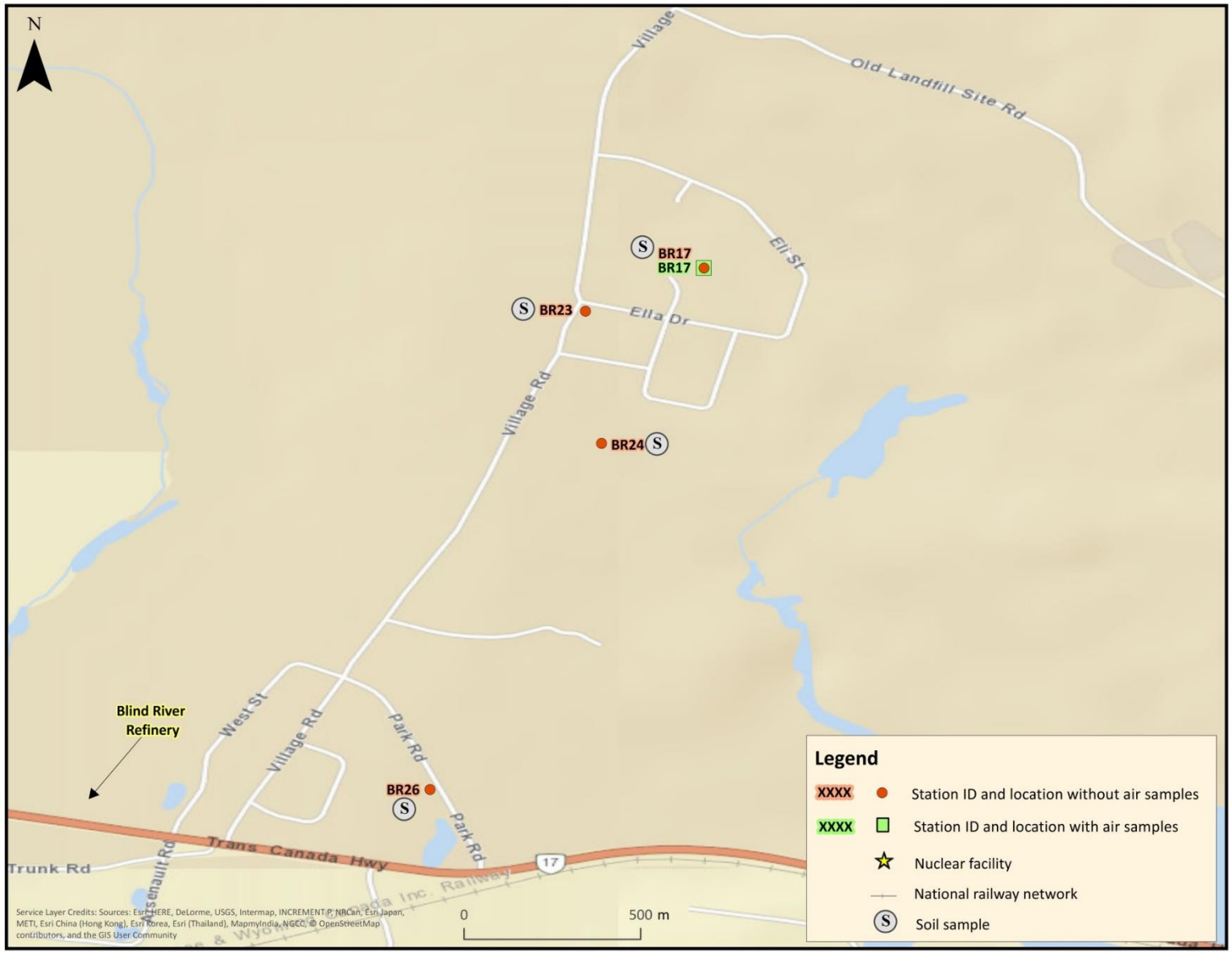


Figure 4.4: Location overview of the 2018 sample locations [50]



5.0 Health studies

The following section draws from the results of regional health studies to provide further independent verification that the health of people living near the BRR facility are protected. The health of populations around the BRR facility are monitored by various organizations and institutions in Ontario such as Cancer Care Ontario, and Public Health Ontario, and by the local public health units. In addition, disease rates around the BRR facility are compared to similar populations to detect any potential health outcomes that may be of concern. CNSC staff keep abreast of any new publications and data related to the health of populations living near nuclear facilities.

There are several health studies and reports that have assessed the health of populations living near the BRR facility, which are discussed below. Additional information on health studies related to nuclear facilities is available on the CNSC webpage on Health Studies.

