Canada's Nuclear Regulator

Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2018

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Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2018

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Weighing uranium concentrate drums before processing them
Fuel pellet and fuel bundle
Exit sign
Radiation cancer treatment equipment

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Executive summary

Each year, the Canadian Nuclear Safety Commission (CNSC) presents the *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada* to the Commission. This report outlines the safety performance of uranium and nuclear substance processing facilities in Canada and, where applicable, includes trends and comparisons with results in previous years.

To assess the safety performance of licensees, the CNSC conducts regulatory oversight activities including onsite inspections, reviews of reports submitted by licensees, reviews of events and incidents, and general communication and exchanges of information with licensees.

The report for the 2018 calendar year focuses on three safety and control areas (SCAs), specifically radiation protection, environmental protection, and conventional health and safety, since, taken together, these SCAs provide a meaningful overview of the safety performance of the facilities addressed in this report. The report includes ratings for each of the 14 SCAs and highlights licensees' public information programs, engagement with Indigenous groups and communities, reportable events, significant facility modifications and areas of increased regulatory focus.

CNSC staff confirmed that, in 2018, the uranium and nuclear substance processing facilities in Canada continued to operate safely. The performance of all uranium and nuclear substance processing facilities was rated as "satisfactory" or better for all 14 SCAs.

Overall, CNSC staff's compliance verification activities determined that:

- radiation protection programs at all facilities adequately controlled radiation exposures, keeping doses as low as reasonably achievable (ALARA)
- environmental protection programs at all facilities were effective in protecting people and the environment
- conventional health and safety programs at all facilities continued to protect workers
- programs in support of the remaining SCAs, which are also required for ensuring the protection of the health and safety of workers, the public and the environment, continued to be effectively implemented

Therefore, CNSC staff concluded that, in 2018, the uranium and nuclear substance processing facilities in Canada made adequate provision for the health and safety of workers, as well as for the protection of the public and the environment, and for meeting Canada's international obligations on the peaceful use of nuclear energy.

This document is available on the CNSC public website, and the documents that the report references are available to the public upon request by contacting:

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1 Overview

The Canadian Nuclear Safety Commission (CNSC) regulates the use of nuclear energy and materials to protect health, safety, security and the environment, implements Canada's international commitments on the peaceful use of nuclear energy, and disseminates objective scientific, technical and regulatory information to the public. Licensees are responsible for operating their facilities safely and are required to implement programs that make adequate provision for meeting legislative and regulatory requirements.

Each year, CNSC staff submit a regulatory oversight report to the Commission on the safety performance of the uranium and nuclear substance processing facilities in Canada regulated by the CNSC. The 2018 report contains information on the licensees' compliance with the legal requirements of the *Nuclear Safety and Control Act* (NSCA) [1] and associated regulations made under the NSCA, as well as with each facility's licence, licence conditions handbook (LCH) and any other applicable standards.

The information provided in this report includes trends and comparisons with previous years, as applicable. The report focuses on three safety and control areas (SCAs) – radiation protection, environmental protection, and conventional health and safety – as they provide a meaningful overview of the safety performance for the facilities. In addition, the document highlights a discussion of licensees' public information programs, engagement with Indigenous groups and communities, ratings for all 14 SCAs, reportable events and incidents, any significant facility modifications, and areas of increased regulatory focus.

The report also includes a list of references, a list of acronyms and their definitions, a glossary and 12 appendices. Appendices A, B and C provide general information on the CNSC's regulatory oversight of uranium and nuclear substance processing facilities in Canada, while appendix D presents the financial guarantee amounts for each facility. Appendices E, F, G and H outline the performance data for each facility on radiation protection, environmental monitoring and releases, and health and safety data, including annual trends. Appendix I lists the licensees' websites and appendix J summarizes any significant changes made to the licences and LCHs in 2018. Appendix K provides a list of all compliance verification inspections conducted during the calendar year for each facility. New to this year's report is appendix L, which provides example criteria developed and used in the CNSC Regulatory Information Bank to determine safety significance.

1.1 Canada's uranium and nuclear substance processing facilities

This report summarizes the CNSC staff assessment of the safety performance of the following facilities and licensees, each of which is located in the province of Ontario:

- Uranium processing facilities*
  - Cameco Corporation Blind River Refinery (BRR) in Blind River (FFOL-3632.00/2022)
  - Cameco Corporation Port Hope Conversion Facility (PHCF) in Port Hope (FFOL-3631.00/2027)
  - Cameco Fuel Manufacturing Inc. (CFM) in Port Hope (FFOL-3641.00/2022)
  - BWXT Nuclear Energy Canada Inc. (formerly GE Hitachi Nuclear Energy Canada Inc.) in Toronto (BWXT Toronto) (FFOL-3620.01/2020)
  - BWXT Nuclear Energy Canada Inc. (formerly GE Hitachi Nuclear Energy Canada Inc.) in Peterborough (BWXT Peterborough) (FFOL-3620.01/2020)
- Nuclear substance processing facilities*
  - SRB Technologies (Canada) Inc. (SRBT) in Pembroke (NSPFOL-13.00/2022)
  - Nordion (Canada) Inc. (Nordion) in Ottawa (NSPFOL-11A.01/2025)
  - Best Theratronics Ltd. (BTL) in Ottawa (NSPFOL-14.01/2019)

*Each alpha-numeric expression refers to the licence held by the licensee.

1.2 Regulatory oversight

The CNSC regulates Canada's uranium and nuclear substance processing facilities through licensing, reporting, verification and enforcement activities. For each facility, CNSC staff conduct onsite inspections, assessments, reviews and evaluations of licensee programs, processes and safety performance reports. The CNSC uses a risk-informed approach when conducting regulatory oversight activities. The purpose is to ensure that each licensee is operating safely – that resources are appropriately allocated and that controls are applied based on the complexity of the facility, hazards and magnitude of potential risks associated with the activities at the facility.

In applying this approach to compliance oversight, CNSC staff establish compliance plans for each facility, to determine the type and level of review, inspection and testing required commensurate with the potential risks posed by the regulated activities. CNSC staff continuously review the compliance plans to take into consideration the complexity of the facility, the hazards and magnitude of the potential risks associated with the activities at the facility, events, facility modifications, changes in licensee performance, and lessons learned.

In 2018, CNSC staff conducted 22 onsite inspections at uranium and nuclear substance processing facilities in Canada. The inspections covered various aspects of the SCAs. Section 2 provides a breakdown of the number of inspections conducted at uranium processing facilities; section 7 provides the breakdown for nuclear substance processing facilities. Appendix K summarizes the inspections.

While some inspections focus on specific SCAs, CNSC inspectors strive to ensure that they cover the strategic outcomes for safety of the radiation protection, environmental protection, and conventional health and safety SCAs in every inspection, to ensure that:

- radiation protection measures are effective and radiation doses to workers remain ALARA, taking into account social and economic factors
- the environmental protection programs are effective and releases are controlled and remain ALARA
- the conventional health and safety programs continue to protect workers from injuries and accidents

CNSC staff also verify compliance through desktop reviews of reports and licensee programs. They further supplement compliance verification activities through presentations and meetings with the licensees.

1.3 Safety and Control Area Framework

CNSC staff use the SCA Framework to evaluate the safety performance of each licensee. The framework includes 14 SCAs, each subdivided into specific areas that define its key components. Appendix A lists all the SCAs and specific areas used in this report.

CNSC staff assess licensee performance in each applicable SCA according to the following four ratings:

- fully satisfactory (FS)
- satisfactory (SA)
- below expectations (BE)
- unacceptable (UA)

Appendix B provides full definitions of the four ratings. Ratings are listed for each applicable SCA. The ratings are derived from the compliance verification activities that CNSC staff conduct in the various SCAs.

A licensee's performance is measured by its ability to minimize all risks posed by the licensed activity and to comply with all regulatory requirements. CNSC staff continually assess performance in each SCA. It is important to understand that each SCA is evaluated individually and every facility has different inputs into the annual rating for a specific SCA. For example, a rating may not have an input from onsite inspections if no onsite inspections were conducted for that SCA during the year. In those cases, the CNSC staff rating input consists of the

information provided in their desktop review and evaluation of licensees' annual compliance reports.

The three SCAs focused on in this report – radiation protection, environmental protection, and conventional health and safety – include key metrics to demonstrate a licensee's performance, such as the radiation dose to workers and the public, releases to the environment and the number of lost-time injuries (LTIs).

1.4 CNSC Independent Environmental Monitoring Program

Under the NSCA, the CNSC stipulates that the licensee of each nuclear facility shall develop, implement and maintain an environmental monitoring program to demonstrate that the public and the environment are protected from emissions resulting from the licensee's licensed activities. The licensees submit the results of these monitoring programs to the CNSC to ensure compliance with applicable requirements, as set out in the applicable regulations.

The CNSC implements its Independent Environmental Monitoring Program (IEMP) to verify that the public and the environment around licensed nuclear facilities are protected. The IEMP is a regulatory tool that complements the CNSC's ongoing compliance verification program. Under the IEMP, samples are taken from public areas around licensed facilities. The amounts of radioactive and hazardous substances in those samples are measured and analyzed, and the results are compared against relevant guidelines, limits and objectives.

In 2018, CNSC staff conducted independent environmental monitoring at BRR, BWXT Toronto, BWXT Peterborough, SRBT and Nordion. The 2018 IEMP results, which are posted on the CNSC's IEMP web page, demonstrate that the public and the environment around these facilities are protected, and that no adverse environmental or health effects are expected as a result of these facility operations.

In addition, these results are consistent with the results submitted by the licensees and demonstrate that the licensees' environmental protection programs continue to protect the health and safety of people and the environment.

1.5 Indigenous and community engagement

As an agent of the Crown and as Canada's nuclear regulator, the CNSC recognizes and understands the importance of consulting and building relationships with Indigenous peoples in Canada.

CNSC staff are committed to building long-term relationships with Indigenous groups who have interests in the regulation of nuclear facilities within their traditional and/or treaty territories. By pursuing informative and collaborative ongoing interactions, the CNSC is committed to building partnerships and trust. The CNSC's Indigenous engagement practices include information sharing and funding support (through the CNSC's Participant Funding Program (PFP)) for Indigenous peoples to meaningfully participate in Commission proceedings and

ongoing regulatory activities. These practices are consistent with the principles of upholding the honour of the Crown and reconciliation.

CNSC staff efforts in 2018 supported the CNSC's ongoing commitment to meet its consultation obligations and build relationships with Indigenous peoples with interests in Canada's uranium and nuclear substance processing facilities. CNSC staff continued to work with Indigenous communities and organizations to identify opportunities for formalized and regular engagement, including meetings and workshops, throughout the lifecycle of these facilities. Through this engagement, CNSC staff welcomed the opportunity to discuss and address topics of interest and concern related to CNSC-regulated activities to interested Indigenous communities.

In addition, to ensure that interested Indigenous communities were made aware of this 2018 regulatory oversight report, CNSC staff provided them with a notice of the PFP opportunity to review and comment on it, as well as the opportunity to submit a written intervention and/or appear before the Commission as part of the Commission meeting. CNSC staff also sent copies of this report to all Indigenous communities and organizations who had requested that they be kept informed of activities at the facilities covered in the report.

CNSC staff continue to monitor the engagement work conducted by licensees in this sector to ensure that they continue to actively engage and communicate with Indigenous groups who have an interest in their facilities. Below is a summary of the engagement activities specific to each facility in this report conducted by CNSC staff and by each facility licensee during the reporting period.

Blind River area

The CNSC-regulated facilities in the Blind River area include a uranium processing facility: the Cameco Blind River Refinery (BRR). BRR is within the traditional and treaty territories of the Mississauga First Nation (MFN), Sagamok Anishnawbek Nation (SAN), Serpent River First Nation (SRFN), Thessalon First Nation (TFN), and the traditional harvesting territory of the Métis Nation of Ontario (MNO).

CNSC staff engagement activities

CNSC staff regularly engage with Indigenous groups with an interest in the BRR facility. In 2018, CNSC staff sent letters with key project information updates, conducted phone calls, and worked to arrange meetings with MFN, SAN, MNO, SRFN and TFN. In October, CNSC staff met separately with the MFN, SAN and MNO to provide updates on several CNSC-regulated facilities and activities, including those of BRR, in the above traditional territories. CNSC staff reached out to TFN and SAN to meet with them in October as well. However, neither group was available at that time. CNSC staff plan to meet with TFN in the fall of 2019, should TFN be available, and are committed to following up with all other groups to arrange meetings, should they be interested. There was interest in having more formalized relationships with the CNSC and a desire to receive information updates from Cameco on a regular basis.

CNSC staff have been working with MNO to develop terms of reference for ongoing collaboration and are open to discussing BRR, as well as other CNSC-regulated facilities, as part of this formalized engagement. CNSC staff are committed to having more meetings with interested Indigenous groups to provide key updates on the BRR facility and nuclear activities and projects in their territories of interest.

Licensee engagement activities

CNSC staff confirmed that Cameco has a dedicated Indigenous engagement program that covers its operations and activities in both Saskatchewan and Ontario. Cameco provides hard copies of the BRR annual compliance reports to the MFN and SRFN, and, when requested, provides presentations and holds meetings with interested Indigenous groups. In 2018, Cameco met with the Chief of the MFN to discuss issues of mutual concern and interest. There were no specific questions or concerns raised during the annual presentation in 2018, outside of requests for possible financial support for various community projects and queries about employment opportunities. Cameco did not meet with other Indigenous communities in 2018, as there were no requests for presentations. The CNSC encourages Cameco to continue to develop relationships and engage with MFN, SAN, MNO, SRFN and TFN, as they have voiced an interest in Cameco's activities.

Facilities in Port Hope, Toronto and Peterborough areas

The CNSC-regulated facilities in the Port Hope, Toronto and Peterborough areas include Cameco's Port Hope Conversion Facility (PHCF), the Cameco Fuel Manufacturing facility (CFM), and the BWXT Nuclear Energy Canada Inc. facilities in Toronto and Peterborough.

All facilities are within the traditional and treaty territories of the Williams Treaties First Nations (WTFN), which include Alderville First Nation (AFN), Curve Lake First Nation (CLFN), Hiawatha First Nation (HFN), the Mississaugas of Scugog Island First Nation (MSIFN), the Chippewas of Beausoleil First Nation (CBFN), the Chippewas of Georgina Island First Nation (CGIFN) and the Chippewas of Rama First Nation (CRFN).

Additionally, PHCF and CFM are within the traditional and treaty territories of the Mississaugas of the Credit First Nation (MCFN) and located in a territory of interest to the Métis Nation of Ontario (MNO) Region 8 and the Mohawks of the Bay of Quinte (MBQ).

CNSC staff engagement activities

CNSC staff regularly engage with Indigenous groups with interest in the PHCF, CFM and BWXT facilities. In 2018, CNSC staff sent letters with key project information updates to the groups identified above. CNSC staff conducted follow-up phone calls with these groups to ensure they had received the letters and to answer any questions.

The CNSC's 2018 BWXT-related engagement activities focused on the licensee's application to renew its operating licence for the BWXT Peterborough and

Toronto facilities. CNSC staff sent notification letters about the upcoming BWXT licence renewal. They conducted follow-up phone calls to ensure that the letters had been received and to answer any questions about the regulatory process and how to get involved in the Commission proceedings.

In 2018, CNSC staff met with the multiple-member nations of the Williams Treaties First Nations (CLFN, AFN, MSIFN) and MNO to provide updates on a number of CNSC-regulated facilities and activities in their traditional and treaty territories, including PHCF, CFM and BWXT. CNSC staff initiated discussions with WTFN to determine if they would be interested in formalizing the engagement relationship between CNSC staff and WTFN. WTFN expressed an interest and discussions were initiated on developing terms of reference with CNSC staff.

CNSC staff worked towards meeting with MBQ leadership in 2018 and did so in spring 2019. At these meetings, CNSC staff provided additional information on topics of interest, such as environmental monitoring and human health studies conducted in the Port Hope region. In response to MCFN's request, CNSC staff continue to provide MCFN with notification of CNSC-regulated activities going on in their traditional and treaty territories, including activities at PHCF and CFM. CNSC staff are committed to providing further information and meeting with MCFN if they are interested.

Licensee engagement activities

CNSC staff confirmed that Cameco has a dedicated Indigenous engagement program that covers Cameco's operations and activities in Saskatchewan and Ontario. When requested, Cameco provides presentations and holds meetings with interested Indigenous groups. In 2018, Cameco participated in a number of public outreach activities pertaining to PHCF and CFM, but did not meet specifically with Indigenous groups as there were no direct requests for presentations or meetings. CNSC staff encourage Cameco to continue to engage directly with Indigenous groups with an interest in the two facilities and to develop relationships, as these Indigenous groups (the Williams Treaties Nations, MBQ and the MNO) have voiced an interest in Cameco's activities.

CNSC staff confirmed that BWXT also has a dedicated Indigenous engagement program that covers its operations and activities, and that the licensee is an active member within the Indigenous Relations Suppliers Network established by Bruce Power. In April 2018, BWXT sent an introductory letter to Indigenous communities; BWXT contacted them again in December of 2018 to inform them about its licence renewal application. BWXT met with the MNO, members of WTFN, and the MBQ to discuss this application. CNSC staff continue to be satisfied with the quality of Indigenous engagement conducted by BWXT on its operations and proposed projects. The CNSC encourages BWXT to continue to develop relationships and engage with Indigenous groups who have voiced an interest in the licensee's activities.

Ottawa Valley facilities

The CNSC-regulated facilities in the Ottawa Valley region include SRB Technologies Inc. (SRBT), Nordion Canada Inc., and Best Theratronics Limited (BTL).

All facilities are within the traditional territories of the Algonquins of Ontario (AOO), Algonquins of Pikwàkanagàn (APFN), Kitigan Zibi Anishinabeg, the Algonquin Anishinabeg Nation Tribal Council (AANTC), and the traditional harvesting territory of the Métis Nation of Ontario (MNO) Regions 5 and 6.

CNSC staff engagement activities

CNSC staff regularly engage with Indigenous groups who have interest in the SRBT, Nordion and BTL facilities. In 2018, CNSC staff sent letters with key project information updates to the groups identified above. CNSC staff phoned these groups to ensure they had received the letters and to answer any questions. CNSC staff met separately with representatives from AOO, APFN and MNO to participate in cultural activities, learn about their community and history, and provide an overview of the CNSC-regulated facilities and activities in their territories. These meetings included discussions on groups' areas of interest such as the CNSC's Independent Environmental Monitoring Program (IEMP).

CNSC staff met with AOO representatives on multiple occasions in 2018 to address comments and concerns raised during AOO's previous interventions regarding SRBT and other facilities situated in their territory. While the AOO do not currently have any outstanding concerns related to Nordion's nuclear activities, they continue to actively participate and make informed contributions to address any potential impacts on AOO rights and interests. CNSC staff also met with the Métis Nation of Ontario (MNO) to provide updates on a number of CNSC-regulated facilities and activities in their traditional territories, including SRBT, Nordion and BTL.

CNSC staff have been working with MNO, AOO and APFN separately to develop terms of reference for ongoing collaboration. CNSC staff are open to discussing the CNSC-regulated facilities within their territories as part of this formalized engagement, should the MNO, AOO or APFN express an interest. CNSC staff welcome the opportunity to continue to provide project updates and discuss any areas of interest and concern with Indigenous groups in relation to CNSC-regulated facilities in the Ottawa Valley.

Licensee engagement activities

CNSC staff confirmed that SRBT has implemented a public information and disclosure program, which targets multiple audiences, including local Indigenous groups. On November 21, 2018, SRBT sent letters to five Indigenous groups (AOO, MNO, Algonquin Anishinabeg Nation Tribal Council, and Kitigan Zibi Anishinabeg). The letters introduced and described SRBT, and offered to meet with the groups and provide tours of the facility. CNSC staff encourage SRBT to continue to engage directly with Indigenous communities with an interest in the facility and to develop relationships with the above Indigenous groups, as they have voiced an interest in SRBT activities.

In 2018, Nordion sent a letter to the AOO inviting them to the facility for a discussion and tour. This was in response to the AOO's submission to the 2017 CNSC regulatory oversight report. CNSC staff encourage Nordion to engage directly with Indigenous communities with an interest in the facility and to develop relationships with the above Indigenous groups, as they have voiced an interest in Nordion activities.

CNSC staff confirmed that BTL has implemented a public information and disclosure program, which targets multiple audiences, including local Indigenous groups. The primary mechanism for distribution of information to the target audiences is through the BTL website. In 2018, BTL invited the Algonquins of Ontario to tour the facility and hold a meeting to answer any questions or concerns they may have regarding BTL's operations. CNSC staff encourage BTL to engage directly with interested Indigenous communities whose traditional territories host the facility and to develop relationships with the above Indigenous groups, as they have voiced an interest in BTL activities.

1.6 Overall conclusions

CNSC staff concluded that uranium processing facilities and nuclear substance processing facilities in Canada operated safely during the 2018 calendar year. This assessment is based on CNSC staff's verification of licensee activities, including onsite inspections, reviews of reports submitted by licensees, and reviews of events and incidents, supported by follow-up and ongoing communications with the licensees.

In 2018, the performance ratings in all 14 SCAs for the facilities were as follows:

- uranium processing facilities were rated as "satisfactory" or better
- nuclear substance processing facilities were rated as "satisfactory" or better

CNSC staff's compliance verification activities confirmed that:

- radiation protection programs at all facilities were effective and adequately controlled radiation exposures, keeping doses ALARA
- environmental protection programs at all facilities were effective in protecting people and the environment
- conventional health and safety programs at all facilities continued to protect workers

Through their regulatory oversight activities, CNSC staff confirmed that Canada's uranium and nuclear substance processing facilities continued to operate safely throughout 2018. Appendix B includes a definition of the rating methodology and ratings.

CNSC staff concluded that, in 2018, the licensees discussed in this report made adequate provision for the health and safety of workers, as well as for the protection of the public and the environment, and for meeting Canada's international obligations on the peaceful use of nuclear energy.

CNSC staff continue to provide regulatory compliance oversight to all licensed facilities.

Part I: Uranium processing facilities

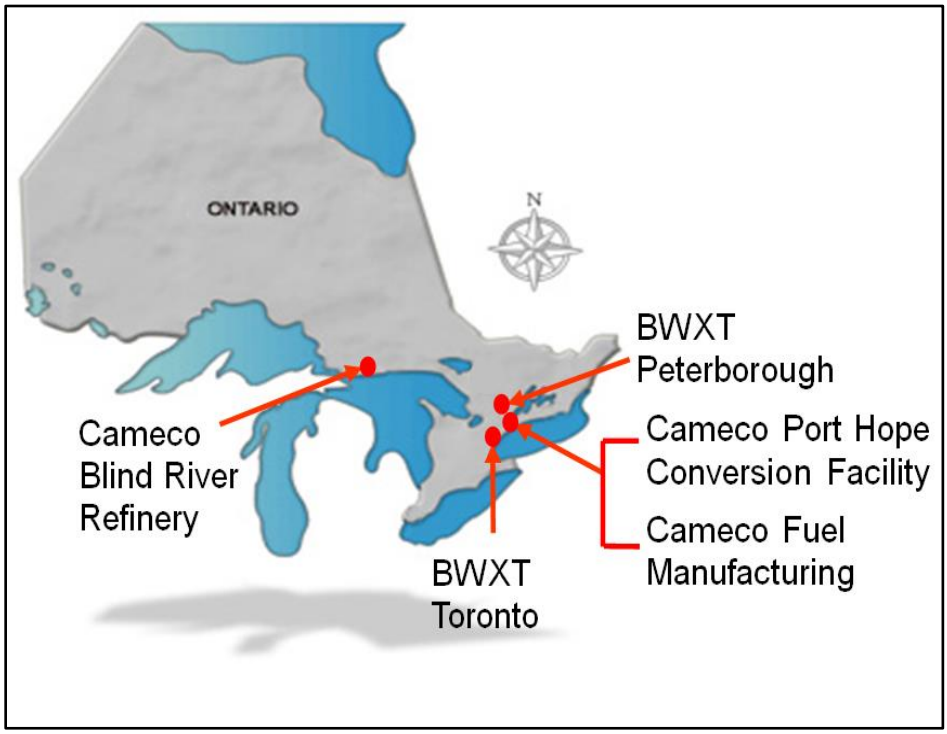
2 Overview

Uranium processing facilities are part of the nuclear fuel cycle that includes refining, conversion and fuel manufacturing. The fuel produced is used in nuclear power plants for the generation of electricity. This part of the report focuses on the five uranium processing facilities in Canada, all of which are located in the province of Ontario:

- Cameco Corporation Blind River Refinery (BRR) in Blind River
- Cameco Corporation Port Hope Conversion Facility (PHCF) in Port Hope
- Cameco Fuel Manufacturing Inc. (CFM) in Port Hope
- BWXT Nuclear Energy Canada Inc. facility in Toronto (BWXT Toronto)
- BWXT Nuclear Energy Canada Inc. facility in Peterborough (BWXT Peterborough)

All five facilities are shown in figure 2-1. Cameco's PHCF operating licence was renewed in March 2017 and expires in February 2027. The licences for the BRR and CFM facilities were issued in March 2012 and will expire in February 2022. The two BWXT facilities operate under a combined licence that was issued in December 2016 and expires in December 2020.

Figure 2-1: Location of uranium processing facilities in Ontario, Canada



CNSC staff conducted risk-informed regulatory oversight activities at Canada's uranium processing facilities in 2018. Table 2-1 presents the licensing and compliance verification efforts from CNSC staff for these facilities throughout 2018.

Table 2-1: CNSC regulatory oversight licensing and compliance verification activities, uranium processing facilities, 2018

Facility	Number of onsite inspections	Person-days for compliance verification activities	Person-days for licensing activities	Number of safeguards inspections led by IAEA*
BRR	5	280	3	3
PHCF	6	393	3	4
CFM	2	166	1	2
BWXT Toronto and Peterborough	4	225	108	4

*International Atomic Energy Agency

In 2018, CNSC staff performed 17 onsite inspections at Canada's uranium processing facilities. All the findings resulting from these inspections were shared with the licensees as part of detailed inspection reports. All resulting regulatory enforcement actions were recorded in the CNSC Regulatory Information Bank to ensure they would be tracked to completion. Appendix K lists the CNSC inspections conducted for each facility in 2018. All instances of non-compliances identified were of low safety significance. Safety significance is determined based on comparison to criteria developed and used in the CNSC Regulatory Information Bank, as provided in appendix L.

In accordance with their respective licences and LCHs, all uranium processing facility licensees must submit annual compliance reports on the operations of their facilities by March 31 every year. These reports to the CNSC must contain facility performance information, such as annual production volumes; improvements to programs in all SCAs; and details related to environmental, radiological and safety performance, including any events and associated corrective actions. CNSC staff review these reports as part of routine regulatory compliance oversight (for example, desktop reviews) to verify that licensees are complying with regulatory requirements and are operating safely. The full versions of these reports are available on the licensees' websites, as listed in appendix I of this report.

Table 2-2 presents the SCA performance ratings for the uranium processing facilities. For 2018, CNSC staff rated all but one SCA as "satisfactory." The exception was BRR's performance in the conventional health and safety SCA, which was rated as "fully satisfactory."

Additional information about these SCA ratings can be found in the facility-specific sections. Appendix C contains the SCA ratings from 2014 to 2018 for each facility.

Table 2-2: SCA performance ratings, uranium processing facilities, 2018

SCA	BRR	PHCF	CFM	BWXT Toronto and Peterborough
Management system	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA
Physical design	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA
Conventional health and safety	FS	SA	SA	SA
Environmental protection	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA
Waste management	SA	SA	SA	SA
Security	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA

FS = fully satisfactory; BE = below expectations; SA = satisfactory

The CNSC requires licensees to develop and maintain preliminary decommissioning plan for each of their respective facilities. CNSC staff review and approve each plan, which is accompanied by a financial guarantee that provides the necessary funding to complete the future decommissioning work. In accordance with the NSCA, the financial guarantees must be acceptable to the Commission. Appendix D lists the current financial guarantee amounts for each facility discussed in this report.

2.1 Radiation protection

The radiation protection SCA covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations* [2]. The program must ensure that contamination levels and radiation doses received by individuals are monitored, controlled and maintained ALARA.

This SCA encompasses the following specific areas:

- application of ALARA
- worker dose control
- radiation protection program performance
- radiological hazard control
- estimated dose to the public

Based on regulatory oversight activities, CNSC staff rated the performance of the uranium processing facilities for the radiation protection SCA as "satisfactory" in 2018, unchanged from the previous year.

Ratings for the radiation protection SCA, uranium processing facilities, 2018

BRR	PHCF	CFM	BWXT Toronto and Peterborough
SA	SA	SA	SA

SA = satisfactory

Application of ALARA

CNSC staff confirmed that in 2018 all uranium processing facility licensees continued to implement radiation protection measures to keep radiation exposures and doses to persons ALARA. The CNSC requirement for licensees to apply the ALARA principle has consistently resulted in these doses staying well below regulatory dose limits.

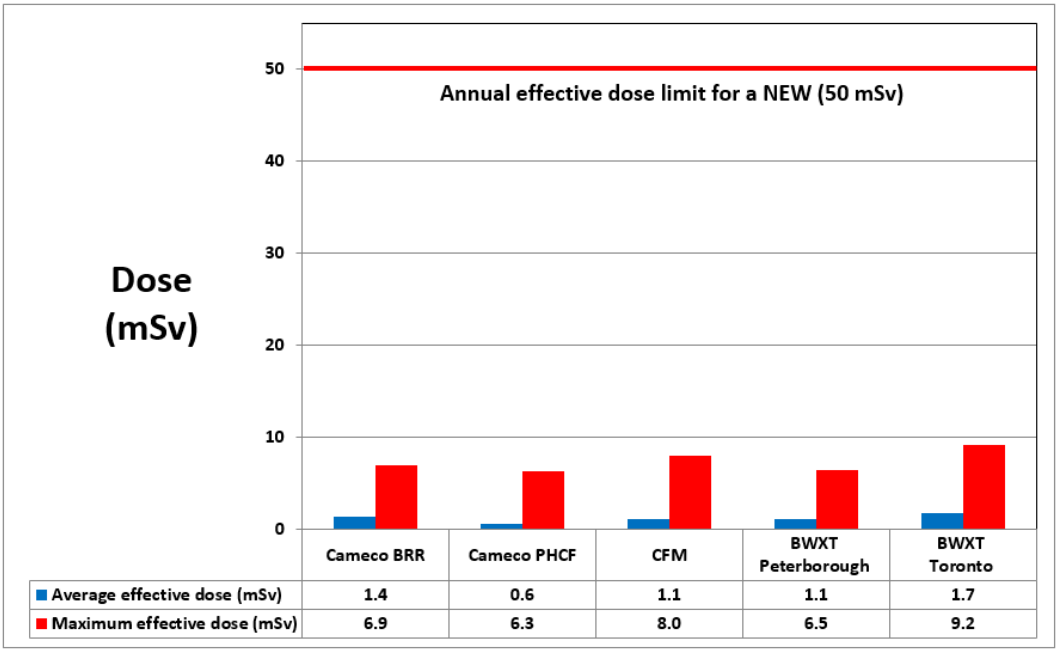
Worker dose control

The design of radiation protection programs includes the dosimetry methods and the determination of workers who are identified as nuclear energy workers (NEWs). These designs vary, depending on the radiological hazards present and the expected magnitude of doses received by workers. The dose statistics

provided in this report are primarily for NEWs, with the inherent differences in the design of radiation protection programs among licensees taken into consideration. Additional information on the total number of monitored persons, including workers, contractors and visitors, is provided in the facility-specific sections.

Figure 2-2 shows the maximum and average effective doses for NEWs at uranium processing facilities. In 2018, the maximum individual effective dose received by a NEW at all facilities ranged from 6.3 millisieverts (mSv) to 9.2 mSv, well below the regulatory dose limit set at 50 mSv in any one year and 100 mSv in five consecutive years for a NEW. These results are further discussed in the respective sections for each facility.

Figure 2-2: Average and maximum effective doses to NEWs, uranium processing facilities, 2018



	Cameco BRR	Cameco PHCF	CFM	BWXT Peterborough	BWXT Toronto
Average effective dose (mSv)	1.4	0.6	1.1	1.1	1.7
Maximum effective dose (mSv)	6.9	6.3	8.0	6.5	9.2

CNSC staff confirmed that in 2018 all uranium processing facility licensees monitored and controlled the radiation exposures and doses received by all persons present at their licensed facilities, including workers, contractors and visitors. Direct comparison of doses received by NEWs among facilities does not necessarily provide an appropriate measure of a licensee's effectiveness in implementing its radiation protection program, since radiological hazards differ across these facilities due to complex and varying work environments.

Radiation protection program performance

CNSC staff conducted regulatory oversight activities at all uranium processing facilities in 2018 to verify that the licensees' radiation protection programs complied with regulatory requirements. These oversight activities included onsite inspections, desktop reviews, and compliance verification activities specific to

radiation protection. Through these activities, CNSC staff confirmed that all these licensees have effectively implemented their radiation protection programs to control occupational exposures to workers and keep doses ALARA.

Action levels

Action levels for radiological exposures are established as part of the licensees' radiation protection programs. Each licensee is responsible for identifying the parameters of its own program(s) to represent timely indicators of potential losses of control of the program(s). These licensee-specific action levels may also change over time, depending on operational and radiological conditions.

If an action level is reached, it triggers the licensee to determine the cause, notify the CNSC and, if applicable, take corrective action to restore the effectiveness of the radiation protection program. It is important to note that occasional action level exceedances indicate that the action level chosen is likely an adequately sensitive indicator of a potential loss of control of the program.

It is possible that action levels which are never exceeded have not been established low enough to detect the emergence of a potential loss of control. For this reason, licensee performance is not evaluated solely on the number of action level exceedances in a given period, but rather on how the licensee responds and implements corrective actions to enhance program performance and prevent reoccurrence.

In 2018, there was one radiological action level exceedance across all uranium processing facility licensees. The exceedance was at PHCF and is further discussed in section 4.2. Cameco reported the exceedance to the CNSC in accordance with its reporting requirements, investigated the exceedance, and established corrective actions to the satisfaction of CNSC staff.

Radiological hazard control

CNSC staff verified that, in 2018, all uranium processing facility licensees continued to implement adequate measures to monitor and control radiological hazards in their facilities. These measures included delineation of zones for contamination control purposes and in-plant air-monitoring systems. Licensees demonstrated that they have implemented workplace monitoring programs to protect workers. The licensees have also demonstrated that levels of radioactive contamination were controlled within their facilities throughout the year.

Estimated dose to the public

The maximum dose to the public from licensed activities at each uranium processing facility is calculated with the use of monitoring results from air emissions, liquid effluent releases and fenceline gamma monitoring. The CNSC's requirement for following the ALARA principle means that licensees must monitor their facilities and keep doses to the public below the annual public dose limit of 1 mSv/year.

