Canada's Nuclear Regulator

Environmental Protection Review Report:
SRB Technologies (Canada) Inc.

January 2022

e-Doc: 6549583 (Word)
e-Doc: 6621499 (PDF)

Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

Canada

Environmental Protection Review Report: SRB Technologies (Canada) Inc.

Catalogue: CC172-240/2022E-PDF
ISBN: 978-0-660-41576-5

Également publié en français sous le titre : Rapport d'examen de la protection de l'environnement : SRB Technologies (Canada) Inc.

Document availability

This document can be viewed on the CNSC website. To request a copy of the document in English or French, please contact:

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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	January 2022
001			

Executive summary

The Canadian Nuclear Safety Commission (CNSC) conducts environmental protection reviews (EPR) for all nuclear facilities with potential project-environmental interactions, in accordance with its mandate under the *Nuclear Safety and Control Act* 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 as a stand alone document, describing the scientific and evidence-based findings from CNSC staff's review of SRB Technologies (Canada) Inc.'s (SRBT) environmental protection measures. Under SRBT's current Class 1B Nuclear Substance Processing Facility Operating Licence, NSPFOL-13.00/2022, SRBT is permitted to operate the SRBT facility in Pembroke, Ontario.

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

This EPR report includes CNSC staff's assessment of documents submitted by the licensee from 2010 to 2021, such as, but not limited to, the following:

- the results of SRBT's environmental monitoring, as reported in Annual Compliance and Performance Reports
- SRBT's Environmental Risk Assessment
- SRBT's Preliminary Decommissioning Plan
- SRBT's groundwater modelling studies
- the results of the CNSC's Independent Environmental Monitoring Program
- the results from other environmental monitoring programs and/or health studies completed by other levels of government in proximity to the SRBT facility

This EPR report also details past regulatory actions from the early years of SRBT operations as it relates to concerns of elevated levels of tritium in groundwater and independent verification activities undertaken by CNSC staff. These activities included the Tritium Studies Project and a groundwater modelling assessment in early 2010, whereby CNSC staff determined that elevated tritium concentrations were due to past historical practices and that concentrations have declined and stabilized as CNSC staff predicted.

Based on CNSC staff's assessment and evaluation of SRBT's documentation and data, CNSC staff have found that potential risks from radiological and hazardous releases to the atmospheric, aquatic, terrestrial and human environments from the SRBT facility are negligible, resulting in no significant adverse effects. The potential risks to the environment from the SBRT operations are similar to natural background and the potential risks to human health are indistinguishable to health outcomes in the general public.

CNSC staff have also found that SRBT 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 SRBT's environmental protection programs through ongoing licensing and compliance activities.

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

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

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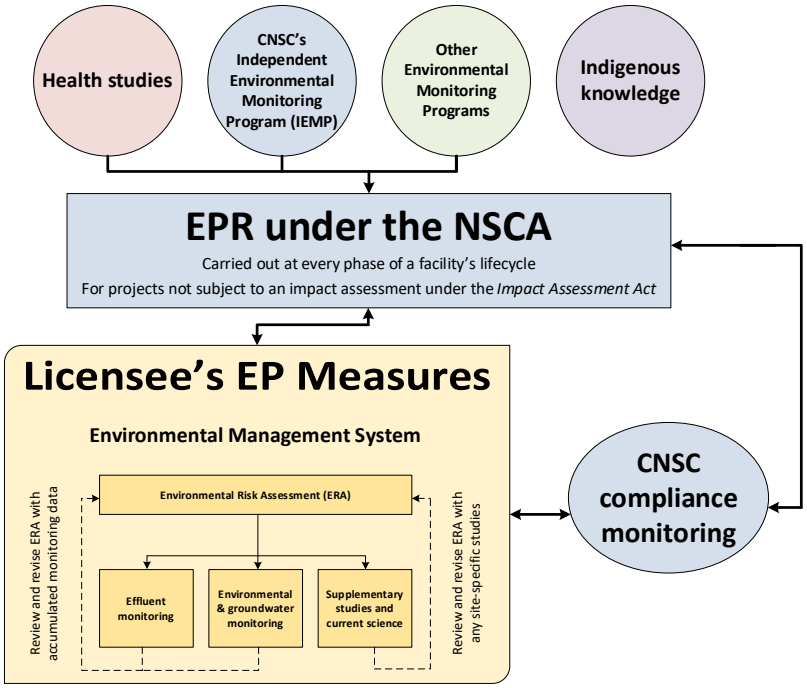
1.0 Introduction

1.1 Purpose

The Canadian Nuclear Safety Commission (CNSC) conducts environmental protection reviews (EPR) for all nuclear facilities with potential interactions with the environment, in accordance with its mandate under the *Nuclear Safety and Control Act* (NSCA) to ensure that licensees make adequate provision for the protection of the environment. CNSC staff assess the environmental and health effects of nuclear facilities and/or activities at every phase of a facility's lifecycle. As seen in figure 1.1, an EPR is a science-based environmental technical assessment conducted by CNSC staff to support the CNSC's mandate for the protection of the environment and human health as set out in the NSCA. 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 five years and are based primarily on information that the applicant or licensee is required to submit to the CNSC through the established licensing process. This information includes a licence application and its supporting documentation, updates to a nuclear facility's environmental risk assessment (ERA), which is reviewed every five years, and regulatory reporting requirements on environmental protection measures.

This EPR report is CNSC staff's review of SRB Technologies (Canada) Inc.'s (SRBT) environmental protection (EP) and environmental compliance activities conducted under the NSCA. As well, this EPR report details independent verification activities, such as the CNSC's independent environmental monitoring program (IEMP), groundwater modelling assessment, as well as relevant health and environmental studies conducted through the CNSC's Tritium Studies Project. This review serves to assess whether SRBT's environmental protection measures at the SRBT facility adequately protects the environment and health of persons.

Figure 1.1: EPR framework



This EPR report presents information pertaining to the protection of the environment and human health. No decision is made on the EPR itself. CNSC staff's findings may inform and support future recommendations to the Commission in future licensing and regulatory decision making, as well as inform CNSC staff's future compliance and verification activities. CNSC staff's findings do not represent the Commission's conclusions. The Commission's conclusions and decisions are informed by information submitted to the Commission by CNSC staff, the licensee, as well as by Indigenous peoples, the public, and any interventions heard during public hearings on licensing matters. The information in this EPR report is intended to inform Indigenous peoples, members of the public and other interested parties.

EPR reports are prepared to thoroughly document CNSC staff's assessment relating to a licensee's EP measures and are posted online for information and transparency. Posting 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 ahead of any licensing hearings or Commission decisions.

This EPR report is based on information submitted by SRBT, as well as the following:

- regulatory oversight activities (section 2.0)
- CNSC staff review of SRBT's 2019 Preliminary Decommissioning Plan (PDP) [1] (section 2.2)
- CNSC staff review of SRBT's Annual Compliance and Performance Reports [2-12]
- CNSC staff review of SRBT's 2021 Environmental Risk Assessment (ERA) [13] (section 3.2)
- CNSC staff review of SRBT's groundwater modelling studies (sections 2.2 and 3.2.3)
- Independent Environmental Monitoring Program (IEMP) results (section 4.0)
- health studies with relevance to the SRBT facility (section 5.0)
- other environmental monitoring programs in proximity to the SRBT facility (section 6.0)

A review has been conducted for all environmental components related to the licenced facility, however only selected 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, other members of the public and the Commission.

This EPR report focuses on topics related to the environmental performance of the facility including atmospheric (emission) and liquid (effluent) 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 components (VCs)[1] including human and non-human biota. The focus is on radiological substances associated with activities undertaken by SBRT. Tritium is the only radiological COPC of significance to human and ecological receptors

[1] Valued components (VCs) refer to environmental biophysical or human features that may be impacted by a project. The value of a component relates not only to its role in the ecosystem, but also to the value people place on it. For example, it may have scientific, social, cultural, economic, historical, archaeological or aesthetic importance.

associated with the activities undertaken by SRBT and there are no significant exposures from hazardous substances to these receptors from SRBT's processes. Additional information is provided on other topics of Indigenous, public and/or regulatory interest such as past environmental performance and regulatory actions, and greenhouse gas (GHG) emissions. CNSC staff also present information on relevant regional environmental or health monitoring, including studies conducted by the CNSC (such as the IEMP) or other governmental organizations.

1.2 Facility overview

This section of the report provides general information on the SRBT 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 environmental and regulatory oversight activities.

1.2.1 Site description

SRBT owns and operates a gaseous tritium light source (GTLS) manufacturing facility in Pembroke, Ontario (see figure 1.2). The facility is situated close to the traditional homelands and treaty territories of many Indigenous Nations and communities, including the Algonquins of Pikwàkanagàn First Nation, the Algonquins of Ontario, the Métis Nation of Ontario, Kitigan Zibi Anishinabeg, Kebaowek First Nation and the Algonquin Anishinabeg Nation Tribal Council. The facility is also approximately 150 kilometres northwest of Ottawa.

SRBT leases a space in an industrial building of the TransCanada Corporate Park, an industrial park within the boundary of the City of Pembroke. SRBT fully controls approximately 1,400 square metres (m^2) of the interior floor space of the industrial building, as well as the immediate surrounding grounds outside of the facility. Within the same building as the SRBT facility are two commercial businesses, namely a company that specializes in the manufacture of personal protective equipment and a company that provides industrial gas and equipment to local customers. Figure 1.3 shows an overview of the area surrounding the SRBT facility. Farmland extends to the west of the facility for approximately 300 to 500 metres, alongside two hotels and a local distillery to the southwest. To the northeast of the property is the Pembroke and Area Community Center, and there are commercial buildings and a lumber yard to the south and southeast. The nearest residence is approximately 250 metres to the northwest of the facility.

Figure 1.2: Overview map of the region where the SRBT facility is located

Source: SRBT [13]

Figure 1.3: Aerial photograph of the SRBT facility

Source: SRBT [13]

1.2.2 Facility operations

The SRBT facility was established in 1990 and began commercial operations in 1991. SRBT holds a CNSC licence and is permitted to use tritium to produce self-luminous GTLS and manufacture radiation devices containing the GTLS, such as self-luminous emergency exit signs, various military applications such as landmine markers, watch dials, and other safety products not requiring batteries or other external sources of power. SRBT distributes both the radiation devices and light sources within Canada and internationally. SRBT seals the colourless, odourless tritium gas in small glass tubes coated on the inside with phosphorescent powder. When tiny particles emitted from the decaying radioactive gas come into contact with the powder, light is generated.

The interior of the facility is divided into three separate radiological zones, described below:

- Zone 1: The largest zoned area within the SRBT facility, Zone 1 consists of offices, the lunchroom, the shipping area, the coating room, the glass shop, and a storage area.
- Zone 2: Staff access to Zone 2 within the SRBT facility is controlled, and the area consists of the assembly room and the silk-screening room.
- Zone 3: Tritium processing equipment is located within Zone 3 of the SRBT facility. The rig room, laser room, and tritium lab are all found within Zone 3. Staff access is controlled and the minimum personal protection equipment required for entry into Zone 3 include a lab coat, shoe covers, safety glasses, and gloves.

Due to the tritium processing equipment and activities performed within Zone 3 it is the radiological zone with the greatest potential for exposure to hazards and tritium gas and is discussed below in further detail.

Tritium processing components

Under their current CNSC licence, SRBT is permitted to operate several processing rigs in order to create the GTLS. The processing rigs, located in Zone 3, are vacuum-based systems of valves, pumps, and tubing, and they are designed with a trap in order to fill the light sources with tritium gas. The traps contain metallic adsorbent which contains pure tritium in a solid form (tritide) at room temperature. The metallic adsorbent releases pure tritium gas when heated to roughly 400 degrees Celsius. The processing rigs function under vacuum in the absence of air or other gaseous contaminants, allowing the tritium gas to effectively fill the light sources. Tritium processing occurs within double-sided ventilated cabinets which house the main filling stations where light sources are filled with tritium.

Tritium laboratory

The tritium laboratory is also housed within Zone 3 of the SRBT facility and contains equipment known as the bulk splitter, which is a system used to subdivide tritium purchased by SRBT. The bulk splitter will take bulk amounts of tritium in specialized containers and will subdivide it into containers that will interface with the processing rigs. The principles of the bulk splitter are the same as those used on the processing rigs.

Active ventilation system

There is a fenced compound maintained on the northwest corner of the SRBT facility which houses the primary active ventilation system components, including fans, motors, and stacks. The active ventilation system at the SRBT site is located within Zone 3 of the facility. The active ventilation system services the tritium processing activities by carrying contaminated air through air handling units, and upwards through the two stacks located at the west corner of the facility. The stacks eject the contaminated gas upwards, dispersing the tritium. The amount of tritium released to the atmosphere is monitored by SRBT and reported to the CNSC to ensure compliance with licensed release limits. More information on airborne emission controls and monitoring is found in section 3.1.2.