5.1 Population and community health studies and reports

5.1.1 Algoma Community Health Profile September 2018 [51]

The most recent Community Health Profile released in 2018 examines health outcomes and factors that affect the health of people living in areas serviced by the District of Algoma Health Unit including Blind River. The report uses data from the Canadian Community Health Survey (CCHS), the Canadian Census, the Discharge Abstract Database, the integrated Public Health Information System, the National Ambulatory Care Reporting System, Panorama, Ontario Mortality Data, Population Estimates, and Population Projections.

The leading causes of mortality from 2009 to 2012 in Algoma included heart disease, lung cancer, and dementia, which was consistent with the rest of Ontario. The leading causes of mortality (2009-2012) for males in Algoma included heart disease, lung cancer, and lung disease, and heart disease, dementia, and lung cancer for females, which was consistent with the rest of Ontario. Algoma's 2012 all-cause mortality rate (844.6 deaths per 100,000 people) was significantly higher than the province (664.2 per 100,000 people), but similar to the North East Local Health Integration Network (NE LHIN) rate (830.8 deaths per 100,000 people). However, the all-cause mortality rate in Algoma has decreased since 2000. A premature death is a death prior to 75 years old. In Algoma, 42.0% of deaths are premature compared to 41.5% in the NE LHIN and 37.3% of deaths in Ontario. Approximately, 75% of premature deaths in Algoma can be prevented through healthy behaviours (e.g., not smoking, having active lifestyle, reducing alcohol intake, and eating a healthy diet), effective public health interventions, or appropriate medical treatment.

From 2000 to 2012, the infant mortality rate in Algoma was 7.5 per 1,000 births, comparable to the NE LHIN at 6.4 per 1,000 births, but significantly higher than Ontario at 5.0 per 1,000 births. The top causes of infant mortality in Algoma are sudden infant death syndrome (SIDS) and extremely low birth weight.

Breast cancer (193.1 per 100,000 people), lung cancer (93.6 per 100,000 people) and prostate cancer (212.8 per 100,000 people) were more commonly diagnosed in Algoma compared to Ontario (141.5 per 100,000 people; 69.8 per 100,000 people; and 118.4 per 100,000 people

respectively). This may be the result of behaviours associated with cancer such as alcohol consumption and smoking.

Approximately 1 in 4 deaths in Algoma were due to cancer, which is similar to the NE LHIN and Ontario. Males were more likely to die from cancer in Algoma, which is similar to Ontario. Mortality rates for lung cancer were significantly higher in Algoma (65.3 per 100,000 people) compared to Ontario (49.8 per 100,000 people). Nearly 30% of Algoma residents smoke compared to 15.5% in Ontario, which is a major risk factor for lung cancer. More than a quarter of Algoma residents are heavy drinkers, defined as 5 or more drinks for males and 4 or more drinks for females on 1 occasion and at least once per month, which is slightly higher than Ontario. Further, Algoma has lower screening rates for major Ontario cancer screening programs among eligible individuals, which often means that the discovery of cancer occurs at a later stage.

5.1.2 Algoma Cancer Report 2015 [52]

This report provides a more in depth description of cancer incidence (newly diagnosed cases) and mortality (deaths attributed to cancer) rates for the time period 2000 to 2009. Algoma rates were compared to Ontario rates and the 2007 defined Sparsely Populated Urban Rural Mix Public Health Unit Peer Group (excluding Algoma) rates, which is a population more reflective of the Algoma population (the Peer Group).

The most common types of cancer in Algoma were prostate, breast, lung and colorectal cancers. These cancers accounted for over half of newly diagnosed cases in Algoma (53.9%), which was similar to Canada (52.0%), Ontario (53.2%), and the Peer Group (55.5%).

The age standardized incidence rate for all cancers, between 2000 and 2009 for Algoma was 427.6 per 100,000 people which was significantly higher compared to Ontario's rate at 410.2 per 100,000 people, but not significantly different than the Peer Group at 439.5 per 100,000 people. The age standardized incidence rates in Algoma between 2006 and 2009 for lung and bronchus, urinary bladder, kidney and renal pelvis, and esophageal cancer was statistically significantly higher than the Ontario rates, but not statistically different from the Peer Group. Whereas the age standardized incidence rates in Algoma between 2006 and 2009 for prostate and liver cancer were significantly lower than Ontario rates, and significantly lower and similar, respectively for the Peer Group.