Table 2-3 compares estimated public doses from 2014 to 2018 for the uranium processing facility licensees. Estimated doses to the public from all these

licensees continued to be well below the regulatory annual public dose limit of 1 mSv/year.

Table 2-3: Public dose comparison table (mSv), uranium processing facilities, 2014–18

Facility	Year					Regulatory limit
	2014	2015	2016	2017	2018	
BRR	0.005	0.005	0.005	0.005	0.005	**1 mSv/year**
PHCF	0.012	0.006	0.020	0.153*	0.173	
CFM	0.018	0.025	0.023	0.022	0.030	
BWXT Toronto	0.0055**	0.010	0.0007	0.0175	0.0004	
BWXT Peterborough	<0.001	<0.001	<0.001	<0.001	<0.001	

*In 2016, PHCF updated the dose calculations related to releases to water and the fenceline gamma locations used for reporting the dose to the public. The amounts in 2017 and 2018 look higher than in previous years, but there has not been an actual increase in emissions/dose from the facility. The results actually represent a much more conservative estimate of dose to the public, as gamma monitoring at the facility fenceline has now been added to the calculations. For this reason, the results beginning in 2017 cannot be compared with previous years' results. See section 4.2 for more information.

**In 2014, GE Hitachi Nuclear Energy Canada Inc. (GEH-C) (now BWXT) Toronto started to use licensed dosimeters to monitor environmental gamma exposure and to include this result in its estimated annual public dose.

Conclusion on radiation protection

CNSC staff concluded that throughout 2018 the uranium processing facility licensees effectively implemented and maintained their radiation protection programs, to ensure the health and safety of persons working in their facilities.

2.2 Environmental protection

The environmental protection SCA covers programs that identify, control and monitor all releases of radioactive and hazardous substances, and the effects on the environment from facilities or as a result of licensed activities.

It encompasses the following specific areas:

- effluent and emissions control (releases)
- environmental management system (EMS)
- assessment and monitoring
- protection of the public

- environmental risk assessment

Based on regulatory oversight activities, CNSC staff rated the performance of all the uranium processing facilities for the environmental protection SCA as "satisfactory" in 2018, unchanged from the previous year.

Ratings for the environmental protection SCA, uranium processing facilities, 2018

BRR	PHCF	CFM	BWXT Toronto and Peterborough
SA	SA	SA	SA

SA= satisfactory

Effluent and emissions control (releases)

To control the release of radioactive and hazardous substances into the environment, CNSC licensees are required to develop and implement policies, programs and procedures that comply with all applicable federal and provincial environmental protection regulations. Licensees are also expected to have trained and qualified personnel to effectively develop, implement and maintain their environmental protection programs.

The CNSC imposes licence limits on controlled releases to the environment to demonstrate respect for the principle of pollution prevention and to ensure protection of the public and environment. Exceedance of a licence limit is a non-compliance and considered to represent a loss of control of part of the licensee's program(s) and/or control measure(s). Exceedance does not necessarily indicate harm to health or the environment. This is because limits are often established at levels well below those expected to cause harm. There were no licence limit exceedances in 2018 in the uranium processing sector. Appendix G provides information on the total annual release of relevant facility-specific radionuclides in emissions to the atmosphere and in effluent released to surface waters.

Action levels

Further controls on releases of radioactive and hazardous substances at licensed facilities involve the use of action levels. These specific doses of radiation and other parameters that make up the action levels are proposed by the licensee for each facility and approved by the CNSC. These levels are used to ensure that licensees demonstrate adequate control and oversight of each of their facilities based on the CNSC-approved facility design and environmental protection programs.

Action levels serve to provide assurance that licence limits, described in the previous subsection, will not be exceeded. If an action level is exceeded by a facility, this provides early indication of a potential reduction in effectiveness of the program(s) and/or control measure(s) and may indicate a deviation from normal operation. An exceedance also triggers a requirement for notification to

the CNSC and specific action to be taken as outlined in the licensee's environmental protection program.

It is important to note that occasional action level exceedances indicate that the action level chosen is likely an adequately sensitive indicator of a potential loss of control of the program. Indeed, occasional exceedance of an action level and the successful implementation of the required follow-up activities (notification, investigation, and implementation of any applicable corrective actions) demonstrate due diligence, and well-maintained and well-managed environmental protection program(s) and/or control measure(s). However, failure to inform the CNSC, complete an investigation or implement any applicable corrective actions would be a non-compliance.

Action level exceedances and their resulting investigation are discussed within the facility-specific sections of this report. These were all appropriately reported, evaluated and addressed to the satisfaction of CNSC staff.

Environmental management system

The CNSC requires each licensee to develop and maintain an environmental management system (EMS) that provides a framework for integrated activities related to environmental protection. EMSs are described in environmental management programs and include activities such as the establishment of annual environmental objectives, goals and targets. Licensees conduct internal audits of their programs at least once a year. CNSC staff, as part of their compliance verification activities, review and assess these objectives, goals and targets. CNSC staff determined that, in 2018, the uranium processing facility licensees established and implemented their EMSs in compliance with the CNSC regulatory requirements.

Assessment and monitoring

CNSC staff verify that each uranium processing facility licensee has environmental monitoring programs at each of its facilities to monitor releases of radioactive and hazardous substances, and to characterize the quality of the environment associated with the licensed facility. These programs include the monitoring of uranium in ambient air and uranium in soil, described below.

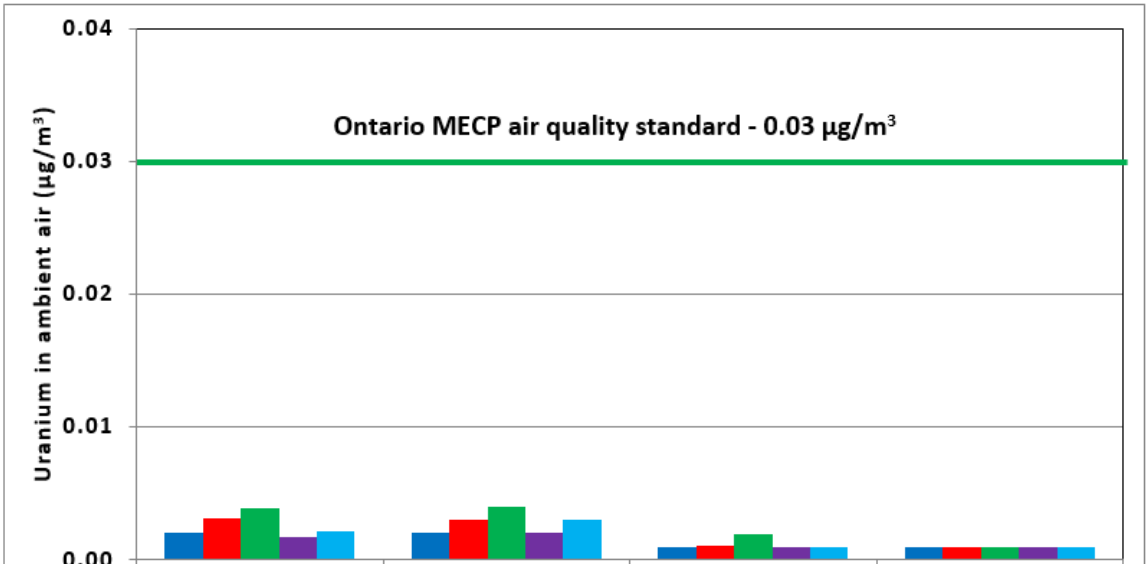
Uranium in ambient air

Licensees measure uranium in ambient air to confirm the effectiveness of emission abatement systems and to monitor the impact of uranium emissions on the environment. The three Cameco facilities and BWXT Toronto operate high-volume air samplers at the perimeter of their facilities. BWXT Peterborough monitors its stack, but does not use fenceline air samplers, as stack emissions at the point of release already meet the Ontario Ministry of the Environment, Conservation and Parks (MECP) annual air standard for uranium, which is equal to 0.03 micrograms per cubic metre ($\mu g/m^3$).

Figure 2-3 shows the results from the high-volume air samplers with the highest values near a facility (maximum annual average) for 2014 through 2018. These values are measured as the total suspended particulate representing the total

amount of uranium in air. The figure shows that the maximum annual average concentration of uranium in ambient air is well below the MECP annual air standard for uranium, which took effect in 2016.

Figure 2-3: Uranium concentration in ambient air (maximum annual average), uranium processing facilities, 2014–18



	Cameco BRR	Cameco PHCF	CFM	BWXT Toronto
2014	0.0020	0.0020	0.0010	0.0010
2015	0.0031	0.0030	0.0011	0.0010
2016	0.0039	0.0040	0.0019	0.0010
2017	0.0017	0.0020	0.0010	<0.0010
2018	0.0022	0.0030	0.0010	<0.0010

Uranium in soil

The three Cameco facilities and BWXT Toronto have soil monitoring programs to monitor the long-term effects of air emissions and to determine whether there is accumulation of uranium in soil around the facility. Sampling takes place every three years at the CFM facility and once a year at the other facilities.

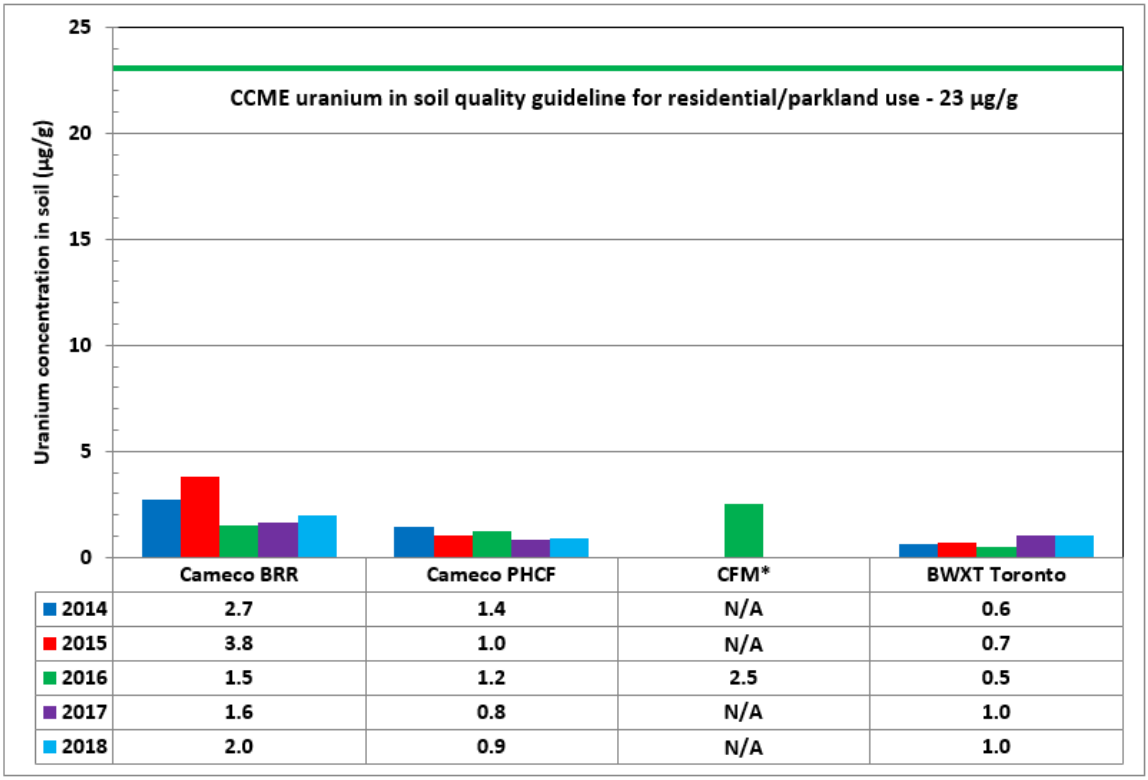
BWXT Peterborough does not conduct uranium-in-soil monitoring. This is because uranium releases from its facility are negligible: the fuel pellets received from the Toronto facility are in solid form and uranium releases to air are very low. As noted in the previous subsection, BWXT Peterborough monitors its stack to confirm that releases to air remain low.

CNSC staff evaluated the results of licensees' soil sampling programs for 2018 and compared them with those of previous years. The results continue to indicate that there is no accumulation of uranium in surrounding soil resulting from current uranium emissions from the uranium processing facilities.

Figure 2-4 provides the annual average uranium concentrations in soil results for 2014 through 2018. In Ontario, natural background concentrations of uranium in soil for rural and urban parkland are generally between 1.9 and 2.1 micrograms per gram (µg/g). The annual average concentrations of uranium in soil at uranium

processing facilities are similar to natural background levels and well below the applicable guideline value for the land-use type of 23 µg/g, as described by the Canadian Council of Ministers of the Environment (CCME) *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health* [9].

Figure 2-4: Uranium concentration in soil (annual average), uranium processing facilities, 2014–18



	Cameco BRR	Cameco PHCF	CFM*	BWXT Toronto
2014	2.7	1.4	N/A	0.6
2015	3.8	1.0	N/A	0.7
2016	1.5	1.2	2.5	0.5
2017	1.6	0.8	N/A	1.0
2018	2.0	0.9	N/A	1.0

*N/A indicates that a value is not available. CFM collects soil measurements once every three years.

Protection of the public

The CNSC requires licensees to demonstrate that the health and safety of the public are protected from exposures to radiological and hazardous (non-radiological) substances released from their facilities. Licensees use effluent and environmental monitoring programs to verify that releases of both types of substances do not result in environmental concentrations that may affect public health. CNSC staff receive reports of discharges to the environment in accordance with the reporting requirements outlined in the licence and the LCH. Based on assessments of the programs at the uranium processing facilities, CNSC staff concluded that the public continues to be protected from facility emissions of radiological and hazardous substances.

Environmental risk assessment

Licensees develop environmental risk assessments (ERAs) to analyze the risks associated with contaminants in the environment as a result of licensed activities. ERAs provide the basis for the scope and complexity of environmental monitoring programs at the uranium processing facilities.

CNSC staff use CSA standard N288.6-12, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills*, to help determine whether licensees are in compliance with regulatory requirements for the protection of the environment and human health. CSA N288.6-12 specifically states: "Facility ERAs should be reviewed on a five-year cycle or more frequently if major facility changes are proposed that would trigger a predictive assessment." CNSC staff expect licensees to periodically review ERAs for their facilities, as appropriate.

Conclusion on environmental protection

CNSC staff concluded that the uranium processing facility licensees implemented their environmental protection programs satisfactorily during 2018. The licensees' programs are effective in protecting the health and safety of the public and the environment.

2.3 Conventional health and safety

The conventional health and safety SCA covers the implementation of a program to manage workplace safety hazards and to protect workers.

It encompasses the following specific areas:

- performance
- practices
- awareness

Based on regulatory oversight activities, CNSC staff rated the performance for the conventional health and safety SCA as "satisfactory" in 2018 for all but one of the uranium processing facilities. The exception was the BRR facility, which was given a "fully satisfactory" rating. These ratings are unchanged from the previous year.

Ratings for the conventional health and safety SCA, uranium processing facilities, 2018

BRR	PHCF	CFM	BWXT Toronto and Peterborough
FS	SA	SA	SA

FS= fully satisfactory; SA= satisfactory

Performance

Employment and Social Development Canada (ESDC) and the CNSC regulate conventional health and safety programs at uranium processing facilities. Licensees submit hazardous-occurrence investigation reports to both ESDC and the CNSC, in accordance with their respective reporting requirements. CNSC staff monitor compliance with regulatory reporting requirements and, when a concern is identified, consult with ESDC staff.

Licensees are required to report to the CNSC as directed by section 29 of the *General Nuclear Safety and Control Regulations* [4]. These reports include serious illnesses or injuries incurred or possibly incurred as a result of a licensed activity.

A key performance measure for the conventional health and safety SCA is the number of LTIs that occur per year. An LTI is an injury that takes place at work and results in the worker being unable to return to work to carry out their duties for a period of time. The number of recordable LTIs reported by all facilities has remained low over the past five years, as summarized in table 2-4. Further information is provided in facility-specific sections, as well as in appendix H, which lists all LTIs reported in 2018 and the actions taken.

Table 2-4: LTIs at uranium processing facilities, 2014–18

Facility	2014	2015	2016	2017	2018
BRR	0	0	0	0	0
PHCF	1	1	4	1	2
CFM	0	1	0	0	0
BWXT Toronto and Peterborough	1	0	0	0	0

Practices

Licensees are responsible for developing and implementing conventional health and safety programs for the protection of their workers. These programs must comply with Part II of the *Canada Labour Code* [5].

CNSC staff conducted desktop reviews and onsite inspections at all uranium processing facilities during 2018 to verify compliance of the licensees' conventional health and safety programs with regulatory requirements. CNSC staff determined, based on these regulatory oversight activities, that these licensees met all regulatory requirements for this specific area.

Awareness

Licensees are responsible for ensuring that workers have the knowledge to identify workplace hazards and take the necessary precautions to protect against these hazards. This is accomplished through training and ongoing internal communications with workers.

During onsite inspections, CNSC staff verify that workers are trained to identify hazards at the facilities. CNSC staff confirmed that the uranium processing facilities have effectively implemented their conventional health and safety programs to keep workers safe.

Conclusion on conventional health and safety

CNSC staff concluded that the uranium processing facility licensees implemented their conventional health and safety programs satisfactorily during 2018. Their programs are effective in protecting the health and safety of persons working in the facilities.

2.4 Regulatory developments

In 2018, no amendments were made to the PHCF, BRR, CFM or BWXT licences, and CNSC staff continued to modernize the regulatory framework with the REGDOC series of regulatory and guidance documents.

Table 2-5 lists the updates made since 2016 to the CNSC regulatory documents that apply to the uranium processing facilities licensees and includes the implementation status.

Table 2-5: Regulatory documents applicable to uranium processing facilities

Regulatory document	Version	PHCF	BRR	CFM	BWXT
REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*	February 2016	Implemented	Documentation received and under review by CNSC staff	Implemented	Implemented
REGDOC-2.2.2, *Personnel Training*	December 2016	Implemented	Implemented	Implemented	Implemented
REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures*	April 2017	Implementation plans expected in 2019	Implementation plans expected in 2019	Implementation plans expected in 2019	Implementation plans expected in 2019
REGDOC-3.1.2, *Reporting Requirements, Volume I: Non-Power Reactor Class I Nuclear Facilities and Uranium Mines and Mills*	January 2018	Implemented	Implemented	Implemented	Implemented
REGDOC-2.13.1, *Safeguards and Nuclear Material Accountancy*	February 2018	Implemented	Implemented	Implemented	Implementation expected by January 2019

Regulatory document	Version	PHCF	BRR	CFM	BWXT
REGDOC-2.1.2, *Safety Culture*	April 2018	Implementation expected by June 2022	Implementation expected by June 2022	Implementation expected by June 2022	Implemented
REGDOC-3.2.1, *Public Information and Disclosure*	May 2018	Implementation plans expected in 2019	Implementation plans expected in 2019	Implementation plans expected in 2019	Implementation plans expected in 2019

CNSC staff are updating the LCHs for each uranium processing facility to reflect these regulatory documents, taking into consideration licensees' implementation plans. CNSC staff verify the implementation as part of ongoing compliance verification activities.

2.5 Public information and outreach

All uranium processing facility licensees are required to maintain and implement public information and disclosure programs, in accordance with regulatory document REGDOC-3.2.1, *Public Information and Disclosure* [6] (which replaced regulatory/guidance document RD/GD-99.3 in 2018). These programs are supported by disclosure protocols that outline the type of facility information to be shared with the public as well as details on how that information is to be shared. This ensures that timely information about the health, safety and security of persons and the environment, and other issues associated with the lifecycle of nuclear facilities, is effectively communicated to the public.

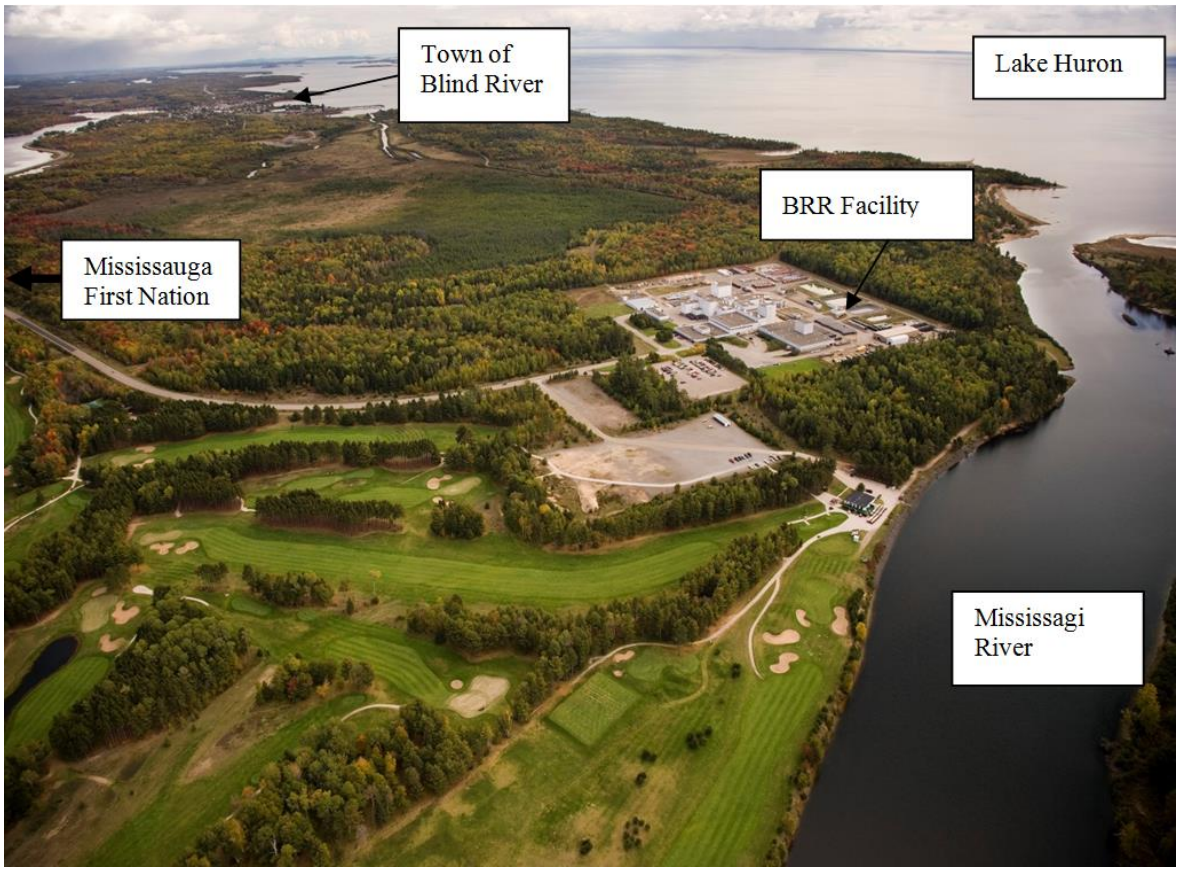
In 2018, CNSC staff evaluated licensees' implementation of their public information and disclosure programs by reviewing the communications activities they conducted. CNSC staff determined that all uranium processing facility licensees were in compliance with requirements and that they issued information in accordance with their public disclosure protocols.

The facility-specific performance sections outline more detailed engagement activities and information shared with the public.

3 Cameco Blind River Refinery

Cameco Corporation owns and operates the Blind River Refinery (BRR) in Blind River, Ontario, under an operating licence that expires in February 2022. The facility is located about 5 km west of the town of Blind River, as shown in figure 3-1.

Figure 3-1: Aerial view of BRR



The BRR facility refines uranium concentrates (yellowcake) received from uranium mines worldwide to produce uranium trioxide (UO_3), an intermediate product of the nuclear fuel cycle. The primary recipient of the UO_3 product is Cameco's PHCF. Figure 3-2 shows shipping totes that are used to transfer UO_3 from the BRR facility to PHCF.

Figure 3-2: Shipping totes used to transfer UO_3 from BRR to PHCF

3.1 Overall performance

For 2018, CNSC staff rated the BRR facility's performance as "satisfactory" in all but one of the safety and control areas (SCAs). The exception was a "fully satisfactory" rating for conventional health and safety. Table C-1 of appendix C provides the performance ratings for the facility from 2014 to 2018. CNSC staff are satisfied that Cameco continued to operate the facility safely and maintained the facility according to its licensing basis throughout 2018.

The facility reported two events to CNSC staff in 2018, in accordance with Cameco's regulatory reporting requirements.

The first event involved a truck that was transporting uranium concentrate from Saskatchewan to the BRR facility. There was no loss of containment nor damage to any of the uranium concentrate drums. Cameco completed an investigation and established corrective actions. CNSC staff reviewed this information to ensure that Cameco's corrective actions were effective to prevent reoccurrence.

The second event was related to a damaged calibrator with a cesium-137 source. Repairs were completed and the cesium-137 source was removed from the facility as it was no longer required. There was no impact on worker health and safety.

In 2018, CNSC staff conducted five onsite inspections at BRR to ensure compliance with the NSCA [1] and its associated regulations, Cameco's operating licence and the programs used to meet regulatory requirements. Table K-1 in

appendix K lists these inspections. The inspections focused on the following SCAs: radiation protection, emergency management, waste management, management systems, and environmental protection. Thirty enforcement actions were raised as a result of the inspections. The findings from these inspections posed a low safety significance to the achievement of regulatory objectives and CNSC expectations.

Cameco continued to communicate with all target audiences about the BRR facility in 2018 and regularly updated its website with safety and environmental information about its licensed activities. The licensee meets yearly with community leaders and other stakeholders as requested. In 2018, Cameco conducted a public opinion survey for the BRR facility, which demonstrated that 78% of the respondents were satisfied with the amount of operational information that Cameco makes available, and that 95% of respondents believed that Cameco protects people and the environment. CNSC staff are satisfied that the facility is in full compliance with regulatory requirements for public information and disclosure.

3.2 Radiation protection

Compliance ratings for the radiation protection SCA, Cameco Blind River Refinery, 2014–18

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

For 2018, CNSC staff continued to rate the radiation protection SCA at BRR as "satisfactory." Cameco has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations* [2]. At this facility, workers handle natural uranium compounds in the production of uranium trioxide (UO_3). This activity presents external radiological hazards to the whole body and internal radiological hazards from inhalation, ingestion, or absorption through the skin. Radiological hazards were effectively controlled at the facility. As a result, radiation doses to workers and members of the public were kept well below the CNSC regulatory dose limits.

Application of ALARA

Cameco established radiation protection objectives and ALARA targets at BRR for 2018. Cameco's site management team reviewed the status of the objectives and targets, and allocated resources, as required, to achieve them. Updates on the status of the radiation protection program were discussed at the joint workplace health and safety committee monthly meetings. In addition, a separate ALARA committee met regularly to review and discuss radiation safety-related incidents and issues and to recommend improvements.

Worker dose control

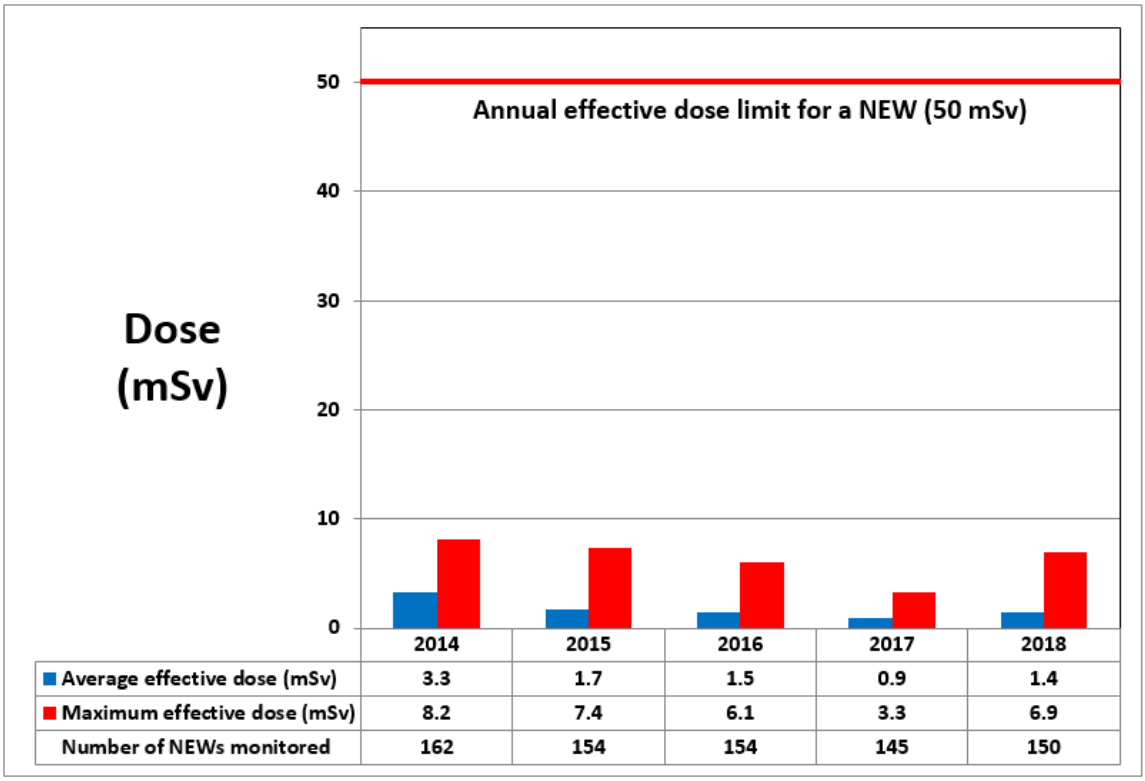
Radiation exposures at BRR are monitored to ensure compliance with CNSC regulatory dose limits and to keep radiation doses ALARA. In 2018, CNSC staff confirmed that radiation exposures at BRR were well below CNSC regulatory dose limits.

Cameco ascertains external doses using whole-body and extremity dosimetry. For internal radiological exposures, Cameco's Fuel Services Division holds a CNSC dosimetry service licence that authorizes Cameco to provide in-house internal dosimetry services at BRR. Internal dose is assessed and assigned through urine analysis and lung counting.

All Cameco employees at BRR are identified as nuclear energy workers (NEWs). Contractors may be identified as NEWs depending on the nature of their work activities. In 2018, total effective dose was assessed for 150 NEWs at the facility, consisting of 133 Cameco employees and 17 contractors. The maximum effective dose received by a NEW in 2018 was 6.9 mSv, which is approximately 14% of the CNSC regulatory effective dose limit of 50 mSv in a one-year dosimetry period.

Figure 3-3 provides the average and maximum effective doses to NEWs at BRR between 2014 and 2018. Average and maximum total effective doses over this five-year period are reflective of the work activities at the facility, and increased in 2018 due to higher production levels.

Figure 3-3: Average and maximum effective doses to NEWs, BRR, 2014–18



	2014	2015	2016	2017	2018
Average effective dose (mSv)	3.3	1.7	1.5	0.9	1.4
Maximum effective dose (mSv)	8.2	7.4	6.1	3.3	6.9
Number of NEWs monitored	162	154	154	145	150

Appendix E provide average and maximum equivalent dose results for the skin and extremities of NEWs, from 2014 to 2018. In 2018, the maximum individual skin

dose received by a NEW at BRR was 28.4 mSv (table E-7), which is approximately 6% of the CNSC regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. The maximum individual extremity dose received by a NEW at BRR was 14.5 mSv (table E-1), which is approximately 3% of the CNSC regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. The average and maximum equivalent doses have been relatively stable over this five-year period.

Site visitors and contractors who are not considered as NEWs are issued dosimeters to monitor their radiological exposures while at BRR. In 2018, the maximum individual effective dose received by a site visitor/contractor was 0.4 mSv, which is well below the CNSC regulatory dose limit of 1 mSv per calendar year for a person who is not a NEW.

Radiation protection program performance

In 2018, CNSC staff carried out various compliance verification activities to assess the performance of Cameco's radiation protection program at BRR; these activities included a focused inspection on radiation protection. Overall, CNSC staff found Cameco's compliance with the *Radiation Protection Regulations* [2] and CNSC licence requirements at the facility to be acceptable. CNSC staff are satisfied with Cameco's progress on implementing corrective actions to address all enforcement actions. Actions included updates to and documenting of practices and procedures.

Action levels for radiological exposures are established as part of the radiation protection program implemented at BRR. If an action level is reached, Cameco must establish the cause, notify the CNSC and, if applicable, restore the effectiveness of the program. In 2018, no action levels were exceeded at BRR.

Radiological hazard control

CNSC staff confirmed that Cameco has radiation and contamination control programs implemented at BRR to control and minimize radiological hazards and the spread of radioactive contamination. Methods of control include the use of radiological zone controls and monitoring to confirm the effectiveness of the program. Cameco conducted in-plant air monitoring, contamination monitoring and radiation dose rate surveys in 2018, and the results were consistent with expected radiological conditions.

Estimated dose to the public

The maximum dose to the public from licensed activities at the BRR facility is calculated with the use of monitoring results of air emissions, water discharges and gamma radiation. Table 3-1 shows the 2014 to 2018 maximum effective doses to a member of the public. The estimated dose to the public remained well below the CNSC regulatory dose limit of 1 mSv per calendar year.

Table 3-1: Maximum effective dose to a member of the public, BRR, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory dose limit
Maximum effective dose (mSv)	0.005	0.005	0.005	0.005	0.005	**1 mSv/year**

3.3 Environmental protection

Compliance ratings for the environmental protection SCA, Cameco Blind River Refinery, 2014–18

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA
For 2018, CNSC staff continued to rate the environmental protection SCA at BRR as "satisfactory." Uranium releases to the environment continued to be effectively controlled and monitored in compliance with the conditions of the operating licence and regulatory requirements. The releases of hazardous substances from the facility to the environment were controlled in accordance with the applicable regulations and certificates of approval of Ontario's Ministry of the Environment, Conservation and Parks (MECP). The measured releases to the environment were well below regulatory limits in 2018. Groundwater monitoring, surface water monitoring, soil sampling and ambient air data indicate that the public and the environment continued to be protected from facility releases.				

Effluent and emissions control (releases)

Atmospheric emissions

Cameco monitors uranium, nitrogen oxides (NO_x), nitric acid (HNO_3) and particulates released from the facility stacks. The monitoring data in table 3-2 demonstrates that atmospheric emissions from the facility continued to be effectively controlled as annual averages were consistently well below their respective licence limits between 2014 and 2018.