2.0 Regulatory oversight

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

To meet the CNSC's regulatory requirements and according to SRBT's licensing basis, SRBT 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 SRBT facility. These EP measures must comply with the regulatory requirements found in SRBT's licence and licence condition handbook (LCH). The relevant regulatory requirements for SRBT's facility are outlined in this section of the report.

2.1 Environmental protection reviews and assessments

EPR reports are produced as part of the CNSC's lifecycle EP framework under the NSCA and its regulations. These reports are posted to inform and 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 as a reference in CNSC staff's Commission Member Document and other regulatory decision making.

To date, one screening assessment and two EPR reports (including this one) have been carried out for the SRBT site, as indicated below. Subsection 2.1.1 provides a description of the screening assesment conducted under the *Canadian Environmental Assessment Act, 1992* (CEAA 1992) [14], predecessor to the *Canadian Environmental Assessment Act, 2012* (CEAA 2012) [15], whereas subsection 2.1.2 provides information on the previous EPR report completed. In 2019, the *Impact Assessment Act of Canada* (IAA) [16] came into force replacing CEAA 2012. Going forward, staff will determine if proposed changes to activities at the SRBT site require an impact assesment under the IAA's *Physical Activities Regulations*. The purpose of any one of these assessments is to identify the possible impacts of a proposed project or activity and to determine whether those effects can be adequately mitigated to protect the environment and the health of persons.

2.1.1 Previous EAs completed under CEAA 1992

Screening assessment under the *Canadian Environmental Assessment Act*

In 2000, the NSCA [17] replaced the former *Atomic Energy Control Act* and the CNSC was established, with an expanded mandate that included the protection of the environment. Under the *Atomic Energy Control Act*, SRBT held two radioisotope licences for its licensed activities. Pursuant to the NSCA and its associated regulations, the SRBT facility was classified as a Class IB nuclear substance processing facility.

Numerous expanded regulatory requirements were then applicable to the operation of the SRBT facility, including heightened quality assurance, radiation protection, and environmental protection measures.

During the initial licensing as a Class IB nuclear substance processing facility in 2000, SRBT applied for authorization to continue its tritium light manufacturing and tritium light recovery operations at the SRBT facility. No new construction activities were planned, and no changes to existing approved operations were proposed. Pursuant to the CEAA 1992 [14], CNSC staff conducted a screening assessment and the EA screening report [18] was submitted to the Commission in December 2000. The screening assessment was performed in consultation with Environment Canada, Health Canada, and the Ontario Ministry of the Environment, and the scope of the assessment included the potential environmental effects of the project, including those that might occur from accidents and malfunctions, and the future decommissioning plans for the facility.

In February 2001, the Commission concluded that SRBT's facility operations were unlikely to cause adverse environmental effects, considering the implementation of mitigation measures [20]. The EA screening process identified the requirements for an EA follow-up monitoring program, the requirements of which were incorporated into SRBT's Annual Compliance and Performance Reports [2-12]. The SRBT facility was granted a Nuclear Substance Processing Facility Operating Licence valid from January 1, 2001 until December 31, 2005.

2.1.2 Previous EPRs completed under the NSCA

Environmental assessment review under the *Nuclear Safety and Control Act*

In 2014, SRBT requested a 10-year licence renewal to continue their operations at the SRBT facility under a Class 1B Nuclear Substance Processing Facility Operating Licence NSPFOL-13.00/2015 [20]. An EA review under the NSCA (now referred to as the EPR under the NSCA) was conducted to ensure the protection of the environment and the health of people [21]. The EA review focused on items of public concern and regulatory actions regarding the past operations of the SRBT facility as detailed below in section 2.2. The EA review focused on groundwater monitoring results, tritium releases, public dose calculations, and specific environmental components. CNSC staff's review determined that SRBT had made adequate provision for the protection of the environment and the health and safety of persons. Information considered by the Commission included submissions by SRBT, CNSC staff's findings from the EA review, IEMP results, and concerns raised by the public and Indigenous communities. On June 29, 2015, the Commission renewed SRBT's operating licence valid from July 1, 2015 until June 30, 2022.

2.2 Previous regulatory actions

In 2005, CNSC sampling of ground and surface water in the community surrounding the SRBT facility showed elevated tritium concentrations in groundwater, as well as in the precipitation and runoff (puddles, etc.) near the facility. This discovery prompted CNSC staff to issue, pursuant to paragraph 37(2)(f) of the NSCA, an order to SRBT on November 16, 2005 [22] to conduct a groundwater contamination study. The order required SRBT to define the extent and magnitude of the groundwater contamination on and around the facility and to assess the potential adverse impacts on the environment, persons and land use.

On January 24, 2006, following a 2-day public licence renewal hearing for SRBT held in September and November 2005, the Commission issued SRBT an operating licence for a period of one year [23]. This licence contained several restrictions obligating SRBT to undertake an action plan to correct identified program deficiencies. In addition, the Commission revoked the

order issued in November 2005, as the requirements of the order were added as conditions of the licence.

The groundwater study was completed, and an initial report was submitted to CNSC staff on March 2006 [24]. CNSC staff determined that the groundwater study report did not adequately define the magnitude of tritium contamination underlying the SRBT facility or consider the potential impact that the contaminated groundwater may have on the future land use of the site. In July 2006, CNSC staff therefore requested, pursuant to subsection 12(2) of the *General Nuclear Safety and Control Regulations* (GNSCR) that SRBT take additional measures and provide additional information respecting the groundwater contamination of the land on which the facility is located [25].

On August 12, 2006, SRBT submitted the additional information on the groundwater contamination respecting the magnitude of the contamination of the land located under the facility, which confirmed the levels of contamination and the fact that mechanisms other than atmospheric dispersion were contributing to this contamination. CNSC staff's review found that SRBT had not taken all reasonable precautions to protect the environment as required under paragraph 12(1)(*c*) of the GNSCR and had not taken all reasonable precautions to control the release of a radioactive nuclear substance into the environment as required under paragraph 12(1)(*f*) of the GNSCR. As result, the Designated Officer issued an order to SRBT on August 15, 2006 to prevent further contamination and unreasonable risk to the environment [26]. The Commission reviewed and amended the order to require SRBT to submit a detailed report describing the specific actions and measures that would be taken to: identify all the sources of groundwater contamination; contain those sources of groundwater contamination; prevent or mitigate further direct contamination of the soil and groundwater under the stacks; and remediate the contaminated groundwater. SRBT was also required to submit an implementation plan and schedule to address the actions described in the report. SRBT submitted this information as part of the licence renewal hearings held in 2006.

On January 31, 2007, following a 2-day public licence renewal hearing held in October and November 2006, the Commission decided to issue an 18-month Nuclear Substance Processing Facility Possession Licence to SRBT [27]. The licence permitted the general possession, transfer, management, storage and disposal of nuclear substances that are part of the Class IB facility located in Pembroke, Ontario. The licence did not allow SRBT to process or use tritium for the purposes of manufacturing gaseous tritium light sources. The Commission had decided not to renew the operating licence based on its opinion that SRBT would not make adequate provision for the protection of the environment when carrying out activities that include the processing of tritium. However, the Commission was also of the opinion that the tritium releases resulting from the operation of the facility did not pose a health and safety risk to the public. The possession licence provided regulatory control of the facility and ensured that the conditions of the licence would prevent unreasonable risk to the environment, the health and safety of persons, and the maintenance of national security and measures required to implement international obligations to which Canada has agreed. In addition, the Commission revoked the order issued in August 2006, on the basis that it was no longer applicable under the activities authorized by the possession licence.

The Commission also directed CNSC staff to initiate research studies on tritium releases in Canada, and to study and evaluate tritium-processing facilities exercising best practices around

the globe. Detailed information on the CNSC's Tritium Studies Project is found below in section 5.3.1.

In January 2008, SRBT submitted a comprehensive report [28] to CNSC staff that documents more than two years of groundwater studies, including hydrogeologic monitoring and testing, and tritium measurements in soil, groundwater, surface water and precipitation. CNSC staff reviewed this report and noted that the monitoring data compiled in the report indicate that the tritium concentrations in most of the monitoring wells were declining or stable.

On June 26, 2008, following a 2-day public licence renewal hearing held in April and June 2008, the Commission decided to issue a 2-year Nuclear Substance Processing Facility Operating Licence to SRBT [29]. The licence permitted SRBT to resume the operation of the SRBT facility and carry on the activities that include the processing and use of tritium. Following this 2-year licence term SRBT was granted a 5-year licence on June 30, 2010 [30] following a 2-day public licence renewal hearing in February and May 2010. During the hearing concerns were raised regarding the upward trend of tritium in the groundwater around the facility. To address the concerns, CNSC staff conducted an independent modelling assessment in early 2010 and SBRT undertook another groundwater study in 2011. The results of these studies are found below in section 3.2.3. Overall, the Commission was satisfied with the work undertaken by SRBT to correct the environmental protection program deficiencies that had been at the cause of the issues for the past several years. The Commission was of the view that SRBT demonstrated an understanding of and commitment to environmental protection. The Commission was also of the view that SRBT had the ability to meet the requirements of the NSCA and its regulations with respect to the protection of the environment while processing and using tritium at its facility.

2.3 Planned end state

The following section provides high-level information with respect to the planned end-state of the SRBT facility and site following decommissioning activities. The decommissioning strategy and end-state objectives for the SRBT facility are documented in the SRBT's 2019 Preliminary Decommissioning Plan (PDP) [1] which CNSC staff have reviewed and accepted. This section is informed by SRBT's PDP.

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 by the licensee and submitted to the CNSC for review and acceptance as early as possible in the lifecycle of the facility or the conduct of the licensed activities. The PDP is progressively updated, where needed, to reflect the appropriate level of detail required for the respective licensed activities. Prior to the commencement of any decommissioning activities and to support an application for a licence to decommission, a detailed decommissioning plan (DDP) is developed by the licensee and submitted to the CNSC for review and acceptance.

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, the principal hazards and protection strategies, and an estimate of costs associated with these activities. The PDP is developed for planning purposes only and the associated cost estimate is used to develop dedicated decommissioning funding in the form of a financial guarantee. The PDP is not meant to be implemented and does not provide sufficient

details for the assessment of environmental impacts 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's regulatory control.

SRBT's preliminary decommissioning strategy for the SRBT facility is for the prompt removal of all nuclear substances once regulatory approvals for decommissioning are obtained. Decommissioning is planned to begin immediately after the shutdown of the facility and will continue, without interruption, until the decommissioning is complete. Inventories of radioactive and hazardous materials will be reduced in the three-month period preceding shutdown, and any remaining inventory of these materials will be dispositioned in the first month following the shutdown of the facility. Decontamination processes will be carried out on all equipment that can be decontaminated to regulatory clearance levels, and equipment that cannot be decontaminated to meet regulatory limits for clearance will be dismantled, packaged, and shipped to a licensed waste management facility, location, or site. Decommissioning will continue until the SRBT site is in a condition that will permit its release from any further regulatory control by the CNSC.

2.4 Environmental regulatory framework and protection measures

The CNSC has a comprehensive EP regulatory framework which includes both radiological and hazardous substances, physical stressors (such as noise), the protection of Indigenous peoples, the public, and the environment. In other words, public dose is considered under the EP framework, as well as from a radiation protection standpoint. Human exposure is a result of interactions with the environment, that is, Indigenous peoples and the public are part of the environment. The focus of this section of the EPR report is on the EP regulatory framework and the status of SRBT's environmental protection program (EPP) [31]. Section 3.0 of this report details the results derived from the EPP.

The EPP at SRBT was designed and implemented in accordance with REGDOC-2.9.1, *Environmental Protection: Policies, Programs and Procedures* (2020) [32] as well as the CSA Group standards on environmental protection listed below. The EPP has several components including derived release limits (DRLs), public dose modelling, and a groundwater monitoring program.

Table 2.1: Status of EP measures to implement regulatory documents and standards

Regulatory document or standard	Status
CSA N288.1-14, *Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities* [33]	Implemented
CSA N288.4-10, *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [34]	Implemented
CSA N288.5-11, *Effluent Monitoring Program at Class I Nuclear Facilities and Uranium Mines and Mills* [35]	Implemented
CSA N288.6-12, *Environmental Risk Assessment at Class I Nuclear Facilities and Uranium Mines and Mills* [36]	Implemented
CSA N288.7-15, *Groundwater Protection Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [37]	Implemented
CSA N288.8-17, *Establishing and Implementing Action Levels to Control Releases to the Environment from Nuclear Facilities* [38]	Implemented
CNSC REGDOC-2.9.1, *Environmental Principles, Assessments and Protection Measures* (2020) [32]	Implemented

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

Licensees are also required to regularly report on the results of their EPPs. Reporting requirements are specified within REGDOC-3.1.2, *Reporting Requirements, Volume I: Non-Power Reactor Class I Nuclear Facilities and Uranium Mines and Mills* [39], the *Radiation Protection Regulations* [40] (for action levels (AL) or dose limit exceedances), the licensees' approved programs and manuals, or the LCH [41].