The age standardized mortality rate for all cancers between 2000 and 2009 in Algoma (186.3 deaths per 100,000 people) was significantly higher than the Ontario rate (165.3 deaths per 100,000 people), but similar to the Peer Group (188.6 deaths per 100,000 people). The age standardized mortality rate for lung and bronchus cancer between 2000 and 2009 in Algoma (52.1 deaths per 100,000 people) was significantly higher than the Ontario rate (41.4 deaths per 100,000 people), but similar to the Peer Group (54.1 deaths per 100,000 people).

5.1.3 Conclusions – Population and community health studies and reports

Reviewing and conducting health studies and reports is an important component of ensuring that the people living near nuclear facilities are protected. The population and community health studies and reports indicate that common causes of death among the population of Algoma,

which includes Blind River, are heart disease, lung cancer, and dementia. This is similar to the rest of Canada where heart disease and cancers are the 2 leading causes of death [63].

5.2 Studies of radiation health effects

The current scientific knowledge about the sources, effects and risks of ionizing radiation is reviewed and published by the international experts that make up the United Nations Scientific Committee on the effects of Atomic Radiation (UNSCEAR). This knowledge in turn informs the recommendations of the International Commission on Radiological Protection (ICRP), which are focused on the protection of human health. The epidemiological evidence of radiation-related health effects comes from several main research populations. These include the atomic bomb survivors, people involved in the Chernobyl disaster, patients treated with radio-therapy for cancer and non-cancer diseases, miners exposed to radon and radon decay products and nuclear energy workers.

2 major findings of these studies are: 1) the excess risk of cancer increases as the radiation dose increases, and 2) statistically significant population effects are only observed at doses above 100 mSv, which are much higher than the natural background (as a reference, the annual Canadian average background is 1.8 mSv [53]).

5.2.1 Health studies of populations living near nuclear processing facilities

There are no specific health studies that look at adverse health effects from the operation of the BRR facility. However, studies carried out over several decades have repeatedly demonstrated that people who live near nuclear facilities are as healthy as the rest of the general population. For instance, many health studies have been carried out in Port Hope, Ontario where the radium and uranium refining, processing, and fabrication industry has existed since 1932. Several environmental and health studies have been conducted to assess the potential contamination effects in the Port Hope community over the last 70 years.

5.2.1.1 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 [54]

This study 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. 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-radioactive contaminants in Port Hope are below levels known to cause adverse health effects. Further, epidemiological studies provide no evidence of health effects as a result of past and present activities of the Port Hope nuclear industries. The ERAs completed for nuclear facilities in Port Hope and the epidemiological studies are consistent and support each other. Port Hope's findings are consistent with the results of over 40 epidemiological studies conducted elsewhere on populations living around similar facilities or exposed to similar environmental contaminants.

5.2.1.2 An ecological study of cancer incidence in Port Hope, Ontario from 1992 to 2007 [55]

In this ecological study, cancer incidence rates in Port Hope were studied for a 16-year period (1992–2007) for continued periodic cancer incidence surveillance of the community. The cancer incidence in the local community for all cancers combined was similar to the Ontario population, health regions with similar socio-economic characteristics in Ontario and in Canada, and the Canadian population. No statistically significant differences in childhood cancer, leukaemia or other radiosensitive cancer incidence were observed, with the exception of statistically significant elevated lung cancer incidence among women. However, the statistical significance was reduced or disappeared when the comparison was made to populations with similar socio-economic characteristics. These findings are consistent with previous ecological, case-control and cohort studies conducted in Port Hope, ERAs and epidemiological studies conducted elsewhere on populations living around similar facilities or exposed to similar environmental contaminants.

5.2.1.3 Conclusions – Health studies of populations living near nuclear processing facilities

These studies demonstrate that there are no adverse health effects attributable to the nuclear industry in Port Hope, even though low-level radioactive waste was improperly disposed of throughout the town from 1932-1966, unlike the BRR facility or surrounding area. While these studies do not look specifically at populations surrounding the BRR facility, the evidence from these studies help to inform the health and protection of other populations living near nuclear processing, fabrication, and refinery facilities, such as the BRR facility.

5.2.2 Health Studies of uranium processing workers

The CNSC has conducted studies looking at the health of uranium processing and fuel fabrication workers in Port Hope, which is detailed below. There are some large studies in the literature [56, 57] that have assessed mortality and cancer incidence for all workers included in the National Dose Registry but these studies do not provide a separate analysis and results for workers at the BRR facility, even though the dose received by workers at the BRR facility is monitored.

In 2017, the average effective dose to a nuclear energy worker at the BRR facility was 0.9 mSv, which is well below the worker dose limit for a nuclear energy worker of 50 mSv. Adverse health effects in these workers would not be expected at these dose levels. However, the CNSC is has initiated a Canadian-wide study of uranium workers including miners, millers and processing workers, which is discussed further below. This study will include workers from BRR facility.