Table 3-2: Air emissions monitoring results (annual averages), BRR, 2014–18

Parameter	2014	2015	2016	2017	2018	Licence limit
Dust collection and exhaust ventilation stack: uranium (kg/h)	0.00005	0.00005	0.00005	0.00004	0.00005	**0.1**
Absorber stack: uranium (kg/h)	<0.00001	0.00001	0.00001	0.00001	0.00001	**0.1**
Incinerator stack: uranium (kg/h)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	**0.01**
NO_X + HNO_3 (kg NO_2/h)	2.0	2.5	1.6	1.7	2.3	**56.0**
Particulate (kg/h)	0.009	0.006	0.006	0.008	0.010	**11.0**

HNO_3 = nitric acid; kg/h = kilogram per hour; NO_2 = nitrogen dioxide; NO_x = nitrogen oxides

Note: Results less than detection limit are denoted as "<".

In addition to licence limits, BRR has action levels that are used to provide assurance that licence release limits will not be exceeded. No action levels for atmospheric emissions were exceeded at any time in 2018.

Liquid effluent

There are three sources of allowable liquid effluent from the BRR facility: plant effluent, storm water runoff and sewage treatment plant effluent. These effluents are collected in lagoons and treated, as required, prior to discharge into Lake Huron. Cameco monitors uranium, radium-226, nitrates and pH in liquid effluents to demonstrate compliance with their respective licence limits. In addition to licence limits, BRR has action levels that are used to provide assurance that the licence release limits will not be exceeded. No action levels for liquid effluents were exceeded at any time in 2018.

Table 3-3 summarizes the average monitoring results from 2014 to 2018. For 2018, the liquid discharges from the facility continued to be within their respective licensed limits.

Table 3-3: Liquid effluent monitoring results (annual averages), BRR, 2014–18

Parameter	2014	2015	2016	2017	2018	Licence limit
Uranium (mg/L)	0.02	0.02	0.01	0.01	0.01	**2**
Nitrates (mg/L)	17	13	11	14	20	**1,000**
Radium-226 (Bq/L)	0.01	<0.01	0.01	0.01	0.01	**1**
pH (min)	7.1	7.2	7.3	7.3	7.3	**Min 6.0**
pH (max)	8.4	8.4	8.6	8.2	8.5	**Max 9.5**

Bq/L = becquerel per litre; mg/L = milligram per litre
Note: Results less than detection limit are denoted as "<".

Environmental management system

CNSC staff confirmed that Cameco has developed and is maintaining an environmental management system (EMS) that provides a framework for integrated activities for the protection of the environment at the BRR site. Cameco's BRR EMS is described in the facility's Environmental Management Program Manual. It includes activities such as the establishment of annual environmental objectives and targets that CNSC staff review and assess through compliance verification activities. Cameco completed three out of four of its environmental objectives set for 2018. These completed objectives were related to updates to the site derived release limit (DRL) report, implementation of the CSA Group's waste management standards, and review of uranium in liquid effluent loadings. The fourth objective was related to the purchase and installation of a new in-process NO_x analyzer for the nitric acid absorbers. The installation is expected to be completed by the third quarter of 2019.

CNSC staff review documents relating to environmental protection, as part of their compliance verification activities, and follow up with Cameco staff at BRR on any outstanding issues. The results of these compliance verification activities demonstrate that, in 2018, Cameco conducted an annual management review in accordance with CNSC requirements and that identified issues were being addressed properly.

Assessment and monitoring

Cameco's environmental monitoring program serves to demonstrate that the BRR site emissions of radioactive and hazardous substances are properly controlled. The program also provides data for estimates of annual radiological doses to the public. This is meant to ensure that the public exposure attributable to Cameco's BRR operations is well below the annual regulatory dose limit of 1 mSv and is ALARA. The principal monitoring activities, described below, focus on the air, groundwater, surface water, soil, and gamma radiation around the BRR site.

In addition, the CNSC conducts periodic monitoring under its Independent Environmental Monitoring Program (IEMP) to verify that the public and the environment around nuclear facilities remain protected.

Uranium in ambient air

The concentrations of uranium in the ambient air, as monitored by Cameco's sampling network around BRR, continued to be consistently low. In 2018, the highest annual average concentration (among the sampling stations) of uranium in ambient air measured was 0.0022 $\mu g/m^3$, which is well below the MECP standard for uranium in ambient air of 0.03 $\mu g/m^3$.

Groundwater monitoring

Cameco has an extensive groundwater monitoring program in place around the facility with 35 monitoring wells: 14 wells located inside the perimeter fence and 21 outside the fenceline.

The average uranium result from all groundwater samples analyzed increased in 2018 compared to 2017. This increase is attributable to results obtained from monitoring well #22 (27 μg/L), located just south of the main UO_3 plant building outside the calcination area. A seasonal trend appears to be developing, with the highest uranium results at this location in recent years from samples collected in the spring and the lowest concentrations from samples collected in late summer or early fall. Slightly elevated results have previously been reported in the groundwater at this location and have been attributed to historical activities. Groundwater results, with the exception of three samples from monitoring well #22 collected over a two-week period in late May/early June, remained below Health Canada's *Guidelines for Canadian Drinking Water Quality* (20 μg/L) [7] and the CCME *Water Quality Guidelines for the Protection of Aquatic Life* (33 μg/L) [8]. Groundwater in the area is not used for drinking water. Table F-1 of appendix F provides groundwater monitoring results.

Surface water monitoring

Cameco continued to monitor surface water for uranium, nitrate, radium-226 and pH at the location of the BRR outfall diffuser in Lake Huron. The concentrations of uranium, nitrate, radium-226 and the pH levels in the lake remained well below the CCME guidelines. Table F-2 of appendix F provides surface water monitoring results.

Soil monitoring

Cameco collects soil samples at the 0 to 5 cm depth each year and at the 5 to 15 cm depth every five years, in order to monitor uranium concentrations in surface soil for long-term effects of air emissions on soil quality due to deposition of airborne uranium on soil in the vicinity of the BRR facility. The 2018 soil monitoring results remained consistent with the respective concentrations detected in previous years (as shown in table F-3, appendix F); that is, that uranium soil concentrations did not appear to increase in the area surrounding the facility. The maximum uranium soil concentrations measured near the facility were slightly above Ontario's natural background levels (between 1.9 and 2.5 μg/g) and well below

23 µg/g, which is the most restrictive soil quality guideline set by the CCME for uranium (for residential and parkland land use) [9]. This data demonstrates that the current BRR operations do not contribute to accumulation of uranium in surrounding soil, and that no adverse consequences to relevant human and environmental receptors are expected.

Gamma monitoring

A portion of radiological public dose from BRR operations is due to gamma radiation sources. Consequently, monitoring of gamma radiation effective dose rates at the fenceline of the BRR main site and the nearby golf course (the critical receptor location) is essential to ensuring that levels of potential gamma radiation exposure are maintained ALARA. The land immediately outside the perimeter fence continues to be owned and controlled by Cameco. Therefore, Cameco sets an action level for gamma dose rates of 1.0 µSv/h at the north fence only, because the critical receptor location for the gamma component of dose to the public is the neighbouring golf course north of the BRR site. Cameco uses environmental dosimeters to measure the effective dose rates for gamma radiation. In 2018, the monthly average of fenceline gamma measurements at the BRR site were 0.39 µSv/h (east), 0.24 µSv/h (north), 0.41 µSv/h (south) and 0.88 µSv/h (west). All north fence results in 2018 were below the action level. These measurements indicate that gamma dose rates are controlled and that the public is protected.

CNSC Independent Environmental Monitoring Program

CNSC staff conducted Independent Environmental Monitoring Program campaigns in the Blind River area in 2013, 2014, 2017 and 2018. The results are available on the CNSC's IEMP web page. The IEMP results indicate that the public and the environment surrounding the BRR site remain protected from facility emissions.

Since 2014, CNSC staff and the Mississauga First Nation (MFN) have been holding regular meetings to discuss Cameco's licensing and CNSC staff's compliance verification activities for BRR. Using the Participant Funding Program, CNSC staff met with the MFN to discuss the MFN's air quality sampling program and air monitoring results and developed an IEMP sampling plan for MFN lands.

A sampling plan that is representative of both parties' needs was developed and executed in October 2017. In October 2018, a subsequent IEMP campaign was completed and, similar to previous years, involved direct communication and collaboration with the MFN.

Protection of the public

The licensee is required to demonstrate that adequate provision is made for protecting the health and safety of the public from exposures to radiological and hazardous (non-radiological) substances released from the facility, as well as to physical stressors. The effluent and environmental monitoring programs that the licensee has currently implemented are used to verify that releases of both types of substances do not result in environmental concentrations that may affect public health.

The CNSC receives reports of discharges to the environment in accordance with the reporting requirements outlined in the BRR licence and licence conditions handbook (LCH). CNSC staff's review and evaluation of radiological and hazardous discharges from BRR to the environment in 2018 indicate that no significant risks to the public or the environment occurred during this period.

CNSC staff concluded, based on their review of these programs at BRR, that the public continues to be protected from facility emissions.

Environmental risk assessment

CNSC staff use CSA standard 288.6-12, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills* [3], to help determine whether licensees are in compliance with regulatory requirements for protection of the environment and human health.

CNSC staff confirmed that Cameco has been in compliance with this CSA standard since November 2016, and that the ERA conclusions on potential risk to human health and the environment from the BRR facility remain valid; that is, that the risk is very low. Cameco currently has acceptable environmental programs in place to ensure protection of the public and the environment.

CNSC staff expect Cameco to address several technical comments and recommendations, as appropriate, in the next iteration of the BRR ERA, which is due in 2021.

3.4 Conventional health and safety

Compliance ratings for the conventional health and safety SCA, Cameco Blind River Refinery, 2014–18

2014	2015	2016	2017	2018
FS	FS	FS	FS	FS
For 2018, CNSC staff continued to rate the conventional health and safety SCA at BRR as "fully satisfactory." Overall, the compliance verification activities that CNSC staff conducted at the facility confirmed that Cameco continued to view conventional health and safety as an important consideration. Safety and control measures implemented by the licensee were highly effective and compliance in this SCA exceeded requirements. Cameco demonstrated a fully satisfactory ability to keep its workers safe from occupational injuries: no LTIs had occurred at the facility in the past 12 years.				

Performance

Cameco's performance related to conventional health and safety at the BRR facility is monitored through CNSC staff's onsite inspections and event reviews. In 2018, Cameco continued to develop and maintain a comprehensive conventional health and safety management program for this facility. The program incorporates various elements, such as accident reporting and investigation, hazard prevention,

preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response.

The number of lost-time injuries (LTIs) remained at zero in 2018, as shown in table 3-4. Cameco has not had an LTI at the BRR facility in the past 12 years.

Table 3-4: Lost-time injury statistics, BRR, 2014–18

	2014	2015	2016	2017	2018
LTIs[1]	0	0	0	0	0
Severity rate[2]	0	0	0	0	0
Frequency rate[3]	0	0	0	0	0

1 An LTI is an injury that takes place at work and results in the worker being unable to return to work for a period of time.
2 The accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
3 The accident frequency rate measures the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

Practices

Cameco's activities and operations at BRR must comply with both the NSCA [1] and its associated regulations and with Part II of the *Canada Labour Code* [5]. Cameco's commitment to safety is captured in a safety charter signed by each employee and displayed at the entrance of the facility. Cameco uses audits, inspections, evaluations, reviews, benchmarking, training and employee engagement to evaluate the effectiveness of conventional health and safety practices at the facility.

CNSC staff confirmed that in 2018 Cameco's Facility Health and Safety Committee continued to inspect the workplace and meet monthly to resolve and track any safety issues. All reported conventional health and safety incidents were tracked and managed through the Cameco Incident Reporting System database. CNSC staff reviewed the committee meeting minutes and any associated corrective actions to verify that issues were promptly resolved.

Awareness

CNSC staff confirmed that in 2018 Cameco continued to hold monthly safety meetings for all employees at the BRR facility on various safety topics, including radiation protection, environmental protection and fire protection. Attendance was tracked at the safety meetings as an indicator for safety performance. Cameco workers at the facility also attended "daily toolbox meetings" where they were notified of any concerns or ongoing maintenance in their area. In 2018, Cameco also undertook a safety initiative in which it held a "safety stand-down" for the workers upon return to work after the summer and Christmas shutdown periods.

4 Cameco Port Hope Conversion Facility

Cameco Corporation owns and operates the Port Hope Conversion Facility (PHCF), which is located in Port Hope, Ontario, situated on the north shore of Lake Ontario, approximately 100 km east of Toronto. Figures 4-1 and 4-2 show aerial photographs of the two sites.

Figure 4-1: Aerial view of PHCF Site 1

Figure 4-2: Aerial view of PHCF Site 2

PHCF converts uranium trioxide (UO_3) powder produced by Cameco's Blind River Refinery (BRR) into uranium dioxide (UO_2) and uranium hexafluoride (UF_6). UO_2 is used in the manufacture of Canada Deuterium Uranium (CANDU) reactor fuel, while UF_6 is exported for further processing before being converted into fuel for light-water reactors.

In 2017, Cameco's operating licence was renewed for a 10-year period. It will expire in February 2027.

4.1 Overall performance

For 2018, CNSC rated PHCF's performance as "satisfactory" in all safety and control areas (SCAs). This included the rating for the management system SCA, which had been "below expectations" in the 2017 regulatory oversight report. Table C-2 of appendix C provides the performance ratings for PHCF from 2014 to 2018.

The 2017 "below expectations" rating for the management system SCA was based on an incident Cameco reported on May 5, 2017, of a small release of hydrogen fluoride (HF) that occurred at its UF_6 plant during maintenance. Cameco conducted an investigation and determined that the required work clearance and permits had not been obtained before the maintenance work started. This was not an isolated incident, and this practice was known to the UF_6 production supervisor. CNSC staff assessed the May 5, 2017, event and the compliance history of procedural non-adherence and determined that Cameco had failed to verify whether work was being performed correctly and according to approved procedures, as required by its management system.

In November 2018, CNSC staff conducted an inspection of PHCF's management system, focusing on the implementation of the corrective actions stemming from the May 2017 HF event. CNSC staff verified that Cameco had implemented unannounced oversight inspection processes to review work practices. CNSC staff were confident that Cameco's corrective actions had been successfully implemented at PHCF and, as a result of these improvements, rated the management system SCA as "satisfactory" for 2018.

CNSC staff are satisfied that Cameco ensured that the PHCF site was maintained in 2018 according to the PHCF licensing basis.

During the summer of 2018, the UO_2 and UF_6 plants underwent scheduled shutdowns to allow for planned maintenance.

Vision in Motion (VIM) is Cameco's project to clean up and renew the site. The project is being carried out under Cameco's operating licence for the facility. In 2018, Cameco carried out work that included:

- repackaging of legacy waste and transfer of stored waste to the Long Term Waste Management Facility
- asbestos abatement and removal of process hazards from the former UF_6 plant
- mobilization for Centre Pier building demolition
- construction of project support trailers
- establishment of supplemental ambient air monitoring equipment

Cameco reported 13 events at PCHF to CNSC staff in 2018. The licensee reported these events in accordance with its regulatory reporting requirements. Two of the events were lost-time injury (LTI) notifications. These are further discussed in section 4.4.

In 2018, CNSC staff conducted six onsite inspections at PHCF to verify compliance with the *Nuclear Safety and Control Act* (NSCA) [1], regulations made under the NSCA, and Cameco's operating licence and programs used to meet regulatory requirements. Table K-2 of appendix K lists these inspections. These planned onsite inspections focused on the following SCAs: management system, fitness for service, radiation protection, environmental protection, emergency management and fire protection, and waste management. Twenty-nine enforcement actions were raised as a result of the inspections. The findings were of low safety significance and did not affect the health and safety of workers, the public or the environment, or the safe operation of the facility. CNSC staff concluded that these findings posed a low risk to the achievement of regulatory objectives and CNSC expectations.

CNSC staff verified that Cameco maintained the commitments of their public information program for PHCF by offering facility tours to the public and other stakeholders, and by updating their website with safety and environmental information, including a yearly compliance report and a waste management overview. Cameco PHCF conducted public opinion polling for PHCF and CFM in accordance with its public information program, finding that 75% of the respondents were satisfied with the operational information that Cameco makes available to the public, and that 83% of the respondents believed that Cameco protects people and the environment. CNSC staff are satisfied that the licensee is in full compliance with regulatory requirements for public information and disclosure.

4.2 Radiation protection

Compliance ratings for the radiation protection SCA, Cameco Port Hope Conversion Facility, 2014–18

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA
For 2018, CNSC staff continued to rate the radiation protection SCA at PHCF as "satisfactory." Cameco has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations* [2]. At this facility, workers handle natural uranium in the production of uranium dioxide (UO_2) and uranium hexafluoride (UF_6). This activity presents external radiological hazards to the whole body and internal radiological hazards from inhalation, ingestion, or absorption through the skin. Radiological hazards were effectively controlled at the facility. As a result, radiation doses to workers and members of the public were kept well below the CNSC regulatory dose limits.				

Application of ALARA

Cameco established radiation protection objectives and ALARA targets for radiation doses at PHCF for 2018. All ALARA targets for radiation doses were met in 2018. Cameco also utilized the "top five" approach in order to follow up on the five workers with the highest year-to-date doses in each dose component. The approach was effective in meeting the ALARA targets for internal urine analysis and external whole-body dose in particular. The radiation protection subcommittee of the Conversion Safety Steering Committee continued to provide support for radiation protection improvement initiatives at PHCF.

Worker dose control

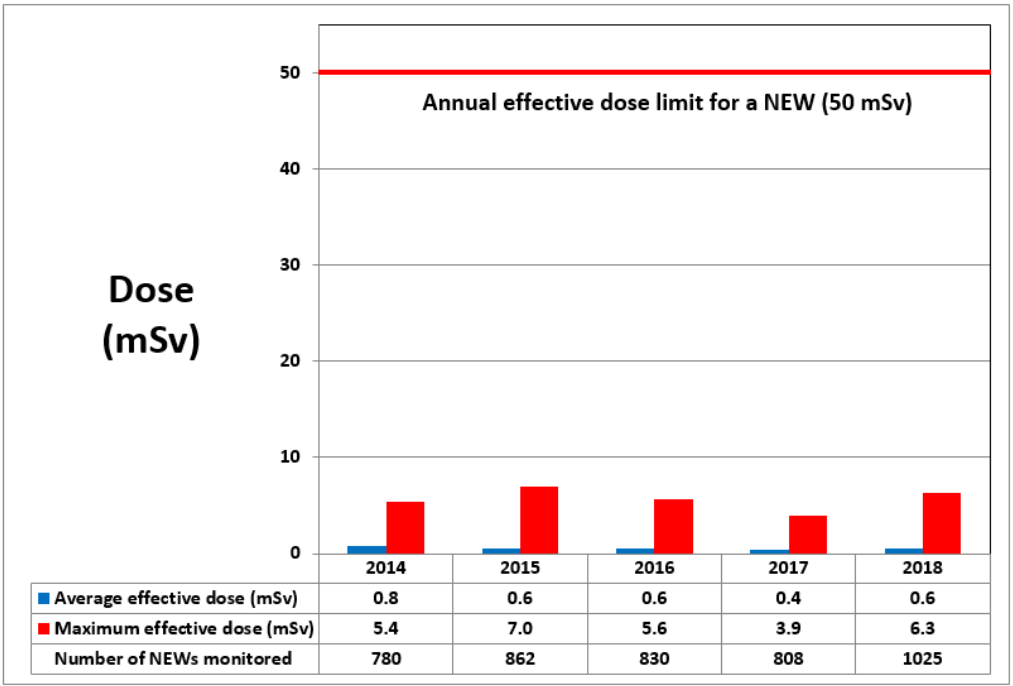
Radiation exposures at PHCF are monitored to ensure compliance with CNSC regulatory dose limits and to keep radiation doses ALARA. In 2018, radiation exposures at PHCF were well below CNSC regulatory dose limits.

Cameco ascertains external doses using whole-body dosimetry. For internal radiological exposures, Cameco's Fuel Services Division holds a CNSC dosimetry service licence that authorizes Cameco to provide in-house internal dosimetry services at PHCF. Internal dose is assessed and assigned at PHCF through two programs: urine analysis and lung counting.

Workers (including contractors) conducting work activities that present a reasonable probability of receiving an annual occupational dose greater than 1 mSv are identified as nuclear energy workers (NEWs) at PHCF. In 2018, total effective dose was assessed for 1,025 NEWs at PHCF, consisting of 453 employees and 572 contractors. The maximum individual effective dose received by a NEW in 2018 was 6.3 mSv, which is approximately 13% of the CNSC regulatory effective dose limit of 50 mSv in a one-year dosimetry period.

Figure 4-3 provides the average and maximum effective doses to NEWs at PHCF between 2014 and 2018. The average and maximum total effective doses over this five-year period are reflective of the work activities and production at PHCF.

Figure 4-3: Average and maximum effective doses to NEWs, PHCF, 2014–18



	2014	2015	2016	2017	2018
Average effective dose (mSv)	0.8	0.6	0.6	0.4	0.6
Maximum effective dose (mSv)	5.4	7.0	5.6	3.9	6.3
Number of NEWs monitored	780	862	830	808	1025

Table E-8 of appendix E provides average and maximum equivalent dose results for the skin of NEWs, from 2014 to 2018. In 2018, the maximum individual skin dose received by a NEW at PHCF was 14.9 mSv, which is approximately 3% of the CNSC regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. Average and maximum skin doses over this five-year period have been relatively stable.

Site visitors and contractors who are not considered as NEWs are issued dosimeters to monitor their radiological exposures while at PHCF. In 2018, the maximum individual effective dose received by a site visitor/contractor who was not a NEW was 0.06 mSv, which is well below the CNSC regulatory dose limit of 1 mSv per calendar year for a person who is not a NEW.

Radiation protection program performance

In 2018, CNSC staff carried out various compliance verification activities to assess the performance of Cameco's radiation protection program at PHCF; these activities included a focused inspection on radiation protection. Overall, CNSC staff found Cameco's compliance with the *Radiation Protection Regulations* [2] and CNSC licence requirements at PHCF to be acceptable. CNSC staff are satisfied with how Cameco has implemented corrective actions that stemmed from action notices raised as a result of the CNSC inspection. Actions included updates to and documenting of practices and procedures supporting the radiation protection program, and improvements to the storage of respirators in work areas.

Action levels for radiological exposures are established as part of the radiation protection program implemented at PHCF. In January 2018, there was one instance where a UF_6 maintenance employee's dosimeter result of 2.45 mSv exceeded the whole-body dose monthly action level of 2 mSv. In accordance with

Cameco's corrective action process, Cameco initiated an investigation to determine the cause of the exposure and identify corrective actions. The employee had been assigned to multiple jobs, none of which stood out as being the cause for the elevated result. The employee indicated that their badge was never lost and was always returned to the badge rack at the conclusion of their shift. While the direct cause could not be established, Cameco implemented additional administrative controls in one of the work areas where there was a potential for elevated dose rates. These controls included requirements for the wearing of direct reading dosimetry in the work area, and gamma dose rate surveys to be performed prior to execution of work activities. CNSC staff are satisfied with Cameco's reporting of, and response to, the action level exceedance.

Radiological hazard control

CNSC staff confirmed that Cameco has radiation and contamination control programs implemented at PHCF to control and minimize radiological hazards and the spread of radioactive contamination. Methods of control include the use of radiation zone controls and monitoring to confirm the effectiveness of the programs. Cameco staff at PHCF conducted in-plant air monitoring, contamination monitoring and radiation dose-rate surveys in 2018, and the results were consistent with expected radiological conditions.

Estimated dose to the public

Cameco applies an operating release level (ORL) based on the releases of uranium and external gamma radiation to the environment, to ensure that dose to the public from PHCF is below 0.3 mSv/year, with the air and water components each less than 0.05 mSv/year, and the gamma component less than 0.3 mSv/year. This ensures that the dose to the public remains well below the CNSC regulatory dose limit for a member of the public of 1 mSv per calendar year.

An ORL equation has been developed to account for all public dose exposure pathways: gamma, air and water. In 2016, Cameco updated the dose calculations related to PHCF releases to water and the fenceline gamma locations used for reporting the dose to the public.

The updates included:

- calculations of dose to the public from facility discharges to the sanitary sewer
- a fenceline monitoring location closer to the operating facility than previously used
- calculations of two estimated doses for members of the public: one for a resident near Site 1 and the other for a resident near Site 2

These revisions came into effect in 2017 and represent a much more conservative estimate of dose to the public. Due to these significant changes, the results in 2017 and 2018 cannot be compared to those in previous years. The increase in dose to the public for 2017 and 2018 compared to those in previous years is a function of including fenceline gamma monitoring in the calculations and is not an actual increase in emissions/dose from PHCF.

Table 4-1 shows the 2013 to 2016 maximum effective doses to a member of the public, while table 4-2 shows doses for 2017 and 2018 to a member of the public for Sites 1 and 2. Both tables show that doses to the public were well below the ORL of 0.3 mSv/year and the CNSC regulatory dose limit for a member of the public of 1 mSv per calendar year.

Table 4-1: Maximum effective dose to a member of the public, PHCF, 2013–16

Dose data	2013	2014	2015	2016	Regulatory dose limit
Maximum effective dose (mSv)	0.021	0.012	0.006	0.020	**1 mSv/year**

Table 4-2: Doses to a member of the public at Sites 1 and 2, PHCF, 2017–18

	Public dose exposure pathway (mSv)			Dose to public (mSv)			
Dose data	**Air**	**Water**	**Gamma – Site 1**	**Gamma – Site 2**	**Total dose – Site 1**	**Total dose – Site 2**	**Regulatory dose limit**
2017	0.001	0.001	0.109	0.152	0.110	0.153	**1 mSv/year**
2018	0.001	0.001	0.141	0.172	0.142	0.173	

4.3 Environmental protection

Compliance ratings for the environmental protection SCA, Cameco Port Hope Conversion Facility, 2014–18

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA
For 2018, CNSC staff continued to rate the environmental protection SCA at PHCF as "satisfactory." Uranium releases to the environment continued to be controlled and monitored to comply with the conditions of the operating licence and regulatory requirements. The releases of hazardous substances from the facility to the environment were controlled in accordance with the applicable requirements of Ontario's Ministry of the Environment, Conservation and Parks (MECP). The measured releases to the environment in 2018 were well below regulatory limits. Fenceline gamma measurements, groundwater monitoring, soil sampling, vegetation and ambient air data indicate that the public and the environment continued to be protected from facility releases.				

SA = satisfactory

Effluent and emissions control (releases)

Atmospheric emissions

Cameco monitors uranium, fluorides and ammonia released from stacks at PHCF. The monitoring data in table 4-3 demonstrates that the atmospheric emissions from the facility continued to be effectively controlled, as annual averages remained consistently below their respective licence limits from 2014 to 2018.

Table 4-3: Air emissions monitoring results (annual averages), PHCF, 2014–18

Location	Parameter	2014	2015	2016	2017	2018	Licence limit
UF_6 plant	Uranium (kg/h)	0.0012	0.0017	0.0012	0.0011	0.0014	**0.280**
	Fluorides (kg/h)	0.0130	0.0170	0.0100	0.021	0.030	**0.650**
UO_2 plant	Uranium (kg/h)	0.0012	0.0012	0.0010	0.0005	0.0007	**0.240**
	Ammonia (kg/h)	2.2	2.4	1.7	1.4	1.7	**58**

UO_2 = uranium dioxide; UF_6 = uranium hexafluoride

In addition to the licence limits, Cameco has action levels at PHCF that are used to provide assurance that the licence release limits will not be exceeded. No action levels for atmospheric emissions were exceeded at any time in 2018.

Liquid effluent

Cameco's operating licence does not allow the discharge of any process waste water effluent from PHCF. In 2018, there were no process liquid discharges from PHCF. Cameco continues to collect and evaporate rather than discharge process liquid effluent.

Cameco does discharge non-process liquid effluent, such as cooling water and sanitary sewer discharges, from PHCF. Cameco monitors these releases in compliance with the requirements of other regulators that have jurisdiction. In 2016 and early 2017, as part of the licence renewal process, a daily sanitary sewage discharge action level of 100 µg uranium per litre (U/L) and a monthly mean release limit of 275 µg U/L were developed and accepted. The sanitary sewage action level was exceeded on multiple occasions in 2017 and 2018. This was attributed to the unusually high Lake Ontario water elevations and associated groundwater infiltration to the sanitary sewer system due to significant precipitation events.

Cameco implemented corrective actions to address the exceedances. Investigation work continues at the UO_2 and UF_6 plants to determine whether infiltration exists. Cameco is repairing sections of the sanitary sewer network and will be upgrading it as part of the VIM project. CNSC staff concluded that in 2018, Cameco met its

licence requirement not to discharge process waste water effluent and to keep the sanitary sewer discharges below their respective release limits.

Environmental management system

CNSC staff confirmed that Cameco has developed and is maintaining an environmental management system (EMS) that provides a framework for integrated activities for the protection of the environment at the PHCF site. The EMS is described in Cameco's Environmental Management Program Manual. It includes annual environmental objectives and targets that CNSC staff review and assess through compliance verification activities. Cameco has updated its Environmental Emergency Plan and aligned its environmental protection program (EPP) with CSA standard N288.4-10, *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [10], and N288.5-11, *Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [11]. Cameco also met its objective relating to the deployment of the long-term waste management plan to dispose of contaminated materials at licensed hazardous facilities as part of the VIM project.

Cameco verifies the EMS through its annual management review where minutes and follow-up to outstanding issues are documented. CNSC staff review these documents as part of their compliance verification activities and, as appropriate, follow up with Cameco staff on any outstanding issues. The results of these compliance verification activities demonstrate that, in 2018, Cameco conducted an annual management review in accordance with CNSC requirements, and that identified issues were properly addressed.

Assessment and monitoring

Cameco's environmental monitoring program serves to demonstrate that the PHCF site emissions of radioactive and hazardous substances are properly controlled. The program also provides data for estimates of the annual radiological dose to the public. This is meant to ensure that the public exposure resulting from Cameco's PHCF operations is below the annual regulatory dose limit of 1 mSv and is ALARA. The principal monitoring activities, described below, focus on the air, groundwater, surface water, soil, vegetation, and gamma radiation around the PHCF site.

In addition, the CNSC conducts periodic monitoring under its Independent Environmental Monitoring Program (IEMP) to verify that the public and the environment around nuclear facilities remain protected.

Uranium in ambient air

Cameco measures uranium in the ambient air (as suspended particulate) at several locations around the PHCF site to confirm the effectiveness of emission abatement systems and monitor the impact of the facility on the environment. For 2018, the measurements showed that the highest annual average uranium concentration in ambient air among the sampling stations was 0.003 $\mu g/m^3$, well below the MECP standard for uranium in ambient air of 0.03 $\mu g/m^3$.

Groundwater monitoring

Currently, the CNSC assesses the groundwater quality at the PHCF site with the use of samples from:

- 12 active pumping wells on a monthly basis
- 66 monitoring wells in the overburden (soil) on a quarterly basis
- 17 monitoring wells in the bedrock on an annual basis
- 21 additional monitoring wells close to the harbour – every two years in support of groundwater discharge estimates

CNSC staff found that the groundwater monitoring program, including the pump-and-treat wells, has been performing as expected. The pump-and-treat wells continue to reduce the mass of groundwater contaminants before discharging water into the harbour, as shown in table F-4 of appendix F.

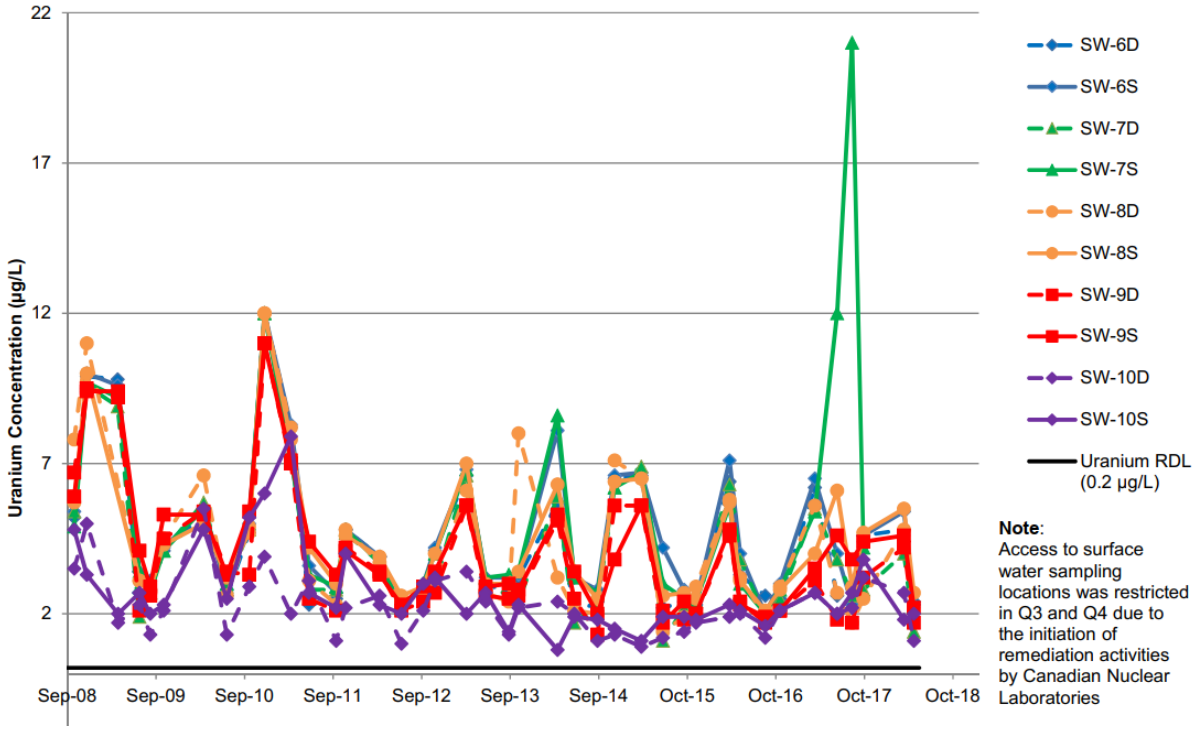
Surface water monitoring

The surface water quality in the harbour near the PHCF site has been monitored since 1977 through the analysis of samples collected from the south cooling water intake near the mouth of the Ganaraska River. The trend of surface water quality over time shows improvement since 1977 and very low uranium levels.

Surface water in the harbour is sampled at 13 locations on a quarterly basis. This activity includes the collection of samples at depths slightly below the water surface and slightly above the harbour sediment layer at each location. In addition, Cameco conducts ongoing monitoring of the cooling water intake located in the Port Hope harbour near the mouth of the Ganaraska River. Table F-5 of appendix F provides annual average and maximum concentrations of uranium, fluoride, nitrate and ammonia monitored in the harbour water from 2014 to 2018.

Surface water concentrations continue to be stable, at levels safe for human health, and generally below CCME *Water Quality Guidelines for the Protection of Aquatic Life* [8] (15 µg/L for long-term exposure or 33 µg/L for short-term exposure) as shown in figure 4-4 below (10 sampling locations are shown).