SRBT is required to submit Annual Compliance and Performance Reports. These reports are reviewed by CNSC staff for compliance and verification, as well as trending. SRBT's Annual Compliance and Performance Reports are available on SRBT's website [42].

CNSC staff regularly report on the licensee performance to the Commission for activities conducted at SRBT. Regulatory Oversight Reports (RORs) [43] are the CNSC's standard mechanism for updating the Commission, Indigenous peoples and the public on the operation and regulatory performance of licensed facilities. RORs are available on the CNSC's website and SRBT's website.

2.4.1 Environmental protection measures

To meet the CNSC's regulatory requirements under REGDOC-2.9.1 (2020) [32], SRBT is responsible for implementing and maintaining EP measures that identify, control and monitor releases of radiological and hazardous substances, and effects on human health and the environment from the facility. EP measures are an important component of the overall requirement of licensees to make adequate provisions to protect the environment and health of persons.

This, and the following subsections, provide a brief summary of SRBT's EPP for the 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 or measures against relevant regulatory limits and environmental quality objectives or guidelines, and discusses, where applicable, any changing trends.

SRBT is required to implement an environmental management system that conforms to REGDOC-2.9.1 (2020) [32] and submit an EPP. SRBT's EPP includes the following components to meet the requirements and guidance as outlined in REGDOC-2.9.1 (2020):

- environmental management system (EMS) (subsection 2.3.2)
- environmental risk assessment (ERA) (subsection 2.3.3)
- effluent emissions control and monitoring program (EffMP) (subsection 2.3.4)
- environmental monitoring program (EMP) (subsection 2.3.5)

2.4.2 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 EPP, including 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 (that is, qualified personnel, organizational infrastructure, technology and financial resources)
- define and delegate roles, responsibilities and authorities essential to effective management

SRBT established and implemented an EMS for its facility in accordance with REGDOC-2.9.1 (2020) [32]. SRBT's EMS includes activities such as establishing annual environmental objectives and targets. The EMS is verified through SRBT's safety meetings, during which environmental protection issues are discussed and documented. CNSC staff review SRBT's annual internal audits, management reviews, and environmental goals, targets and objectives to ensure compliance with REGDOC-2.9.1 (2020) during environment-focused compliance inspections. CNSC staff also review the status of SRBT's annual goals, targets and objectives and the implementation of the EMS as part of staff's reviews of SRBT's Annual Compliance and Performance Reports.

The results of these reviews demonstrate that SRBT's EMS for its facility meets the CNSC's requirements as outlined in REGDOC-2.9.1 (2020) [32]. The implementation of the EMS ensures that SRBT continues to improve environmental performance at its facility.

2.4.3 Environmental risk assessment

An ERA of nuclear facilities is a systematic process used by licensees to identify, quantify and characterize physical stressors, and radiological and hazardous substances that have the potential to cause an adverse effect to ecological or human receptors. The ERA also includes the magnitude and extent of the potential effects associated with a facility. Through the ERA radiological and hazardous substances that have the potential to cause an adverse effects to ecological or human receptors are identified as COPCs. 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 ERA.

In 2020, SRBT submitted an ERA [45] to the CNSC. The ERA included an ecological risk assessment (EcoRA) and a human health risk assessment (HHRA). A revised ERA was submitted in 2021 to address CNSC staff's comments [13]. CNSC staff reviewed SRBT's revised ERA and found it to be compliant with CSA standard N288.6-12, *Environmental Risk Assessment at Class I Nuclear Facilities and Uranium Mines and Mills* [36].

SRBT's conclusions from the 2021 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 SRBT facility were found to be negligible [13]. It is important to note that the only radiological COPC of significance to human and ecological receptors is tritium, through both gaseous emissions and liquid effluent pathways and there are no hazardous COPCs associated with the operation of the SRBT facility.

Table 2.2: Summary of SRBT's ERA conclusions [13]

Type	Members of the public	Aquatic and terrestrial biota
Radiological	No adverse impacts expected from radiological COPCs released from the SRBT facility.	No adverse impacts expected from radiological COPCs released from the SRBT facility.
Hazardous (non-radiological)	No adverse impacts expected from hazardous COPCs released from the SRBT facility.	No adverse impacts expected from hazardous COPCs released from the SRBT facility.
Physical stressors (noise was the only physical stressor considered in the assessment)	No adverse impacts expected from physical stressors (such as noise) at the SRBT facility.	No adverse impacts expected from physical stressors (such as noise) at the SRBT facility.

2.4.4 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 (such as in design) and *as low as reasonably achievable* (ALARA) principles, the Canadian Council of Ministers of the Environment guidelines, and results of the licensee's ERAs.

SRBT's EPP [32] was reviewed and approved by CNSC staff in August 2021. It contains licence limits, DRLs and site-specific ALs to control radiological effluents. ALs are established to serve as early indicators of potential loss of control or deviation from expected quality of releases. SRBT has also established internal administrative limits to serve as an early warning signal that increased oversight or program improvements may be required to prevent an AL exceedance.

DRLs are calculated to demonstrate that the public dose limit of 1 mSv/year has not been exceeded. DRLs inform licensed release limits for nuclear facilities and typically represent the maximum acceptable level of emitted contaminants from facility operations. SRBT has calculated DRLs for their facility; however SRBT is regulated using more stringent licence release limits. The calculated DRLs for the SRBT facility are much higher than the current licence release limits. The licence release limits were imposed to ensure protection of groundwater resources around the facility. More information on the licence release limits is provided in section 3.1.1.

SRBT's EffMP is in compliance with REGDOC-2.9.1 (2020) [32] and the relevant standards, including CSA N288.5-11, *Effluent Monitoring Program at Class I Nuclear Facilities and Uranium Mines and Mills* [35].

Based on compliance and technical assessment activities, CNSC staff determined that the EffMP currently in place for SRBT continues to protect human health and the environment.

2.4.5 Environmental monitoring program

The CNSC requires licensees to design and implement an EMP specific to the monitoring and assessment requirements associated with the 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 gather the necessary environmental data to calculate public dose and demonstrate compliance with the regulatory public dose limit (1 mSv/year). The program design must also address the potential environmental interactions identified at the facility or site. SRBT's EMP consists of monitoring tritium in the following environmental media:

- air through passive air monitoring
- precipitation
- surface water
- downspout runoff
- food (local produce, milk, and wine)
- drinking water
- groundwater
- municipal sewage sludge cake

Monitoring frequency is specified in the EMP. Monitoring of air, precipitation, and surface water are conducted monthly, monitoring of drinking water and milk[2] are conducted three times a year, and monitoring of wine[3] and produce are conducted annually. There is no set frequency for monitoring of downspout runoff monitoring because samples are collected after a large precipitation event.

SRBT is required to maintain its EMP to be in compliance with REGDOC-2.9.1(2020) [32] and relevant standards, including CSA N288.4-10, *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [34].

Based on compliance activities and technical assessments, CNSC staff determined that SRBT is in compliance with REGDOC-2.9.1 (2020) and continues to implement and maintain an effective EMP for their facility that adequately protects the environment and the health of persons.

2.5 Reporting of airborne emissions under other Federal or Provincial legislation

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

2.5.1 Greenhouse gas emissions

While there are a range of broadly applicable federal environmental regulations (i.e. *Environmental Emergency Regulations*), the management of GHG emissions has been identified as a national priority.

Under the federal *Canadian Environmental Protection Act, 1999* (CEPA 1999) [46], SRBT is required to monitor and report on GHG emissions [47]. Nuclear facilities that emit more than the emission reporting threshold (that is, 10,000 tons of CO_2 equivalent) on an annual basis must report its GHG emissions to Environment and Climate Change Canada (ECCC). SRBT has

[2] In 2021, SRBT began sampling milk twice per year. This change was reviewed and approved by CNSC staff.

[3] In 2020, SRBT stopped sampling wine because the business that provided the product closed permanently.

continually been below the GHG emission threshold and is therefore not required to report. If the GHG emission threshold were exceeded, SRBT would report the exceedance to 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.

3.0 Status of the environment

This section provides a summary of the status of the environment around the SRBT facility. It first includes a description of the radiological and hazardous releases to the environment (section 3.1), followed by a description of the environment surrounding the SRBT facility and an assessment of any potential effects to the different components of the environment, as a result of exposure to these contaminants (section 3.2).

CNSC staff regularly review the environmental components through annual reporting requirements and compliance verification activities, as detailed in other areas of this report. This information is reported to the Commission in the EP Safety and Control Area of licensing commission member documents (CMDs) and annual RORs. Annual Compliance and Performance Reports submitted by SRBT are made publicly available and can be viewed on SRBT's website [42].

3.1 Releases to the environment

Radiological and hazardous substances that have the potential to cause an adverse effect to ecological or human receptors are identified as COPCs. Once COPCs are emitted from a facility or licensed site, they are considered a release to the environment and how they get to the different receptors considered by a licensee's ERA are called pathways. Figure 3.1 below illustrates a conceptual model of the environment around SRBT to show the relationship between releases (airborne emissions or waterborne effluent) and human and ecological receptors or exposure pathways. The movement of the releases through the environment to the receptors are termed exposure pathways. This graphic is meant to provide an overall conceptual model of the releases, exposure pathways and receptors for SRBT, and thus, should not be interpreted as a complete depiction of the site and its surrounding environment. The specific releases and COPCs associated with SRBT are explained in detail in the following subsections.

Figure 3.1: Conceptual model of the environment around the SRBT facility

3.1.1 Licensed release limits

As summarized in table 3.1, the SRBT facility has licensed release limits to the atmosphere and to the sewer, in order to control releases to the environment. The licensed release limits were derived based on conservative estimates of tritium concentrations that could potentially develop in groundwater as a result of SRBT's operations.

Table 3.1: Licensed release limits for SRBT

Parameter	Licence limit (GBq/year)*
Airborne - Tritium as tritium oxide (HTO)	67,200
Airborne - Total tritium as HTO + HT	448,000
Waterborne to sewer – Tritium water soluble	200

* Releases are measured in gigabecquerels per year (GBq/year). The becquerel is the International System of Units (SI) unit for radioactivity, and one becquerel (Bq) is the activity of a quantity of radioactive material in which one nucleus decays per second, hence the greater the number of Bq, the higher the radioactivity.

3.1.2 Airborne emissions

SRBT controls and monitors airborne emissions from the facility to the environment under its EffMP. This program is based on CSA N288.5-11, *Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [35] and includes the monitoring radiological emissions.

Airborne emissions from the SRBT facility are monitored by active ventilation systems that direct contaminated air through two air handling units, before it is released upwards through two stacks located at the west corner of the facility. The only radionuclide released by SRBT is tritium. The radionuclide is released in two forms: elemental tritium gas (HT), and oxidized tritium or tritiated water (HTO). SRBT does not release any hazardous (non-radiological substance) through gaseous effluent pathways in any significant quantity.

HTO is formed when a tritium atom replaces a hydrogen atom in water (H_2O). HTO has the same chemical properties as water and is also odourless and colourless and can be transferred to humans by inhalation, skin absorption or ingestion of drinking water or food. HTO exposure is generally the most important consideration in assessing radiation dose. HT is formed when a tritium atom replaces a hydrogen atom to form a tritium-hydrogen bond. In its elemental form, HT is an invisible, odourless gas chemically identical to hydrogen gas. HT is relatively inert in biological systems and has a very low uptake into humans. Some of the tritium released into the environment will be naturally incorporated into nutrients such as carbohydrates, fats, or proteins. This is called organically bound tritium (OBT). OBT can enter the body directly by eating tritiated food. OBT poses a slightly greater health risk because as an organic material, the body will retain it longer than tritiated water. This means that there is a greater likelihood that the tritium atom will decay while in the body and possibly cause damage. OBT is generally found in much smaller concentrations in the body than HTO.

SRBT measures gaseous effluent for tritium concentration in real time and does so by obtaining a sample of representative gas being released and monitoring it for tritium concentration using equipment designed to measure tritium-in-air. The point of release for gaseous effluent is monitored, which is the active ventilation systems' common duct in the ceiling space just prior to the stacks. SRBT also measures gaseous effluent using an integrated weekly sample collection method that allows for the distinction between the quantity of tritium released in the elemental form, and the oxide form.