5.2.2.1 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 [58]

This study looked at cancer incidence and mortality among uranium and radium processing workers in the Port Hope community. Uranium processing workers are exposed primarily to uranium, radium, gamma-ray radiation, and radon decay products to a lesser extent. The risks of these exposures in a cohort of workers from Port Hope radium and uranium refinery and processing plant in Port Hope, Ontario were examined for mortality (1950–1999) and cancer

incidence (1969–1999). Overall, workers had lower mortality and cancer incidence compared with the general Canadian population.

5.2.2.2 The International Pooled Uranium Workers Study

The CNSC is also involved in an international collaborative pooled analysis of cohorts of uranium milling, processing, and fabrication workers to address questions concerning low exposure and low exposure rate health effects. There is an emerging consensus that exposures of workers in the uranium milling, processing and fabrication industry are substantially different from those of uranium underground miners, enrichment workers or nuclear reactor workers, and that these workers should be carefully evaluated in separate studies.

The recent UNSCEAR 2016 Report [59] reviewed published epidemiological studies of occupational exposures to uranium. In addition to known effects of exposures to radon decay products (RDP) and external gamma-radiation, it is important to examine long-term health effects of uranium associated with its chemical and radiological toxicity, which depend on the degree of uranium enrichment, the compound solubility, the chemical speciation and the mode of incorporation. Organs most at risk from chemical toxicity of uranium are kidneys, while bones, lungs, liver and brain are mostly affected by irradiation from alpha-emitting particles.

Only a few studies have examined risks of exposures in the uranium processing industry and reported contradictory results, necessitating further research in this area. In comparison to the general population, uranium processing workers in some studies had higher mortality rates from lung cancer (likely due to RDP exposure), lymphatic and hematopoietic cancers, particularly non-Hodgkin lymphoma (NHL) and multiple myeloma (MM), and kidney or bladder cancers. Recent studies have reported increased risks of cardiovascular disease and non-malignant respiratory diseases, but overall mortality was similar to the general population. Only a few studies conducted dose-response analyses of uranium processing workers with individual radiation doses [58, 60, 61, 62].

The International Pooled Uranium Workers Study will include 16 cohorts of uranium processing workers, including the Port Hope radium and uranium processing facility. Findings from this study will be relevant for radiation protection of current and future uranium milling, processing, and fabrication workers. The study is planned to be completed in 2022.

5.2.2.3 The Canadian Uranium Workers Study

The CANUWS is a multi-year project initiated by the CNSC in 2017 to assess the health effects of occupational radiation exposure among uranium workers. The project is a partnership between the CNSC, Government of Saskatchewan and the uranium industry, and involves researchers from the CNSC, Health Canada and the University of Saskatchewan. This retrospective cohort study will assess the information of over 80,000 Canadian uranium mine, mill and processing workers with occupational radiation exposure rates from 1932 to 2017. The study will follow-up workers' mortality (1950 to 2017) and cancer incidence (1969 to 2017).

The main objective of the CANUWS is to study the radon-lung cancer relationship, especially the potential health effects of low cumulative exposures and exposure rates. This is possible due to high-quality exposure measurements and the long-term follow-up of workers' health outcomes, with consideration of workers employed after radiation protection measures were in

place. The findings of the study will help to assess the adequacy of occupational radiation safety standards.

Over the past year, CNSC staff sent letters to potentially interested Indigenous communities to either provide representatives for the study Working Group or to be kept informed through annual updates. CNSC staff also presented an update of the study's progress at the Engagement Meeting with Indigenous Communities and Organizations in Northern Saskatchewan, and introduced the study at meetings with the Métis Nation of Ontario, Curve Lake First Nation, and Birch Narrows Déné Nation.

In November 2020, the study Working Group had their first meeting (virtually).The study Working Group includes a diverse group of people with a wide variety of knowledge and experience – including radiation specialists, workers, unions, Indigenous community representatives, and researchers. They are committed to keeping stakeholders informed as the study progresses and ensuring that the process and results are relevant and meaningful. The study Working Group welcomed that information to Indigenous communities will be provided in Cree and Déné, and emphasized the importance of communicating early and regularly through fact sheets, newsletters and local radio stations.

5.2.2.4 Conclusions - Health studies of uranium processing workers

This work will advance the international understanding of radiation risk, and support the international radiation protection framework, especially for radon. The findings will also support the CNSC's mandate to protect the health and safety of workers and to disseminate objective scientific information.