Figure 4-4: Uranium concentrations in surface water approach channel, 2008–18



RDL = reported detection limit

Cameco attributes the spike of the uranium concentration of contaminants of potential concern that occurred in 2017 to the high water level and slightly different sample locations. CNSC staff have requested that Cameco continue to explore the cause of the spike.

Surface water was not sampled in Q3 2018 and Q4 2018 because access to the harbour was restricted due to remediation activities carried out by Canadian Nuclear Laboratories.

Soil monitoring

Cameco's soil monitoring program consists of five monitoring locations beyond the facility's fenceline in Port Hope. Three of these locations are within a 0 to 500 m radius zone from the facility, while the remaining two monitoring locations are within the 500 to 1,000 m and 1,000 to 1,500 m radius zones. This includes one location (waterworks side yard) remediated with clean soil to avoid interference from historical uranium soil contamination. Cameco takes samples annually at various depths within the soil profile to determine whether the concentration of uranium has changed as compared with previous sample results.

The measured average uranium-in-soil concentrations in 2018 have remained similar to those of past years. This suggests that uranium emissions from current PHCF operations do not contribute to accumulation of uranium in soil. Table F-6 of appendix F provides soil sampling results. The results have been well below the most restrictive CCME *Soil Quality Guidelines for the Protection of Environmental and Human Health* [9] for residential and parkland land use

(23 µg/g) and within the range of the natural background levels for Ontario (up to 1.9 to 2.5 µg/g).

Cameco has made a commitment to maintain the existing five soil monitoring locations and to report the results to the CNSC each year. Reclamation activities, as part of the Port Hope Area Initiative, will provide an opportunity for Cameco to review the locations of its soil monitoring stations throughout the Port Hope community.

Fluoride monitoring

The impact of fluoride emissions from PHCF on the environment is determined each growing season. At that time, samples of fluoride-sensitive vegetation are collected and then analyzed for fluoride content. The vegetation sampling program was modified in 2017, when sampling locations were standardized to Manitoba maple locations where clusters of trees were sampled as composite samples versus single location sampling. The results in 2018 continued to be well below the MECP's Upper Limit of Normal Guideline of 35 parts per million. Table F-7 of appendix F provides details.

Gamma monitoring

A portion of radiological public dose from PHCF operations is due to gamma radiation sources. Consequently, monitoring gamma radiation effective dose rates at the fenceline of the two PHCF sites is essential to ensuring that levels of potential gamma radiation exposure are maintained ALARA. The gamma radiation effective dose rates for both sites are measured with environmental dosimeters supplied by a licensed dosimetry service. Per the 2016 ORL, the dose to the public is calculated for both Sites 1 and 2 using specific gamma fenceline monitoring locations. The modifications to the ORL in 2016 came into effect in 2017 and represent a much more conservative estimate of dose to the public. Due to these significant changes, the results beginning in 2017 cannot be compared with those of previous years. Refer to the "Radiation protection" section above on "Estimated dose to the public" for further information about the updates made to the ORL.

The 2014 to 16 annual average of public doses for gamma are shown in table F-8 of appendix F.

The 2017 and 2018 maximum monthly public doses for gamma are shown in table F-9. For those years, the specific gamma fenceline monitoring locations used for Site 1 included results from stations 2 and 13; for Site 2, they included results from stations 2 and 21. In 2018, the maximum monthly gamma measurements were all below the respective licensed limits for Cameco:

- Station 2 results measured 0.26 µSv/h; the licensed limit was 0.57 µSv/h.
- Station 13 results measured 0.07 µSv/h; the licensed limit was 0.40 µSv/h.
- Station 21 results measured 0.07 µSv/h; the licensed limit was 0.26 µSv/h.

These measurements indicate that gamma dose rates are controlled and the public is protected.

CNSC Independent Environmental Monitoring Program

CNSC staff conducted independent environmental monitoring in the Port Hope area in 2014, 2015 and 2017. The results are available on the CNSC's IEMP web page. The IEMP results indicate that the public and the environment surrounding the PHCF site remain protected from facility emissions. Further independent environmental monitoring campaigns at PHCF are scheduled for 2020.

Protection of the public

The licensee is required to demonstrate that adequate provision is made to protect the health and safety of the public from exposures to radiological and hazardous (non-radiological) substances released from the facility, as well as to physical stressors. The effluent and environmental monitoring programs currently implemented by the licensee are used to verify that releases of both types of substances do not result in environmental concentrations that may affect public health.

The CNSC receives reports of discharges to the environment in accordance with the reporting requirements outlined in the PHCF licence and licence conditions handbook (LCH). CNSC staff's review and evaluation of radiological and hazardous discharges from PHCF to the environment in 2018 indicate that no significant risks to the public or environment occurred during this period.

CNSC staff concluded, based on their review of these programs at PHCF, that the public continues to be protected from facility emissions.

Environmental risk assessment

CNSC staff use CSA standard 288.6-12, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills* [3], to help determine whether licensees are in compliance with regulatory requirements for protection of the environment and human health.

In January 2016, Cameco submitted an ERA for the PHCF to the CNSC. CNSC staff reviewed the ERA and concluded that it is in compliance with CSA N288.6-12, and that the ERA conclusions on potential risk to human health and the environment from PHCF are valid; that is, that the risk is very low. Cameco currently has acceptable environmental programs in place to ensure protection of the public and the environment.

CNSC staff have requested that Cameco address several technical comments and recommendations, as appropriate, in the next iteration of the PHCF ERA, which is due in 2021.

4.4 Conventional health and safety

Compliance ratings for the conventional health and safety SCA, Cameco Port Hope Conversion Facility, 2014–18

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA
For 2018, CNSC staff continued to rate the conventional health and safety SCA at PHCF as "satisfactory." Overall, the compliance verification activities that CNSC staff conducted at the facility confirmed that Cameco continued to view conventional health and safety as an important consideration. Cameco has demonstrated a satisfactory ability to keep its workers safe from occupational injuries.				

SA = satisfactory

Performance

Cameco's performance at PHCF related to conventional health and safety is monitored through CNSC staff's onsite inspections and event reviews. In 2018, Cameco continued to develop and maintain a comprehensive occupational health and safety management program for PHCF. The program incorporates various elements, such as accident reporting and investigation, hazard prevention, preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response.

Table 4-4 outlines the number of lost-time injuries (LTIs) over the past five years at PHCF. Cameco reported two LTIs in 2018. The first LTI was a result of an employee falling approximately four feet while taking confined-space training offsite. The employee was initially put on restricted duty and later instructed by their doctor to cease work. The second LTI was a result of a contracted truck driver spraining their ankle while stepping down onto a rig mat in the Centre Pier loading area. Cameco conducted an investigation and implemented corrective actions, which are summarized in table H-1 of appendix H. CNSC staff reviewed the corrective actions and are satisfied with the actions taken by Cameco to prevent reoccurrence.

Table 4-4: Lost-time injury statistics, PHCF, 2014–18

	2014	2015	2016	2017	2018
LTIs[1]	1	1	4	1	2
Severity rate[2]	7.58	7.64	2.40	1.67	7.58
Frequency rate[3]	0.27	0.26	0.80	0.28	0.49

1 An LTI is an injury that takes place at work and results in the worker being unable to return to work for a period of time.
2 The accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
3 The accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

Practices

Cameco's activities and operations at PHCF must comply with the NSCA [1] and its associated regulations, and with Part II of the *Canada Labour Code* [5]. Cameco uses audits, inspections, evaluations, reviews, benchmarking, training and employee engagement to evaluate the effectiveness of conventional health and safety practices at PHCF.

CNSC staff confirmed that Cameco's Conversion Safety Steering Committee continued to support conventional health and safety efforts at PHCF in 2018. This joint committee, created in 2013, inspects the workplace and meets monthly to improve the safety performance of the site and promote continuous improvement.

All reported conventional health and safety incidents were tracked and managed as part of the Cameco Incident Reporting System database. CNSC staff reviewed health and safety documentation to verify that any issues were promptly resolved.

Awareness

CNSC staff confirmed that in 2018 Cameco continued to hold monthly safety meetings for all employees at PHCF on various safety topics, including radiation protection, environmental protection and fire protection. Attendance was tracked at the safety meetings as an indicator for safety performance. Cameco workers at PHCF also attended daily "toolbox meetings" where they were notified of any concerns or ongoing maintenance in their area.

5 Cameco Fuel Manufacturing Inc.

The Cameco Fuel Manufacturing Inc. (CFM) facility is a wholly owned subsidiary of Cameco Corporation. CFM operates two facilities: a nuclear fuel fabricating facility licensed by the CNSC in Port Hope, Ontario; and a metals manufacturing facility in Cobourg, Ontario, which manufactures zircaloy tubes (non-nuclear activity). This latter facility is not licensed by the CNSC and is not discussed further in this report. Figure 5-1 shows an aerial view of the CFM facility in Port Hope.

Figure 5-1: Aerial view of the CFM facility

The CFM facility in Port Hope operates under a CNSC licence that expires in February 2022. The facility manufactures nuclear reactor fuel bundles from uranium dioxide (UO_2) and zircaloy tubes. The finished fuel bundles are primarily shipped to Canadian nuclear power reactors.

The risks associated with the licensed activities at this Class IB facility are mainly due to conventional industrial hazards and radiological hazards of UO_2.

5.1 Overall performance

For 2018, CNSC staff rated Cameco's performance at the CFM facility as "satisfactory" in all safety and control areas (SCAs). The performance ratings for the facility from 2014 to 2018 are found in table C-3 of appendix C.

Cameco continued to operate the CFM facility safely throughout 2018. The facility underwent two planned shutdowns during the year to conduct routine maintenance activities and implement facility upgrades. CNSC staff are satisfied that Cameco ensured that the CFM site was maintained according to the CFM licensing basis.

Cameco reported one event to the CNSC in 2018. The event (reported in February) was an exceedance of the CFM action level for liquid effluent. Section 5.3 provides additional information about the event.

In 2018, CNSC staff conducted two onsite inspections to verify compliance with the NSCA [1] and its associated regulations, Cameco's operating licence, and the programs used to meet regulatory requirements. Table K-3 of appendix K lists these inspections. The inspections focused on the following SCAs: emergency management and fire protection, conventional health and safety, and waste management. Five enforcement actions were raised as a result of the inspections. The findings were of low safety significance and did not affect the health and safety of workers, the public or the environment, or the safe operation of the facility.

Although other SCAs were not the focus of inspections at CFM in 2018, CNSC staff performed desktop compliance verification of the various SCAs by reviewing Cameco's compliance reporting submissions (such as annual and quarterly compliance monitoring reports) and specific program documents.

Cameco upheld the commitments of its public information program for CFM throughout the year. Cameco held an open house for members of the public at the facility and leveraged its social media channels to ensure information was being disseminated. Cameco provided updated health and safety information for CFM on its website, and also conducted public opinion polling (along with PHCF) in accordance with Cameco's public information program. In addition to 83% of the respondents reporting that they believed Cameco protects people and the environment, 74% also indicated that they were aware of Cameco's open community forums about its Port Hope operations. CNSC staff are satisfied that the licensee is in full compliance with regulatory requirements for public information and disclosure.

5.2 Radiation protection

Compliance ratings for the radiation protection SCA, Cameco Fuel Manufacturing Inc., 2014–18

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

For 2018, CNSC staff continued to rate the radiation protection SCA at CFM as "satisfactory." Cameco has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations* [2]. At this facility, workers handle natural uranium in the production of ceramic-grade UO_2 pellets and nuclear fuel bundles. This activity presents radiological hazards to the whole body and internal radiological hazards from inhalation, ingestion, or absorption through the skin. Radiological hazards were effectively controlled at CFM. As a result, radiation doses to workers and members of the public were kept well below the CNSC regulatory dose limits.

Application of ALARA

Cameco established radiation protection objectives and ALARA initiatives for CFM for 2018. One ALARA initiative in 2018 was a project to "Put U In Its Place", with the intent to reduce airborne uranium in the workplace. CFM was also supported in its radiation reduction efforts by a Personal and Radiation Protection subcommittee, which has an objective to implement initiatives to lower employee radiation exposure. The success of the above initiatives and programs were measured against set ALARA dose targets, and the targets for total effective and skin doses were met.

Worker dose control

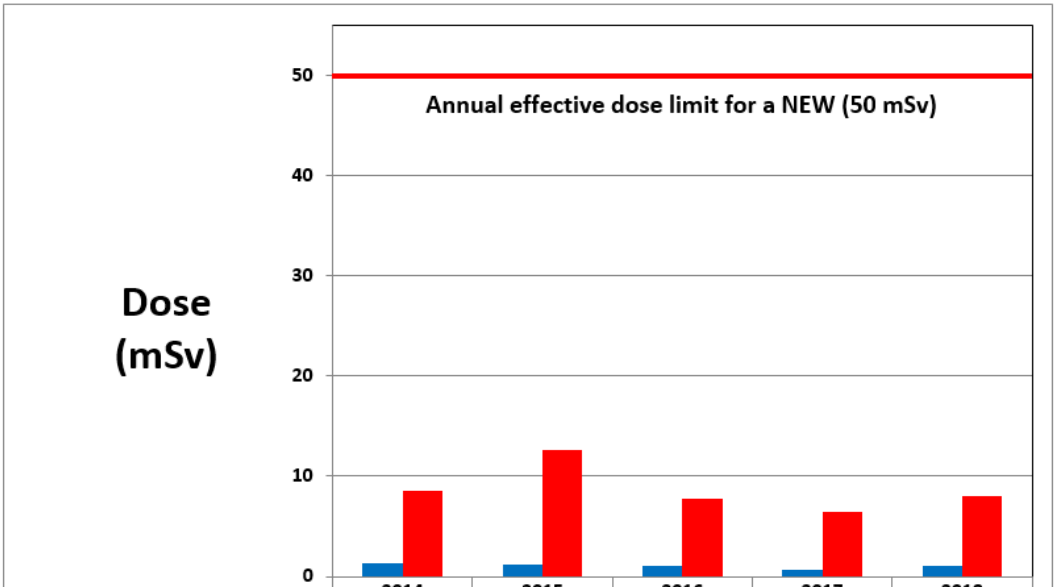
Radiation exposures at CFM are monitored to ensure compliance with CNSC regulatory dose limits and to keep radiation doses ALARA. In 2018, radiation exposures at CFM were well below CNSC regulatory dose limits.

Cameco ascertains external doses using whole-body and extremity dosimetry. For internal radiological exposures, Cameco's Fuel Services Division holds a CNSC dosimetry service licence that authorizes Cameco to provide in-house internal dosimetry services at CFM. Internal dose is assessed and assigned at CFM by lung counting.

All Cameco employees at CFM are identified as nuclear energy workers (NEWs). Contractors may also be identified as NEWs depending on their work activities. In 2018, the total effective dose at the facility was assessed for 267 NEWs, consisting of 235 Cameco employees and 32 contractors. The maximum individual effective dose received by a NEW in 2018 was 8 mSv, which is approximately 16% of the CNSC regulatory effective dose limit of 50 mSv in a one-year dosimetry period.

Figure 5-2 provides the average and maximum effective doses to NEWs at CFM between 2014 and 2018. Average and maximum total effective doses over this five-year period are aligned with the work activities and production at the facility.

Figure 5-2: Average and maximum effective doses to NEWs, CFM, 2014–18



	2014	2015	2016	2017	2018
Average effective dose (mSv)	1.3	1.2	1.0	0.7	1.1
Maximum effective dose (mSv)	8.5	12.6	7.8	6.4	8.0
Number of NEWs monitored	317	336	278	270	267

Appendix E provides the average and maximum equivalent dose results for the skin and extremities of NEWs, from 2014 to 2018. In 2018, the maximum skin dose received by a NEW at CFM was 59 mSv (table E-9), which is approximately 12% of the CNSC regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. The maximum extremity dose received by a NEW at CFM was 57.1 mSv (table E-2), approximately 11% of the CNSC regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. The average and maximum equivalent doses over this five-year period have been relatively stable.

Visitors are not considered as NEWs, and are issued dosimeters to monitor their radiological exposures while at CFM. In 2018, there were no measurable doses recorded on dosimeters issued to visitors.

Radiation protection program performance

In 2018, CNSC staff carried out various compliance verification activities to assess the performance of Cameco's radiation protection program at CFM. Overall, CNSC staff found Cameco's compliance with the *Radiation Protection Regulations* [2] and CNSC licence requirements at the facility to be acceptable.

Action levels for radiological exposures are established as part of the radiation protection program implemented at CFM. If an action level is reached, Cameco staff must establish the cause, notify the CNSC and, if applicable, restore the effectiveness of the program. In 2018, there were no action level exceedances reported by Cameco for the facility.

Radiological hazard control

CNSC staff confirmed that Cameco has radiation and contamination control programs implemented at CFM to control and minimize radiological hazards and the spread of radioactive contamination. Methods of control include radiological zone controls and monitoring to confirm the effectiveness of the program. In 2018, Cameco staff at the facility conducted in-plant air monitoring as well as contamination monitoring and radiation dose-rate surveys, and the results were consistent with expected radiological conditions.

Estimated dose to the public

The maximum dose to the public from licensed activities at the CFM facility is calculated with the use of monitoring results of air emissions and gamma radiation. Table 5-1 shows the maximum 2014 to 2018 effective doses to a member of the public. The doses are well below the CNSC regulatory dose limit of 1 mSv per calendar year for a member of the public.

Table 5-1: Maximum effective dose to a member of the public, CFM, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory dose limit
Maximum effective dose (mSv)	0.018	0.025	0.023	0.022	0.030	**1 mSv/year**

5.3 Environmental protection

Compliance ratings for the environmental protection SCA, Cameco Fuel Manufacturing Inc., 2014–18

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA
For 2018, CNSC staff continued to rate the environmental protection SCA at CFM as "satisfactory." Uranium releases from the facility to the environment continued to be effectively controlled and monitored, in satisfactory compliance with the conditions of the operating licence and regulatory requirements. Groundwater monitoring, soil sampling and high-volume air sampler data indicate that the public and the environment continued to be protected from facility releases.				

SA = satisfactory

Effluent and emissions control (releases)

Atmospheric emissions

Cameco continued to monitor uranium released as atmospheric emissions from the facility. The monitoring data in table 5-2 demonstrates that stack and building exhaust ventilation emissions from the facility continued to be effectively controlled as annual averages remained consistently well below their licence limits between 2014 and 2018.

Table 5-2: Air emissions monitoring results, CFM, 2014–18

Parameter	2014	2015	2016	2017	2018	Licence limit
Total uranium discharge through stacks (kg/year)	0.01	0.01	0.03	0.01	0.01	**14**
Total uranium discharge through building exhaust ventilation (kg/year)	0.40	0.45	0.70*	0.57*	1.25**	

kg = kilogram
* In 2016 and 2017, the annual value was calculated by adding the quarterly results, while in 2014 and 2015 the annual average was used.
** In 2018, the annual value was calculated on a daily basis with a total sum provided for the year.

In 2018, the annual uranium discharge through building exhaust ventilation was calculated by using a summation of the daily release values with a total sum provided for the year. This capability was built into the CFM facility's new environmental monitoring software and is a better reflection of day-to-day operations compared to using an average result. Previously, the annual value was calculated by adding the quarterly results. This caused the 2018 annual result to be higher when compared with those of previous years due to the number of days and weeks used in the annual calculation compared to the number of weeks used in the quarterly calculation. The summation of the daily values is more representative of the actual building ventilation emissions.

In addition to the licence limits, Cameco uses action levels to provide assurance that licence release limits will not be exceeded. No action levels for atmospheric emissions were exceeded at any time in 2018.

Liquid effluent

After liquid effluent generated from the production process is collected, an evaporator process is used to remove the majority of the uranium. The condensed liquid is sampled and analyzed prior to a controlled release to the sanitary sewer line. Cameco continues to monitor uranium released as liquid effluent from the facility. The monitoring data in table 5-3 demonstrates that liquid effluent from the facility in 2018 remained consistently well below the licence limit and continued to be effectively controlled.

Table 5-3: Liquid effluent monitoring results, CFM, 2014–18

Parameter	2014	2015	2016	2017	2018	Licence limit
Total uranium discharge to sewer (kg/year)	1.58	1.24	0.85	0.64	0.84	**475**

kg = kilogram

For liquid effluent releases to the municipal sewer system, Cameco has an action level of 0.10 mg U/L. During the first quarter of 2018, Cameco recorded an action

level exceedance when the concentration of uranium in an effluent sample was measured at 0.11 mg U/L. Cameco notified CNSC staff of the exceedance and conducted an investigation to identify the cause. Following the investigation, Cameco submitted the event report to the CNSC, concluding that the elevated measurement was likely due to recent equipment modifications within the facility. Subsequent liquid effluent monitoring results were all below 0.10 mg U/L for the remainder of 2018.

Environmental management system

CNSC staff confirmed that Cameco has developed and is maintaining an environmental management system (EMS) that provides a framework for integrated activities for the protection of the environment at the CFM site. The EMS is described in Cameco's Radiation and Environmental Protection Manual and includes activities such as the establishment of annual environmental objectives and targets that CNSC staff review and assess through compliance verification activities. Cameco met its environmental objectives in 2018 by implementing a new environmental tracking database, continuing groundwater monitoring twice a year, implementing CSA Group standards and CNSC regulatory documents related to environmental protection, and completing planned activities related to Phase 2 noise abatement activities.

Cameco holds an annual management review meeting at which environmental protection issues are discussed and documented. CNSC staff review these documents, as part of their compliance verification activities, and follow up with CFM staff on any outstanding issues. The results of these compliance verification activities demonstrate that Cameco conducted an annual management review in accordance with CNSC requirements and that identified issues were being addressed properly.

Assessment and monitoring

Cameco's environmental monitoring program serves to demonstrate that the CFM site emissions of radioactive and hazardous substances are properly controlled. The program also provides data for estimates of the annual radiological dose to the public. This is meant to ensure that the public exposure attributable to Cameco's CFM operations is below the annual regulatory dose limit of 1 mSv and is ALARA. The principal monitoring activities, described below, focus on the air, groundwater, surface water, soil, and gamma radiation around the CFM site.

In addition, the CNSC conducts periodic monitoring under its Independent Environmental Monitoring Program (IEMP) to verify that the public and the environment around nuclear facilities remain protected.

Uranium in ambient air

Cameco operates high-volume air samplers to measure the airborne concentrations of uranium at points of impingement of stack plumes. The samplers are located on the east, north, southwest and northwest sides of the facility. In 2018, the results from these samplers showed that the highest annual average concentration of uranium in ambient air (among the sampling stations) was 0.0006 $\mu g/m^3$. This is well below Ontario's Ministry of the Environment,

Conservation and Parks (MECP) standard for uranium in ambient air of 0.03 μg/m^3.

Due to the benefits offered by ICP-MS (inductively coupled plasma – mass spectrometry), CFM ceased alpha counting and exclusively used ICP-MS in 2018 to analyze filters. The ICP-MS method allows results to be reported directly through the Cameco database system.

Groundwater monitoring

Groundwater has been monitored at the site twice a year since 1999 with a network of 70 monitoring wells, including 43 overburden, 23 shallow-bedrock and 4 deep-bedrock wells. The groundwater monitoring results confirmed that the operations in 2018 were not contributing to the concentrations of uranium in groundwater on the licensed property.

Surface water monitoring

In 2018, Cameco collected surface water samples at nine locations in May, June and September. The sample locations were on and adjacent to the facility, and were analyzed for uranium.

Uranium concentrations in all surface water samples collected in 2018 met the applicable CCME *Water Quality Guidelines for the Protection of Aquatic Life* [8]. All surface water samples satisfied the CCME guidelines for short-term exposure (33 μg/L) and long-term exposure (15 μg/L) when the short-term guideline was applied to the locations in the intermittent drainage feature and the long-term guideline to the locations in the Gages Creek tributary. The highest uranium concentration was collected at SW-9 (17 μg/L in September) and was below the applicable CCME guideline for short-term exposure. Uranium concentrations were measured at one offsite location (immediately downstream of the CFM facility) and were well below the applicable CCME guideline for each round of sampling. CNSC staff will continue to oversee Cameco's monitoring at locations in the vicinity of the CFM facility to confirm that uranium concentrations remain at safe levels in surface water.

Soil monitoring

Every three years, Cameco collects soil samples from 23 locations surrounding the CFM facility. Soil samples were last collected in 2016 and analyzed for uranium content. The average uranium levels in soil near the CFM facility are just slightly above the Ontario natural background level of 1.9 to 2.5 μg/g (table F-10, appendix F). The maximum concentrations detected are attributable to historical contamination in Port Hope, which has long been recognized and continues to be the focus of environmental studies and cleanup activities. The results for all samples were below the CCME *Soil Quality Guidelines for the Protection of Environmental and Human Health* [9] of 23 μg/g. This is the most restrictive guideline; therefore, no adverse consequences to human and environmental receptors are expected. The next soil samples will be collected in 2019.

Gamma monitoring

For the CFM facility, a portion of radiological public dose is due to gamma radiation sources. Consequently, monitoring of gamma radiation effective dose rates at the fenceline of the CFM site is essential to ensuring that levels of potential gamma radiation exposure are maintained ALARA. The gamma radiation effective dose rates for the site are measured with environmental dosimeters supplied by a licensed dosimetry service. In 2018, the annual average of fenceline gamma measurements at the CFM site was 0.05 µSv/h. CFM has a licensed limit for fenceline gamma dose rates of 0.35 µSv/h at the monitoring station corresponding to the critical receptor and 1.18 µSv/h at all other monitoring locations. These measurements indicate that gamma dose rates are effectively controlled and that the public is protected.

In addition to licence limits, CFM has action levels for the critical receptor and other locations. There were no exceedances of the action levels in 2018.

CNSC Independent Environmental Monitoring Program

CNSC staff conducted independent environmental monitoring in the Port Hope area in 2014, 2015 and 2017. The results are available on the CNSC's IEMP web page. The IEMP results indicate that the public and the environment surrounding CFM remain protected from facility emissions. Further independent environmental monitoring campaigns at the site are scheduled for 2020.

Protection of the public

The licensee is required to demonstrate that adequate provision is made to protect the health and safety of the public from exposures to radiological substances released from the facility, as well as to physical stressors. The effluent and environmental monitoring programs that the licensee currently conducts are used to verify that releases of radiological both types of substances do not result in environmental concentrations that may affect public health.

The CNSC receives reports of discharges to the environment in accordance with the reporting requirements outlined in the CFM licence and licence conditions handbook (LCH). CNSC staff's review and evaluation of radiological discharges from CFM to the environment in 2018 indicated that no significant risks to the public or the environment occurred during this period.

CNSC staff concluded, based on their review of these programs at CFM, that the public continues to be protected from facility emissions.

Environmental risk assessment

CNSC staff use CSA standard N288.6-12, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills* [3], to help determine whether licensees are in compliance with regulatory requirements for protection of the environmental and human health.

In 2016, Cameco submitted an ERA for the CFM facility to the CNSC. CNSC staff reviewed the ERA and concluded that it is in compliance with CSA N288.6-12, and that the ERA conclusions on potential risk to human health

and the environment at the CFM facility are valid; that is, that the risk is very low. Cameco has acceptable environmental programs in place to ensure protection of the public and the environment.

CNSC staff expect Cameco to address several technical comments and recommendations, as appropriate, in the next iteration of the CFM ERA, which is due in 2021.

5.4 Conventional health and safety

Compliance ratings for the conventional health and safety SCA, Cameco Fuel Manufacturing Inc., 2014–18

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA
For 2018, CNSC staff continued to rate the conventional health and safety SCA at CFM as "satisfactory." Overall, compliance verification activities that CNSC staff conducted at the facility confirmed that Cameco continued to view conventional health and safety as an important consideration. Cameco has demonstrated a satisfactory ability to keep its workers safe from occupational injuries.				

SA = satisfactory

Performance

Cameco's performance related to conventional health and safety at the CFM facility is monitored through CNSC staff's onsite inspections and event reviews. In 2018, Cameco continued to maintain a comprehensive occupational health and safety management program for this facility. The program incorporates various elements, such as accident reporting and investigation, hazard prevention, preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response.

As indicated in table 5-4, there were no lost-time injuries (LTIs) at the facility in 2018.

Table 5-4: Lost-time injury statistics, CFM, 2014–18

	2014	2015	2016	2017	2018
LTIs[1]	0	1	0	0	0
Severity rate[2]	0	0.6	0	0	0
Frequency rate[3]	0	0.6	0	0	0

1 An LTI is an injury that takes place at work and results in the worker being unable to return to work for a period of time.
2 The accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
3 The accident frequency rate measures the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

Practices

Cameco's activities and operations at CFM must comply with the NSCA [1] and its associated regulations, and Part II of the *Canada Labour Code* [5]. Cameco uses audits, inspections, evaluations, reviews, benchmarking, training, and employee engagement to evaluate the effectiveness of conventional health and safety practices at the facility.

CNSC staff confirmed that in 2018 Cameco continued to maintain a Joint Health and Safety Committee at the CFM facility, which investigated all safety-related incidents there, including near misses. All reported conventional health and safety incidents were tracked and managed as part of the Cameco Incident Reporting System database. In addition, the committee conducted monthly inspections of the workplace and provided input into all new and revised health and safety policies, procedures and programs. In 2018, Cameco implemented or updated safety initiatives including the job task observation program; self-check standard; employee concerns responsiveness; physical demands analysis for all jobs; noise surveys; and the heat stress procedure. CNSC staff reviewed health and safety documentation to verify that any issues identified were promptly resolved.

Awareness

CNSC staff confirmed that in 2018 Cameco continued to hold monthly safety meetings for all employees at the CFM facility on various safety topics, including radiation protection, environmental protection and fire protection. Attendance was tracked at the safety meetings as an indicator for safety performance. Cameco workers at the facility also attended daily "toolbox meetings" where they were notified of any concerns or ongoing maintenance in their area.

6 BWXT Nuclear Energy Canada Inc.

BWXT Nuclear Energy Canada Inc. (BWXT) (formerly known as GE-Hitachi Nuclear Energy Canada Inc.) produces nuclear fuel and fuel bundles used by Ontario Power Generation's (OPG) Pickering and Darlington nuclear generating stations. BWXT has licensed operations in two locations: Toronto and Peterborough, Ontario. The Toronto site produces uranium dioxide (UO_2) fuel pellets, and the Peterborough site manufactures the fuel bundles, using the pellets from Toronto and zircaloy tubes manufactured in-house. The Peterborough site also runs a fuel services business involved with the manufacturing and maintenance of equipment for use in nuclear power plants.

The primary radiological hazard at these facilities is the inhalation of airborne UO_2 particles. The facilities are designed such that there are several layers of engineered barriers (defence in depth) to minimize any exposure to workers and prevent any unauthorized releases to the environment. The Peterborough facility also processes beryllium, which poses inhalation hazards and is also treated in a similar fashion. Apart from various safety features in place to prevent any occupational exposure to employees, all personnel working in potentially hazardous areas are monitored for exposure to ensure safe operation. The facilities' operations have low environmental releases. All releases are controlled, monitored and reported. Figure 6-1 shows the BWXT Toronto facility, while figure 6-2 shows the BWXT Peterborough facility.

Figure 6-1: BWXT Toronto facility

Figure 6-2: BWXT Peterborough facility

During 2018, no significant changes to operations occurred at either facility, and the licensee continued to maintain its obligations under the licence. No changes were made to BWXT's LCH during this period. In November 2018, BWXT submitted an application to renew its operating licence for a 10-year period. The current licence expires in December 2020. The licence renewal hearing is scheduled the week of March 3, 2020 in Toronto.

6.1 Overall performance

For 2018, CNSC staff rated BWXT's performance as "satisfactory" in all safety and control areas (SCAs). Table C-4 in appendix C shows the performance ratings for the BWXT facilities from 2014 to 2018.

In October 2018, BWXT notified the CNSC of the appointment of a new Peterborough fuel production manager. This production manager is responsible for all fuel assembly manufacturing and engineering at the Peterborough facility. A detailed organizational chart including appointments and reporting structure was provided to the CNSC per the requirements under section 15 of the *General Nuclear Safety and Control Regulations* [4].

BWXT continued to operate the Toronto and Peterborough facilities safely in 2018. The facilities underwent four scheduled shutdowns throughout the year for engineering projects and equipment maintenance. There were no significant changes to the physical plants nor modifications that affected the safety analysis of the facilities. CNSC staff are satisfied that BWXT ensured that the facilities were maintained according to the licensing basis.

In February 2018, BWXT reported a small spill (approximately 5 to 10 litres) of metal working fluid that leaked from a metal recycling bin outside onto the concrete pad at its Peterborough facility. BWXT submitted an event report that detailed corrective actions, such as the use of absorbent materials to clean up the spill, as well as the removal of the affected soil and return of the recycling bins to the vendors to prevent reoccurrence. CNSC staff reviewed the corrective actions and their implementation and found them acceptable.

In August 2018, BWXT reported a power outage at its Toronto facility. The outage was a result of a large rain event, and water entered the basement of Building 7 at an excessive rate, also as a result of this event. BWXT activated its Emergency Operations Centre in accordance with its emergency program and reported the event to the CNSC in accordance with its reporting requirements. BWXT submitted an event report that detailed corrective actions, such as the collection of approximately 50 drums of water and diversion of it to the water treatment system for treatment. CNSC staff reviewed the corrective actions and their implementation and found them acceptable.

There were no action level exceedances related to radiation protection and environmental protection. BWXT reported that there were no LTIs in 2018.

In 2018, CNSC staff conducted four planned Type II inspections at BWXT's two facilities to verify licensee compliance with the NSCA [1] and its associated regulations, the operating licence and LCH. Table K-4 of appendix K lists these inspections. The inspections focused on the following SCAs: operating performance, fitness for service, radiation protection, conventional health and safety, packaging and transport, environmental protection, and emergency management and fire protection. BWXT addressed all the enforcement actions from these inspections.

BWXT communicated the facilities' activities to members of the public by being active on social media throughout the year, and by updating its website with environmental monitoring results. BWXT continued to focus on community engagement and met with members of the community regularly through its Community Liaison Committee meetings in Toronto. Facility tours were also conducted with elected officials, as well as with interested stakeholders. CNSC staff are satisfied that the licensee is in full compliance with regulatory requirements for public information and disclosure.

6.2 Radiation protection

Compliance ratings for the radiation protection SCA, BWXT Nuclear Energy Canada's Toronto and Peterborough facilities, 2014–18

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

For 2018, CNSC staff continued to rate the radiation protection SCA at BWXT as "satisfactory." BWXT has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations* [2]. Workers at BWXT Toronto handle UO_2 powder in the production of ceramic-grade pellets. This activity presents radiological hazards to the whole body as well as internal radiological hazards from inhalation, ingestion, or absorption through the skin. Workers at BWXT Peterborough handle natural UO_2 pellets and nuclear fuel bundles, which present external radiological hazards to the whole body and to the extremities. Radiological hazards were effectively controlled at both facilities. As a result, radiation doses to workers and members of the public were kept well below the CNSC regulatory dose limits.