Air emissions from the SRBT facility are provided in table 3.2 and compared against the licenced release limits. In addition to licence limits, the SRBT facility has established air emission ALs and internal administrative limits, 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. SRBT did not report any AL exceedances during the current licensing period. Air emissions of elemental tritium and tritium oxide have been consistently well below licence limits throughout the current licensing period.

Table 3.2: Annual airborne releases from SRBT compared to applicable release limits (2016-2020) [2-6]

Parameter	Licence limit (GBq/year)	2016	2017	2018	2019	2020
Tritium as tritium oxide (HTO) (GBq/year)	67,200	6,293	7,198	10,741	11,858	9,755
Total tritium as HTO + HT (GBq/year)	448,000	28,945	24,822	33,180	31,769	25,186

Conclusions

Based on CNSC staff's review of the results of SRBT's EMP, CNSC staff found that the reported air emissions to the environment from the 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.

3.1.3 Waterborne effluent

SRBT also controls and monitors liquid (waterborne) effluent from the facility to the environment under its implementation of the EffMP. This program is based on CSA N288.5-11, *Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [35] and includes monitoring of radiological releases.

Liquid effluent from the SRBT facility is not continuously discharged, but is rather released in a controlled manner to the municipal sewer system, and is directed to the Pembroke Pollution Control Center for wastewater treatment.

SRBT monitors liquid effluent for water-soluble tritium using a batch collection strategy, whereby the water is collected in batches and analyzed for tritium concentrations through a method called liquid scintillation counting assays. Based on these assays, calculations are

performed in order to measure the amount of water-soluble tritium per batch that is to be released through the liquid effluent pathway. Once verified that the tritium concentrations in the samples meet all acceptance criteria associated with SRBT's licensing basis (that is, has not exceeded any internal administrative limits, ALs, or regulatory requirements), the batch is authorized for release into the sewer system. Authorized liquid effluent is released from the facility through sinks in Zone 2 and 3, and the sink in the Zone 1 shipping/receiving area.

Table 3.3 summarizes the concentrations of liquid effluent released over a five-year period from 2015 to 2020. In addition to licence limits, the SRBT facility has established liquid effluent ALs and internal administrative limits, 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. SRBT did not report any AL exceedances during the current licensing period. Waterborne releases of tritium have been consistently well below licence limits throughout the current licensing period.

Table 3.3: Annual waterborne releases from SRBT compared with applicable release limits (2015-2020) [2-6]

Parameter	Licence limit (GBq/year)	2015	2016	2017	2018	2019	2020
Tritium-water soluble (GBq/year)	200	6.0	5.18	6.85	10.02	13.67	5.56

Conclusion

CNSC staff found that SRBT's reported liquid effluent from the facility into the municipal sewer system 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.

3.2 Environmental effects assessment

This section presents an overview of the assessment of predicted effects from licensed activities on the environment and the health of persons. CNSC staff reviewed SRBT's assessment of current and predicted effects on the environment and health of persons due to licensed activities included in the ERA (see subsection 2.3.3 above). The ERA conducted by SRBT confirmed that tritium is the only COPC released from the facility and that operations at the SRBT facility do not pose a risk to the human health and the environment. SRBT completed their ERA in a stepwise manner by performing the following:

- quantifying the releases (COPCs) to the environment from current (section 3.1) and future activities
- identifying the environmental interactions of the current and expected releases of COPCs, and COPC exposure pathways in the environment
- identifying predicted COPC exposure for ecological and human receptors
- identifying potential effects to receptors

- determining whether the environment and health of persons is and will continue to be protected

To inform this section of the report, CNSC staff reviewed SRBT's 2021 ERA submission [13], and the annual reports submitted between 2011 and 2020, inclusively [2-12].

While CNSC staff conducted a review for all environmental components, only a selection of components is presented in detail in the following subsections. The environmental components were selected based on licensing requirements, as well as those that have historically been of interest to the Commission, Indigenous peoples and the public.

3.2.1 Atmospheric environment

An assessment of the atmospheric environment requires SRBT to characterize both the meteorological conditions and the ambient air quality at the SRBT 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 Petawawa Weather Station between 1989 and 2004 and SRBT's own weather station from 2011 to 2019.

The climate of Pembroke is classified as warm-summer humid continental, as with much of southern and eastern Ontario. The prevailing wind direction is typically dominated by West to East patterns with average daily temperatures ranging from -11.8°C to 20.3°C. Average annual precipitation is 795.3 mm rain equivalent precipitation.

ERA predictions

Within the ERA [13], SRBT predicted and assessed the potential impacts to ambient air quality as a result of routine airborne emissions of tritium, released to the environment from its facility.

None of the hazardous substances used in facility operations exceeded applicable provincial screening criteria and tritium emissions remained below annual release limits, the ERA therefore did not indicate a requirement for follow-up monitoring of air emissions. However, the emissions monitoring program described below is in place to support the operation of the SRBT facility to ensure environmental risk is managed in a fashion that adheres to the principle of as low as reasonably achievable, validate existing air dispersion models, and support future updates to the ERA.

Airborne tritium monitoring

As part of SRBT's EffMP, airborne tritium emissions are measured in real-time from the facility's stacks, using tritium-to-air monitors to establish the tritium concentration. A weekly sample of tritium emissions is also assessed using liquid scintillation counting to discriminate between oxide and elemental species of tritium. The annual release limits for tritium were calculated conservatively using airborne dispersion modelling to determine the amount of tritium that could be released from the facility without resulting in a potential risk to public or the environment [48]. See section 3.1.2 for results of annual airborne releases from SRBT over the past five years. Air emissions of tritium have remained well below licence limits throughout the current licensing period.

Conclusion

CNSC staff found, based on their review of the annual EffMP data from the current licensing period and the ERA results for the SRBT facility, that atmospheric emissions of tritium remain significantly below release limits 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 biota at the SRBT facility and the surrounding area consists of characterizing the local habitat and species (including considering 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.

3.2.2.1 Habitat

Pembroke is located within the Lake Simcoe - Rideau Ecoregion of the Mixedwoods Plains Ecozone [49]. The SRBT facility is located in an industrial park in the city's southern outskirts where the immediate surrounding area is varied. There are limited areas of forest, wetland, and other natural cover within 1,000 metres of the facility and the land use in the area is a mix of commercial, business and industrial facilities, and moderately dense urban and suburban development to the north, northeast and northwest of the facility. Despite the amount of urban and suburban development around the facility, the flora and fauna is diverse. Farmland to the west of the facility extends approximately 300-500 metres. To the south, east and west of the facility, there are open fields with grass cover, dispersed housing, a small river, swamps, streams, seasonal creeks, and drainage ditches. The regional climate vegetation consists of mixed hardwoods and some notable terrestrial plants in the area are maple, white pine, poplar, birch, butternut, goldenrod, and various species of mosses.

There are no large water bodies close to the facility. Neither the SRBT facility nor its property directly impact or influence any bodies of water. The closest body of water is the Muskrat River approximately 400 metres east and southeast of the edge of the facility's property line. The Muskrat River is narrow and measures up to approximately 40 metres across with an elevation of approximately 20 metres below the facility. Depending on the rainfall and season, this river has a highly variable volumetric flow rate. There is limited riparian habitat along the banks of the Muskrat River within the City of Pembroke but more wetland habitat is found along its banks outside of the city limits as dwellings and population density decreases. The Indian River is a smaller water body located approximately 1,000 metres northwest of the facility. These two water bodies are used recreationally and not generally used for sport fishing. They combine within the City of Pembroke, meander for 1.5 km north and discharge into the Ottawa River at approximately 2.5 km north of the facility.

3.2.2.2 Non-human biota

The urban wildlife that may be found in the area around the facility includes the chipmunk, common raccoon, groundhog, muskrat, red squirrel, white-tailed deer, eastern garter snake and the eastern ribbon snake. Some birds that are known or suspected to be in the area include the American crow, barn swallow, bank swallow, bobolink, Canada goose, chimney swift, eastern meadowlark, ring-billed gull, and the snow bunting. Some types of known aquatic species in the

assessment area include the Blanding's turtle, northern leopard frog, rainbow trout, walleye, bulrushes, and various ferns.

Table 3.4 lists the 10 terrestrial and aquatic species that were identified as potentially present around SRBT and that were assessed in SRBT's 2021 ERA [13].

Species at Risk

In Ontario, the following legislation applies to species at risk: the provincial *Endangered Species Act* (ESA) [50] and the federal *Species at Risk Act* (SARA) [51]. As part of their 2021 ERA, SRBT identified valued components to represent all categories of organisms in the area, including those that may hold Indigenous importance, and to identify the species at risk potentially present on or around the SRBT site (table 3.4).

Table 3.4: Status of terrestrial and aquatic species potentially present around SRBT [13]

Common name	Ontario ESA status [50]	SARA status [51]
Birds		
Ring-billed gull (*Larus delawarensis*)	No status	No status
Barn swallow (*Hirundo rustica*)	No status	Threatened
Mammals		
Muskrat (*Ondatra zibethicus*)	No status	No status
Red squirrel (*Tamiasciurus hudsonicus*)	No status	No status
Plants		
Bulrushes (*Typha latifolia*)	Threatened	Endangered
Butternut tree (*Juglans cinerea*)	Endangered	Endangered
Fish		
Lake sturgeon (*Acipenser fulvescens*)	Special concern	Special concern
Aquatic invertebrate		
Benthic invertebrates	No status	No status

Common name	Ontario ESA status [50]	SARA status [51]
Terrestrial invertebrate		
Earthworms (*Lumbricus terrestris*)	No status	No status
Amphibians and reptiles		
Blanding's turtle (*Emydoidea blandingii*)	Threatened	Endangered

ERA predictions

The most recent assessment of potential effects on terrestrial and aquatic biota near SRBT was provided in the 2021 ERA [13]. As discussed in subsection 2.3.3, the ERA fully complied with requirements of CSA N288.6-12, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills* [36] and incorporated recent environmental monitoring data.

Exposure to radiological substances

The potential radiological effects to ecological receptors were assessed by comparing the estimated radiation dose received by each ecological receptor from radiological COPC through all applicable pathways The pathways include external and internal exposure due to radionuclides in air, soil, and water and the exposures were compared to the recommended benchmark values.

SRBT's ERA provides calculated dose rates that include all internal and external doses from all exposure pathways. The values for the most-exposed terrestrial and aquatic receptor are compared to benchmark values in table 3.5 below.

Table 3.5: Calculated dose rates for the most-exposed ecological receptor compared to dose rate benchmarks [13]

Most-Exposed Receptor	Calculated Dose Rate (µGy/h)	Radiological Dose Rate Benchmarks (µGy/h)*
Terrestrial earthworm (terrestrial receptor)	2.73	100
Lake sturgeon (aquatic receptor)	6.96E-03	400

* Dose rates are measured in micrograys per hour (µGy/h). The Gray (Gy) is the International System of Units (SI) unit of measurement for absorbed dose [52] which is the amount of energy absorbed in the human body from radiation exposure and is equivalent to 1 joule of energy deposited in 1 kilogram of a substance [53].

The overall radiation dose for ecological receptors were significantly lower than the radiological dose benchmarks of 100 µGy/h for terrestrial receptors and 400 µGy/h for aquatic receptors recommended in CSA 288.6-12 [36]. These results indicate no potential for adverse effects and no need for further protective measures and no need for a more details assessment.

Exposure to hazardous substances

A review of all of SRBT's processes, including the use of radiological and hazardous substances, identified candidate COPCs which were examined through a screening level assessment. The screening level assessment concluded that tritium is the only radiological COPC of significance to human and ecological receptors and there are no significant exposures from hazardous substances to these receptors from SRBT's activities and not considered a COPC.

Exposure to physical stressors - noise

From SRBT's screening level assessment with in the ERA, noise was identified as the only physical stressor of possible concern. At the facility, there are very limited and insignificant sources of noise, road management activities, and vehicular traffic. Noise exposure for a 24 hour period was measured at six points around the facility at the boundary of the area controlled by SRBT. The highest noise level recorded at the facility's perimeter was 56 decibels (dB), which is similar to that of normal human conversation at 60 dB. Noise analysis associated with SRBT operations has indicated they are within acceptable levels and the risk to ecological receptors is low.

Conclusion

Based on CNSC staff's review of SRBT's ERA results, CNSC staff found that terrestrial and aquatic receptors remain protected from radiological releases from SRBT as well as from physical stressors associated with the facility. There are no significant exposures to human and ecological receptors from hazardous releases from SRBT processes.

3.2.3 Hydrogeological environment

An assessment of the hydrogeological environment at the SRBT site consists primarily of identifying potential sources of groundwater contamination on the site, determining the extent of contamination, if any, which could lead to an exposure pathway for 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.