5.3 Conclusions - Health Studies

The health studies summarized in the previous sections are descriptive studies, which compare the occurrence of health outcomes within a population at a certain time in a given geographical area to the "expected" occurrence of the disease in a stable reference population (such as the general population of the province or Canada). Descriptive studies have some limitations, such as: 1) the results are averaged over a group and do not look at the individual level, and 2) individual exposures are not known, and they cannot be used to determine the cause of a health outcome, however they are used to generate hypotheses regarding potential risk factors for health outcomes. For further information regarding advantages and disadvantages of health study designs, please see the document titled INFO-0812 [64].

These health studies and reports provide a snapshot of the health of a population living near the BRR facility. Based on exposure and health data, CNSC staff have not observed and do not expect to observe any adverse health outcomes attributable to the operation of the BRR facility.

6.0 Other environmental monitoring programs

CNSC staff have reviewed other regional monitoring programs carried out by other levels of government. The nearest Health Canada's Canadian Radiological Monitoring Network (CRMN) [65] station is in Toronto (about 400 km away) and the nearest Health Canada Fixed Point Surveillance (FPS) [66] station is in Port Elgin (about 230 km away). Given the large distance between these monitoring stations and the BRR facility, CNSC staff determined that it is unlikely that any activities from the facility will be detected by these 2 monitoring programs. Regardless, it is important to note that the 2019 results from both the CRMN's Toronto station and the FPS's Port Elgin station are consistent with data from previous years and are well below the acceptable public dose limit.

ECCC operates the National Pollutant Release Inventory (NPRI) [67], which is Canada's public inventory of releases, disposals and transfers, tracking over 320 pollutants from over 7,000 facilities across Canada. 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 of hazardous substances from facilities to air, water or land
- disposals at facilities or other locations
- transfers to other locations for treatment and recycling
- facilities' activities, location and contacts
- pollution prevention plans and activities [68]

CNSC staff conducted a search of the NPRI database and found that the BRR facility is the only reporting facility in the Blind River community. It is also worth noting that radionuclides are not included in the inventory of pollutants in the NPRI database but radionuclide release datasets are available through the Open Government platform [69].

ECCC and the United States of America Environmental Protection Agency publish a joint annual report for each of the Great Lakes to summarize the results of recent studies performed and to assess the status of the Great Lakes. In the most recent Lake Huron Lakewide Action and Management Plan - 2018 Annual Report, Lake Huron was given a good status for being a source of safe, high-quality drinking water [70]. The 2 agencies also published the State of the Great Lakes 2019 – Highlights Report (external) [72] in 2020 to summarize the status of all the Great Lakes. In this report, the entire Great Lakes basin is assessed as good and unchanging, related to quality as a source of drinking water. Treated water tested in the basin met Ontario Drinking Water Quality Standards 99.8% of the time from 2015 to 2017, with none of the instances of non-compliances relate to the BRR facility [71].

The MECP has performed industrial sewage works sampling throughout the current licensing period as the BRR facility is operated under Industrial Sewage Works certificate of approvals. The MECP has also conducted soil and vegetation sampling in the vicinity of the BRR facility during the current licencing period. Furthermore, the MECP performs aquatic toxicity tests on rainbow trout and daphnia magna and produces Municipal Industrial Strategy for Abatement (MISA) reports that provides effluent results at the final point of discharge from the BRR facility. MECP sampling for industrial sewage, and for soil and vegetation is not reported publicly, however CNSC staff have reviewed this data and concluded that the health and safety of people and the environment remains protected.

7.0 Conclusions

This EPR Report focused on items of current Indigenous, public, and regulatory interest, including physical stressors, airborne and waterborne releases from ongoing operations at the BRR Facility. CNSC staff conclude that the potential risk from physical stressors, and radiological and hazardous releases to the atmospheric, terrestrial, hydrogeological, aquatic and human environment are low to negligible.

7.1 CNSC staff follow-Up

The following section summarizes CNSC staff's comments regarding the EP measures implemented by Cameco for the BRR facility. The following are not expected to change CNSC staff's conclusions and are included for transparency with Indigenous peoples and the public. It is CNSC staff's expectation that Cameco will:

- establish and implement EBRLs for the BRR facility by February 2022 (section 3.1.3)
- conduct a thorough identification and description of both federally and provincially listed species potentially present at the BRR site (section 3.2.2)

7.2 CNSC staff's conclusions

CNSC staff's conclusions may inform and support staff recommendations to the Commission in future licensing and regulatory decision making. These conclusions are based on CNSC staff's reviews of documents associated with Cameco's BRR facility, such as the submitted ERA 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 CNSC staff's conclusions. CNSC staff also conducted IEMP sampling around the BRR facility in 2013, 2014, 2017, and 2018.