SA= satisfactory

Application of ALARA

BWXT established radiation protection goals and initiatives for the Toronto and Peterborough facilities for 2018. BWXT has an ALARA Committee which meets quarterly and sets annual ALARA goals focused on reducing worker dose and surface contamination throughout the facilities.

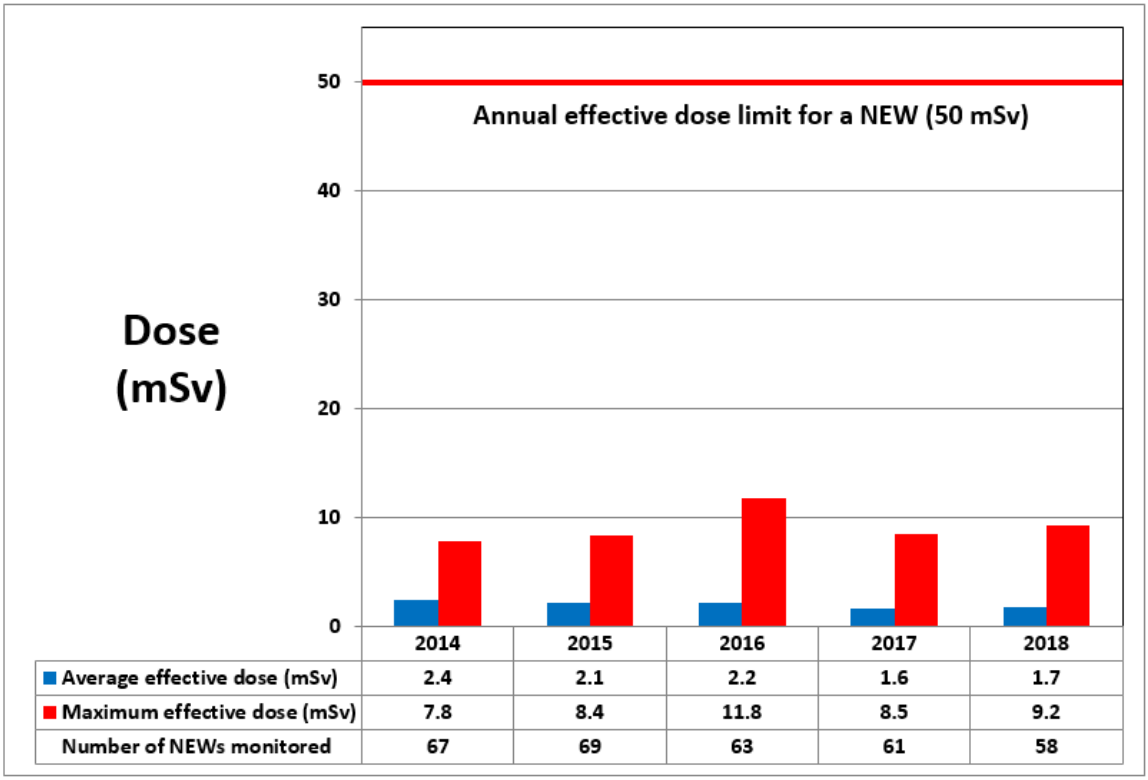
Worker dose control

Radiation exposures are monitored to ensure compliance with the CNSC's regulatory dose limits and to keep radiation doses ALARA. In 2018, no worker's radiation exposure exceeded the CNSC's regulatory dose limits.

BWXT's workers are exposed externally to UO_2 pellets. At the Toronto facility, workers have the potential to be exposed internally to UO_2 powder. External whole-body and equivalent doses are ascertained with the use of dosimeters. Internal dose is assessed and assigned at the BWXT Toronto facility through a uranium-in-air breathing zone monitoring program.

At both facilities, most employees are identified as NEWs. The maximum effective dose received by a NEW in 2018 at the Toronto facility was 9.2 mSv, or approximately 18% of the CNSC regulatory effective dose limit of 50 mSv in a one-year dosimetry period. Figure 6-3 provides the average and maximum effective doses to NEWs BWXT Toronto from 2014 to 2018.

Figure 6-3: Average and maximum effective doses to NEWs, BWXT Toronto, 2014–18

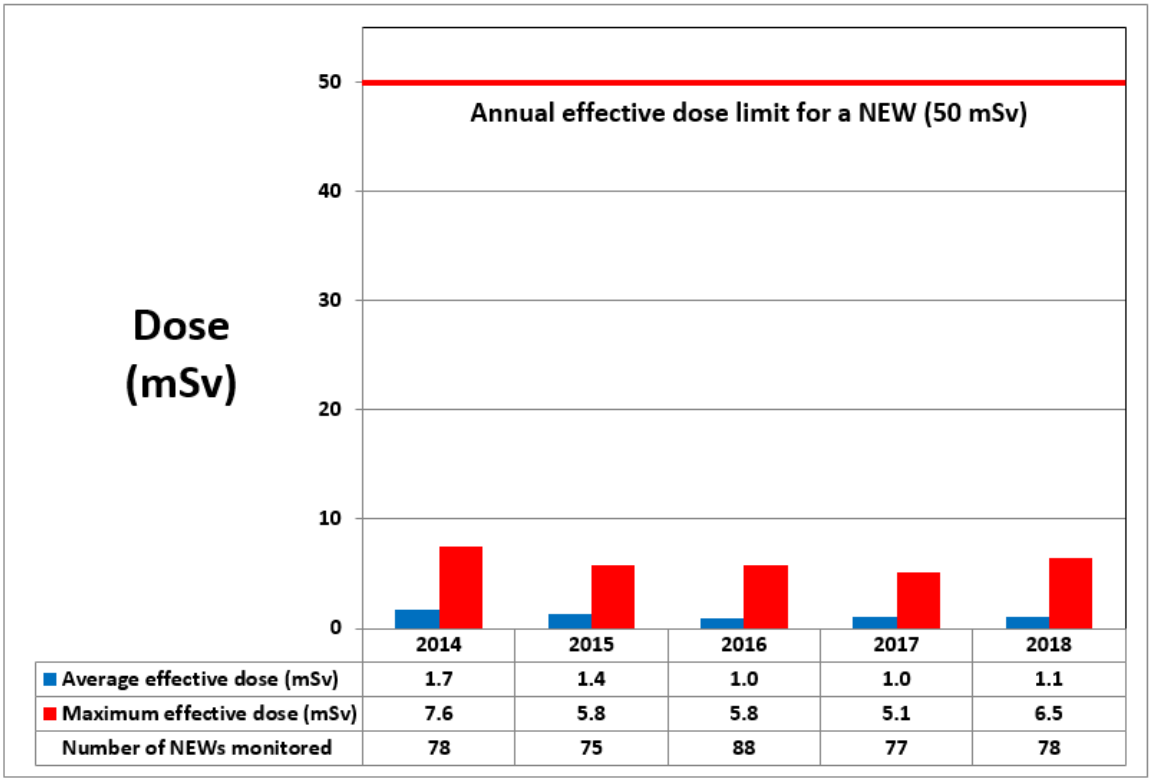


	2014	2015	2016	2017	2018
Average effective dose (mSv)	2.4	2.1	2.2	1.6	1.7
Maximum effective dose (mSv)	7.8	8.4	11.8	8.5	9.2
Number of NEWs monitored	67	69	63	61	58

The maximum effective dose received by a NEW in 2018 at the Peterborough facility was 6.5 mSv, or approximately 13% of the CNSC regulatory effective dose limit of 50 mSv in a one-year dosimetry period. Figure 6-4 provides the average and maximum effective doses to NEWs at BWXT Peterborough from 2014 to 2018.

Overall, average external whole-body doses have been trending downward at BWXT Peterborough. This has been due to ongoing efforts to improve ALARA awareness, as well as recent improvements to ergonomics and shielding for workers.

Figure 6-4: Average and maximum effective doses to NEWs, BWXT Peterborough, 2014–18



	2014	2015	2016	2017	2018
Average effective dose (mSv)	1.7	1.4	1.0	1.0	1.1
Maximum effective dose (mSv)	7.6	5.8	5.8	5.1	6.5
Number of NEWs monitored	78	75	88	77	78

Non-NEWs and contractors (who are all considered non-NEWs) are not directly monitored at either facility. Estimates of doses are based on in-plant radiological conditions and occupancy factors, to ensure that radiation doses are controlled well below the CNSC regulatory dose limit of 1 mSv/year for a person who is not a NEW.

Appendix E also shows annual average and maximum equivalent dose results from 2014 to 2018. In 2018, the maximum individual equivalent skin dose for both facilities was 58.36 mSv (Toronto, table E-10), while the maximum individual equivalent extremity dose was 83.33 mSv (Toronto, table E-3). These maximum individual equivalent doses are approximately 12% and 17%, respectively, of the CNSC regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period.

Over the past five years, average equivalent extremity and skin doses have been relatively stable at both facilities. The reason for the consistently lower skin doses (table E-11) and extremity doses (table E-4) at the Peterborough facility is the low likelihood of direct pellet handling, as opposed to the Toronto facility, where this practice is considered routine. At the Peterborough facility, except in the end cap welding station, all pellets are shielded in zirconium tubes, bundles or boxes.

Radiation protection program performance

In 2018, CNSC staff carried out various compliance verification activities to assess the performance of BWXT's radiation protection programs at the Toronto and Peterborough facilities. Overall, CNSC staff found BWXT's compliance with the

Radiation Protection Regulations [2] and the CNSC licence requirements to be acceptable.

Action levels for radiological exposures, urine analysis results and contamination control are established as part of the BWXT radiation protection programs. In 2018, there were no action level exceedances reported by BWXT for either facility.

Radiological hazard control

CNSC staff confirmed that BWXT has established radiation contamination controls at both facilities to control and minimize the spread of radioactive contamination. Methods of control include a radiation zone control program, as well as the use of surface contamination swipes to monitor contamination and confirm the effectiveness of the program. In 2018, the number of swipe locations remained relatively constant, and no adverse trends were identified in monitoring results at the facilities.

Estimated dose to the public

Table 6-1 shows the 2014 to 2018 annual effective doses to a member of the public for BWXT Toronto. BWXT Peterborough has consistently reported doses of 0 mSv to a member of the public from 2014 to 2018. Effective doses to the public were well below the CNSC regulatory dose limit of 1 mSv/year.

Table 6-1: Maximum effective dose to a member of the public, BWXT Toronto, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Maximum effective dose (mSv)	0.0055*	0.0101	0.0007	0.0175	0.0004	1 mSv/year

*In 2014, GEH-C Toronto implemented environmental gamma exposure monitoring by using licensed dosimeters and began to include this result in the estimated annual public dose.

6.3 Environmental protection

Compliance ratings for the environmental protection SCA, BWXT Nuclear Energy Canada's Toronto and Peterborough facilities, 2014–18

2014	2015	2016	2017	2018
FS	SA	SA	SA	SA
For 2018, CNSC staff continued to rate the environmental protection SCA at the BWXT facilities as "satisfactory." All uranium releases from BWXT facilities to the environment continued to be well below the regulatory limits. Fenceline gamma measurements, soil sampling and ambient air data indicate that the public and the environment continued to be protected from facility releases.				

FS = fully satisfactory; SA = satisfactory

Effluent and emissions control (releases)

Atmospheric emissions

To ensure compliance with licence limits, air from the BWXT facilities is filtered and sampled prior to its release into the atmosphere. In 2018, the annual releases of uranium from the BWXT facilities in Toronto and Peterborough were 0.00628 kg and 0.000002 kg, respectively. Table 6-2 provides BWXT's annual uranium emissions from both facilities from 2014 to 2018. The annual uranium emissions remained well below the licence limits for both facilities. The results demonstrate that air emissions of uranium were being controlled effectively at both BWXT facilities.

Table 6-2: Air emission monitoring results, BWXT, 2014–18

Parameter	2014	2015	2016	2017	2018	Licence limit
BWXT Toronto – Uranium discharged to air (kg/year)	0.0109	0.0108	0.0108	0.00744	0.00628	**0.76**
BWXT Peterborough – Uranium discharged to air (kg/year)	0.000003	0.000003	0.000004	0.000002	0.000002	**0.55**

kg = kilogram

In addition to licence limits, the two facilities have action levels that are used to provide assurance that licence release limits will not be exceeded. No action levels for atmospheric emissions were exceeded at any time in 2018.

Liquid effluent

To ensure compliance with licence limits, waste water from the BWXT Toronto and Peterborough facilities is collected, filtered and sampled prior to its release into sanitary sewers. In 2018, the annual releases of uranium from the facilities were 0.935 kg and 0.00001 kg, respectively. Table 6-3 provides BWXT's annual uranium effluent releases from both facilities for 2014 to 2018. In 2018, the releases continued to be well below the licence limit. The results demonstrate that liquid effluent releases were being controlled effectively.

Table 6-3: Liquid effluent monitoring results, BWXT, 2014–18

Parameter	2014	2015	2016	2017	2018	Licence limit
BWXT Toronto – Uranium discharged to sewer (kg/year)	0.72	0.39	0.65	0.941	0.935	**9,000**
BWXT – Peterborough Uranium discharged to sewer (kg/year)	0.0001	0.0001	0.00013	0.00003	0.00001	**760**

In addition to licence limits, BWXT Toronto and Peterborough have action levels that are used to provide assurance that licence release limits will not be exceeded. No action levels for liquid effluent releases were exceeded at any time in 2018.

Environmental management system

CNSC staff confirmed that BWXT has developed and is maintaining an environmental management system (EMS) that provides a framework for integrated activities for the protection of the environment at the BWXT facilities. BWXT's EMS is described in its Environmental Management Program Manual. It includes activities such as the establishment of annual environmental objectives and targets that CNSC staff review and assess through compliance verification activities. In 2018, BWXT met its objectives related to updating the chemical spill response plan, improving spill containment at the Berg chiller, completing one asbestos abatement project, reducing identified air leaks (greenhouse gases), reducing the chemical onsite inventory by 5% of the 2017 inventory, replacing three janitorial chemicals to environmentally friendly substitutes, and trialling new cleaning machines for decontamination of materials.

BWXT holds an annual safety meeting at which environmental protection issues are discussed and documented. CNSC staff review these documents, as part of their compliance verification activities, and follow up with BWXT staff on any outstanding issues. The results of these compliance verification activities demonstrate that, in 2018, BWXT conducted an annual management review in accordance with CNSC requirements and that identified issues were being addressed properly.

Assessment and monitoring

BWXT's environmental monitoring programs serve to demonstrate that the site emissions of radioactive and hazardous substances are properly controlled. The programs also provide data for estimates of annual radiological dose to the public to ensure that the public exposure attributable to BWXT's Toronto and Peterborough operations is well below the annual regulatory dose limit of 1 mSv and ALARA. The principal monitoring activities, described below, focus on the air and soil at BWXT Toronto, as well as gamma radiation around both sites.

In addition, the CNSC conducts periodic monitoring under its Independent Environmental Monitoring Program (IEMP) to verify that the public and the environment around nuclear facilities remain protected.

Uranium in ambient air

BWXT Toronto operates five high-volume air samplers to measure the airborne concentrations of uranium at points of impingement of stack plumes. The results from these samplers show that the annual average concentration of uranium (among the sampling stations) in ambient air measured around the facility in 2018 was below the minimum detection limit. This demonstrates that the results are well below the Ontario Ministry of the Environment, Conservation and Parks (MECP) standard for uranium in ambient air of 0.03 $\mu g/m^3$. Table F-11 of appendix F provides air monitoring results for BWXT Toronto.

BWXT Peterborough does not monitor uranium in ambient air because the atmospheric emissions discharged from the facility already meet the MECP standard of 0.03 $\mu g/m^3$ at the point of release, thus eliminating the need for additional ambient monitoring.

Soil monitoring

BWXT conducts soil sampling at its Toronto facility as part of its environmental program. In 2018, soil samples were taken from 49 locations and analyzed for uranium content. The samples were collected on the BWXT site, on commercial lands located along the south border of the site and in the nearby residential neighbourhood. In 2018, the measured soil concentration of uranium was below the respective 2017 data and well below the applicable CCME *Soil Quality Guidelines for the Protection of Environmental and Human Health* [9] for uranium for industrial, commercial and residential/parkland land use.

This data demonstrates that current BWXT operations do not contribute to the accumulation of uranium in surrounding soil, and that no adverse consequences to relevant human and environmental receptors are expected. Tables F-12, F-13 and F-14 of appendix F provide soil sampling results.

Gamma monitoring

A portion of radiological public dose from both the BWXT Toronto and Peterborough facilities is due to gamma radiation sources. Consequently, it is necessary to monitor gamma radiation effective dose rates at the fenceline of the Toronto site and at the Peterborough plant boundary to ensure that levels of potential gamma radiation exposure are maintained ALARA.

Since 2014, BWXT has used environmental dosimeters to measure the effective dose rates for gamma radiation for the Toronto site. The estimated effective dose as a result of gamma radiation during 2018 was 0 mSv, for a total estimated critical receptor dose of 0.00041 mSv when combined with the contribution from the air emissions. This is well below the regulatory dose limit of 1 mSv per year to a member of the public.

Since 2016, the gamma radiation effective dose rate for the BWXT Peterborough plant has also been measured with environmental dosimeters. The estimated

effective dose as a result of gamma radiation during 2018 was 0 mSv, for a total estimated critical receptor dose of 0 mSv when combined with the contribution from the air emissions. These estimates indicate that gamma dose rates from both BWXT facilities are controlled and that the public is protected.

CNSC Independent Environmental Monitoring Program

CNSC staff conducted independent environmental monitoring at the BWXT facilities in 2014, 2016 and 2018. The results are available on the CNSC's IEMP web page. The IEMP results indicate that the public and the environment surrounding the two BWXT facilities remain protected from facility emissions. An IEMP campaign for both sites was completed in May 2019.

Protection of the public

The licensee is required to demonstrate that adequate provision is made to protect the health and safety of the public from exposures to radiological and hazardous (non-radiological) substances released from the facility, as well as to physical stressors. The effluent and environmental monitoring programs that BWXT currently conducts are used to verify that releases of both types of substances do not result in environmental concentrations that may affect public health.

The CNSC receives reports of discharges to the environment in accordance with the reporting requirements outlined in the BWXT licence and LCH. CNSC staff's review and evaluation of radiological and hazardous discharges to the environment for BWXT in 2018 indicated that these discharges would not pose significant risks to the public or the environment during this period.

CNSC staff concluded, based on their review of these programs at the BWXT Toronto and Peterborough facilities, that the public continues to be protected from facility emissions.

Environmental risk assessment

CNSC staff use CSA standard N288.6-12, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills* [3], to help determine whether licensees are in compliance with regulatory requirements for protection of the environment and human health.

BWXT submitted ERAs for its facilities in Toronto and Peterborough in 2017. CNSC staff reviewed the BWXT ERAs and concluded that they are consistent with the overall methodology and in compliance with all the applicable requirements of CSA N288.6-12. CNSC staff concluded that the ERA conclusions and recommendations are valid; that is, that the risk from current BWXT operations in Toronto and Peterborough is very low. BWXT currently has acceptable environmental programs in place to ensure protection of the public and the environment.

In November 2018, BWXT submitted an ERA for nuclear fuel pellet operation in Toronto that may be consolidated with existing nuclear fuel assembly operations in Peterborough. This ERA was submitted in support of BWXT's licence renewal application. The ERA was prepared to identify potential health and ecological risks associated with the consolidation of the two BWXT facilities, as this would be a

significant change to the Peterborough operations. CNSC staff have reviewed this document and found that the BWXT ERA is compliant with all the applicable requirements of CSA N288.6-12.

CNSC staff determined that the BWXT ERA includes sufficient information to allow the CNSC to conclude with confidence that risks attributable to emissions of radiological and non-radiological substances from BWXT consolidated operations in Peterborough would be very low and, therefore, no adverse effects to human health and non-human biota would be expected.

In accordance with CSA N288.6-12, ERAs must be reviewed every five years – or more often, if there is a change in operations or scientific knowledge. Therefore, if BWXT proceeds with consolidating the activities of the Toronto facility into the Peterborough facility, an updated ERA would need to be completed within five years and include the new monitoring data.

6.4 Conventional health and safety

Compliance ratings for the conventional health and safety SCA, BWXT Nuclear Energy Canada's Toronto and Peterborough facilities, 2014–18

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA
For 2018, CNSC staff continued to rate the conventional health and safety SCA at BWXT Toronto and Peterborough as "satisfactory." Overall, compliance verification activities that CNSC staff conducted at the facility confirmed that BWXT continued to view conventional health and safety as an important consideration. BWXT has demonstrated a satisfactory ability to keep its workers safe from occupational injuries.				

SA = satisfactory

Performance

BWXT's performance related to conventional health and safety at BWXT Toronto and Peterborough is monitored by CNSC staff through onsite inspections and event reviews. In 2018, BWXT's conventional health and safety program incorporated various elements, such as an environmental health and safety (EHS) policy, hazard analysis and regulatory compliance, employee involvement, EHS specialist, accident/incident investigation, EHS training, housekeeping, personal protective equipment, contractor safety, emergency preparedness/response, risk assessments, high-risk operations, industrial hygiene, chemical management, ergonomics, and lock-out tag-out. BWXT conducts routine self-assessments and program evaluations to ensure compliance with several key performance indicators tracked under the oversight of the Workplace Safety Committee (WSC).

In 2018, Employment and Social Development Canada (ESDC) conducted a routine inspection at the Toronto facility to assess compliance with federal health and safety legislation. The governing legislation includes Part II of the *Canada Labour Code* and the *Canada Occupational Health and Safety Regulations*. As a

result of the inspection, six minor non-compliances were identified. The non-compliances were related to posting of required documents, contents of the Workplace Violence Prevention Policy, and electrical panel obstructions. All actions were assigned and tracked to closure in BWXT's Action Tracking System.

For 2018, the Toronto facility reported zero lost-time injuries (LTIs), 11 near-miss events, 13 first-aid responses and three recordable injuries. Of the 16 injuries, 11 involved an injury to the hand or arm. Six of the injuries were classed as "contact with a sharp object" and two were classed as "lifting, lowering, carrying, pushing, or pulling." The Peterborough facility reported zero LTIs, 17 near-miss events and 19 first aid responses. The most common categories were "rubbed/abraded," "falls same level," "lifting/lowering/carrying/pushing or pulling," and "struck by." Figure 6-2 shows details for both facilities.

Table 6-2: Lost-time injury statistics, BWXT Toronto and Peterborough, 2014–18

	2014	2015	2016	2017	2018
BWXT Toronto					
LTIs[1]	1	0	0	0	0
Severity rate[2]	3.55	0	0	0	0
Frequency rate[3]	1.77	0	0	0	0
BWXT Peterborough					
LTIs[1]	0	0	0	0	0
Severity rate[2]	0	0	0	0	0
Frequency rate[3]	0	0	0	0	0

1 An LTI is an injury that takes place at work and results in the worker being unable to return to work for a period of time.
2 The accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
3 The accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

Practices

CNSC staff confirmed that in 2018 BWXT continued to comply with the NSCA [1] and its associated regulations, and with Part II of the *Canada Labour Code* [5]. BWXT also maintained four committees under its conventional health and safety program: the Health and Safety Policy Committee, the WSC, the Beryllium Safety Committee and the Ergonomics Committee.

At its Toronto facility, BWXT conducted a combined total of 41 investigations and inspections in accordance with its health and safety program. This activity included WSC inspections; manager inspections; and near-miss, incident and injury investigations. These investigations and inspections led to 151 actions being identified and tracked to closure. The most common finding categories from WSC

inspections at the Toronto facility were housekeeping, unsafe condition, chemical, electrical, and personal protective equipment.

At its Peterborough facility, BWXT conducted a combined total of 39 investigations and inspections, in accordance with its health and safety program. This activity included WSC inspections; manager inspections; and near-miss, incident and injury investigations. These investigations and inspections led to 178 actions logged and tracked to closure. The most common finding categories from WSC inspections at the Peterborough facility were housekeeping, policies/procedures/written programs, emergency equipment, walking/working surfaces, and chemical management.

BWXT management regularly reviews performance metrics for each facility, and these metrics are summarized in the licensee's annual compliance report. CNSC staff reviewed health and safety documentation to verify that any identified issues related to health and safety in 2018 were promptly resolved.

Awareness

BWXT provides training on areas such as mental health for supervisors; lockout/tagout awareness; spill response; accident investigation; radiation protection manual – area classification; radiation protection manual – waste and transport; environmental; radiation safety officer; and emergency preparedness and fire prevention. BWXT's internal compliance with regulatory training completion is a key performance indicator that is tracked throughout the year.

In 2018, BWXT updated its chemical management programs and associated labelling systems, performed site-wide chemical sweeps, and revised education and training programs in consultation with the WSCs to meet the requirements of Workplace Hazardous Material Information System (WHMIS) 2015.

Through ongoing regulatory oversight activities, CNSC staff determined that BWXT continued to maintain a safe working environment at its Toronto and Peterborough facilities and that BWXT has demonstrated a satisfactory ability to keep its workers safe from occupational injuries.

Part II: Nuclear substance processing facilities

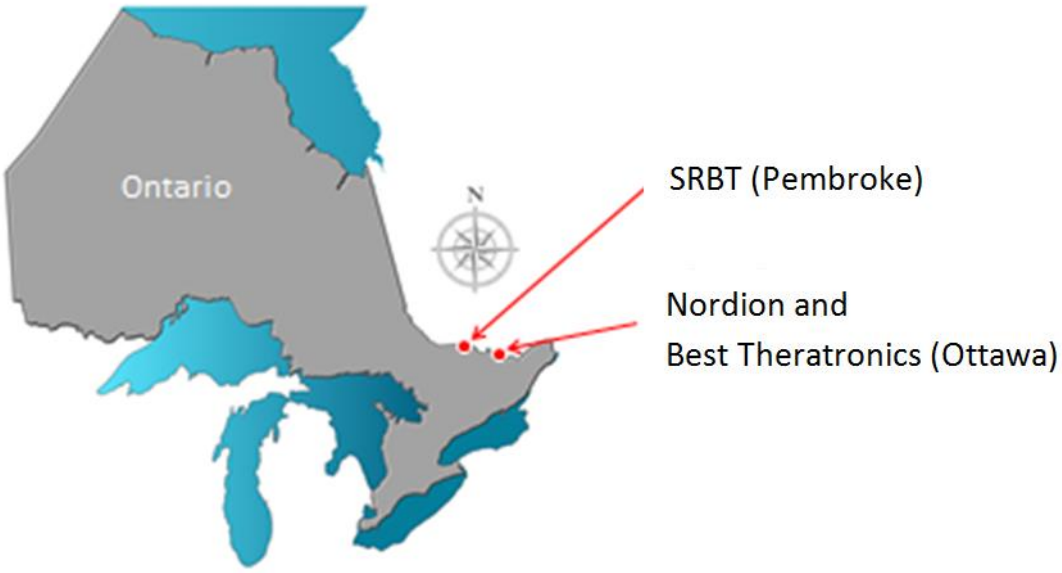
7 Overview

Nuclear substance processing facilities process nuclear substances for a variety of end uses in industrial or medical applications. The nuclear substances can be used for lighting self-luminous emergency and exit signs, sterilizing items for sanitary reasons such as surgical gloves, and providing cancer diagnosis and treatment. This part of the report outlines the performance of three nuclear substance processing facilities in Canada, all of which are located in Ontario:

- SRB Technologies (Canada) Inc. (SRBT) in Pembroke
- Nordion (Canada) Inc. (Nordion) in Ottawa
- Best Theratronics Ltd. (BTL) in Ottawa

All three facilities are shown in figure 7-1. SRBT's licence was issued in July 2015 and expires in June 2022. Nordion's licence was issued in November 2015 and expires in October 2025. BTL's licence was issued in June 2019 and expires in June 2029.

Figure 7-1: Location of nuclear substance processing facilities in Ontario, Canada



CNSC staff conducted risk-informed regulatory oversight activities at each nuclear substance processing facility in 2018. Table 7-1 presents the licensing and compliance verification efforts from CNSC staff for these facilities throughout the year.

Table 7-1: CNSC regulatory oversight licensing and compliance verification activities, nuclear substance processing facilities, 2018

Facility	Number of onsite inspections	Person-days for compliance verification activities	Person-days for licensing activities	Number of safeguards inspections led by IAEA*
SRBT	2	57	2	0
Nordion	2	181	24	0
BTL	1	82	85	0

*International Atomic Energy Agency

In 2018, CNSC staff conducted five onsite inspections at the above nuclear substance processing facilities. All the findings resulting from these inspections were shared with the licensees as part of detailed inspection reports. All resulting regulatory enforcement actions were recorded in the CNSC's Regulatory Information Bank to ensure they would be tracked to completion. Appendix K lists the CNSC inspections conducted for each facility in 2018. All instances of non-compliances identified were of low safety significance. Safety significance is determined based on comparison with criteria developed and used in the CNSC Regulatory Information Bank, as provided in appendix L.

In accordance with their respective licences and LCHs, all nuclear substance processing facility licensees must submit annual compliance reports on the operations of their facilities by March 31 every year. These reports to the CNSC must contain all environmental, radiological and safety-related information, including any events and the associated corrective actions taken. CNSC staff review these reports as part of routine regulatory compliance oversight (for example, desktop reviews) to verify that licensees are complying with regulatory requirements and are operating safely. The full versions of these reports are available on the licensees' websites, as listed in appendix I of this report.

Table 7-2 presents the SCA performance ratings for these nuclear substance processing facilities. For 2018, CNSC staff rated all but four SCAs as "satisfactory." The exceptions were:

- SRBT's performance in the fitness for service and the conventional health and safety SCAs, which were rated as "fully satisfactory"
- Nordion's performance for the environmental protection and security SCAs, which were rated as "fully satisfactory"

Additional information about these SCA ratings can be found in the facility-specific sections. Appendix C contains the SCA ratings from 2014 to 2018 for each of the three facilities.

Table 7-2: SCA performance ratings, nuclear substance processing facilities, 2018

SCA	SRBT	Nordion	BTL
Management system	SA	SA	SA
Human performance management	SA	SA	SA
Operating performance	SA	SA	SA
Safety analysis	SA	SA	SA
Physical design	SA	SA	SA
Fitness for service	FS	SA	SA
Radiation protection	SA	SA	SA
Conventional health and safety	FS	SA	SA
Environmental protection	SA	FS	SA
Emergency management and fire protection	SA	SA	SA
Waste management	SA	SA	SA
Security	SA	FS	SA
Safeguards and non-proliferation	N/A*	SA	SA
Packaging and transport	SA	SA	SA

FS = fully satisfactory; N/A = not available; SA = satisfactory

*There are no safeguard verification activities associated with this facility.

The CNSC requires licensees to develop and maintain preliminary decommissioning plans for each of their respective facilities. CNSC staff review and approve each plan, which is accompanied by a financial guarantee that provides the necessary funding to conduct the future decommissioning activities. In accordance with the NSCA, the financial guarantees must be acceptable to the

Commission. Appendix D lists the current financial guarantee amounts for each facility discussed in this report.

7.1 Radiation protection

The radiation protection SCA covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations* [2]. The program must ensure that contamination levels and radiation doses received by individuals are monitored, controlled and maintained ALARA.

The radiation protection SCA encompasses the following specific areas:

- application of ALARA
- worker dose control
- radiation protection program performance
- radiological hazard control
- estimated dose to the public

Based on regulatory oversight activities, CNSC staff rated the performance of the nuclear substance processing facilities for the radiation protection SCA as "satisfactory" in 2018, unchanged from the previous year.

Ratings for the radiation protection SCA, nuclear substance processing facilities, 2018

SRBT	Nordion	BTL
SA	SA	SA

SA = satisfactory

Application of ALARA

CNSC staff confirmed that in 2018, the nuclear substance processing facility licensees continued to implement radiation protection measures to keep radiation exposures and doses to persons ALARA. The CNSC's requirement for licensees to follow the ALARA principle has consistently resulted in these doses staying well below regulatory dose limits.

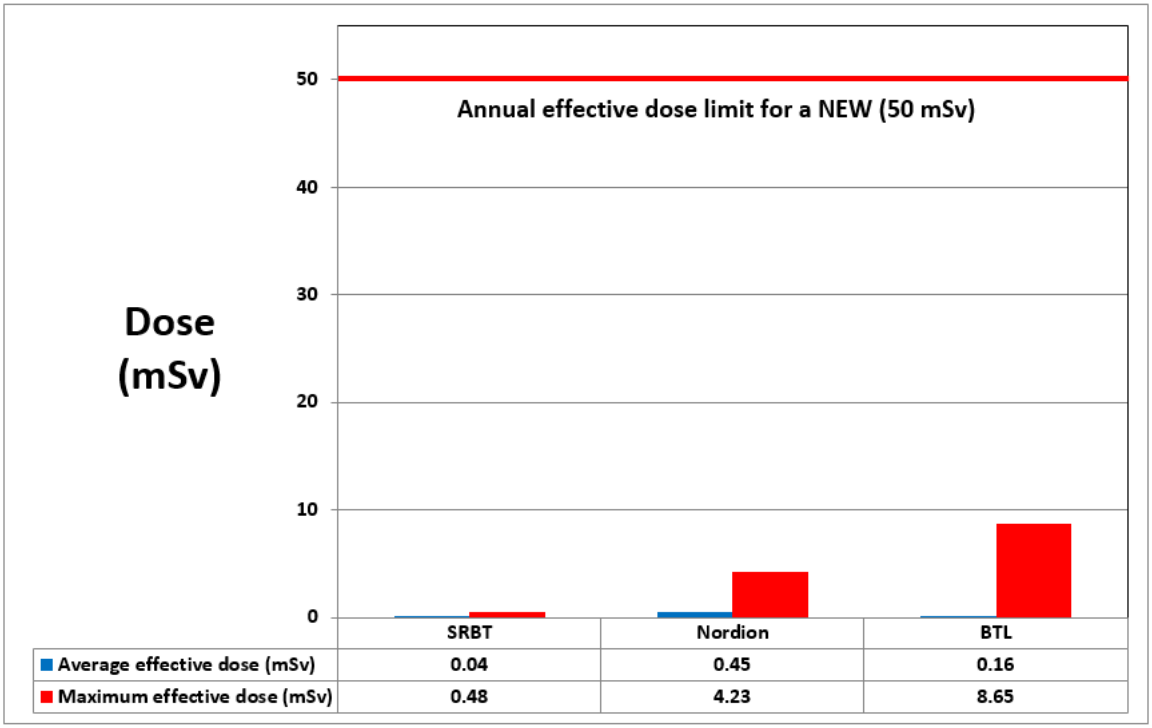
Worker dose control

The design of radiation protection programs includes the dosimetry methods and the determination of workers who are identified as nuclear energy workers (NEWs). These designs vary, depending on the radiological hazards present and the expected magnitude of doses received by workers. The dose statistics provided in this report are primarily for NEWs, with the inherent differences in the design of radiation protection programs among licensees taken into consideration. Additional information on the total number of monitored persons, including workers, contractors and visitors, is provided in the facility-specific sections.