The groundwater originating at the SRBT is moving easterly towards Muskrat River. The Muskrat River represents the main discharge area for shallow groundwater in the area and is about 420 metres from the SRB property along the shortest pathway. The horizontal velocity in the fractured shallow bedrock in the region is estimated to 4 metres/year.

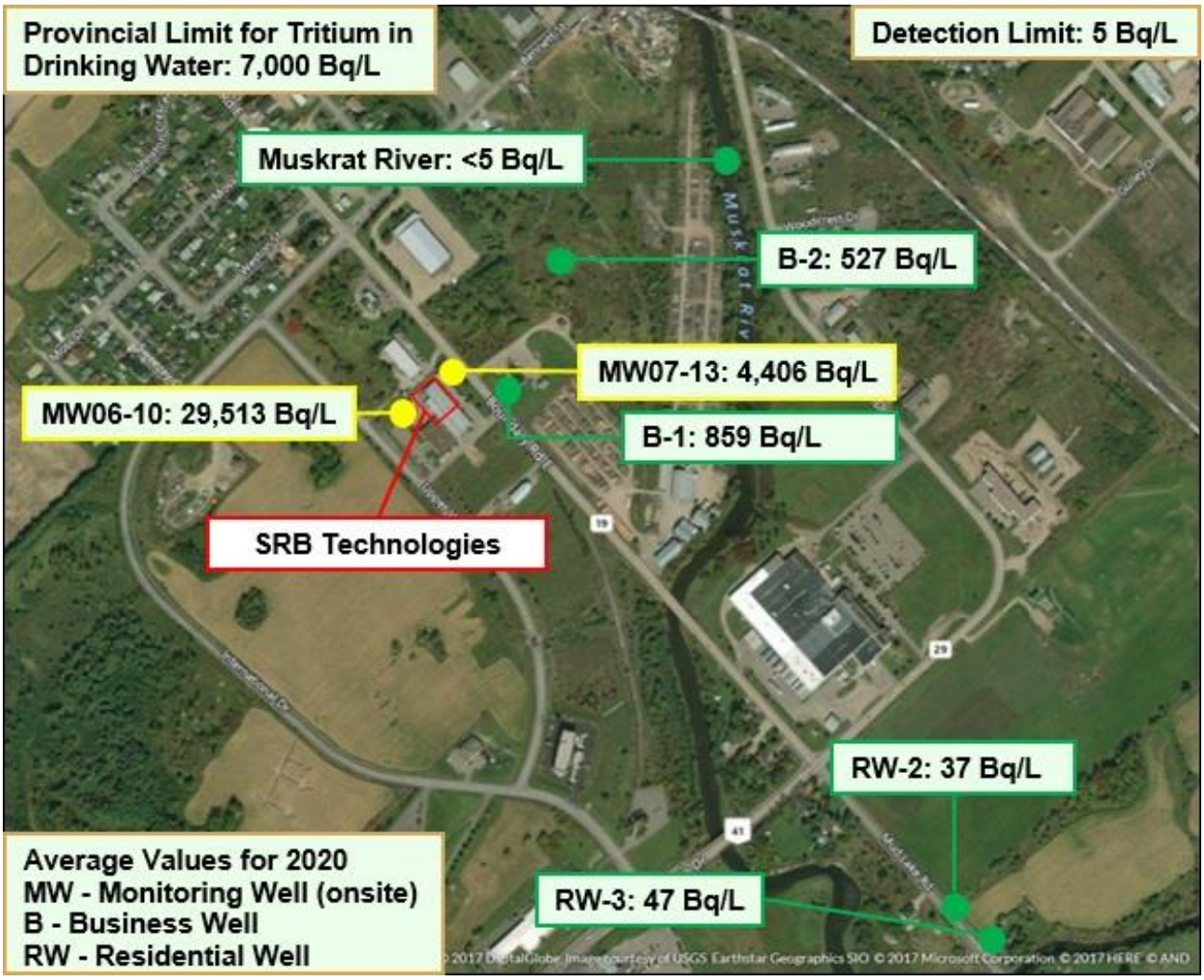
Groundwater monitoring

SRBT monitors tritium in groundwater around the site with 29 surrounding wells, which were sampled monthly until 2020 and then sampled on a quarterly basis onwards. CNSC staff reviewed SRBT's request to move to quarterly sampling and determined this change was acceptable, given the stability of tritium concentrations and overall decreasing trends over the last 15 years. CNSC staff stated that, should groundwater behaviour change in the future, a

higher sampling frequency would be reinstated. SRBT's groundwater monitoring program is designed in accordance with CSA N288.7-15, *Groundwater monitoring programs for Class I nuclear facilities and uranium mines and mills* [37] and complies with the standard.

In 2020, concentrations of tritium in samples obtained from all wells were below the Ontario Drinking Water Quality Standard value of 7,000 Bq/L [54] with the exception of one well (MW06-10) with a mean groundwater tritium concentration of 29,513 Bq/L. This well is located at the northwestern corner of the facility (figure 3.2) and is directly beneath the area where the active ventilation stacks are located. These high tritium concentrations are representative of historical contamination from the site in the early 2000's and wet deposition under normal operational conditions. This well is a dedicated, engineered groundwater monitoring well at the facility within a secured area, and is not available to be used as a source of water consumption.

Figure 3.2: Tritium concentrations around the SRBT facility



SRBT also samples five nearby residential wells around the site, although none of the residential wells are in the groundwater flow pathway. The closest one, RW-2, is 1,100 metres away from SRBT (figure 3.2). The tritium concentrations among the sampled residential wells monitored

are currently under 60 Bq/L. The tritium concentrations above the limit of detection in the residential wells are a result of deposition of tritium released into the air, not through groundwater movement from SRBT area.

Tritium concentrations decrease significantly at locations farther away from SRBT through natural processes such as radioactive decay, hydrodynamic dispersion and retardation. Over the years tritium concentrations in the Muskrat River (the receiving surface water environment) have been consistently near or below the minimum detectable activity (MDA) (between 5-10 Bq/L).

As discussed above in section 2.2, groundwater contamination from the early operations of SRBT were of a concern and have been addressed through several corrective measures (e.g., stopping historical practices of releasing waste water into the ground, reducing air emissions, conducting a comprehensive hydrogeological study and establishing a groundwater monitoring program) and regulatory oversight. During SRBT's licence renewal hearing in 2010, concerns remained regarding the upward trend of tritium in the groundwater around the facility. To address the concerns, CNSC staff conducted an independent groundwater modelling assessment in early 2010's [55] [56]. As well SRBT completed another groundwater study in 2011 [57]. These studies confirmed that the elevated tritium concentrations in groundwater well MW06-10 was mainly caused by high tritium concentrations in the soil due to historical practices. CNSC staff's modelling [55] [56] also predicted that while some monitoring wells were showing an upward trend, concentrations would decrease as tritium in the soil is gradually flushed out by infiltrated precipitation, and would eventually stabilize (figures 3.3 and 3.4).

As part of CNSC staff's regulatory oversight, staff continue to assess the groundwater monitoring data collected by SRBT against predicted values using staff's modelling assessment which was initiated in 2010. As shown in figures 3.2 and 3.3, using the two monitoring wells in close proximity to SRBT as an example, the relatively good agreement between the modelling results and measurements provides validation of CNSC staff's 2010 prediction of the behaviors of tritium in the groundwater system around the facility. It also demonstrates that releases of tritium resulting from SRBT's operation are under control and the tritium movement in groundwater around the SRBT facility is well understood. CNSC staff have determined that that tritium concentrations in groundwater have declined and stabilized as predicted.

Figure 3.3: Predicted vs measured tritium concentrations at MW06-10

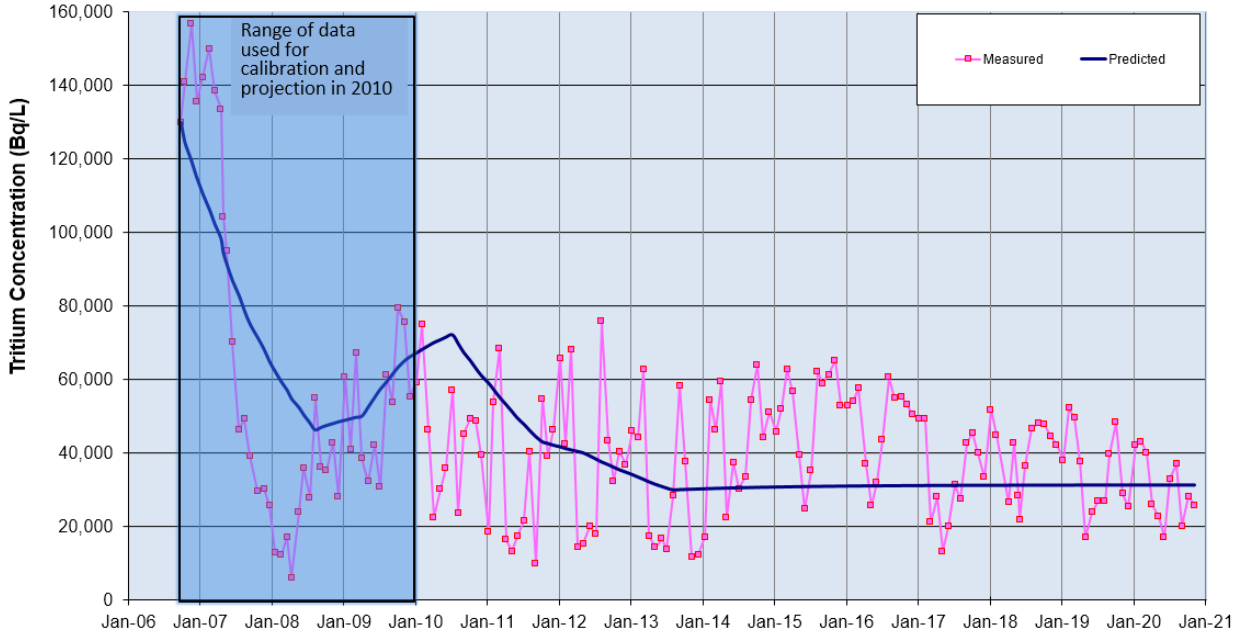
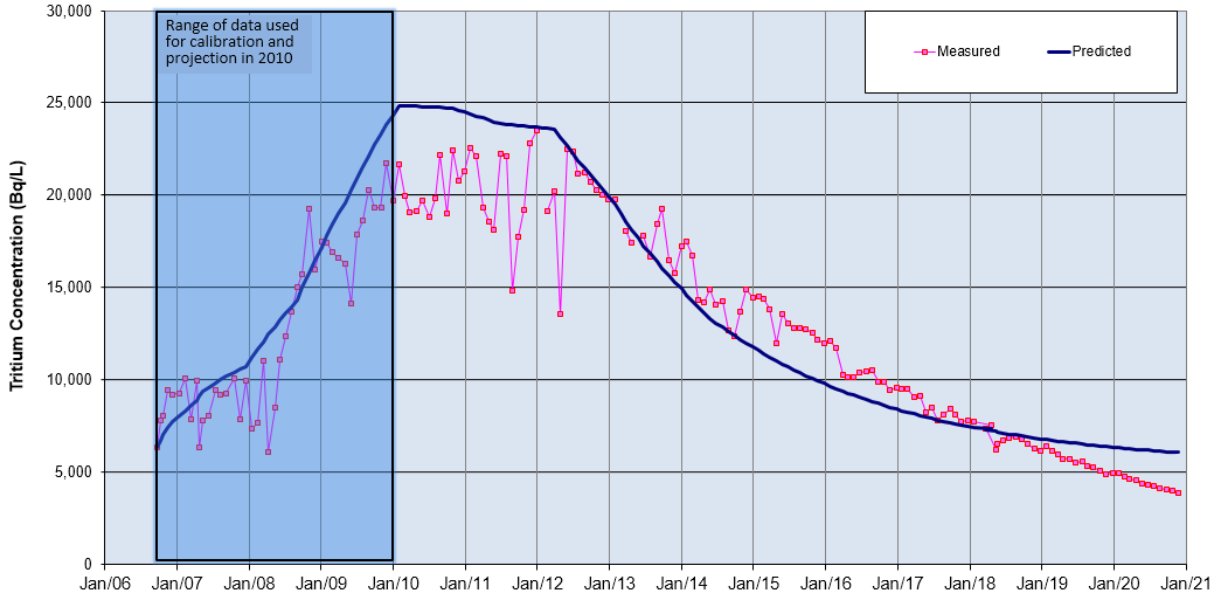


Figure 3.4: Predicted vs measured tritium concentrations at MW07-13



The increasing trend of tritium concentrations in the groundwater system around SRBT observed prior to early 2010, mainly caused by historical practices, has stopped and the tritium concentrations have been stabilizing over the years. SRBT's operation has not adversely impacted the groundwater quality, and the groundwater quality around SRBT continues to improve.