Based on CNSC staff's assessment of Cameco's documentation, CNSC staff conclude that the potential risks from radiological and hazardous releases to the atmospheric, terrestrial, aquatic, geological, hydrogeological and human environments are negligible. The potential risks to the environment from these releases are not distinguishable from natural background and the potential risk to humans is similar to health outcomes in the general public. From this CNSC staff conclude that Cameco 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 Cameco's EP programs, through ongoing licensing and compliance activities and reviews.

Acronyms

Acronym	Term
ACMOPR	Annual Compliance Monitoring and Operational Performance Report
AL	Action Level
ALARA	As Low As Reasonably Achievable
BRR	Blind River Refinery
Cameco	Cameco Corporation
CANUWS	Canadian Uranium Workers Study
CCME	Canadian Council of Ministers of the Environment
CCHS	Canadian Community Health Survey
CEAA	Canadian Environmental Assessment Act
CMD	Commission Member Document
CNSC	Canadian Nuclear Safety Commission
COPC	Contaminant of Potential Concern
CRMN	Canadian Radiological Monitoring Network
CSA	Canadian Standards Association
DCEV	Dust Collection Exhaust Vent
EA	Environmental Assessment
EBRL	Exposure Based Release Limit
ECCC	Environment and Climate Change Canada
EMP	Environmental Monitoring Program
EMS	Environmental Management System
EP	Environmental Protection
EPP	Environmental Protection Program
EPR	Environmental Protection Review
ERA	Environmental Risk Assessment
FPS	Fixed Point Surveillance
FFOL	Fuel Facility Operating Licence
FLOL	Facility Licence Operating Limits
GCDWQ	Guidelines for Canadian Drinking Water Quality

GHG	Greenhouse Gas
HHRA	Human Health Risk Assessment
Hi-Vol	High Volume Air Sampler
IEMP	Independent Environmental Monitoring Program
iPHIS	Integrated Public Health Information System
LTWMF	Long Term Waste Management Facility
NO_X	Nitrogen Oxides
NPRI	National Pollutant Release Inventory
NSCA	Nuclear Safety and Control Act
MECP	Ontario Ministry of Environment, Conservation and Parks
MFN	Mississauga First Nation
MOU	Memorandum of Understanding
MNO	Métis Nation of Ontario
NE LHIN	North East Local Health Integration Network
PDP	Preliminary Decommissioning Plan
PHCF	Port Hope Conversion Facility
ROR	Regulatory Oversight Report
SFN	Sagamok First Nation
SIDS	Sudden Infant Death Syndrome
STP	Sewage Treatment Plant
TBP	Tributyl Phosphate
TLD	Thermoluminescent Dosimeter
UO_2	Uranium Dioxide
UO_3	Uranium Trioxide

References

[1] SNC Lavalin, 2017, *Blind River Refinery Preliminary Decommissioning Plan 2016, Report to Cameco Corporation.*

[2] Cameco Corporation, 2015, *Annual Compliance Monitoring & Operational Performance Report, Reporting Period January 1 – December 31, 2015 - Blind River Refinery.*

[3] Cameco Corporation, 2016, *Annual Compliance Monitoring & Operational Performance Report, Reporting Period January 1 – December 31, 2016 - Blind River Refinery.*

[4] Cameco Corporation, 2017, *Annual Compliance Monitoring & Operational Performance Report, Reporting Period January 1 – December 31, 2017 - Blind River Refinery.*

[5] Cameco Corporation, 2018, *Annual Compliance Monitoring & Operational Performance Report, Reporting Period January 1 – December 31, 2018 - Blind River Refinery.*

[6] Cameco Corporation, 2019, *Annual Compliance Monitoring & Operational Performance Report, Reporting Period January 1 – December 31, 2019 - Blind River Refinery.*

[7] Arcadis Canada Inc., 2016, *Environmental Risk Assessment for the Cameco Blind River Refinery, November 2016,* Prepared for Cameco Corporation.

[8] Cameco, 2020, *Review of the Environmental Risk Assessment for the Blind River Refinery*.

[9] CNSC, 2020, *Nuclear Facilities: Uranium Processing and Fuel Fabrication – Blind River Refinery*.

[10] CNSC, 2018, *CMD 18-M47 Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2017.*

[11] Government of Canada, 2019, *Impact Assessment Act*.

[12] Government of Canada, 2012, *Canadian Environmental Assessment Act, 2012*.