Figure 7-2 shows the maximum and average effective doses for NEWs at nuclear substance processing facilities. In 2018, the maximum individual effective dose

received by a NEW at all facilities ranged from 0.48 millisieverts (mSv) to 8.65 mSv, well below the regulatory dose limit of 50 mSv in any one year and 100 mSv in five consecutive years for a NEW. These results are further discussed in the facility-specific sections.

Figure 7-2: Average and maximum effective doses to NEWs, nuclear substance processing facilities, 2018



CNSC staff confirmed that in 2018 all nuclear substance processing facility licensees monitored and controlled the radiation exposures and doses received by all persons present at their licensed facilities, including workers, contractors and visitors. Direct comparison of doses to NEWs among facilities does not necessarily provide an appropriate measure of a licensee's effectiveness in implementing its radiation protection program, since radiological hazards differ across these facilities due to complex and varying work environments.

Radiation protection program performance

CNSC staff conducted regulatory oversight activities at all nuclear substance processing facilities in 2018 to verify that the licensees' radiation protection programs complied with regulatory requirements. These oversight activities included onsite inspections, desktop reviews, and compliance verification activities specific to radiation protection. Through these activities, CNSC staff confirmed that all these licensees have effectively implemented their radiation protection programs to control exposures to workers and keep doses ALARA.

Action levels

Action levels for radiological exposures are established as part of the licensees' radiation protection programs. Each licensee is responsible for identifying the

parameters of its own program(s) to represent timely indicators of potential losses of control of the program(s). These licensee-specific action levels may also change over time, depending on operational and radiological conditions.

If an action level is reached, it triggers the licensee to determine the cause, notify the CNSC and, if applicable, take corrective action to restore the effectiveness of the radiation protection program. It is important to note that occasional action level exceedances indicate that the established action level is likely an adequately sensitive indicator of a potential loss of control of the program.

It is possible that action levels which are never exceeded have not been established low enough to detect the emergence of a potential loss of control. For this reason, licensee performance is not evaluated solely on the number of action level exceedances in a given period, but rather on how the licensee responds and implements corrective actions to enhance its program performance and to prevent reoccurrence.

In 2018, there was one radiological action level exceedance across all three licensees. The exceedance was at the BTL facility and is further discussed in section 10.2. BTL reported the exceedance to the CNSC in accordance with its reporting requirements, investigated the exceedance, and established corrective actions to the satisfaction of CNSC staff.

Radiological hazard control

CNSC staff verified that, in 2018, all nuclear substance processing facility licensees continued to implement adequate measures to monitor and control radiological hazards in their facilities. These measures included delineation of zones for contamination control purposes and, for certain facilities, in-plant air-monitoring systems. Licensees demonstrated that they have implemented workplace monitoring programs to protect workers. The licensees have also demonstrated that levels of radioactive contamination were controlled within their facilities throughout the year.

Estimated dose to the public

The maximum dose to the public resulting from licensed activities at the SRBT facility in Pembroke is based on radiation monitoring results, while the maximum dose to the public from licensed activities at the Nordion facility in Ottawa is calculated from derived release limits (DRLs). A DRL is the release rate that would cause an individual of the most highly exposed group to receive and be committed to a dose equal to the regulatory annual dose limit due to release of a given radionuclide to air or surface water during normal operation of a nuclear facility over the period of a calendar year. The CNSC's requirement for following the ALARA principle means that licensees must monitor their facilities and keep doses to the public below the annual public dose limit of 1 mSv/year. Since BTL's licensed activities involve sealed sources and there are no airborne or liquid radiological releases to the environment, public dose estimates are not provided for BTL.

Table 7-3 compares the estimated public doses from 2014 to 2018 for the three licensees. Estimated doses to the public from these licensees continued to be well below the regulatory annual public dose limit of 1 mSv/year.

Table 7-3: Public dose comparison table (mSv), nuclear substance processing facilities, 2014–18

Facility	Year					Regulatory limit
	2014	2015	2016	2017	2018	
SRBT	0.0067	0.0068	0.0046	0.0033	0.0038	**1 mSv/year**
Nordion	0.010	0.0056	0.0021	0.000052	0.000067	
BTL	N/A	N/A	N/A	N/A	N/A	

N/A = not available; mSv = millisievert

Conclusion on radiation protection

CNSC staff concluded that throughout 2018 the nuclear substance processing facility licensees effectively implemented and maintained their radiation protection programs, to ensure the health and safety of persons working in their facilities.

7.2 Environmental protection

The environmental protection SCA covers programs that identify, control and monitor all releases of radioactive and hazardous substances, and the effects on the environment from facilities or as a result of licensed activities.

It encompasses the following specific areas:

- effluent and emissions control (releases)
- environmental management system
- assessment and monitoring
- protection of the public
- environmental risk assessment

Based on regulatory oversight activities, CNSC staff rated the performance for the environmental protection SCA as “satisfactory” in 2018 for all but one of the nuclear substance processing facilities. The exception was Nordion, which was given a “fully satisfactory” rating. These ratings remain unchanged from the previous year.

Ratings for the environmental protection SCA, nuclear substance processing facilities, 2018

SRBT	Nordion	BTL
SA	FS	SA

FS = fully satisfactory; SA = satisfactory

Effluent and emissions control (releases)

To control the release of radioactive and hazardous substances into the environment, CNSC licensees are required to develop and implement policies, programs and procedures that comply with all applicable federal and provincial environmental protection regulations. Licensees are also expected to have trained and qualified personnel to effectively develop, implement and maintain their environmental protection programs.

The CNSC imposes licence limits on controlled releases to the environment to demonstrate respect for the principle of pollution prevention and to ensure protection of the public and environment. Exceedance of a licence limit is a non-compliance and considered to represent a loss of control of part of the licensee's program(s) and/or control measure(s). Exceedance does not necessarily indicate harm to health or the environment. This is because limits are often established at levels well below those expected to cause harm. There were no licence limit exceedances in 2018 for the nuclear substance processing sector. Appendix G provides information on the total annual release of relevant facility-specific radionuclides in emissions to the atmosphere and in effluent released to surface waters.

Action levels

Further controls on releases of radioactive and hazardous substances at licensed facilities involve the use of action levels. These specific doses of radiation and other parameters that make up the action levels are proposed by the licensee for each facility and approved by the CNSC. These levels are used to ensure that licensees demonstrate adequate control and oversight of each of their facilities based on the CNSC-approved facility design and environmental protection program.

Action levels serve to provide assurance that licence limits, described in the previous subsection, will not be exceeded. If an action level is exceeded by a facility, this provides early indication of a potential reduction in the effectiveness of the program(s) and/or control measure(s) and may indicate a deviation from normal operation. An exceedance also triggers a requirement for notification to the CNSC and specific action to be taken as outlined in the licensee's environmental protection program.

It is important to note that occasional action level exceedances indicate that the action level chosen is likely an adequately sensitive indicator of a potential loss of control of the program. Indeed, occasional exceedance of an action level and the successful implementation of the required follow-up activities (notification, investigation and implementation of any applicable corrective actions) clearly

demonstrate due diligence and well-maintained and well-managed environmental protection program(s) and/or control measure(s). However, failure to inform the CNSC, complete an investigation or implement any applicable corrective action would be a non-compliance.

Action level exceedances and their resulting investigation are discussed within the facility-specific sections of this report. These were all appropriately reported, evaluated and addressed to the satisfaction of CNSC staff.

Environmental management system

The CNSC requires each licensee to develop and maintain an environmental management system (EMS) that provides a framework for integrated activities related to environmental protection. EMSs are described in environmental management programs and include activities such as the establishment of annual environmental objectives, goals and targets. Licensees conduct internal audits of their programs at least once a year. CNSC staff, as part of their compliance verification activities, review and assess these objectives, goals and targets. CNSC staff determined that, in 2018, the nuclear substance processing facility licensees established and implemented their EMSs in compliance with the CNSC regulatory requirements.

Assessment and monitoring

CNSC staff verify that each nuclear substance processing facility licensee has environmental monitoring programs at each of its facilities to monitor releases of radioactive and hazardous substances, and to characterize the quality of the environment associated with the licensed facility.

Protection of the public

The CNSC requires licensees to demonstrate that the health and safety of the public are protected from exposures to radiological and hazardous (non-radiological) substances released from their facilities. Licensees use effluent and environmental monitoring programs to verify that releases of both types of substances do not result in environmental concentrations that may affect public health. CNSC staff receive reports of discharges to the environment in accordance with reporting requirements outlined in the licence and the LCH. Based on assessments of the programs at the nuclear substance processing facilities, CNSC staff concluded that the public continues to be protected from facility emissions of radiological and hazardous substances.

Environmental risk assessment

Licensees develop environmental risk assessments (ERAs) to analyze the risks associated with contaminants in the environment as a result of licensed activities. ERAs provide the basis for the scope and complexity of environmental monitoring programs at the nuclear substance processing facilities.

CNSC staff use CSA standard N288.6-12, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills*, to help determine whether licensees are in compliance with regulatory requirements for protection of the environment and human health. CSA N288.6-12 specifically states: “Facility ERAs

should be reviewed on a five-year cycle or more frequently if major facility changes are proposed that would trigger a predictive assessment." CNSC staff expect licensees to periodically review ERAs for their facilities, as appropriate.

Conclusion on environmental protection

CNSC staff concluded that the nuclear substance processing facility licensees implemented their environmental protection programs satisfactorily during 2018. The licensees' programs are effective in protecting the health and safety of the public and the environment.

7.3 Conventional health and safety

The conventional health and safety SCA covers the implementation of a program to manage workplace safety hazards and to protect workers.

It encompasses the following specific areas:

- performance
- practices
- awareness

Based on regulatory oversight activities, CNSC staff rated the performance of all but one of the nuclear substance processing facilities for the conventional health and safety SCA as "satisfactory" in 2018. The exception was SRBT, which was given a "fully satisfactory" rating.

Ratings for the conventional health and safety SCA, nuclear substance processing facilities, 2018

SRBT	Nordion	BTL
FS	SA	SA

SA = satisfactory

Performance

Employment and Social Development Canada (ESDC) and the CNSC regulate conventional health and safety programs at nuclear substance processing facilities. Licensees submit hazardous-occurrence investigation reports to both ESDC and the CNSC, in accordance with their respective reporting requirements. CNSC staff monitor compliance with regulatory reporting requirements and, when a concern is identified, consult with ESDC staff.

Licensees are required to report to the CNSC as directed by section 29 of the *General Nuclear Safety and Control Regulations* [4]. These reports include serious illnesses or injuries incurred or possibly incurred as a result of a licensed activity.

A key performance measure for the conventional health and safety SCA is the number of LTIs that occur per year. An LTI is an injury that takes place at work and results in the worker being unable to return to work to carry out their duties for a period of time. Table 7-4 summarizes the number of recordable LTIs reported by

nuclear substance processing facilities from 2014 to 2018. Further information is provided in facility-specific sections, as well as appendix H, which lists all LTIs reported in 2018 and the actions taken.

Table 7-4: LTIs at nuclear substance processing facilities, 2014–18

Facility	2014	2015	2016	2017	2018
SRBT	0	0	0	3	0
Nordion	3	0	3	1	0
BTL	1	1	3	1	2

Practices

Licensees are responsible for developing and implementing conventional health and safety programs for the protection of their workers. These programs must comply with Part II of the *Canada Labour Code* [5].

CNSC staff conducted desktop reviews and onsite inspections at all nuclear substance processing facilities during 2018 to verify compliance of the licensees' conventional health and safety programs with regulatory requirements. CNSC staff determined, based on these regulatory oversight activities, that these licensees met all regulatory requirements for this specific area.

Awareness

Licensees are responsible for ensuring that workers have the knowledge to identify workplace hazards and take the necessary precautions to protect against these hazards. This is accomplished through training and ongoing internal communications with workers.

During onsite inspections, CNSC staff verify that workers are trained to identify hazards at the facilities. CNSC staff confirmed that the nuclear substance processing facilities have effectively implemented their conventional health and safety programs to keep workers safe.

Conclusion on conventional health and safety

CNSC staff concluded that the nuclear substance processing facility licensees implemented their conventional health and safety programs satisfactorily throughout 2018. The programs are effective in protecting the health and safety of persons working in these facilities.

7.4 Regulatory developments

In 2018, no amendments were made to the SRBT, Nordion and BTL licences. The CNSC continued to modernize the regulatory framework with its REGDOC series of regulatory and guidance documents. Table 7-5 lists the updates made since 2016 to the CNSC regulatory documents that apply to the nuclear substance processing facilities licensees; the table includes the implementation status.

Table 7-5: Regulatory documents applicable to nuclear substance processing facilities

Regulatory document	Version	SRBT	Nordion	BTL
REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*	February 2016	Implemented	Implemented	Implemented
REGDOC-2.2.2, *Personnel Training*	December 2016	Implemented	Implemented	Implemented
REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures*	April 2017	Implementation plans expected in 2019	Implementation plans expected in 2019	Implementation expected by December 2020
REGDOC-3.1.2, *Reporting Requirements, Volume I: Non-Power Reactor Class I Nuclear Facilities and Uranium Mines and Mills*	January 2018	Implemented	Implemented	Implemented
REGDOC-2.13.1, *Safeguards and Nuclear Material Accountancy*	February 2018	N/A	Implemented	Implemented
REGDOC-2.1.2, *Safety Culture*	April 2018	Implemented	Implemented	Implementation expected by December 2020
REGDOC-3.2.1, *Public Information and Disclosure*	May 2018	Implementation plans expected in 2019	Implementation plans expected in 2019	Implementation expected by December 2020

N/A = not applicable

CNSC staff are updating the LCHs for each nuclear substance processing facility to reflect these regulatory documents, taking into consideration licensees' implementation plans. CNSC staff verify the implementation as part of ongoing compliance verification activities.

7.5 Public information and outreach

Nuclear substance processing facility licensees are required to maintain and implement public information and disclosure programs, in accordance with regulatory document REGDOC-3.2.1, *Public Information and Disclosure* [6] (which replaced regulatory/guidance document RD/GD-99.3 in 2018). These programs are supported by disclosure protocols that outline the type of facility information to be shared with the public as well as details on how that information is to be shared. This ensures that timely information about the health, safety and security of persons and the environment, and other issues associated with the lifecycle of nuclear facilities, is effectively communicated to the public.

In 2018, CNSC staff evaluated licensees' implementation of their public information and disclosure programs by reviewing the communications activities they conducted. CNSC staff determined that all nuclear substance processing facility licensees were in compliance with requirements and that they issued information in accordance with their public disclosure protocols.

The facility-specific performance sections below outline more detailed engagement activities and information shared with the public.

8 SRB Technologies (Canada) Inc.

SRB Technologies (Canada) Inc. (SRBT) operates a Class IB facility manufacturing gaseous tritium light source (GTLS) on the outskirts of Pembroke, Ontario, located approximately 150 km northwest of Ottawa. The nuclear facility has been in operation since 1990 and employs approximately 43 employees. In 2015, the Commission renewed the SRBT facility's operating licence. This licence (NSPFOL-13.00/2022) will expire in June 2022. An aerial view of the SRBT facility in Pembroke is shown in figure 8-1.

Figure 8-1: Aerial view of the SRBT facility

The SRBT facility processes tritium gas (HT) to produce sealed glass capsules coated with phosphorescent powder and filled with HT to generate continuous light. Examples of such GTLS include signs, markers and tactical devices. SRBT distributes its products in Canada and internationally. Figure 8-2 shows examples of GTLS exit signs and other markers manufactured at the facility.

Figure 8-2: GTLS signs and markers manufactured at the SRBT facility

8.1 Overall performance

For 2018, CNSC staff rated SRBT's performance in all but two of the safety and control areas (SCAs) as "satisfactory." The exceptions were the fitness for service and the conventional health and safety SCAs, which were rated as "fully satisfactory." SRBT has implemented highly effective measures for both SCAs. For example, SRBT performs preventive maintenance activities according to its maintenance plan, tracks corrective maintenance and identifies trends. No safety-significant equipment failures occurred at the facility; this indicates the effectiveness of SRBT's maintenance program. In addition, SRBT maintains an effective Workplace Health and Safety Committee, and promptly addresses and reports any arising problems in accordance with regulatory requirements. Table C-5 of appendix C provides the SRBT performance ratings for all SCAs from 2014 to 2018.

At the public hearing for the renewal of SRBT's operating licence in 2015, the Commission requested that CNSC staff include more detailed information about not only the number of shipments, but also the volume of processed material, as well as the number of received signs, and the quantity of these amounts that had been directed to waste [12]. In 2018, SRBT processed 31,251,329 gigabecquerels (GBq) of tritium, resulting in 948 shipments of self-luminous products to customers in 22 countries, including Canada. The facility also receives expired self-luminous products for reuse and disposal. In 2018, the facility received 518 consignments composed of returned devices, which contained 3,691 terabecquerels (TBq) of tritium activity. The majority of returned devices are sent to a licensed waste management facility at Canadian Nuclear Laboratories (CNL) in Chalk River, while a small number are reused in other applications. In 2018, a total of 4,488.40 TBq of tritium activity from expired GTLS was transferred as low-level waste material, which represents a decrease of 18.27 TBq compared with the quantity transferred in 2017.

In 2018, CNSC staff conducted two inspections at the SRBT facility to ensure compliance with the NSCA [1] and its associated regulations, the SRBT operating licence and the programs used to meet regulatory requirements. Table K-5 of

appendix K lists these inspections. The inspections focused on the security SCA and the packaging and transport SCA. One notice of non-compliance was raised as a result of these inspections. CNSC staff reviewed and were satisfied with the corrective actions taken by SRBT, and closed all actions.

SRBT reported one event in 2018 to the CNSC, in accordance with regulatory reporting requirements. In February 2018, SRBT notified the CNSC of an error in classification of a shipment made to CNL. SRBT had offered a package for transport that contained a Type B quantity of tritium in a package categorized as Type A (UN 2915). The package used for this shipment was a Type B package, so the actual quantity was within the limit of the package as assembled and tested. The shipment took place without any incident and there was no impact to the public or the environment as a result of this event. CNSC staff reviewed and accepted SRBT's corrective actions in response to this event and considers it closed.

SRBT maintained its commitment to having open and transparent communication with its key audiences by continuing to conduct quarterly sampling from public wells and providing the results directly to the public. Communications products related to environmental findings, as well as general facility information, were updated. SRBT provided facility tours to members of the public and stakeholders. CNSC staff are satisfied that the licensee is in full compliance with regulatory requirements for public information and disclosure.

CNSC staff are satisfied, based on their compliance verification activities, that SRBT continued to operate the tritium processing facility safely throughout 2018 and made no significant changes to the processes that affect the safe operation of the facility. There were no exceedances of action levels at the SRBT facility in 2018.

8.2 Radiation protection

Compliance ratings for the radiation protection SCA, SRB Technologies (Canada) Inc., 2014–18

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA
For 2018, CNSC staff continued to rate the radiation protection SCA at SRBT as "satisfactory." The facility has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations* [2]. At this facility, tritium is handled in the form of tritium gas, which presents an internal radiological hazard to workers through ingestion, inhalation, and absorption through the skin. This radiological hazard was effectively controlled at the facility. As a result, radiation doses to workers and members of the public were kept well below the CNSC regulatory dose limits.				

SA= satisfactory

Application of ALARA

In 2018, SRBT continued to implement radiation protection measures at its facility to keep radiation exposures and doses to persons ALARA. Due to good and stable performance against internal dose targets, SRBT has once again lowered its targets for maximum and average doses to workers for 2019, even though production has increased.

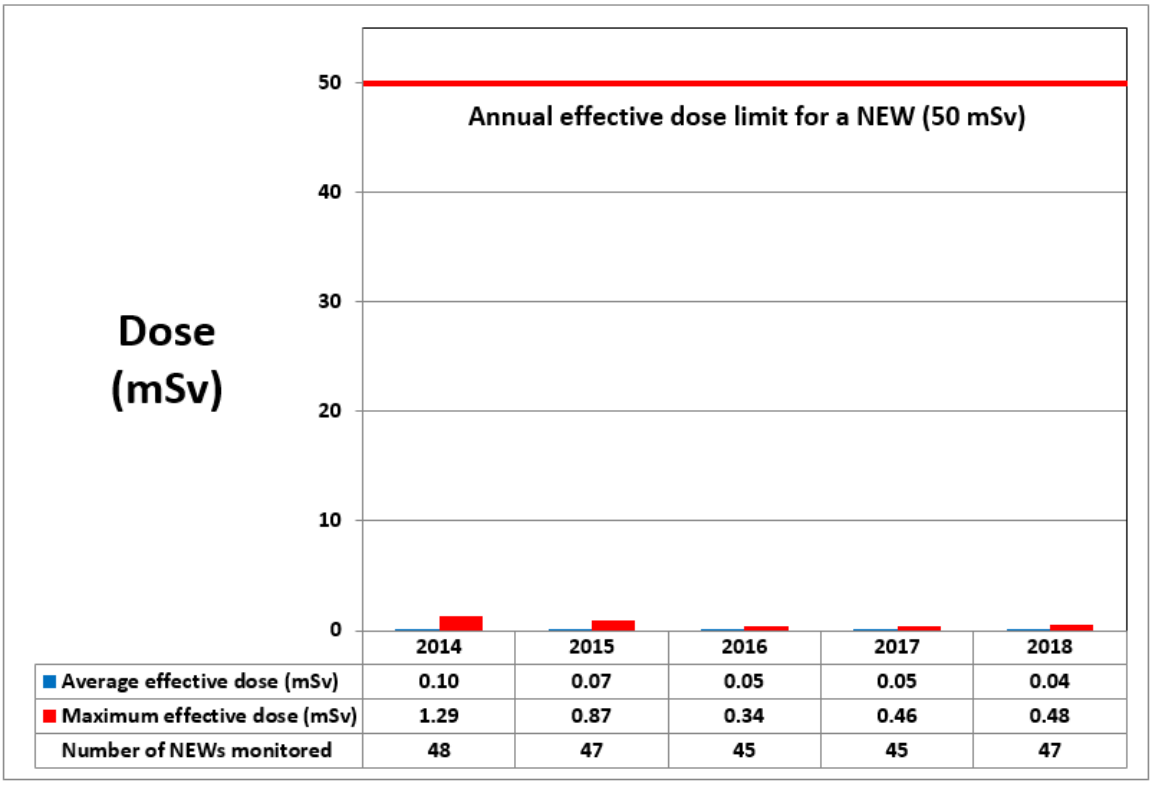
Worker dose control

Inhalation, ingestion and absorption of tritium are the main radiological hazards to SRBT workers. SRBT ascertains internal tritium exposures through a urine analysis program that is part of its CNSC-licensed internal dosimetry service.

All workers employed at SRBT are identified as NEWs. In 2018, none of the radiation exposures reported by SRBT for NEWs exceeded the CNSC's regulatory dose limits. The maximum effective dose received by a NEW in 2018 was 0.48 mSv, approximately 1% of the CNSC regulatory effective dose limit of 50 mSv in a one-year dosimetry period.

Figure 8-3 provides the average and maximum effective doses to NEWs at SRBT from 2014 to 2018. Overall, there has been a downward trend in the average effective doses and maximum effective doses at SRBT, demonstrating SRBT's continued improvements to its radiation protection program.

Figure 8-3: Average and maximum effective doses to NEWs, SRBT, 2014–18



	2014	2015	2016	2017	2018
Average effective dose (mSv)	0.10	0.07	0.05	0.05	0.04
Maximum effective dose (mSv)	1.29	0.87	0.34	0.46	0.48
Number of NEWs monitored	48	47	45	45	47

Due to the uniform distribution of tritium in body tissues, equivalent skin doses are essentially the same as the effective whole-body dose and are therefore not

reported separately. For this same reason, extremity doses are not separately monitored for workers at SRBT.

While contractors are not generally identified as NEWs, since they do not perform radiological work, their radiological exposures are monitored while they are at the SRBT facility to ensure that their doses remain ALARA and below the CNSC regulatory dose limit of 1 mSv/year for a person who is not a NEW. In 2018, no contractors received a recordable dose that resulted from work activities performed at the facility.

Radiation protection program performance

In 2018, CNSC staff carried out various compliance verification activities to assess the performance of SRBT's radiation protection program. Overall, CNSC staff found SRBT's compliance with the *Radiation Protection Regulations* [2] and the CNSC licence requirements to be acceptable.

Action levels for effective doses to workers and urine bioassays are established as part of SRBT's radiation protection program. In 2018, there were no action level exceedances reported by SRBT.

Radiological hazard control

CNSC staff confirmed that SRBT has radiation and contamination control programs to control and minimize radiological hazards and the spread of radioactive contamination. These controls include a radiation zone control program, as well as the monitoring of surface and airborne tritium concentrations to confirm the effectiveness of that program. In 2018, SRBT did not identify any adverse trends in its radiological monitoring results.

Estimated dose to the public

The maximum dose to the public from licensed activities at SRBT is calculated with the use of monitoring results. Table 8-1 shows the 2014 to 2018 maximum effective doses to a member of the public. Doses to the public remained well below the regulatory dose limit of 1 mSv/year.

Table 8-1: Maximum effective dose to a member of the public, SRBT, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Maximum effective dose (mSv)	0.0067	0.0068	0.0046	0.0033	0.0038	**1 mSv/year**

mSv = millisievert

8.3 Environmental protection

Compliance ratings for the environmental protection SCA, SRB Technologies (Canada) Inc., 2014–18

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA
For 2018, CNSC staff continued to rate the environmental protection SCA at SRBT as "satisfactory." SRBT's radioactive releases to the environment continued to be controlled and monitored to comply with the regulatory requirements and the conditions of the operating licence. Throughout 2018, the measured releases of radioactive substances to the environment via gaseous and liquid effluent were below regulatory limits, and there were no releases of hazardous substances from SRBT that would pose a risk to the environment or the public. Monitoring data of ambient air, groundwater, precipitation, runoff, surface water, produce, milk and wine around the facility indicates that the public and the environment continued to be protected from the facility releases.				

SA = satisfactory

Effluent and emissions control (releases)

Atmospheric emissions

SRBT monitors tritium releases from the facility stacks and reports them annually. The monitoring data for 2014 to 2018 (provided in table F-15, appendix F) demonstrates that atmospheric emissions from the facility continued to be effectively controlled, as they remained consistently below the licence limits.

In addition to licence limits, SRBT has action levels in place that are used to provide assurance that licence release limits will not be exceeded. No action levels for atmospheric emissions were exceeded at any time in 2018 at SRBT.

Liquid effluent

SRBT continued to monitor and control tritium released as liquid effluent from the facility. The monitoring data for 2014 through 2018 (provided in table F-16, appendix F) demonstrates that liquid effluent from the facility continued to be effectively controlled, as tritium releases were consistently well below the licence limit.

In addition to licence limits, SRBT has action levels that are used to provide assurance that licence release limits will not be exceeded. No action levels for liquid effluent were exceeded at any time in 2018.

Environmental management system

CNSC staff confirmed that SRBT has developed and is maintaining an environmental management system (EMS) that provides a framework for integrated activities for the protection of the environment at the SRBT facility. SRBT's EMS includes activities such as the establishment of annual environmental objectives and targets, which CNSC staff review and assess through compliance verification activities. The EMS is verified through the licensee's

safety meeting, during which environmental protection issues are discussed and documented. CNSC staff review these documents, as part of their compliance verification activities, and follow up with SRBT staff on any outstanding issues, as appropriate. SRBT's 2018 scheduled audit of its EMS was deferred to 2019 due to SRBT's shift in internal resources.

Assessment and monitoring

SRBT's environmental monitoring program serves to demonstrate that the SRBT site emissions of radioactive substances are properly controlled. The program also provides data for estimates of annual radioactive doses to the public to ensure that the public exposure attributable to SRBT's operations is below the annual regulatory dose limit of 1 mSv and is ALARA. The principal monitoring activities focus on the air, groundwater, precipitation, runoff, surface water, produce, milk and wine around the SRBT site.

In addition, the CNSC conducts periodic monitoring under its Independent Environmental Monitoring Program (IEMP) to verify that the public and the environment around nuclear facilities remain protected.

Tritium in ambient air

SRBT has 40 passive air samplers located within a 2-km radius of the facility. These samplers represent tritium exposure pathways for inhalation and skin absorption, and are used in the calculations to determine public dose. Samples are collected and analyzed by a qualified third-party laboratory. The 2018 air monitoring results from these samplers demonstrated that tritium levels in ambient air near SRBT remained low.

Groundwater monitoring

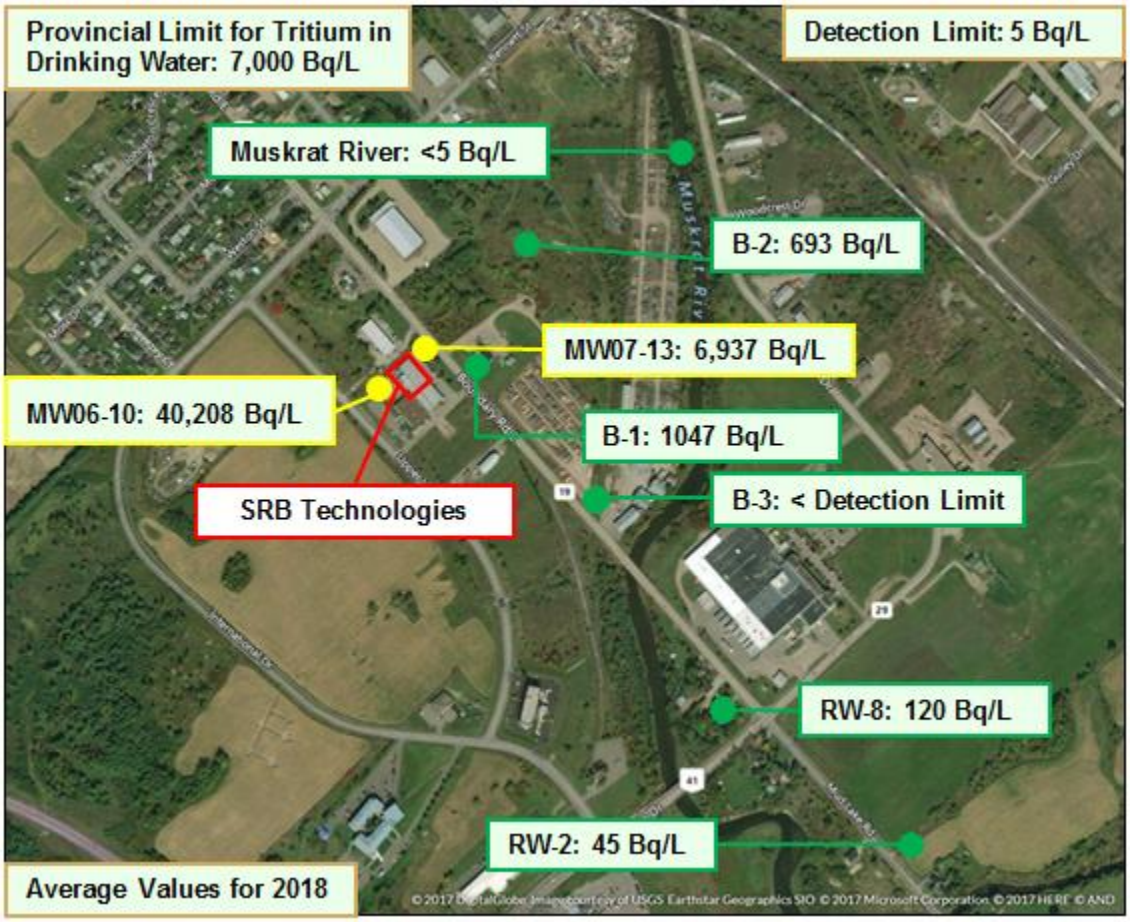
Groundwater is sampled from 21 SRBT-installed monitoring wells at the SRBT site plus an additional 25 wells at surrounding residential and business properties. From the 2018 sampling results, the highest average tritium concentration was reported for monitoring well MW06-10 (40,208 Bq/L, with a minimum of 21,859 Bq/L and maximum of 51,809 Bq/L). This well is located directly beneath the area where the active ventilation stacks are located. As of the end of 2018, this represents the only well where tritium concentration exceeds the Ontario Drinking Water Guideline value of 7,000 Bq/L. This well is a dedicated, engineered groundwater monitoring well very near the facility and within a secured area, and is not available as a source of water consumption.

Tritium concentrations decrease significantly at locations farther away from SRBT. In 2018, the highest tritium concentration in a potential drinking water well was found in residential well RW-08 (now disconnected), which is located approximately 250 m away from SRBT and is not in the groundwater flow pathway. One concentration of 120 Bq/L was reported for this well, which is a slight decrease in the highest concentration measured in 2017 (132 Bq/L) and far below Ontario's drinking quality standard of 7,000 Bq/L. CNSC staff concluded that, overall, the tritium inventory in the groundwater system around the facility has been trending downward since 2006. This trend is due to SRBT's initiative to reduce emissions; measures include the commissioning of improved tritium trap

valves and remote display units, the real-time monitoring of gaseous effluent, and a reduction in the amount of failed leak tests of manufactured light sources. Along with the reduced emissions, the concentration of tritium in the groundwater is decreasing due to the natural decay of tritium and the flushing of historical tritium emissions through the groundwater system.

Since 2016 SRBT has been in compliance with CSA standard N288.7-15, *Groundwater Protection Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [13].

Figure 8-4: Annual average tritium concentrations in groundwater and the Muskrat River, SRBT, 2018



Other monitoring

SRBT samples and analyzes runoff water from its site, and engages a qualified third party to perform monitoring and analysis of precipitation, surface water, produce, milk and wine. The 2018 monitoring results for these items show very low numbers and are consistent with previous years' data. This monitoring complements the principal monitoring activities, which focus on air and groundwater.

CNSC Independent Environmental Monitoring Program

CNSC staff conducted Independent Environmental Monitoring Program campaigns at SRBT in 2013, 2014, 2015 and 2018. The results are available on the CNSC's IEMP web page. The IEMP results indicate that the public and the environment surrounding SRBT remain protected from facility emissions. The next IEMP campaign at SRBT is scheduled for 2020.

Protection of the public

The licensee is required to demonstrate that adequate provision is made for protecting the health and safety of the public from exposures to radiological and hazardous (non-radiological) substances released from the facility, as well as to other physical stressors. In 2018, there were no releases of either type of substance to the environment from SRBT that would pose a risk to the public or environment.

CNSC staff concluded, based on their review of these programs at SRBT, that the public continues to be protected from facility emissions.