Table 3.6 provides a summary of the average and maximum values of tritium in the monitoring well over the most recent five-year period.

Table 3.6: Tritium concentrations in groundwater at the SRBT site ([2] and [58])

Parameter	Units	Data Measured	Value	2016	2017	2018	2019	2020	Ontario drinking water quality standard [54]
Tritium as tritium oxide (HTO)	Bq/L	All Monitoring Wells	Maximum*	60,571	49,457	51,809	52,321	43,247	N/A***
			Average	3,814	2,837	2,883	2,510	2,063	
		All Monitoring Wells without MW06-10	Maximum**	12,133	9,594	7,785	6,436	4,951	
			Average	2,166	1,739	1,534	1,329	1,067	
		Residential Wells	Average	59	36	23	21	20	7,000

***** The maximum values in the dataset represents the high values at Well MW06-10 and skews the average high.

** The maximum values without MW06-10 corresponds to well MW07-13, the next closest well to the tritium source, after MW06-10.

*** These wells are used for monitoring purposes only and are not used for drinking water.

Conclusion

Based on the review of the hydrogeological conditions and monitoring results reported in SRBT supporting documents, CNSC staff found that tritium releases from SRBT present negligible impact to surrounding residential wells and to the nearest receiving surface waterbody of the Muskrat River and at levels that are protective of the environment and human health.

3.2.4 Human environment

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

SRBT's 2021 ERA [13] included a HHRA to assess the risk to humans from both radioactive and hazardous substances released from activities at the SRBT facility. Tritium was identified as the only radiological COPC of significance to humans and there were no significant exposures from hazardous substance to human from SRBT's processes. The following human receptors were selected for the HHRA:

- Representative persons – closest residents living within 250 metres in the nearby Johnson Meadows subdivision. Assumed to be residing there 100% of the year with a 95th percentile breathing rate and conservative consumption of local produce, drinking water, and time spent bathing and swimming, in order to calculate a conservative dose. This represents a member of the public with the highest exposure to a COPC from the SRBT facility living nearest to the facility.
- A full-time worker at the Pembroke Pollution Control Centre (PPCC) – assumed to spend 40 h/week at the PPCC facility with an elevated breathing rate in order to calculate a conservative dose. This human receptor was included to represent someone who may be exposed to a COPC in liquid effluent through releases to the municipal sewer system.
- Members of the Algonquins of Pikwàkanagàn First Nation (AOPFN) – closest Indigenous community residing approximately 25-35 km south-southeast of the facility with unique traditional land uses and dietary habits.

The age classes for the representative persons included the following: a one-year old infant, a ten-year old child, an adult resident, and an adult worker.

3.2.4.1 Human Exposure to Radiological Substances

Potential impacts to human health from radiological substances released from a nuclear facility are assessed through a licensee's radiological HHRA. The estimated dose to human receptor(s) from licensed activities at SRBT is calculated using data from the environmental and effluent monitoring programs. SRBT uses the monitoring results in combination with methods described in CSA N288.1-14, *Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities* [33] to characterize radiological risk for the HHRA, and the final calculation is a summation of the following:

- Tritium uptake from inhalation and absorption through skin
- Tritium uptake due to consumption of well water
- Tritium uptake due to consumption of produce
- Tritium uptake due to consumption of dairy products

Dose from tritium to humans were calculated in SRBT's ERA by taking the maximum measured concentration of tritium in releases from the facility over the last five years and applying it to radiological dose calculations, as outlined in CSA N288.1-14 [33]. The following conservative input values were used in SRBT's 2021 ERA to derive the effective dose to human receptor(s):

Table 3.7: Input parameters for Human Health Risk Assessment [13]

Input Parameter	Units	Max 5-year measurement *	Applied Input Value
Air concentration, residential, HTO	Bq/m^3	24.4	49
Air concentration, occupational, HTO	Bq/m^3	14.40	29

Air concentration, PPCC, HTO	Bq/m^3	0.82**	1
Drinking water, HTO	Bq/L	232	464
Residential produce, HTO (cucumber, 2018)	Bq/kg	210	420
Residential produce, OBT (carrot, 2016)	Bq/kg	13	26
Commercial produce, HTO (cucumber, 2019)	Bq/kg	12	24
Commercial produce, OBT (tomato, 2017)	Bq/kg	3	6
Animal produce, HTO (milk, 2019)	Bq/kg	5	10

* These values were conservatively multiplied by 2 for the ERA calculations.
**This value was conservatively rounded up to 1 Bq/m^3 for the ERA calculations.

The evaluation resulted in the following total dose estimates for the selected representative persons:

- 0.023 mSv/year for the adult worker
- 0.020 mSv/year for the infant resident
- 0.022 mSv/year for the child resident
- 0.024 mSv/year for the adult resident

SRBT's 2021 ERA [13] estimated that the dose to the most-exposed human receptor (adult resident) is 0.024 mSv/year, which is far lower than the public dose limit of 1 mSv/year.

SRBT also calculates the effective dose to the public each year as part of its EMP. The 2015 to 2020 calculated annual doses to a member of the public are shown in table 3.8. The results show that the estimated doses to the public remain well below the regulatory dose limit of 1 mSv/year.

Table 3.8: Calculated annual dose to a member of the public, SRBT (2015-2020) [2]

Dose data	2015	2016	2017	2018	2019	2020	Regulatory dose limit
Maximum effective dose (mSv)	0.0068	0.0046	0.0033	0.0038	0.0021	0.0024	**1 mSv/year**

3.2.4.2 Environmental Monitoring Campaign with the Algonquins of Pikwàkanagàn First Nation

In 2020, SRBT undertook a collaborative environmental sampling campaign with the AOPFN, who reside approximately 25-35 km south-southeast of the facility. Air samples, precipitation samples, and plant samples of cultural importance to the community were collected and analyzed for tritium concentration. The plant samples collected included ironwood tree bark, mullein, red cedar, raspberry leaves, and sumac berries. AOPFN members shared knowledge of plants, including their uses and cultural significance, and helped harvest samples for the campaign. Below is a summary of the results (table 3.9).

Table 3.9: Results of the 2020 monitoring campaign with the AOPFN [13]

Input Parameter	Minimum Detectable Concentration (MDC)	Measured Result
Average HTO in air – Oct., Bq/m^3	0.70	< MDC
Average HTO in air – Nov., Bq/m^3	0.76	< MDC
Average HTO in precipitation – Oct., Bq/L	14.32	15
Average HTO in precipitation – Nov., Bq/L	14.38	15
Ironwood tree bark, Bq/kg (fw)*	0.26	9
Mullein, Bq/kg (fw)	0.58	12
Red cedar, Bq/kg (fw)	0.32	12
Raspberry leaves, Bq/kg (fw)	0.51	42
Sumac berries, Bq/kg (fw)	0.20	11

*fw = fresh weight

The results in table 3.9 show that the amount of tritium found in air, precipitation, and foods during the campaign with the AOPFN is low and unlikely to pose a health risk to the AOPFN

community. Health effects from tritium ingestion may arise when a person takes in an extraordinarily large quantity of tritium into the body (ie. billions of becquerels of tritium) [59]. For example, using the highest measured results from table 3.9 for raspberry leaves, one would need to ingest approximately 24 million kg[4] of raspberry leaves to potentially see a health effect from tritium. These results and the fact that the AOPFN community is further from the facility than the most exposed human receptor indicate it is highly unlikely that members of the AOPFN residing in their community would be exposed to an unreasonable risk from operations of the SRBT facility.

3.2.4.3 Conclusion

Between 2015 and 2020, the estimated radiological doses to a member of the public around SRBT remained well below the annual regulatory public dose limit of 1 mSv/year, indicating that radiological releases from SRBT pose a negligible risk to human health.

Based on CNSC staff's assessments conducted at SRBT, including the review of the 2021 ERA, the results of the 2020 monitoring campaign with the AOPFN and Annual Compliance Performance Reports, CNSC staff found that impacts to the human environment from radiological substances released from SRBT are negligible, and that people living or working near the site remain 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 one type of cumulative effect that the federal guidance document titled *Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012* [60] defines "as the sum of individual effects of two or more physical activities". 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 SRBT, based on the data assessed thus far and presented in this EPR report, CNSC staff found that no additive cumulative effects are occurring in the surrounding environment.

[4] To reach 1 billion Bq (1 billion = 1,000,000,000) of tritium from raspberry leaves analyzed from this study and using the measured value of 42 Bq/kg: 1,000,000,000 Bq ÷ 42 Bq/kg = 23,809,524 kg (or approximately 24 million kg)

4.0 CNSC Independent Environmental Monitoring Program

The CNSC has implemented its IEMP as an additional verification 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 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 SRBT facility

CNSC staff conducted IEMP sampling around SRBT in 2013, 2014, 2015 and 2018. CNSC staff developed site-specific sampling plans, which focused on radiological substances and were based on SRBT's comprehensive environmental protection program and the CNSC's regulatory knowledge of the site. CNSC staff are conducting its next sampling campaign in the summer 2021 with results available in 2022 on the CNSC's IEMP webpage.

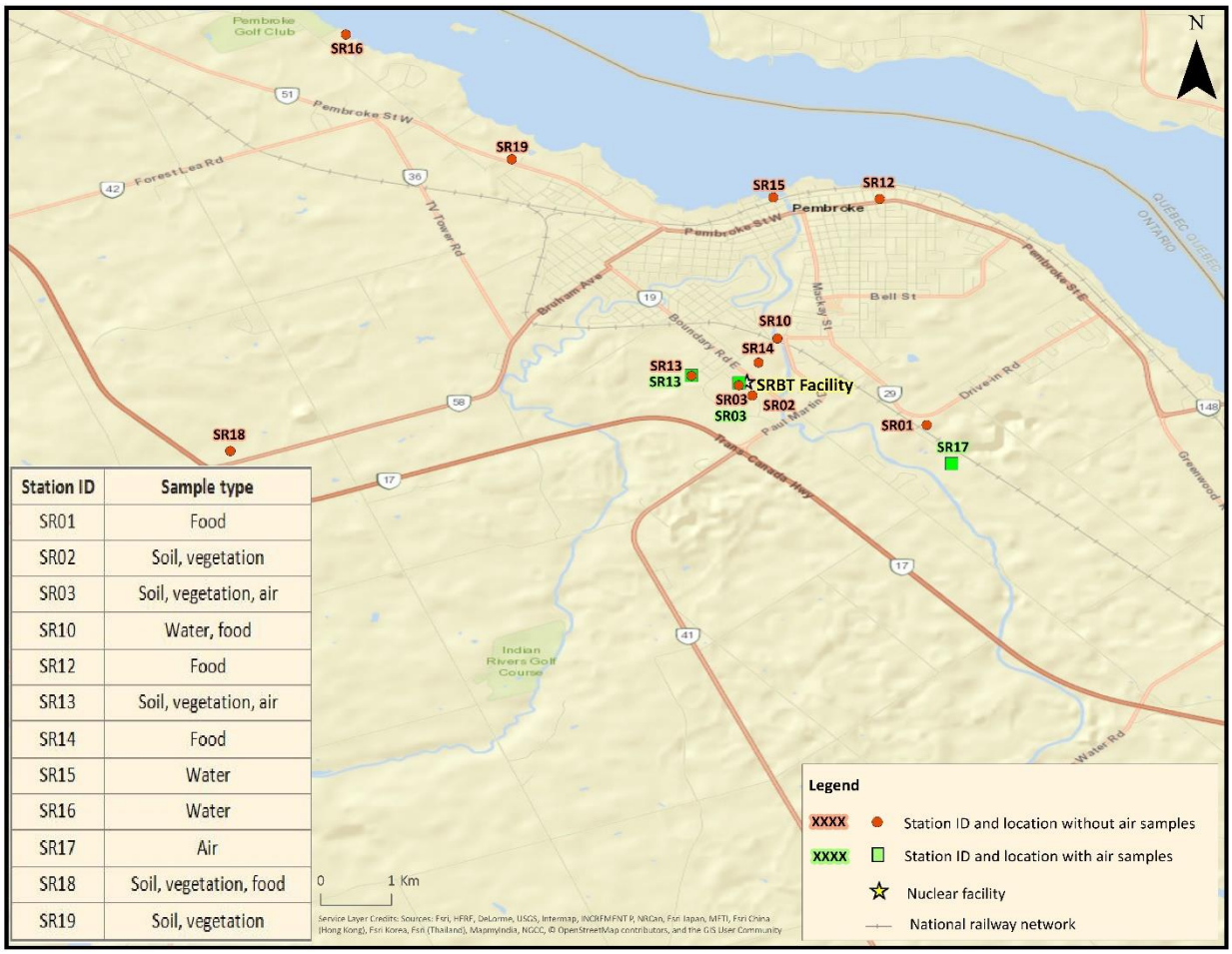
In 2018, the most recent completed campaign, CNSC staff collected the following samples in publicly accessible areas outside the perimeter of SRBT:

- air (3 locations)
- water (2 locations)
- vegetation (4 locations)
- soil (4 locations)
- food (4 locations)

Collected samples were analyzed by qualified laboratory specialists in the CNSC's laboratory in Ottawa, using best industry practices. Water and soil samples were analysed for tritium. Air samples were analysed for HTO and HT. Food and vegetation samples were analysed for HTO and OBT.