[13] Government of Canada, 1992, *Canadian Environmental Assessment Act, 1992*.

[14] CNSC, 2006, *CMD 06-H131-Recommendation for Approval of the Environmental Assessment Screening Report for the Proposed Modification to the operation of the Blind River Refinery Incinerator, Blind River, Ontario and For a Decision in Accordance with Section 20 the Canadian Environmental Assessment Act*.

[15] CNSC, 2007, *CMD 07-H105-Information and Recommendation from Canadian Nuclear Safety Commission Staff in the Matter of Cameco Blind River Refinery Application by Cameco Corporation's Blind River Refinery for amendment of its Class IB Nuclear Fuel Facility Operating Licence*.

[16] CNSC, 2007, *Record of Proceedings, Including Reasons for Decision in the Matter of Cameco Corporation Application to Amend the Class IB Nuclear Fuel Facility Operating Licence for the Blind River Refinery*.

[17] CNSC, 2008, *CMD 08-H130 Recommendation for the Acceptance of the Proposed Environmental Assessment Screening Report Regarding the Proposed Production Increase at the Blind River Refinery, Ontario*.

[18] CNSC, 2008, *Record of Proceedings, Including Reasons for Decisions in the Matter of Cameco Corporation Environmental Assessment Screening Report for the Proposed Increase of the Annual Production Capacity at the Blind River Refinery*.

[19] CNSC, 2013, *REGDOC-2.9.1, Environmental Protection: Policies, Programs and Procedures*.

[20] CNSC 2017, *REGDOC-2.9.1, Environmental Protection: Environmental Principles, Assessments and Protection Measures*.

[21] CSA Group, 2014, *CSA N288.1-14, Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities,* Update No.2.

[22] CSA Group, 2015, *CSA N288.4-10, Environmental Monitoring Programs at Class I Facilities and Uranium Mines and Mills,* Update No.2.

[23] CSA Group, 2010, *CSA N288.5-11, Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills.*

[24] CSA Group, 2012, *CSA N288.6-12, Environmental Risk Assessment at Class I nuclear Facilities and Uranium Mines and Mills.*

[25] CSA Group, 2015, *CSA Standard N288.7-15, Groundwater Protection Programs at Class 1 Facilities and Uranium Mines and Mills*.

[26] CSA Group, 2017, *CSA N288.8-17, Establishing and Implementing Action Levels to Control Releases to the Environment from Nuclear Facilities.*

[27] CNSC, 2017, *Radiation Protection Regulations*, Canada Gazette Part II, Vol. 134, No. 13, SOR/2000-203, amended September 22, 2017.

[28] CNSC, 2015, *Licence Conditions Handbook Cameco Blind River Refinery Fuel Facility Operating Licence LCH-CAMECO-BRRF-R002, Revision 2*.

[29] Cameco Corporation, 2020, *Blind River Refinery – Media - Media Library – Documents*.

[30] CNSC, 2018, *Regulatory Oversight Reports*.

[31] CSA Group, 2015, *CSA ISO 14001:2015 Standard, Environmental Management Systems – Requirements with Guidance for Use.*

[32] Cameco Corporation, 2020, *Blind River Refinery – ERA – Redacted*.

[33] CNSC, 2020, *DERPA Technical Assessment for the Review of the Environmental Risk Assessment for the Blind River Refinery*.

[34] Cameco Corporation, 2018, *Environmental Protection Program for the Blind River Refinery*.

[35] Government of Canada, 1999, *Canadian Environmental Protection Act, 1999*.

[36] Canada Gazette, 2016, *Part I, Notice with Respect to Reporting of Greenhouse Gases for 2016.*

[37] Ministry of the Environment, Conservation and Parks, 2020, *Ontario Regulation 390/18: Greenhouse Gas Emissions: Quantification, Reporting, and Verification*.

[38] Government of Canada, 2003, *Federal Halocarbon Regulations* (SOR/2003-289).

[39] Ontario Ministry of the Environment, 2011, *Ontario Air Standards for Uranium and Uranium Compounds.*

[40] Ontario Ministry of the Environment, 2011, *Soil, ground water and sediment standards for use under Part XV.1 of the Environmental Protection Act*.

[41] Canadian Council of Ministers of the Environment, 1999, *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health*.

[42] Canadian Council of Ministers of the Environment, 1999, *Canadian Water Quality Guidelines for the Protection of Aquatic Life*.

[43] European Chemicals Agency, 2020, *Tributyl phosphate: registration dossier*.

[44] Health Canada, 2020, *Guidelines for Canadian Drinking Water Quality – Summary Table*.