Environmental risk assessment

CNSC staff use CSA standard N288.6-12, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills* [3], to help determine whether licensees are in compliance with regulatory requirements for the protection of the environment and human health. CSA N288.6-12 specifically states: "Facility ERAs should be reviewed on a five-year cycle or more frequently if major facility changes are proposed that would trigger a predictive assessment." In January 2016, SRBT submitted a gap analysis and action plan for several environmental protection standards, including CSA N288.6-12. SRBT has indicated that it will conduct an environmental risk assessment by December 2020 in advance of its next licence renewal application, expected in 2022. In general, CNSC staff found the gap analysis conducted by SRBT for REGDOC-2.9.1 and CSA N288.6-12 to be acceptable. SRBT provided an action plan and a time frame for full implementation by 2020. CNSC staff are satisfied with SRBT's progress toward implementing the CSA Group requirements. SRBT currently has acceptable environmental programs in place to ensure the protection of the public and the environment.

8.4 Conventional health and safety

Compliance ratings for the conventional health and safety SCA, SRB Technologies (Canada) Inc., 2014–18

2014	2015	2016	2017	2018
FS	FS	FS	SA	FS
For 2018, CNSC staff rated the conventional health and safety SCA at SRBT as "fully satisfactory." SRBT's implemented measures for conventional health and safety are highly effective. SRBT promptly addresses and reports any arising problems in accordance with regulatory requirements. SRBT also maintains an effective Workplace Health and Safety Committee. Overall, the compliance verification activities that CNSC staff conducted confirmed that SRBT continued to view conventional health and safety as an important consideration. SRBT has demonstrated a fully satisfactory ability to keep its workers safe from occupational injuries.				

FS = fully satisfactory; SA = satisfactory

Performance

SRBT's performance related to conventional health and safety is monitored through CNSC staff's onsite inspections and event reviews. In 2018, SRBT continued to develop and maintain a comprehensive occupational health and safety management program for its facility. The program incorporated various elements, such as accident reporting and investigation, hazard prevention, preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response.

Table 8-2 outlines the number of lost-time injuries (LTIs) over the past five years at SRBT. In 2018, no LTIs occurred at SRBT.

Table 8-2: Lost-time injury statistics, SRBT, 2014–18

	2014	2015	2016	2017	2018
LTIs[1]	0	0	0	3	0
Severity rate[2]	0	0	0	17.7	0
Frequency rate[3]	0	0	0	7.6	0

1 An LTI is an injury that takes place at work and results in the worker being unable to return to work for a period of time.
2 The accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
3 The accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

Practices

SRBT's activities and operations must comply with the NSCA [1] and its associated regulations, and with Part II of the *Canada Labour Code* [5]. This means that SRBT is required to report to ESDC on incidents resulting in an injury. The SRBT Workplace Health and Safety Committee inspects the workplace and meets frequently to resolve and track any issues related to health and safety. In 2018, this committee met nine times. CNSC staff reviewed health and safety documentation to verify that any identified issues related to health and safety were promptly resolved.

In 2018, SRBT implemented a number of health and safety initiatives; here are several of them:

- The Workplace Health and Safety Committee conducted all-staff safety meetings, focused on reinforcing the responsibilities and duties of both the employees and the employer when it comes to safety in the workplace.
- Health and safety procedures were improved and expanded.
- Sound-level testing was completed for all facility processes, with protective measures put in place where advisable.
- SRBT installed new compressed air hose nozzles, designed to reduce sound levels during use.
- A sink used for washing light-source preforms in the coating room was replaced with a safer design.
- A comprehensive, independent assessment of SRBT's Health and Safety Program against the requirements of the *Canada Labour Code* and the *Canada Occupational Health and Safety Regulations* was completed. An implementation plan was put into place to address the key issues identified.

Awareness

CNSC staff confirmed that in 2018 SRBT continued to maintain a comprehensive conventional health and safety program. Workers were made aware of this program and workplace hazards, through training and ongoing internal communications with SRBT.

In October 2018, an employer and an employee representative of the Workplace Health and Safety Committee attended a health and safety training conference in Ottawa.

In December 2018, all SRBT staff were given refresher training in the Workplace Hazardous Materials Information System (WHMIS) at the annual SRBT training day.

Through ongoing regulatory oversight activities, CNSC staff determined that SRBT continued to maintain a safe working environment at its facility. CNSC staff are satisfied that SRBT has demonstrated a fully satisfactory ability to keep its workers safe from occupational injuries.

9 Nordion (Canada) Inc.

Nordion (Canada) Inc. is located adjacent to industrial and residential property in Ottawa, Ontario, and is licensed to operate a Class IB nuclear substance processing facility. Nordion's licence NSPFOL-11A.01/2025 expires in October 2025. Figure 9-1 shows an aerial view of the facility.

Figure 9-1: Aerial view of the Nordion facility (highlighted in blue)

At this facility, Nordion processes unsealed radioisotopes (such as yttrium-90 (Y-90)) for health and life sciences applications, and manufactures sealed radiation sources (cobalt-60 (Co-60)) for industrial and medical applications. The facility is composed of two major production operations, one involving the processing of radioisotopes used in nuclear medicine (medical isotopes) and the other involving sealed sources used in cancer therapy and irradiation technologies (gamma technologies). Figure 9-2 shows a Nordion worker using a hot cell manipulator.

As reported in previous regulatory oversight reports, Nordion ceased the production of molybdenum-99, iodine-125, iodine-131 and xenon-133 in November 2016. Nordion has not resumed the production of these radioisotopes.

Figure 9-2: Nordion worker using a hot cell manipulator

In April 2018, BWX Technologies Ltd. (BWXT) announced an agreement to acquire Nordion's medical isotope business. The acquisition was completed in August 2018. CNSC staff assessed the information provided by Nordion on the acquisition, including the proposed management system, and determined that the proposed change would have a neutral impact on safety and was within the licensing basis. No licence amendment or Commission approval was required for the acquisition to proceed, as Nordion will continue to operate the medical isotope facility until BWXT obtains a separate Class IB nuclear substance processing facility operating licence.

9.1 Overall performance

For 2018, CNSC staff rated all but two of Nordion's safety and control areas (SCAs) as "satisfactory." The exceptions were environmental protection and security, which were rated as "fully satisfactory." Table C-6 of appendix C provides the performance ratings for the Nordion facility from 2014 to 2018.

CNSC staff are satisfied that in 2018 Nordion ensured that its facility was maintained in accordance with the licensing basis. Nordion did not make any modifications to the physical design of the facility, but completed upgrades to existing systems and equipment as part of facility maintenance and continuous improvement.

No action levels or regulatory limits were exceeded in 2018. All measurable doses received by workers and the public were within the regulatory limits, and no internal dose levels or limits were exceeded.

As required by the *Nuclear Safety and Control Act* (NSCA) [1], its associated regulations and Nordion's licence, Nordion submitted reports to the CNSC on events or incidents that occurred in 2018. CNSC staff reviewed these reports, eight in all, and concluded that none of the events or incidents compromised the health or safety of persons or the environment. Seven of the reports were related to packaging and transport, with all these events involving low-risk items, such as visible damage to Type A and Type B packages sustained in transit, traffic incidents that did not affect the transport containers, and a temporarily misplaced package that was subsequently located. The eighth event report was related to the discovery of non-fixed contamination on a returned transport container. CNSC staff reviewed, and are satisfied with, the corrective actions taken by Nordion for the events and incidents described in all these reports for 2018.

In 2018, CNSC staff conducted two inspections at Nordion's facility to ensure compliance with the NSCA [1] and its regulations, Nordion's operating licence and the programs used to meet regulatory requirements. Table K-6 of appendix K lists these inspections, which focused on the following SCAs: management system, conventional health and safety, operating performance, fitness for service, radiation protection, environmental protection, and waste management. Four enforcement actions were raised as a result of the inspections. CNSC staff concluded that the findings from these inspections posed a low risk to the achievement of regulatory objectives and CNSC expectations.

In November 2018, CNSC staff issued a 12(2) request under the *General Nuclear Safety and Control Regulations* to Nordion as a result of a non-compliance with an export licence condition. The non-compliance did not represent a risk to the health and safety of persons or the environment. Nordion responded to the request and implemented corrective actions. CNSC staff reviewed and were satisfied with Nordion's corrective actions. No further action is required.

Nordion continued to meet the commitments made in its public information program by providing the public with updated information related to waste management initiatives, radiation protection, environmental monitoring and the transport of nuclear substances. Nordion maintains an online survey to help improve its public disclosure, and offers an online virtual tour of its facility to the public. CNSC staff are satisfied that the licensee is in full compliance with regulatory requirements for public information and disclosure.

9.2 Radiation protection

Compliance ratings for the radiation protection SCA, Nordion (Canada) Inc., 2014–18

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA
For 2018, CNSC staff continued to rate the radiation protection SCA at Nordion as "satisfactory." Nordion has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations* [2]. Workers at Nordion are involved in medical isotope processing and the production of sealed sources for industrial applications and medical therapy. These activities present external radiological hazards to the whole body and internal radiological hazards from inhalation, ingestion, or absorption through the skin. Radiological hazards were effectively controlled at the facility. As a result, radiation doses to workers and members of the public were kept well below the CNSC regulatory dose limits.				

SA= satisfactory

Application of ALARA

In 2018, Nordion continued to implement radiation protection measures at its facility to keep radiation exposures and doses to persons ALARA. Nordion's Environmental Health and Safety Committee met regularly to discuss various aspects of the program, including worker doses, radiological-hazard monitoring results and internal audit results. An ALARA study was carried out for four months to analyze and document whole-body dose to quality control and production technicians during Y-90 packaging. This study raised awareness of dose rates from lead pots and packages; no further improvements were identified.

Worker dose control

The radiological hazards to workers at Nordion include exposure to alpha, beta and gamma radiation emitted from the radioisotopes processed for medical purposes, and from the production of sealed sources for industrial applications and medical therapy. Nordion ascertains external whole-body and equivalent doses with the use of dosimeters. For internal radiological exposures, Nordion has a screening program for routine thyroid monitoring of workers working with iodine-125 and iodine-131. There are also provisions for whole-body counting and urinalysis in the event of elevated air or contamination monitoring results. There were no internal doses recorded in 2018.

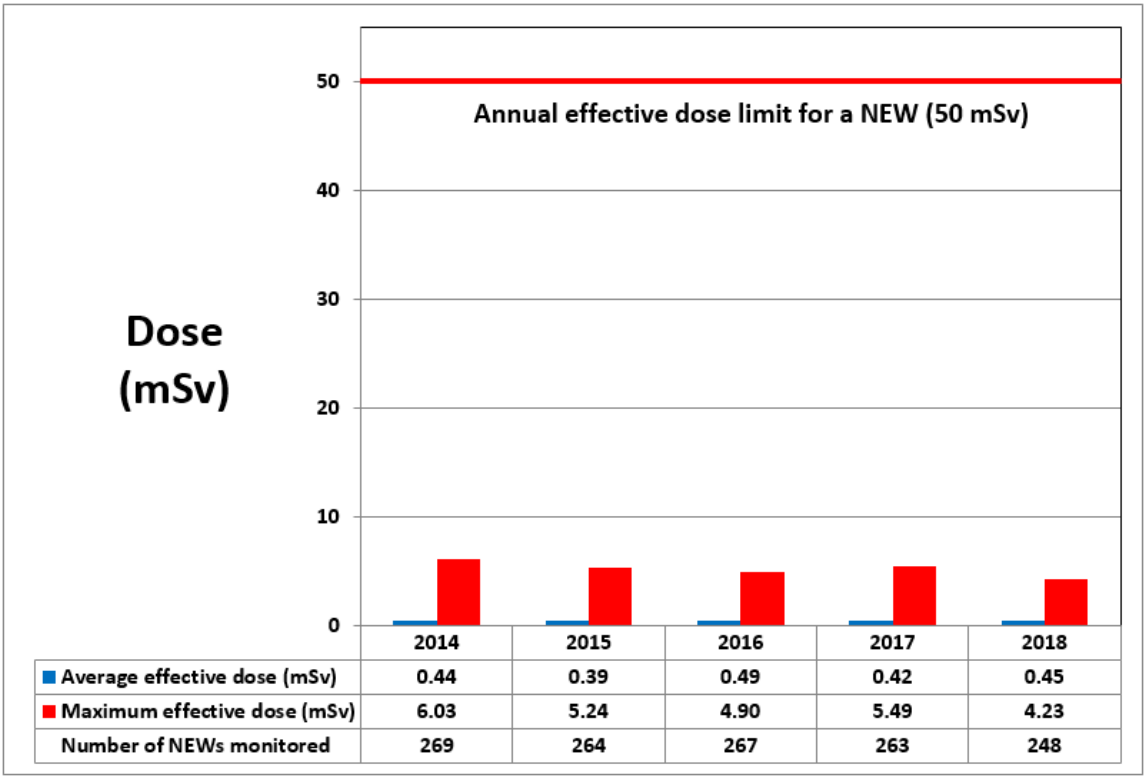
Nordion identifies all employees who work in or enter an area where radiological work is performed (such as the active area), as nuclear energy workers (NEWs). Nordion monitors radiation exposures for all NEWs to ensure compliance with the CNSC's regulatory dose limits and to keep doses ALARA.

In 2018, Nordion ascertained the total effective dose for 248 NEWs, consisting of 137 workers working in the active area and 111 workers who work primarily in the

non-active area but may perform some work duties in the active area. Nordion reported that the maximum effective dose received by a NEW in 2018 was 4.23 mSv, approximately 8.5% of the CNSC's regulatory effective dose limit of 50 mSv in a one-year dosimetry period.

Figure 9-3 provides the average and maximum effective doses to NEWs at Nordion from 2014 to 2018. Average and maximum effective doses have been relatively stable over these years.

Figure 9-3: Average and maximum effective doses to NEWs, Nordion, 2014–18



	2014	2015	2016	2017	2018
Average effective dose (mSv)	0.44	0.39	0.49	0.42	0.45
Maximum effective dose (mSv)	6.03	5.24	4.90	5.49	4.23
Number of NEWs monitored	269	264	267	263	248

Nordion also identifies non-NEWs who may enter the active area but do not perform any radiological work. Nordion monitors non-NEWs as required and provides relevant training to ensure that their doses are kept ALARA. In 2018, Nordion monitored 55 non-NEWs. Nordion reported that the maximum effective dose received by a non-NEW was 0.25 mSv, which is well below the CNSC's regulatory effective dose limit of 1 mSv in a calendar year for a person who is not a NEW. The average effective dose for non-NEWs in 2018 was 0.05 mSv.

Appendix E shows annual average and maximum equivalent (extremity) and equivalent (skin) dose results from 2014 to 2018. Nordion reported that the maximum equivalent skin dose for all NEWs monitored at Nordion in 2018 was 4.26 mSv (table E-12), and that the maximum equivalent extremity dose for a worker in the active area was 9.08 mSv (table E-5). These doses represent approximately 1% and 2% respectively of the CNSC's regulatory equivalent dose limits of 500 mSv in a one-year dosimetry period.

CNSC staff acknowledge Nordion's good performance for extremity dose in 2018, as Nordion was able to reduce the extremity doses despite increased production. With respect to the decrease in the maximum extremity dose, from 2014 to 2017, the same individual had received the maximum extremity dose. The lower dose observed in 2018 was the result of changes to work assignments and work processes that were identified through an internal audit.

Radiation protection program performance

In 2018, CNSC staff assessed the performance of Nordion's radiation protection program through various compliance verification activities. Overall, CNSC staff found Nordion's compliance with the *Radiation Protection Regulations* [2] and the CNSC licence requirements to be acceptable.

Nordion has established action levels (annual and by dosimetry period) as part of its radiation protection program. No worker received a dose of radiation exceeding an action level in 2018.

Radiological hazard control

CNSC staff confirmed that Nordion has radiation and contamination control programs at the facility to control and minimize radiological hazards and the spread of radioactive contamination. Methods of control include radiation zone controls, surface contamination monitoring, in-plant air-monitoring systems and radiological surveys. In 2018, Nordion did not identify any adverse trends in its radiological monitoring results.

Estimated dose to the public

The maximum dose to the public from licensed activities at the Nordion facility is calculated with the use of monitoring results. Table 9-1 shows the 2014 to 2018 maximum effective doses to a member of the public. In 2018, the dose to a member of the public was well below the regulatory dose limit of 1 mSv/year.

Table 9-1: Maximum effective dose to a member of the public, Nordion, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Maximum effective dose (mSv)	0.010	0.0057	0.0021	0.000052	0.000067	**1 mSv/year**

9.3 Environmental protection

Compliance ratings for the environmental protection SCA, Nordion (Canada) Inc., 2014–18

2014	2015	2016	2017	2018
FS	FS	FS	FS	FS
For 2018, CNSC staff continued to rate the environmental protection SCA at Nordion as "fully satisfactory." Nordion continued to implement and maintain a highly effective environmental protection program per regulatory requirements to control and monitor gaseous and liquid releases of radioactive substances from its facility into the environment. From 2014 to 2018, the gaseous emissions and liquid effluents remained stable and well below the derived release limits (DRL). No action levels were exceeded in 2018. Groundwater monitoring, soil sampling and gamma exposure measurements indicate that the public and the environment continued to be protected from facility releases.				

Effluent and emissions control (releases)

Atmospheric emissions

Nordion continued to monitor and control the releases of radioactive materials from its facility to prevent unnecessary releases of radioisotopes to the atmosphere. Table F-17 of appendix F shows Nordion's radioactive air emissions monitoring results from 2014 to 2018. Nordion determined the DRL values using Impact software, consistent with the most current version of the CSA standard N288.1-14, *Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities* [14]. The monitoring data demonstrates that the radioactive air emissions from the facility in 2018 continued to be effectively controlled as they were consistently well below the DRLs. The cessation of production of molybdenum-99, iodine-125, iodine-131 and xenon-133 in 2016 has resulted in zero releases of noble gases and significant reductions in radioiodine releases from Nordion since 2017.

In addition to licence limits, Nordion has action levels that are used to provide assurance that licence limits will not be exceeded. No action levels for atmospheric emissions were exceeded at any time in 2018.

Liquid effluent

In 2018, Nordion continued to collect, sample and analyze all liquid effluent releases before discharge into the municipal sewer system. Table F-18 of appendix F shows Nordion's monitoring results for radioactive liquid emissions from 2014 to 2018. The monitoring data demonstrates that the authorized radioactive liquid effluent releases from the facility in 2018 were consistently well below the DRLs. No action levels for liquid effluent releases were exceeded in 2018.

Environmental management system

CNSC staff confirmed that Nordion has developed and is maintaining an environmental management system (EMS) to describe the integrated activities associated with the protection of the environment at its facility. The EMS is described in Nordion's EMS Manual and includes annual environmental objectives and targets set by Nordion.

Nordion verifies the EMS through an annual management review, which involves the evaluation of actions from the previous annual meeting, Nordion's environmental health and safety policy, the adequacy of its resources, its EHS objectives and targets, as well as any changing circumstances and recommendations for improvement. CNSC staff evaluate the results of the annual review, as part of their compliance verification activities, and follow up with Nordion staff on any outstanding issues.

In 2018, Nordion had a third-party ISO 14001:2015 environmental management systems certification audit. As a result, Nordion implemented changes to its EMS to meet the requirements of ISO 14001:2015. CNSC staff reviewed the revised EMS and found it acceptable.

Assessment and monitoring

CNSC staff are satisfied that Nordion is in compliance with CSA N288.4-10, *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [10], and CSA N288.5-11, *Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [11]. Nordion's environmental monitoring program serves to demonstrate that the site emissions of radioactive and hazardous materials are properly controlled. Nordion conducts groundwater monitoring, collects soil samples and measures environmental gamma radiation by using thermoluminescent dosimeters deployed onsite and offsite to demonstrate that emissions from the facility do not pose risks to public health or to the environment. Monitoring results since 2014 are further described in the sections below.

In addition, the CNSC conducts periodic monitoring under its Independent Environmental Monitoring Program (IEMP) to verify that the public and the environment around nuclear facilities remain protected.

Groundwater monitoring

Nordion has nine groundwater monitoring wells on the site. Since 2005, Nordion has been monitoring groundwater at least once a year for non-radioactive contaminants, to ensure that no significant changes have occurred since monitoring began. The monitoring results from 2014 to 2018 demonstrate that there were no significant changes in the groundwater in 2018 compared with those of previous years.

Since 2014, Nordion has been monitoring groundwater at least once a year for radioactive contaminants. The results since then have detected only naturally occurring radionuclides that are not processed at the Nordion facility. These results, which are either below detection limits or at natural background levels,

indicate that releases of radioactive and hazardous substances from the facility have had no measurable impact on groundwater quality.

Soil sampling

Nordion performed soil sampling in 2012, 2014, 2016, 2017 and 2018. No radionuclides attributable to licensed activities were detected in the soil samples.

Environmental thermoluminescent dosimeters program

Nordion monitors environmental gamma radiation with the use of thermoluminescent dosimeters. The dosimeters are deployed at locations to generally cover the points of a compass and preferentially to the east of the facility, which receives the prevailing west winds. Dosimeters are also placed in residences of Nordion employees located near the facility. The annual monitoring results for 2018 showed that the levels of gamma radiation at offsite monitoring locations are in the range of natural background levels. These results indicate that Nordion is not contributing to the public's exposure to gamma radiation at, and beyond, the perimeter of the facility.

CNSC Independent Environmental Monitoring Program

Through the CNSC's IEMP, CNSC staff conducted monitoring at Nordion in 2016 and 2018. The results are available on the CNSC's IEMP web page. The IEMP results indicate that the public and the environment surrounding the Nordion site remain protected from facility emissions. The next IEMP campaign at Nordion is scheduled for 2020.

Protection of the public

The licensee is required to demonstrate that adequate provision is made for protecting the health and safety of the public from exposures to radiological and hazardous (non-radiological) substances released from the facility, as well as to other physical stressors. In 2018, there were no releases of either type of substance to the environment from Nordion that would pose a risk to the public or environment.

CNSC staff concluded, based on their review of these programs at Nordion, that the public continues to be protected from facility emissions.

Environmental risk assessment

Nordion has acceptable environmental programs in place to ensure the protection of the public and the environment. CNSC staff are satisfied that the licensee's current environmental risk assessment and derived release limits report meet the requirements of CSA standard N288.6-12, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills* [3], and CSA N288.1-14, *Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities* [14], respectively. In accordance with CSA N288.6-12, ERAs must be reviewed every five years – or more often, if there is a change in operations or scientific

knowledge. Therefore, CNSC staff anticipate that Nordion will provide the next iteration of the ERA in 2021.

9.4 Conventional health and safety

Compliance ratings for the conventional health and safety SCA, Nordion (Canada) Inc., 2014–18

2014	2015	2016	2017	2018
FS	SA	SA	SA	SA
For 2018, CNSC staff continued to rate the conventional health and safety SCA at Nordion as "satisfactory." Compliance verification activities that CNSC staff conducted confirmed that Nordion continued to view conventional health and safety as an important consideration for all activities.				

FS = fully satisfactory; SA = satisfactory

Performance

Nordion's performance related to conventional health and safety is monitored through CNSC staff's onsite inspections and event reviews. In 2018, Nordion continued to maintain a comprehensive occupational health and safety management program for its facility. The program incorporates various elements, such as accident reporting and investigation, hazard prevention, preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response.

Nordion made several improvements to its conventional health and safety program in 2018, including implementation of WHMIS 2015 requirements, confined-space rescue training, chemical-spill response training, and improvements to the lead-control program.

As table 9-2 indicates, there were no lost-time injuries (LTIs) at Nordion in 2018.

Table 9-2: Lost-time injury statistics, Nordion, 2014–18

	2014	2015	2016	2017	2018
LTIs[1]	3	0	3	1	0
Severity rate[2]	23.08	0	70.04	5.61	0
Frequency rate[3]	2.39	0	2.32	0.93	0

1 An LTI is an injury that takes place at work and results in the worker being unable to return to work for a period of time.
2 The accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
3 The accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

Practices

Nordion's activities and operations must comply with not only the NSCA [1] and its regulations, and with Part II of the *Canada Labour Code* [5]. Nordion's conventional health and safety program is also under the oversight of its Workplace Health and Safety Committee, which met 11 times in 2018. CNSC staff reviewed the meeting minutes and any associated corrective actions during onsite inspections to ensure that issues were promptly resolved.

Awareness

CNSC staff confirmed that in 2018 Nordion continued to maintain a comprehensive occupational health and safety management program for its facility. Workers were made aware of the program, as well as workplace hazards, through training and ongoing internal communications.

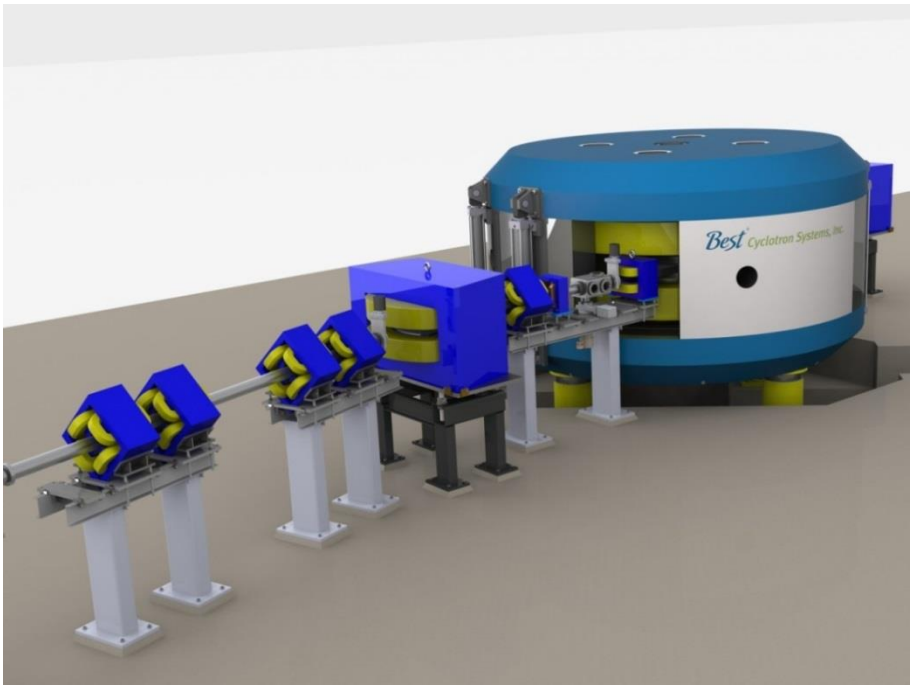
10 Best Theratronics Ltd.

Best Theratronics Ltd. (BTL) owns and operates a manufacturing facility in Ottawa, Ontario, under a Class IB licence that expires in June 2029. Figure 10-1 shows an aerial view of the BTL facility highlighted in red.

Figure 10-1: Aerial view of the BTL facility

BTL manufactures cyclotrons and medical equipment, including cobalt-60 radiation therapy units and cesium-137 blood irradiators. Figure 10-2 shows a 70-megaelectronvolt (MeV) cyclotron manufactured by BTL.

Figure 10-2: 70-MeV cyclotron manufactured by BTL



Best Theratronics is licensed by the CNSC for the development and testing of Co-60 teletherapy devices, the manufacturing of self-shielded irradiators, the storage of nuclear substances, and construction and testing of particle accelerators (cyclotrons).

On September 7, 2018, BTL submitted an application for the renewal of its Class IB licence that authorizes the construction and testing of cyclotrons, the manufacture of prescribed equipment and radiation devices, and research and development using teletherapy machines. Additionally, BTL's current licence authorizes the storage of nuclear substances. A Commission proceeding was held on May 16, 2019, and BTL was issued a Class IB licence that is valid from July 1, 2019 to June 30, 2029 [15]. A regulatory hold point is currently on the licence that requires BTL to get prior approval from the Commission before operating any cyclotrons above 1 MeV. This regulatory hold point was added to ensure that certain safety and control measures were in place prior to operating these cyclotrons.

10.1 Overall performance

For 2018, CNSC staff rated BTL's performance as "satisfactory" in all safety and control areas (SCAs). Table C-7 of appendix C shows the performance ratings for BTL from 2014 to 2018.

In 2018, CNSC staff conducted one onsite inspection at the BTL facility to verify compliance with the NSCA [1] and its associated regulations, BTL's operating licence and the programs used to meet regulatory requirements. Table K-7 of appendix K lists the inspection. The inspection focused on the following SCAs: radiation protection, operating performance, fitness for service, human performance management, conventional health and safety, and physical design. Four enforcement actions were raised as a result of the inspection. The findings from this inspection posed a low safety significance to the achievement of regulatory objectives and CNSC expectations.

There were two radiation protection action level exceedances in 2018; section 10.2 provides more details. There were two LTIs in 2018; section 10.4 discusses them.

BTL upheld its commitments to be open and transparent with its stakeholders. The licensee provided material on its website related to its regular licensed activities, as well as its 2019 licence renewal application. BTL disclosed its annual compliance report online, and hosted a community information session on its operations. CNSC staff are satisfied that the licensee is in full compliance with regulatory requirements for public information and disclosure.

10.2 Radiation protection

Compliance ratings for the radiation protection SCA, Best Theratronics Ltd., 2014–18

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA
For 2018, CNSC staff continued to rate the radiation protection SCA at BTL as "satisfactory." BTL has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations* [2]. Workers at BTL work with sealed sources of radiation, which present external radiological hazards to the whole body and to the extremities. Radiological hazards were effectively controlled at BTL. As a result, radiation doses to workers were kept well below the CNSC regulatory dose limits. Activities at the facility have no impact on doses to members of the public.				

SA = satisfactory

Application of ALARA

In 2018, BTL continued to implement radiation protection measures to keep radiation exposures and doses to persons ALARA. BTL has documented expectations for its ALARA program, including a clear substantiation for the existence of the program, clearly delineated management control over work practices, and provisions for dose trend analysis.

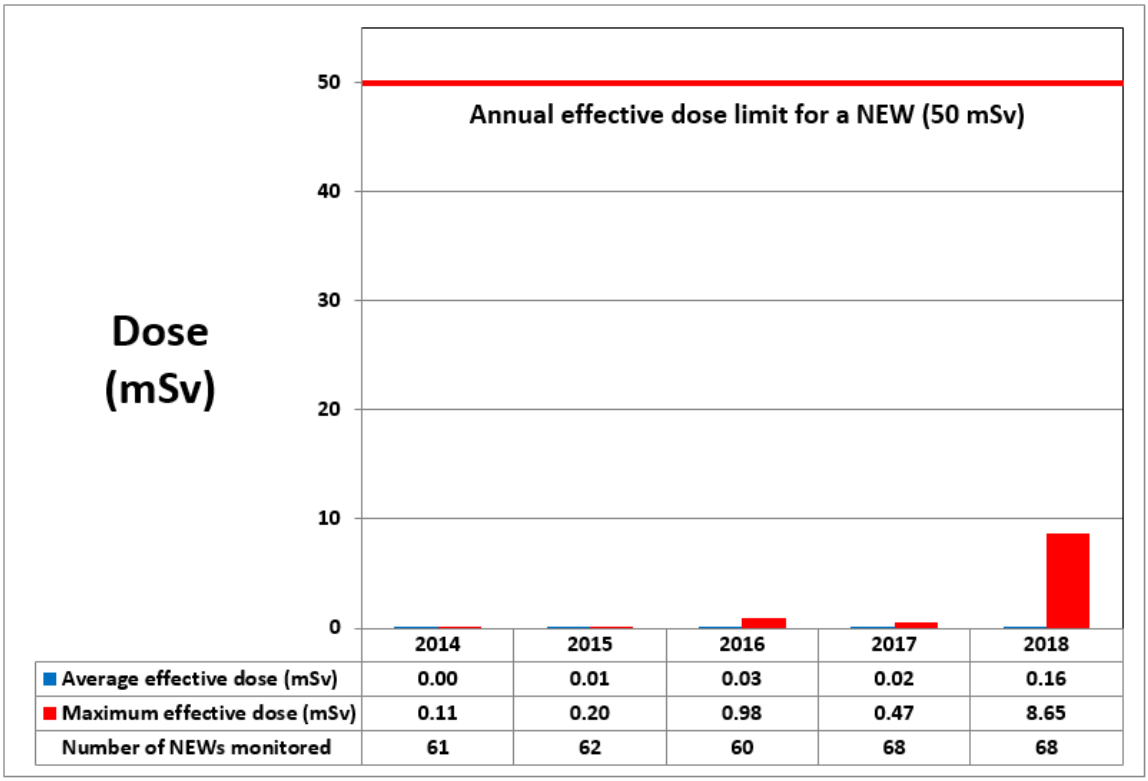
Worker dose control

Radiation exposures are monitored to ensure compliance with the CNSC's regulatory dose limits and to keep radiation doses ALARA. This regulatory oversight report for 2018 includes data on the doses received by workers performing activities under the Class IB licence only. Previously, BTL's annual compliance report related to this licence included doses for all workers; that is, both the manufacturing workers as well as the service technicians performing work activities under a separate Class II servicing licence.

BTL workers are exposed externally to sealed sources of radiation and are identified as NEWs if they have a reasonable probability of receiving an annual occupational dose greater than 1 mSv. Such workers include service technicians and source handlers. In 2018, radiation exposures at BTL were well below the CNSC regulatory dose limits.

In 2018, the maximum effective dose received by a NEW at BTL was 8.65 mSv, which is approximately 17% of the regulatory limit for the effective dose of 50 mSv in a one-year dosimetry period. Figure 10-3 provides the average and maximum effective doses received by NEWs at BTL from 2014 to 2018.

Figure 10-3: Average and maximum effective doses to NEWs, BTL, 2014–18



	2014	2015	2016	2017	2018
Average effective dose (mSv)	0.00	0.01	0.03	0.02	0.16
Maximum effective dose (mSv)	0.11	0.20	0.98	0.47	8.65
Number of NEWs monitored	61	62	60	68	68

Table E-6 of appendix E shows annual average and maximum equivalent dose results from 2014 to 2018. The maximum equivalent extremity dose for 2018 was 13.51 mSv. Over the past five years, average extremity equivalent doses have been relatively stable, between approximately 0 mSv and 1.41 mSv. Equivalent skin doses are also ascertained, but due to the nature of exposure, they are essentially equal to the effective dose and are not included in the report.

Both the maximum effective and equivalent dose to the extremities for 2018 were due to an unplanned event, which is detailed below.

BTL workers identified as non-NEWs, such as administrative staff, are restricted from accessing controlled areas where radioactive material is stored and areas where there is potential for a worker to exceed the annual dose limit of 1 mSv. In 2018, non-NEWs did not receive any reportable doses.

Radiation protection program performance

Radiation protection program performance at BTL was assessed in 2018 through various CNSC staff compliance verification activities and desktop reviews. CNSC staff found BTL's compliance with the *Radiation Protection Regulations* [2] and the CNSC licence requirements to be acceptable.

Action levels for effective dose for various categories of workers have been established to alert BTL management of a potential loss of control of the radiation protection program.