The IEMP results are posted on the CNSC's IEMP webpage [61]. Figure 4.1 provides an overview of the sampling locations for the 2018 IEMP sampling campaign around SRBT [62].

Figure 4.1: Overview of the 2018 sampling locations



Station ID	Sample type
SR01	Food
SR02	Soil, vegetation
SR03	Soil, vegetation, air
SR10	Water, food
SR12	Food
SR13	Soil, vegetation, air
SR14	Food
SR15	Water
SR16	Water
SR17	Air
SR18	Soil, vegetation, food
SR19	Soil, vegetation

4.2 Indigenous participation in the IEMP

It is a priority for the CNSC that IEMP sampling reflects Indigenous traditional knowledge and land use and values where possible. In addition to routine IEMP sampling activities, the CNSC seeks input from local Indigenous communities on its IEMP sampling plans.

In 2018, in advance of the IEMP sampling campaigns at SRBT, notification emails were sent to all Indigenous communities near SRBT, inviting suggestions for species of interest, valued components or potential sampling locations where traditional practices and activities may take place.

Letters were sent to the Algonquins of Ontario, William Treaties First Nations, Algonquin Anishinabeg Nation Tribal Council, Algonquin Nation Secretariat and the Métis Nation of Ontario to notify them of the sampling campaign and to seek their input into the sampling plan. The CNSC received no responses from Indigenous communities for input into the 2018 sampling campaign.

For the 2021 sampling campaign CNSC staff reached out to the above mentioned Indigenous communities with the addition of the AOPFN. As of the publishing date of this EPR report, no Indigenous group responded to the CNSC's invitation to participate in the 2021 IEMP sampling for SRBT. As with all campaigns CNSC staff will continue to engage with Indigenous

communities to ensure that IEMP sampling incorporates Indigenous knowledge in future sampling.

4.3 Summary of results

The level of radioactivity measured in water, soil, vegetation, air and food samples were below available guidelines and CNSC screening levels in all of the samples measured during the IEMP sampling campaigns in 2013, 2014, 2015 and 2018. Results for all campaigns are posted on the CNSC's website [61].

The IEMP results indicate that Indigenous peoples, the public and the environment near SRBT are protected and that there are no expected health impacts from the operations at the SRBT facility. These results are consistent with those submitted by SRBT, in particular SRBT's monitoring results near the community of Pikwakanagan and reviewed by CNSC's environmental protection staff, demonstrate that the licensee's environmental protection program protects the health and safety of people and the environment.

Figure 4.2: CNSC staff collecting vegetation samples near SRBT in 2021

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 SRBT facility are protected. Various organizations and institutions in Ontario, such as Cancer Care Ontario, Public Health Ontario, and the Renfrew County and District Health Unit (RCDHU), monitor the health of populations living near the SRBT facility. In addition, they compare disease rates around the SRBT facility 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.

Various health studies and reports assessed the health of populations living near the SRBT facility. Select publications are discussed and highlighted in subsections below. Additional information on health studies related to nuclear facilities, with a focus on tritium, is available on the CNSC webpage on Health Studies [64].

5.1.1 Community Health Profile Renfrew County and District 2016

The most recent Community Health Profile released in 2016 [65] examines health outcomes and factors that affect the health of people living in areas serviced by the RDCHU, including Pembroke. The report uses data from the Canadian Community Health Survey, the Canadian Census, Canadian Cancer Statistics, National Household Survey, Public Health Ontario Snapshots, and Ontario Population Estimates and Population Projections.

The leading causes of mortality in Renfrew County in 2011 included cancers, circulatory diseases, respiratory diseases and injuries, which accounted for 75% of deaths. Circulatory diseases include ischemic heart diseases, cerebrovascular diseases and stroke. Injuries include both unintentional (motor vehicle crashes, falls, burns, drownings, etc.) and intentional injuries (suicide/self harm and assault). In 2011, age-standardized mortality rates in Renfrew County and District were similar to Ontario, except for circulatory diseases, which was significantly higher for both sexes combined.

In 2013 and 2014, adults in Renfrew County District had significantly higher current smoking and obesity rates compared to Ontario adults overall, but had similar rates to other mainly rural health units.

5.1.2 Ontario cancer profiles

Ontario Cancer Profiles [66] provide interactive sets of data that show recent provincial and regional statistics on cancer burden, screening, risk factors, and socio-demographic factors. Regional statistics are available by public health unit and Local Health Integration Network. In 2018, RDCHU had similar incidence for all cancers for both sexes compared to Ontario. RDCHU had significantly higher all cancer mortality rates compared to Ontario for males and for both sexes combined.

In 2018, lung cancer incidence was significantly higher in females, and for both sexes combined in RDCHU compared to Ontario. Lung cancer incidence in males was similar to that of Ontario. Lung cancer mortality was also significantly higher for both sexes combined, compared to Ontario.

From 2015 to 2017, the rates of being overweight and obese in RDCHU were significantly higher for males, females, and both sexes combined compared to Ontario. The percent of current smokers (daily or occasional) in the region were also higher for males, females, and both sexes combined compared to Ontario; however, not significantly so. Alcohol consumption in the region was also higher for both sexes combined compared to Ontario. Obesity, smoking and alcohol consumption are major risk factors for cancer incidence and mortality. Smoking is also a major risk factor for lung cancer incidence and mortality.

5.1.3 Conclusions – Population and community health studies and reports

The review of health reports is an important component to ensure the health of people living near nuclear facilities is protected. The population and community health studies and reports indicate that common causes of death among the population of Renfrew County and District are cancers, circulatory diseases, respiratory diseases and injuries. Causes of death among the population of Renfrew County and District are similar to the rest of Canada, where heart disease and cancers are the two leading causes of death [67]. Cancer mortality is higher in Renfrew County and District compared to Ontario, however risk factors for cancer mortality such as smoking, overweight and obesity and alcohol consumption are also higher within the region compared to Ontario.

5.2 Broader scientific understanding of radiation health effects

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) is composed of international experts who review and publish consensus reports on the best current scientific information on the sources and health effects of ionizing radiation. This information in turn informs the recommendations of the International Commission on Radiological Protection (ICRP), which are focuses on the protection of human health. The epidemiological evidence of radiation-related health effects comes largely from several main research populations. These include patients who received medical treatment using radiation, people occupationally exposed to radiation (that is, radon-exposed miners, nuclear energy workers) and most importantly, the survivors of the atomic bombings. These studies build the foundation of the knowledge about the relationship between cancer and radiation exposure [68].

Two major conclusions of these studies are:

1) The probability (likelihood) of the occurrence 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.

To put these findings into perspective, the average Canadian's exposure to natural background radiation is about 1.8 mSv each year, which varies between 1 and 4 mSv/year [69]. Similarly, the average radiation doses of workers at SRBT is less than 1 mSv/year (0.077 mSv for 2020) and the environmental exposures to the public living near SRBT are less than about 0.01 mSv/year (0.0024 mSv for 2020).

In conclusion, experts worldwide study radiation health effects to ensure protection of workers and members of the public. The international understanding is that low doses of radiation are associated with low risks to health.

5.3 Studies of radiation effects on the environment and the health of people living near or working at tritium processing facilities

5.3.1 CNSC's tritium studies project

SRBT uses tritium, to make self-luminous emergency exit signs, various military applications such as landmine markers and other safety products not requiring batteries or other external sources of power. CNSC inspectors identified environmental tritium exposures from SRBT, which led to the January 2007 Commission proceeding, in which the Commission directed CNSC staff to initiate research studies on tritium releases in Canada, and to study and evaluate tritium-processing facilities exercising best practices around the globe. In June 2007, CNSC staff initiated the Tritium Studies Project (the Project) [70], intended to enhance the information used in the regulatory oversight of tritium processing and tritium releases in Canada. Staff provided the Commission with the conclusions of the Project in 2010. Certain follow-up activities were recommended and these were reported to the Commission in 2013 while still in progress. All follow-up activities are now complete and a final summary of the work, along with relevant information on related strategic research concerning tritium, was presented to the Commission in November 2017. Details can be found in staff's presentation to the Commission [71] and the Commission meeting minutes [72]. In January 2019, the CNSC published *the Implementation of Recommendations from the Tritium Studies Project Synthesis Report* [73] to summarize the activities staff have been involved in to address the recommendations from the Project.

A number of studies are highlighted below. More information on the Project is available on the CNSC website.

5.3.1.1 Environmental fate studies

Tritium activity in garden produce from Pembroke in 2007 and dose the public [74]

This report provides results of CNSC-funded research by the University of Ottawa on tritium activity in garden vegetables and fruits, and soil samples collected in late summer of 2007. The research found expected levels of tritium in local garden vegetables and fruits grown in Pembroke in 2005 and 2007. There was no evidence of significant accumulation of tritium in surface soils after 16 years of tritium releases from the SRBT facility. The dose resulting from the consumption of tritium in fruits and vegetables grown in Pembroke declines considerably with increasing distance of gardens from the SRBT facility. The highest annual dose in 2007 from consumption of tritium in fruits and vegetables grown in Pembroke was about 0.004 mSv. This is well below the annual dose limit of 1 mSv/year and orders of magnitude below doses known to cause health effects.

Environmental fate of tritium in soil and vegetation [75]

This report provides results of CNSC-funded research by the University of Ottawa on the amount of tritium in soil, garden produce, animal fodder and animal products near four tritium-releasing facilities during the 2008 and 2009 growing seasons. The four facilities studied were: SRBT, Shield Source Incorporated[5], Darlington Nuclear Generating Station and Gentilly-2 Nuclear

[5] Shield Source Incorporated no longer operates and in 2014 was released from regulatory oversight.

Generating Station.[6] The study found that in general, tritium levels decreased in samples collected further away from the facility with the trend being more pronounced in samples obtained near nuclear processing facilities such as SRBT. The study concluded that levels of organically bound tritium and tritiated water in soil and vegetation near nuclear facilities were low and pose no health risks and public doses are extremely low and well below regulatory limits.

Measurements and dose consequences of tritium in municipal sewage sludge report [76]

In 2013, the Commission requested CNSC staff to measure the concentrations of tritium in sewage sludge in various municipalities in Ontario (11 in total). This request was in response to concerns raised in 2011 by members of the public during the Commission meeting for SRB Technologies (Canada) Incorporated's (SRB) *Annual Status Report on the Safety Performance of the Facility*.

The tritium concentrations in sewage sludge and liquid effluent were below the analytical detection limit (i.e., the minimum concentration that can be detected by instrumentation) for all the wastewater treatment plants (WWTPs) sampled, except those in Peterborough and Pembroke.

Using the findings from the Pembroke WWTP, the doses of radiation from the measured concentration of tritium in sewage sludge were calculated for two representative persons – a worker at a WWTP involved in sewage sludge loading, and a worker at a municipal landfill who is involved in applying landfill cover to waste. The estimated annual effective doses were well below both the annual public dose limit of 1 mSv and the doses known to cause health effects. The dose from tritium in sewage sludge also represents a small fraction of the natural background radiation. As a result, the report concludes that there is no impact on public health.

5.3.1.2 Laboratory and epidemiological studies

Another objective of the Project was to conduct an independent staff review of the scientific literature, to assess the health risk to workers and the public from tritium exposures. The review looked at both laboratory and epidemiological studies.

Laboratory studies

Laboratory studies with animals demonstrate that tritium, like other sources of radiation, can induce genetic and reproductive effects and cell death, but only if delivered at doses millions of times higher than those to which the public is exposed. Tritium does induce and promote cancer in animals under some experimental conditions, but only at similarly high doses. The quantity of tritium required to induce these severe effects in animals is about several gigabecquerels (that is, billions of tritium atoms decaying and emitting a beta particle per second). This equates to doses above 500 mSv.

[6] The Gentilly-2 nuclear facility was permanently shutdown in 2012.

Epidemiological studies

Epidemiological studies based on good-quality radiation exposure data provide the best source of evidence for estimating human health risks from radiation exposure. This is because such studies assess actual health outcomes in humans from radiation exposure.