[45] Cameco Corporation, 2019, *Response to CNSC Comments on 2018 BRR Annual Report*.

[46] Arcadis, 2015, *Plume Modelling, Delineation and Sediment Study. Prepared for Cameco Blind River Refinery*.

[47] CNSC, 2017, *DERPA Technical Assessment for the Environmental Risk Assessment for the Cameco Blind River Refinery*.

[48] Canadian Environmental Assessment Agency, 2018, *Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012*.

[49] CNSC, 2019, *Independent Environmental Monitoring Program (IEMP)*.

[50] CNSC, 2018, *2018 Site Specific Sampling Plan Blind River Refinery*.

[51] Algoma Public Health, 2018. *Algoma Community Health Profile September 2018*.

[52] Algoma Public Health, 2015, *Algoma Cancer Report 2015*.

[53] Grasty, L.R. and Lamarre, J.R., 2004, *The Annual Effective Dose from Natural Sources of Ionising Radiation in Canada*, Radiation Protection Dosimetry, Vol. 108, no. 3, pg. 215-226.

[54] Patsy Thompson & CNSC, 2011, *Use of a Weight of Evidence Approach to Determine the Liklihood of Adverse Effects on Human Health from the Presence of Uranium Facilities in Port Hope, Ontario*, Journal of Environmental Protection, Vol. 2, no. 9.

[55] Chen J., Moir D., Lane R., & Patsy Thompson, 2013, An Ecological Study of Cancer Incidence in Port Hope, Ontario from 1992 to 2007, Journal of Radiological Protection, Vol. 33, no. 1.

[56] Ashmore J. P., Krewski D., Zielinski J. M., Jiang H., Semenciw R., & Band P. R., 1998, *First analysis of mortality and occupational radiation exposure based on the National Dose Registry of Canada*. American Journal of Epidemiology, Vol. 148, Issue 6.

[57] Sont W. N., Zielinski J. M., Ashmore J. P., Jiang H., Krewski D., Fair M. E., Band P. R., & Letourneau E. G., 2001, *First analysis of cancer incidence and occupational radiation exposure based on the National Dose Registry of Canada*. American Journal of Epidemiology, Vol. 153, Issue 4, pg. 309-318.

[58] Zablotska L. B., Lane R. & Frost S. E., 2013, 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 Y-Ray Doses. BMJ Open, Vol. 3, Issue 2.

[59] United Nations Scientific Committee on the Effects of Atomic Radiation, 2017, *Sources and Effects of Ionizing Radiation. UNSCEAR 2016 Report to the General Assembly. Annex D: Biological effects of selected internal emitters – uranium*.

[60] Dupree-Ellis E., Watkins J., Ingle J. N., & Phillips J., 2000, *External radiation exposure and mortality in a cohort of uranium processing workers.* American Journal Epidemiology, Vol. 152, Issue 1, pg. 91-95.

[61] Kreuzer M., Dufey F., Laurier D., Nowak D., Marsh J. W., Schnelzer M., Sogl M., & Walsh L., 2015, *Mortality from internal and external radiation exposure in a cohort of male German uranium millers, 1946–2008*, International Archives of Occupational Environmental Health, Vol. 88, Issue 4, pg. 431-441.

[62] Silver S. R., Bertke S. J., Hein M. J., Daniels R. D., Fleming D. A., Anderson J. L., Pinney S. M., Hornung R. W., & Tseng C. Y., 2013, *Mortality and ionising radiation exposures among workers employed at the Fernald Feed Materials Production Center (1951–1985)*, Occupational & Environmental Medicine, Vol. 70 Issue 7, pg. 453–463.

[63] Statistics Canada, 2018, *Deaths, Causes of Death and Life Expectancy, 2016*.

[64] CNSC, 2011, *INFO-0812, Setting Radiation Requirements on the Basis of Sound Science: The Role of Epidemiology*.

[65] Health Canada, 2019, *Canadian Radiological Monitoring Network*.

[66] Health Canada, 2019, *Fixed Point Surveillance Network*.

[67] Environment and Climate Change Canada, 2020, *National Pollutant Release Inventory*.

[68] Environment and Climate Change Canada, 2020, *National Pollutant Release Inventory*.

[69] Environment and Climate Change Canada and the U.S. Environmental Protection Agency, 2018, *Lake Huron Lakewide Action and Management Plan 2018 Annual Report*.

[70] Government of Canada, 2019, *Open Government – Radionuclide Release Datasets*.

[71] Environment and Climate Change Canada and the U.S. Environmental Protection Agency, 2020, *State of the Great Lakes 2019 Highlights Report*.