Tritium exposures are highly unlikely to cause adverse health effects in the public or in workers. The doses to which these groups are exposed are far below doses where we observe radiation effects.

In Canada, doses to the public from tritium releases from nuclear facilities are far below the public dose limit of 1 mSv/year. Doses from tritium exposures among people living near Canadian nuclear facilities are in the range of 0.0001 to 0.1 mSv/year. These doses are well below not only the limit, but also are negligible compared to natural background radiation, (an average of about 1.8 mSv each year, which varies between 1-4 mSv/year depending upon geographic location).

The worker dose limit is 50 mSv/year or 100 mSv over a 5-year period. Workers in tritium handling facilities receive an average effective dose of under 1 mSv/year. We do not expect to observe adverse health effects at such low doses. The average annual dose workers at SRBT received in 2020 was 0.077 mSv and the maximum annual dose to a worker was 0.43 mSv.

Based on the extensive epidemiological research and the lack of excess risk found from total radiation exposures, there is little evidence to suggest that increased cancer incidence or mortality occurs in populations exposed to tritium at current environmental or occupational levels. The lack of current evidence of an excess risk among these populations suggests that any tritium specific risk is small and not distinguishable from the risk of similar health outcomes in the general population.

5.3.1.3 Implementation of recommendations from the Tritium Studies Synthesis Report

The CNSC's current regulatory oversight of tritium-releasing facilities in Canada demonstrates that doses to members of public living near these facilities are low and below levels known to cause health effects. In January 2019, the CNSC published *the Implementation of Recommendations from the Tritium Studies Project Synthesis Report* [73] to summarize the activities staff have been involved in to address the recommendations from the Project.

CNSC staff have engaged in several research projects to expand the body of knowledge on tritium releases and to enhance the regulatory oversight of tritium-related activities. Project findings have been communicated to the Commission and the public through Commission meetings, open houses, eight CNSC information documents, papers in peer-reviewed scientific literature, and a chapter in the Encyclopedia of Sustainability Science and Technology [77].

Research conducted as part of the project resulted in the CNSC laboratory expanding its capability to analyze tritium in environmental samples. This has allowed the laboratory to support CNSC-funded research projects, participate in national and international inter-comparisons and analyze samples as part of the CNSC's IEMP. Staff at the CNSC's laboratory remain up-to-date with the latest techniques by participating in working groups and field research.

The results of the CNSC's IEMP data collected around facilities that emit tritium were used to estimate dose to a member of the public. Conservative assumptions were used in the dose

calculation. The results support the conclusion that the dose to a member of the public due to exposure from tritium releases is a small fraction of the regulatory dose limit and levels known to cause health effects.

As a result of the follow-up work that CNSC staff have now completed, staff are of the opinion that the recommendations from the Tritium Studies Project Synthesis Report have been met. Overall, the project met its objective of increasing the information available regarding tritium releases and enhancing the regulatory oversight of tritium-releasing facilities. Based on the research that has been previously presented to the Commission and staff's subsequent work, CNSC staff have found that adequate provisions have been made through existing regulatory mechanisms for the protection of all Canadians from exposure to tritium releases.

5.3.2 UNSCEAR 2016 – Biological effects of selected internal emitters – tritium

The UNSCEAR 2016 Report [78] summarizes their comprehensive review of the scientific literature on tritium. This section will focus on the epidemiological studies reviewed in this report. While researchers conducted a number of epidemiological studies of workers and members of the public potentially exposed to tritium, the majority of these studies do not calculate tritium-specific doses for use in the analyses. Consequently, little information on tritium-specific risk can be derived from epidemiological studies of tritium workers or members of the public potentially exposed to tritium beyond the conclusion that tritium-specific risks have not been seriously underestimated. However, because doses are so low, they are unlikely to have measureable impacts on the existing risk of radiation exposure because overall doses from radiation exposure are low.

Large quantities of tritium were released into the environment by atmospheric nuclear weapon testing in the early 1960's and there is no evidence of an increase in childhood leukaemia rates following exposure to tritium fallout. It is therefore unlikely that risk of childhood leukemia from exposure to tritium is majorly underestimated. Suggestions that reports of excesses of childhood leukaemia incidence near certain nuclear facilities could actually be due to releases of tritium because of a serious underestimation of risk are implausible.

5.3.3 A reanalysis of cancer mortality in Canadian nuclear workers (1956-1994) based on revised exposure and cohort data

In 2014, Zablotska et al, conducted an analysis of Canadian nuclear power industry workers exposed to chronic low-doses of radiation [79]. Approximately 45,500 Canadian nuclear power industry workers were studied, including the contribution of tritium to the total whole-body dose (mean tritium dose = 3.02 mSv). Tritium doses were generally low and analyses of all outcomes showed that risks were due solely to gamma doses and that tritium exposures did not contribute to any adverse health effects.

5.4 Summary of heath studies

Reviewing and conducting health studies and reports is an important component of ensuring that the health of people living near or working in nuclear facilities is protected. CNSC staff have considered the most recent international radiation epidemiology reports, our own information and scientific publications, as well as various community, provincial, and national level studies and reports for their evaluation of the health of population living near or working at SRBT.

Workers and the public are protected from current radiation exposures, including tritium exposures, from the operation of SRBT. Major health risk factors, such as smoking, overweight/obesity, and alcohol consumption, may account for increases in certain disease rates within Renfrew County.

These health studies and reports provide a snapshot of the health of a population living near the SRBT 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 SRBT facility.

6.0 Other environmental monitoring programs

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

6.1 National Pollutant Release Inventory

ECCC operates the National Pollutant Release Invetory (NPRI) [80], which is Canada's public inventory of pollutant releases, disposals and transfers, tracking over 320 pollutants from over 7,000 facilities across the country. Reporting facilities include factories that manufacture a variety of goods, mines, oil and gas operations, power plants and sewage treatment plants. Information that is collected includes:

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

SRBT is not required to report to the NPRI because they do not meet the reporting thresholds of any of the NPRI reportable substances.

CNSC staff conducted a search of the NPRI database for the Pembroke region and found that only one facility in the region reports to the NPRI. This facility reports releases of manganese and its compounds and these are not released from SRBT. It is also worth noting that radionuclides are not included in the inventory of pollutants in the NPRI database. The CNSC receives radionuclide release data from annual reports. This information has been used in this report, but the complete dataset is available for download on the CNSC's Open Government Portal [81].

6.2 Health Canada's Canadian radiological monitoring network and fixed point surveillance program

The Radiation Protection Bureau of Health Canada manages the Canadian Radiological Monitoring Network (CRMN) [82]. The CRMN routinely collects drinking water, precipitation, atmospheric water vapour, air particulate, and external gamma dose for radioactivity analysis at

26 monitoring locations. The closest CRMN monitoring location to SRBT is in Ottawa. The results at the Ottawa station for 2020 are consistent with data from previous years and are well below the public dose limit of 1 mSv/year.

In addition, Health Canada has complemented the CRMN with a fixed point surveillance (FPS) system. The FPS functions as a real-time radiation detection system designed to monitor public dose from radioactive materials in the air, including atmospheric emissions associated with nuclear facilities and activities both nationally and internationally. Monitoring stations continuously measure gamma radioactivity levels from ground-deposited (ground-shine) and airborne contaminants.

Health Canada measures the radiation dose rate as Air KERMA (kinetic energy released in unit mass of material) reported as nanogray per hour (nGy/h) of absorbed dose. These measurements are conducted every 15 minutes at 79 sites of its FPS network across the country. Air KERMA is also measured for three radioactive noble gases associated with nuclear fission, which may escape into the atmosphere during normal operation of nuclear facilities. These three noble gases are argon-41, xenon-133 and xenon-135. CNSC staff converted the absorbed dose rate to an effective dose, reported in mSv/year, which allows for comparison to annual background dose estimates and the regulatory public dose limit.

The 2020 total external gamma dose reported at the FPS network nearest SRBT, which is located in Petawawa, are similar to the Canadian average for natural background from gamma (the range is 0.007 to 0.027 mSv/year). These results indicate that total external gamma dose at these stations is not significantly influenced by activities at SRBT. Further evidence of this is provided by the fact that the monitored noble gases were all below the minimum detectable dose, as outlined in table 6.1. It should be noted that SRBT releases only tritium to the environment and therefore, does not contribute to these external gamma dose measurements and all results are significantly below the public dose limit of 1 mSv/year.

Table 6.1: Annual external gamma dose (mSv/year) for 2020 at the FPS network monitoring station near SRBT [82]

Monitoring station near SRBT	External gamma dose (mSv/year)			
	All gamma sources	Monitored noble gases (fission products)		
		Argon-41	Xenon-133	Xenon-135
Petawawa	0.018	*	*	*

* No data is reported when results were below the minimum detectable dose.

(a) Assumptions: Adult located at monitoring station for 24 hours a day, 365 days per year. Air KERMA in nanoGray corrected. Total Dose: 0.69 Sv for every Gray of absorbed dose measured. Argon-41: 0.74; Xenon-133: 0.75; Xenon-135: 0.67.

7.0 Conclusions

This EPR report focused on items of current Indigenous, public and regulatory interest, including groundwater monitoring, physical stressors, airborne and waterborne releases from ongoing operations at the SRBT facility. CNSC staff conclude that the potential risks from physical stressors, as well as from radiological releases from the SRBT facility to the atmospheric, hydrogeologic, aquatic, terrestrial and human environments are negligible.

7.1 CNSC staff follow-up

CNSC staff currently have no follow-up comments regarding the EP measures implemented by SRBT.

7.2 CNSC staff conclusions

CNSC staff's finding from this EPR report may inform and support staff recommendations to the Commission in future licensing and regulatory decision making that pertain to the SRBT facility. These findings are based on CNSC staff's reviews of documents associated with the SRBT 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 conclusions do not represent the Commission's conclusions. 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 SRBT facility in 2013, 2014, 2015, and 2018, and returned in the summer of 2021, with results available in 2022.

Based on CNSC staff's assessment of SRBT's EP documentation, CNSC staff have found that the potential risks from physical stressors, as well as from radiological and hazardous releases to the atmospheric, hydrogeological, aquatic, terrestrial and human environments from the SRBT facility are negligible, resulting in no significant adverse effects. The potential risks to the environment from these releases are similar to natural background and the potential risks to human health are indistinguishable to health outcomes in the general public. Therefore, CNSC staff have found that SRBT implements and maintains effective EP measures to adequately protect the environment and the health of persons. CNSC staff will continue to verify and ensure that, through ongoing licensing and compliance activities and reviews, the environment and the health of persons are protected.

CNSC staff's findings in this EPR report do not represent the Commission's conclusions. The Commission's decision-making will be informed by submissions from CNSC staff, the licensee, as well as by Indigenous peoples, the public, and any interventions heard during public hearings on licensing matters.

ABBREVIATIONS

Units

Becquerel	Bq
Cubic metre	m^3
Decibel	dB
Fresh weight	fw
Kilogram	kg
Litre	L
Metre	m
Microgray	µGy
Microsievert	µSv
Milligray	mGy
Millisievert	mSv
Nanogray	nGy

ACRONYMS

AL	Action levels
ALARA	As low as reasonable achievable
AOPFN	Algonquins of Pikwàkanagàn First Nation
CEAA	*Canadian Environmental Assessment Act, 1992*
CEAA 2012	*Canadian Environmental Assessment Act, 2012*
CMD	Commission member document
CNSC	Canadian Nuclear Safety Commission
COPC	Contaminants of potential concern
CRMN	Canadian Radiological Monitoring Network
DDP	Detailed decommissioning plan
DRL	Derived release limits
EA	Environmental assessment
ECCC	Environment and Climate Change Canada
EMS	Environmental management system
EP	Environmental protection

EPP	Environmental protection program
EPR	Environmental protection review
ERA	Environmental risk assessment
ESA	*Endangered Species Act*
FPS	Fixed point surveillance
GHG	Greenhouse gas
GTLS	Gaseous tritium light source
HHRA	Human health risk assessment
HT	Elemental tritium gas
HTO	Oxidized tritium
IAA	*Impact Assessment Act*
ICRP	International Commission on Radiological Protection
IEMP	Independent Environmental Monitoring Program
KERMA	Kinetic energy releases in unit mass of material
LCH	Licence condition handbook
MOU	Memorandum of understanding
NPRI	National Pollutant Release Inventory
NSCA	*Nuclear Safety and Control Act*
OBT	Organically bound tritium
PDP	Preliminary decommissioning plan
PPCC	Pembroke Pollution Control Center
RDCHU	Renfrew County and Health District Health Unit
ROR	Regulatory oversight report
SARA	*Species at Risk Act*
SRBT	SRB Technologies (Canada) Inc.
VC	Valued component

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