In 2018, there were two action level exceedances at BTL. In October 2018, BTL reported that two workers conducting servicing activities exceeded BTL's

radiation protection action levels during a source loading procedure for a prototype design teletherapy head. The incident occurred when a tungsten screw securing the end plug for the teletherapy head failed and part of the source drawer exited the other end of the source head. The source was immediately pulled back into the transport container and safely stored. The first worker exceeded the monthly extremity action level of 10 mSv, with an equivalent dose to the right extremity of 13.51 mSv. The second worker exceeded the monthly whole-body dose action level of 4 mSv, with an effective dose of 8.65 mSv.

As part of its corrective actions, BTL replaced the tungsten screws with stainless steel screws and took radiation measurements to ensure that localized dose rates at screw locations remain low. CNSC staff are satisfied with BTL's reporting of and response to the action level exceedance.

Radiological hazard control

CNSC staff confirmed that BTL's radiation protection program ensures that measures are in place to monitor and control radiological hazards. This includes contamination and radiation dose rate monitoring and controls.

Most radioisotopes in use at BTL are sealed sources; therefore, the potential for contamination is very low. Nonetheless, the licensee has implemented a thorough surface contamination monitoring procedure to monitor any potential contamination at its facility. Contamination checks are performed monthly in designated areas where radioactive materials may be handled, and following work where the potential for contamination exists. Over the last five years, there has been no indication of the presence of contamination from routine contamination swipes at the BTL facility.

Monthly dose rate measurements are also performed in all radiation areas. In addition, fixed dose rate monitors are in place with set alarm thresholds in a variety of designated locations within the BTL facility. These measurements and alarm thresholds help to ensure a safe workplace.

Estimated dose to the public

No activities occur inside the BTL facility that result in the release of radioactive material to the environment. In addition, gamma radiation is kept ALARA to protect staff within the BTL facility. Consequently, the dose impact to members of the public attributable to BTL's licensed activities is insignificant and too low to be measured.

10.3 Environmental protection

Compliance ratings for the environmental protection SCA, Best Theratronics Ltd., 2014–18

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA
For 2018, CNSC staff continued to rate the environmental protection SCA at BTL facility as "satisfactory." BTL does not have identified radioactive releases to the environment. Therefore, the risk of radiation exposure to members of the public from normal operations is very low. In 2018, there were no releases of hazardous (non-radiological) substances to the environment that would pose a risk to the public or the environment. Environmental monitoring is not conducted around the facility. BTL has implemented an environmental management system (EMS) to conform to CNSC REGDOC-2.9.1, *Environmental Protection Policies, Programs and Procedures* [16].				

SA = satisfactory

Effluent and emissions control (releases)

There are no radiological releases (liquid or airborne) at the BTL facility that require controls or monitoring. BTL's operation uses radioactive sealed sources that do not produce any radioactive releases.

Hazardous liquid effluents from routine operations are safely managed. They are collected, temporarily stored onsite, and then regularly removed for disposal by a certified third-party contractor. Lubricating oil for onsite boring and milling machines is recovered and recirculated. Therefore, there are no hazardous waterborne releases into the environment requiring controls or effluent monitoring.

Airborne hazardous emissions from BTL are related to the exhausting of the lead-pouring, paint booth, fire torching and sandblasting areas. Engineering controls, such as filters and ventilation, are in place to reduce or eliminate emissions generated during operations. As a result, BTL does not have an effluent monitoring program or an environmental monitoring program.

Environmental management system

In 2015, BTL implemented a new EMS to conform to REGDOC-2.9.1, *Environmental Protection Policies, Programs and Procedures* [16], a requirement of its Class IB licence. CNSC staff have verified that BTL continues to meet the requirements outlined in the regulatory document.

Assessment and monitoring

As there are no radiological releases that require controls or monitoring, BTL does not conduct environmental monitoring around its facility. With respect to air emissions, the main non-radiological sources pertain to exhausting associated with the lead-pouring area. BTL submits a report on lead, and its compounds, to the National Pollutant Release Inventory, maintaining annual compliance with the *Toxics Reduction Act*. There have not been any abnormal instances within the licensing period.

In 2013, an air emission summary and dispersion modelling study was completed for BTL's facility in support of BTL's application for an environmental compliance approval with the Ontario Ministry of the Environment and Climate Change. The report showed that all emissions were below the provincial point of impingement (POI) limits and thus would not result in changes to local air quality that would affect the health and safety of the public or the environment.

Protection of the public

BTL works with Category 1 or 2 sealed sources. The radioactive material is contained within a welded stainless steel encapsulation. In addition, the sealed sources are further contained in a shielded Type B transport container or self-shielded irradiator. The transport container or self-shielded irradiator is stored within a radiation-designated area within the facility. The source material cannot be released and therefore does not pose an exposure hazard to the public. Since the BTL facility uses only sealed sources, the risk of radiation exposure to members of the public from normal operations is very low. Members of the public are protected from hazardous (non-radiological) emissions, as BTL implements engineering controls that reduce or eliminate emissions generated during operations.

Environmental risk assessment

In 2011, BTL commissioned a Phase 1 environmental site assessment (ESA) for the facility. This assessment was used as both a risk assessment and means for monitoring environmental releases. The Phase 1 ESA identified areas within and outside the facility with potential environmental risks and reported the mitigating measures in place. BTL is expected to be in compliance with CSA standard N288.6, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills* [3], during the next licensing period. CNSC staff reviewed BTL's submission and are satisfied with the measures BTL has put in place for the protection of the environment.

10.4 Conventional health and safety

Compliance ratings for the conventional health and safety SCA, Best Theratronics Ltd., 2014–18

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA
For 2018, CNSC staff continued to rate the conventional health and safety SCA at BTL as "satisfactory." The compliance verification activities that CNSC staff conducted confirmed that BTL views conventional health and safety as an important consideration. BTL has demonstrated that it implements an effective occupational health and safety management program, which has resulted in the ability to keep its workers safe from occupational injuries.				

SA = satisfactory

Performance

BTL's performance related to conventional health and safety is monitored through CNSC staff's onsite inspections and event reviews. In 2018, BTL continued to develop and maintain a comprehensive occupational health and safety management program for its facility. The program incorporates various elements, such as accident reporting and investigation, hazard prevention, preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response.

As indicated in table 10-1 and further detailed in table H-2 of appendix H, two lost-time injuries (LTIs) were reported at the BTL facility in 2018. An employee received a cut and abrasion to the stomach area when the grinder being used caught their coveralls and pulled them in. This resulted in one lost day, and the employee was reminded to use the proper guard when performing the work.

The second LTI resulted in an employee hurting their back when applying an upward force to a large pipe wrench. This LTI was an isolated incident, and the work has not been performed since. This resulted in 11 lost days, and the employee was put on light-duty work upon their return. CNSC staff reviewed the corrective actions and are satisfied with the actions taken by BTL to prevent reoccurrence.

Table 10-1: Lost-time injury statistics, BTL, 2014–18

	2014	2015	2016	2017	2018
LTIs[1]	1	1	3	1	2
Severity rate[2]	4.786	0.684	37.607	15.043	8.205
Frequency rate[3]	0.684	0.684	2.051	0.684	1.368

1 An LTI is an injury that takes place at work and results in the worker being unable to return to work for a period of time.
2 The accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
3 The accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

Practices

BTL's activities and operations must comply with the NSCA [1] and its associated regulations, and with Part II of the *Canada Labour Code* [5]. BTL has a Health and Safety Committee that inspects the workplace and meets monthly to resolve and track any safety issues. CNSC staff reviewed the monthly meeting minutes of this committee and any associated corrective actions to ensure that issues in 2018 had been promptly resolved. CNSC staff have confirmed that when issues have been raised through BTL's workplace health and safety inspections, BTL addresses the issues and takes corrective actions.

Awareness

CNSC staff confirmed that in 2018 BTL continued to develop and maintain a comprehensive occupational health and safety management program for its facility. Workers were made aware of the program, as well as workplace hazards, through training and ongoing internal communications with BTL.

11 Overall conclusions

CNSC staff concluded that uranium processing facilities and nuclear substance processing facilities in Canada operated safely during the 2018 calendar year. This assessment is based on CNSC staff's verification of licensee activities, including onsite inspections, reviews of reports submitted by licensees, and reviews of events and incidents, supported by follow-up and general communication with the licensees.

In 2018, the performance ratings in all 14 SCAs for the facilities were as follows:

- uranium processing facilities were rated as "satisfactory" or better
- nuclear substance processing facilities were rated as "satisfactory" or better

CNSC staff's compliance verification activities confirmed that:

- radiation protection programs at all facilities were effective and adequately controlled radiation exposures, keeping doses ALARA
- environmental protection programs at all facilities were effective in protecting people and the environment
- conventional health and safety programs at all facilities continued to protect workers

CNSC staff concluded that, in 2018, the licensees discussed in this report made adequate provision for the health and safety of workers, as well as for the protection of the public and the environment, and for meeting Canada's international obligations on the peaceful use of nuclear energy.

CNSC staff continue to provide regulatory compliance oversight to all licensed facilities.

References

[1] *Nuclear Safety and Control Act*, S.C. 1997, c. 9.

[2] *Radiation Protection Regulations* (2000), SOR/2000-203.

[3] CSA Group, CSA N288.6-12, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills*, 2012.

[4] *General Nuclear Safety and Control Regulations* (2000), SOR/2000-202.

[5] *Canada Labour Code*, R.S.C., 1985, c. L-2.

[6] CNSC, REGDOC-3.2.1, *Public Information and Disclosure*, Ottawa, Canada, 2018.

[7] Health Canada, *Guidelines for Canadian Drinking Water Quality*, 2017.

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

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

[10] CSA Group, CSA N288.4-10, *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills*, 2010.

[11] CSA Group, CSA N288.5-11, *Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills*, 2011.

[12] CNSC, Record of Proceedings, including Reasons for Decision, *In the Matter of SRB Technologies (Canada) Inc., Application to Renew the Class IB Nuclear Substance Processing Facility Operating Licence for the Gaseous Tritium Light Source Facility in Pembroke, Ontario*, June 29, 2015.

[13] CSA Group, CSA N288.7-15, *Groundwater Protection Programs at Class I Nuclear Facilities and Uranium Mines and Mills*, 2015.

[14] CSA Group, CSA N288.1-14, *Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities*, 2014.

[15] CNSC, Summary Record of Decision, *In the Matter of Best Theratronics Ltd., Application to Renew the Best Theratronics Limited Class IB Nuclear Substance Processing Facility Licence*, June 25, 2019.

[16] CNSC, REGDOC-2.9.1, *Environmental Protection: Policies, Programs and Procedures*, Ottawa, Canada, 2016.

Acronyms and abbreviations

AANTC	Algonquin Anishinabeg Nation Tribal Council
ALARA	as low as reasonably achievable, taking into account social and economic factors
AFN	Alderville First Nation
AOO	Algonquins of Ontario
APFN	Algonquins of Pikwàkanagàn First Nation
BE	below expectations
Bq	becquerel
BRR	Blind River Refinery
BTL	Best Theratronics Ltd.
BWXT	BWXT Nuclear Energy Canada Inc.
CAD	Canadian dollar
Cameco	Cameco Corporation
CANDU	Canada Deuterium Uranium
CBFN	Chippewas of Beausoleil First Nation
CCAB	Canadian Council for Aboriginal Business
CCME	Canadian Council of Ministers of the Environment
CFM	Cameco Fuel Manufacturing Inc.
CGIFN	Chippewas of Georgina Island First Nation
CLFN	Curve Lake First Nation
cm	centimetre
CNL	Canadian Nuclear Laboratories
CNSC	Canadian Nuclear Safety Commission
Co-60	cobalt-60
CRFN	Chippewas of Rama First Nation
CSA	Canadian Standards Association (now CSA Group)
DRL	derived release limit
EHS	environment, health and safety
EMS	environmental management system
EPP	environmental protection plan
ERA	environmental risk assessment
ERT	emergency response team
ESA	environmental site assessment
ESDC	Employment and Social Development Canada

FFOL	fuel facility operating licence
FS	fully satisfactory
g	gram
GBq	gigabecquerel
GEH-C	GE Hitachi Nuclear Energy Canada Inc.
GTLS	gaseous tritium light source
h	hour
HF	hydrogen fluoride
HFN	Hiawatha First Nation
HT	tritium gas
HTO	hydrogenated tritium oxide or tritiated water
HNO_3	nitric acid
IAEA	International Atomic Energy Agency
ICP-MS	inductively coupled plasma mass spectrometry
IEMP	Independent Environmental Monitoring Program
kg	kilogram
Km	kilometre
L	litre
LCH	licence conditions handbook
LTI	lost-time injury
m^3	cubic metres
MBq	megabecquerel
MeV	megaelectronvolt
mg	milligram
mg/L	milligram per litre
MBQ	Mohawks of the Bay of Quinte
MCFN	Mississaugas of the Credit First Nation
MFN	Mississauga First Nation
MECP	Ontario Ministry of the Environment, Conversation and Parks
MNO	Métis Nation of Ontario
MSIFN	Mississaugas of Scugog Island First Nation
mSv	millisievert
N	nitrogen
NEW	nuclear energy worker

NOx	nitrogen oxides
NO_2	nitrogen dioxide
Nordion	Nordion (Canada) Inc.
NSCA	*Nuclear Safety and Control Act*
NSPFOL	nuclear substance processing facility operating licence
ORL	operating release limit
OPG	Ontario Power Generation
PFP	Participant Funding Program
PHCF	Port Hope Conversion Facility
POI	point of impingement
ppm	parts per million
ROR	regulatory oversight report
RP	radiation protection
SA	satisfactory
SAN	Sagamok Anishnawbek Nation
SCA	safety and control area
SRBT	SRB Technologies (Canada) Inc.
SRFN	Serpent River First Nation
T_2	tritiated gas
TBq	terabecquerel
TFN	Thessalon First Nation
UA	unacceptable
µg	microgram
µSv	microsievert
UF_6	uranium hexafluoride
UO_2	uranium dioxide
UO_3	uranium trioxide
VIM	Vision in Motion
WHMIS	Workplace Hazardous Material Information System
WSC	Workplace Safety Committee
WTFN	Williams Treaties First Nations

Glossary

For definitions of terms used in this document, see REGDOC-3.6, *Glossary of CNSC Terminology*, which includes terms and definitions used in the *Nuclear Safety and Control Act* and the regulations made under it, and in CNSC regulatory documents and other publications. REGDOC-3.6 is provided for reference and information.

A. Safety And Control Area Framework

The CNSC evaluates how well licensees meet regulatory requirements and CNSC expectations for the performance of their programs in 14 SCAs. These SCAs are grouped according to their functional areas of management, facility and equipment, and core control processes. They are further divided into specific areas that define the key components of the SCA. The following table shows the CNSC SCA Framework.

Functional area	Safety and control area	Definition	Specific areas
Management	Management system	Covers the framework that establishes the processes and programs required to ensure an organization achieves its safety objectives, continuously monitors its performance against these objectives, and fosters a healthy safety culture.	▪ Management system ▪ Organization ▪ Performance assessment, improvement and management review ▪ Operating experience (OPEX) ▪ Change management ▪ Safety culture ▪ Configuration management ▪ Records management ▪ Management of contractors ▪ Business continuity
	Human performance management	Covers activities that enable effective human performance through the development and implementation of processes that ensure a sufficient number of licensee personnel are in all relevant job areas and have the necessary knowledge, skills, procedures and tools in place to safely carry out their duties.	▪ Human performance program ▪ Personnel training ▪ Personnel certification ▪ Initial certification examinations and requalification tests ▪ Work organization and job design ▪ Fitness for duty

Functional area	Safety and control area	Definition	Specific areas
	Operating performance	Includes an overall review of the conduct of the licensed activities and the activities that enable effective performance.	▪ Conduct of licensed activity ▪ Procedures ▪ Reporting and trending ▪ Outage management performance ▪ Safe operating envelope ▪ Severe accident management and recovery ▪ Accident management and recovery
Facility and equipment	Safety analysis	Covers maintenance of the safety analysis that supports the overall safety case for the facility. Safety analysis is a systematic evaluation of the potential hazards associated with the conduct of a proposed activity or facility and considers the effectiveness of preventative measures and strategies in reducing the effects of such hazards.	▪ Deterministic safety analysis ▪ Hazard analysis ▪ Probabilistic safety analysis ▪ Criticality safety ▪ Severe accident analysis ▪ Management of safety issues (including R&D programs)
	Physical design	Relates to activities that impact the ability of structures, systems and components to meet and maintain their design basis given new information arising over time and taking changes in the external environment into account.	▪ Design governance ▪ Site characterization ▪ Facility design ▪ Structure design ▪ System design ▪ Component design

Functional area	Safety and control area	Definition	Specific areas
	Fitness for service	Covers activities that impact the physical condition of structures, systems and components to ensure that they remain effective over time. This area includes programs that ensure all equipment is available to perform its intended design function when called upon to do so.	▪ Equipment fitness for service / equipment performance ▪ Maintenance ▪ Structural integrity ▪ Aging management ▪ Chemistry control ▪ Periodic inspection and testing
Core control processes	Radiation protection	Covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations*. The program must ensure that contamination levels and radiation doses received by individuals are monitored, controlled and maintained ALARA.	▪ Application of ALARA ▪ Worker dose control ▪ Radiation protection program performance ▪ Radiological hazard control ▪ Estimated dose to public
	Conventional health and safety	Covers the implementation of a program to manage workplace safety hazards and to protect workers.	▪ Performance ▪ Practices ▪ Awareness

Functional area	Safety and control area	Definition	Specific areas
	Environmental protection	Covers programs that identify, control and monitor all releases of radioactive and hazardous substances and effects on the environment from facilities or as the result of licensed activities.	▪ Effluent and emissions control (releases) ▪ Environmental management system (EMS) ▪ Assessment and monitoring ▪ Protection of the public ▪ Environmental risk assessment
	Emergency management and fire protection	Covers emergency plans and emergency preparedness programs that exist for emergencies and for non-routine conditions. This area also includes any results of participation in exercises.	▪ Conventional emergency preparedness and response ▪ Nuclear emergency preparedness and response ▪ Fire emergency preparedness and response
	Waste management	Covers internal waste-related programs that form part of the facility's operations up to the point where the waste is removed from the facility to a separate waste management facility. This area also covers the planning for decommissioning.	▪ Waste characterization ▪ Waste minimization ▪ Waste management practices ▪ Decommissioning plans

Functional area	Safety and control area	Definition	Specific areas
	Security	Covers the programs required to implement and support the security requirements stipulated in the regulations, the licence, orders, or expectations for the facility or activity.	▪ Facilities and equipment ▪ Response arrangements ▪ Security practices ▪ Drills and exercises ▪ Cyber Security
	Safeguards and non-proliferation	Covers the programs and activities required for the successful implementation of the obligations arising from the Canada/International Atomic Energy Agency (IAEA) safeguards agreements, as well as all other measures arising from the *Treaty on the Non-Proliferation of Nuclear Weapons*.	▪ Nuclear material accountancy and control ▪ Access and assistance to the IAEA ▪ Operational and design information ▪ Safeguards equipment, containment and surveillance ▪ Import and export
	Packaging and transport	Programs that cover the safe packaging and transport of nuclear substances to and from the licensed facility.	▪ Package design and maintenance ▪ Packaging and transport ▪ Registration for use
Other matters of regulatory interest			
▪ Environmental assessment ▪ CNSC consultation – Aboriginal ▪ CNSC consultation – other ▪ Cost recovery ▪ Financial guarantees ▪ Improvement plans and significant future activities ▪ Licensee public information program ▪ Nuclear liability insurance			

B. Rating methodology and definitions

Fully satisfactory (FS)

Safety and control measures implemented by the licensee are highly effective. In addition, compliance with regulatory requirements is fully satisfactory, and compliance within the safety and control area (SCA) or specific area exceeds requirements and CNSC expectations. Overall, compliance is stable or improving, and any problems or issues that arise are promptly addressed.

Satisfactory (SA)

Safety and control measures implemented by the licensee are sufficiently effective. In addition, compliance with regulatory requirements is satisfactory. Compliance within the SCA meets requirements and CNSC expectations. Any deviation is minor and any issues are considered to pose a low risk to the achievement of regulatory objectives and CNSC expectations. Appropriate improvements are planned.

Below expectations (BE)

Safety and control measures implemented by the licensee are marginally ineffective. In addition, compliance with regulatory requirements falls below expectations. Compliance within the SCA deviates from requirements or CNSC expectations to the extent that there is a moderate risk of ultimate failure to comply. Improvements are required to address identified weaknesses. The licensee is taking appropriate corrective action.

Unacceptable (UA)

Safety and control measures implemented by the licensee are significantly ineffective. In addition, compliance with regulatory requirements is unacceptable and is seriously compromised. Compliance within the SCA is significantly below requirements or CNSC expectations, or there is evidence of overall non-compliance. Without corrective action, there is a high probability that the deficiencies will lead to unreasonable risk. Issues are not being addressed effectively, no appropriate corrective measures have been taken and no alternative plan of action has been provided. Immediate action is required.

C. Safety and control area ratings

Table C-1: SCA ratings, BRR facility, 2014–18

SCAs	2014 rating	2015 rating	2016 rating	2017 rating	2018 rating
Management system	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA	SA
Conventional health and safety	FS	FS	FS	FS	FS
Environmental protection	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA
Security	SA	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA

FS = fully satisfactory; SA = satisfactory

Table C-2: SCA ratings, PHCF, 2014–18

SCAs	2014 rating	2015 rating	2016 rating	2017 rating	2018 rating
Management system	SA	SA	SA	BE	SA
Human performance management	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA
Security	SA	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA

BE = below expectations; SA = satisfactory

Table C-3: SCA ratings, CFM, 2014–18

SCAs	2014 rating	2015 rating	2016 rating	2017 rating	2018 rating
Management system	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA
Security	SA	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA

SA = satisfactory

Table C-4: SCA ratings, BWXT Toronto and Peterborough, 2014–18

SCAs	2014 rating	2015 rating	2016 rating	2017 rating	2018 rating
Management system	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA	SA
Environmental protection	FS	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA
Security	SA	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA

FS = fully satisfactory; SA = satisfactory

Table C-5: SCA ratings, SRBT, 2014–18

SCAs	2014 rating	2015 rating	2016 rating	2017 rating	2018 rating
Management system	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA
Fitness for service	FS	FS	FS	FS	FS
Radiation protection	SA	SA	SA	SA	SA
Conventional health and safety	FS	FS	FS	SA	FS
Environmental protection	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA
Security	SA	SA	SA	SA	SA
Safeguards and non-proliferation*	N/A	N/A	N/A	N/A	N/A
Packaging and transport	SA	SA	SA	SA	SA

FS = fully satisfactory; N/A = not applicable; SA = satisfactory
*There are no safeguard verification activities associated with this facility.

Table C-6: SCA ratings, Nordion, 2014–18

SCAs	2014 rating	2015 rating	2016 rating	2017 rating	2018 rating
Management system	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA	SA
Conventional health and safety	FS	SA	SA	SA	SA
Environmental protection	FS	FS	FS	FS	FS
Emergency management and fire protection	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA
Security	FS	FS	FS	FS	FS
Safeguards and non-proliferation	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA

FS = fully satisfactory; SA = satisfactory

Table C-7: SCA ratings, BTL, 2014–18

SCAs	2014 rating	2015 rating	2016 rating	2017 rating	2018 rating
Management system	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	BE	SA	SA	SA
Waste management	SA	SA	SA	SA	SA
Security	SA	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA

BE = below expectations; SA = satisfactory

D. Financial guarantees

Table D-1: Financial guarantees, uranium processing facilities

Facility	Amount (CAD)
BRR	$48,000,000
PHCF	$128,600,000
CFM	$21,000,000
BWXT Toronto	$45,568,100
BWXT Peterborough	$6,803,500

Table D-2: Financial guarantees, nuclear substance processing facilities

Facility	Amount (CAD)
SRBT	$686,996
Nordion	$45,124,748
BTL	$1,800,000

E. Worker dose data

Extremity doses: uranium processing facilities

Table E-1: Equivalent (extremity) dose statistics for NEWs, BRR, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Average extremity dose (mSv)	5.4	1.5	1.2	1.0	3.5	**N/A**
Maximum individual extremity dose (mSv)	48.2	15.3	10.6	13.6	14.5	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table E-2: Equivalent (extremity) dose statistics for NEWs, CFM, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Average extremity dose (mSv)	15.5	15.5	13.2	10.6	15.8	**N/A**
Maximum individual extremity dose (mSv)	88.4	87.0	98.4	59.0	57.1	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table E-3: Equivalent (extremity) dose statistics for NEWs, BWXT Toronto, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Average extremity dose (mSv)	31.96	30.30	27.71	27.36	24.56	**N/A**
Maximum individual extremity dose (mSv)	102.44	109.62	119.47	115.07	83.33	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table E-4: Equivalent (extremity) dose statistics for NEWs, BWXT Peterborough, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Average extremity dose (mSv)	18.64	12.61	9.78	13.62	14.34	**N/A**
Maximum individual extremity dose (mSv)	98.98	39.34	32.84	43.18	46.06	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Extremity doses: nuclear substance processing facilities

Table E-5: Equivalent (extremity) dose statistics for NEWs, Nordion, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Average extremity dose (mSv)	0.73	0.46	0.79	0.53	0.96	**N/A**
Maximum individual extremity dose (mSv)	9.5	9.3	8.3	16.4	9.08	**500 mSv/year**

mSv = millisievert; N/A = not applicable
Note: Only the workers who routinely work in the active area are monitored for extremity dose.

Table E-6: Equivalent (extremity) dose statistics for NEWs, BTL, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Average extremity dose (mSv)	0.21	0.00	0.09	0.07	1.41	**N/A**
Maximum individual extremity dose (mSv)	3.70	0.00	1.10	0.50	13.51	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Skin doses: uranium processing facilities

Table E-7: Equivalent (skin) dose statistics for NEWs, BRR, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Average skin dose (mSv)	5.3	3.9	3.3	3.1	4.1	**N/A**
Maximum individual skin dose (mSv)	41.2	28.1	26.0	16.2	28.4	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table E-8: Equivalent (skin) dose statistics for NEWs, PHCF, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Average skin dose (mSv)	0.6	0.8	0.8	0.6	0.7	**N/A**
Maximum individual skin dose (mSv)	10.3	23.4	16.9	13.7	14.9	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table E-9: Equivalent (skin) dose statistics for NEWs, CFM, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Average skin dose (mSv)	8.1	6.3	6.6	5.5	3.4	**N/A**
Maximum individual skin dose (mSv)	108.4	95.6	95.7	88.1	59.0	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table E-10: Equivalent (skin) dose statistics for NEWs, BWXT Toronto, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Average skin dose (mSv)	11.08	9.89	10.23	7.85	8.92	**N/A**
Maximum individual skin dose (mSv)	51.67	54.99	74.26	54.27	58.36	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table E-11: Equivalent (skin) dose statistics for NEWs, BWXT Peterborough, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Average skin dose (mSv)	4.75	4.1	2.66	2.77	2.87	**N/A**
Maximum individual skin dose (mSv)	29.91	22.47	21.15	25.14	17.87	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Skin doses: nuclear substance processing facilities

Table E-12: Equivalent (skin) dose statistics for NEWs, Nordion, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Average skin dose (mSv)	0.46	0.42	0.59	0.42	0.45	**N/A**
Maximum individual skin dose (mSv)	6.11	5.24	5.20	5.52	4.26	**500 mSv/year**

mSv = millisievert; N/A = not applicable

F. Environmental data

Blind River Refinery

Table F-1: Annual groundwater monitoring results, 2014–18

Parameter	2014	2015	2016	2017	2018	GCDWQ*
Average uranium concentration (µg/L)	0.6	1.7	1.3	1.2	2.3	**20**
Maximum uranium concentration (µg/L)	8.9	18.5	14.0	11.0	27.0	**20**

GCDWQ = *Guidelines for Canadian Drinking Water Quality*; µg/L = microgram per litre
*None of the groundwater wells monitored are used for drinking water.

Table F-2: Surface water annual average results at outfall diffuser in Lake Huron, 2014–18

Parameter	2014	2015	2016	2017	2018	CCME guidelines*
Average uranium concentration (µg/L)	<0.2	0.2	<0.8**	<0.8	<0.7**	**15**
Average nitrate concentration (mg/L as N)	0.2	0.2	0.2	0.2	0.2	**13**
Average radium-226 concentration (Bq/L)	<0.005	<0.005	<0.005	<0.005	0.008	**N/A**
Average pH	7.6	7.3	8.0	7.3	8.0	**6.5–9.0**

Bq/l = becquerel per litre; CCME = Canadian Council of Ministers of the Environment; mg/L = milligrams per litre; µg/L = microgram per litre

Note: Results below the detection limit are denoted as "<".

*****CCME, *Canadian Water Quality Guidelines for the Protection of Aquatic Life*

**The ambient water method detection limit was reassessed by Cameco in 2016 and again in late 2017.

Table F-3: Soil monitoring results, 2014–18

Parameter	2014	2015	2016	2017	2018	CCME guidelines*
Minimum uranium concentration (µg/g)	0.1	0.1	0.2	0.3	0.5	**23**
Average uranium concentration (µg/g) (within 1,000 m, 0–5 cm depth)	2.7	3.8	1.5	1.6	2.0	
Maximum uranium concentration (µg/g)	7.2	9.7	2.9	2.8	3.7	

cm = centimetre; CCME = Canadian Council of Ministers of the Environment; µg/g = microgram per gram
*CCME, *Soil Quality Guidelines for the Protection of Environmental and Human Health* (for residential/parkland land use)

Port Hope Conversion Facility

Table F-4: Mass (kg) of contaminants removed by pumping wells, 2014–18

Parameter	2014	2015	2016	2017	2018
Uranium	31.0	25.3	22.8	34.0	27.0
Fluoride	53.0	48.3	36.9	61.0	57.0
Ammonia	75.0	63.7	73.6	70.0	66.0
Nitrate	53.0	44.0	42.6	56.0	124.0
Arsenic	2.5	2.6	1.9	3.0	1.0

kg = kilogram

Table F-5: Harbour water quality, 2014–18

Parameter	Value	2014	2015	2016	2017	2018	CCME* guidelines
Uranium (µg/L)	Average	3.3	2.9	2.6	3.3	5.2	**15**
	Maximum	7.6	6.6	10	8.8	31	
Fluoride (mg/L)	Average	0.11	0.13	0.15	0.19	0.16	**0.12**
	Maximum	0.39	0.17	0.22	0.29	0.36	
Nitrate (mg/L)	Average	0.86	0.89	0.85	1.0	1.0	**13**
	Maximum	1.5	1.7	1.6	2.2	1.8	
Ammonia + ammonium (mg/L)	Average	0.23	0.20	0.16	0.18	0.13	**0.3**
	Maximum	0.52	0.66	0.58	0.40	0.47	

CCME = Canadian Council of Ministers of the Environment; mg/L = milligrams per litre; µg/g = microgram per gram
*****CCME, *Canadian Water Quality Guidelines for the Protection of Aquatic Life*

Table F-6: Uranium concentrations at waterworks side yard remediated with clean soil (µg/g), 2014–18

Soil depth (cm)	2014	Soil depth (cm)	2015	2016	2017	2018	CCME guidelines*
0–2	1.4	**0–5**	1.0	1.2	0.8	0.91	**23**
2–6	1.2						
6–10	1.1	**5–10**	1.0	1.1	0.8	0.85	
10–15	1.1	**10–15**	1.2	1.0	0.9	0.98	
70 cm composite	1.4						

CCME = Canadian Council of Ministers of the Environment; cm = centimetre; µg/g = microgram per gram
*CCME, *Soil Quality Guidelines for the Protection of Environmental and Human Health* (for residential/parkland land use)

Table F-7: Fluoride concentration in local vegetation, 2014–18

Parameter	2014	2015	2016	2017	2018	MECP guidelines*
Fluoride in vegetation (ppm)	2.6	3.2	3.0	11.0	5.0	**35**

MECP = Ontario Ministry of the Environment, Conservation and Parks; ppm = parts per million
*****MECP's Upper Limit of Normal Guidelines

Table F-8: Gamma monitoring results, annual average, 2014–16

Parameter	2014	2015	2016	Licence limit
Site 1 (µSv/h)	0.003	0.007	0.005	**0.14**
Site 2 (Dorset Street)) (µSv/h)	0.054	0.044	0.054	**0.40**

µSv/h = microsievert per hour

Table F-9: Gamma monitoring results, maximum monthly, 2017–18

Station number and site	2017	2018	Licence limit
Station 2 - Sites 1 and 2 (µSv/h)	0.25	0.26	**0.57**
Station 13 - Site 1 (µSv/h)	0.03	0.07	**0.40**
Station 21 - Site 2 (µSv/h)	0.08	0.07	**0.26**

µSv/h = microsievert per hour

Cameco Fuel Manufacturing Inc.

Table F-10: Soil monitoring results*

Parameter	2008	2009	2010	2013	2016	CCME guidelines**
Average uranium concentration (µg/g)	5.4	5.2	4.5	3.7	2.5	**23**
Maximum uranium concentration (µg/g)	20.8	17.0	21.1	17.4	11.2	**23**

µg/g = microgram per gram
***** CFM reverted to a three-year soil monitoring program and did not monitor soil in 2011, 2012, 2014, 2015, 2017 and 2018.
** CCME, *Soil Quality Guidelines for the Protection of Environmental and Human Health* (for residential and parkland land use)

BWXT Toronto

Table F-11: Uranium in boundary air monitoring results, 2014–18

Parameter	2014	2015	2016	2017	2018
Average concentration (µg/m^3)	0.001	0.001	0.001	0.000	0.000

µg = microgram
Note: Ontario standard for uranium in ambient air is 0.03 µg/m^3.

Table F-12: Uranium in soil monitoring results, BWXT property, 2014–18

Parameter	Industrial lands				
	2014	2015	2016	2017	2018
Number of samples	1	1	1	1	1
Uranium concentration (µg/g)	2.3	1.4	1.2	1.7	1.3
CCME guideline (µg/g)*	**300**				

CCME = Canadian Council of Ministers of the Environment; µg/g = microgram per gram
*CCME, *Soil Quality Guidelines for the Protection of Environmental and Human Health*

Table F-13: Uranium in soil monitoring results, commercial lands, 2014–18

Parameter	Commercial lands				
	2014	2015	2016	2017	2018
Number of samples	34	30	34	34	34
Average uranium concentration (µg/g)	5.0	2.9	2.7	3.0	2.3
Maximum uranium concentration (µg/g)	22.1	8.7	13.6	20.6	11.9
CCME guideline (µg/g)*	33				

CCME = Canadian Council of Ministers of the Environment; µg/g = microgram per gram
*CCME, *Soil Quality Guidelines for the Protection of Environmental and Human Health*

Table F-14: Uranium in soil monitoring results, residential locations, 2014–18

Parameter	Residential locations				
	2014	2015	2016	2017	2018
Number of samples	14	18	14	14	14
Average uranium concentration (µg/g)	0.6	0.7	0.5	1.0	< 1.0
Maximum uranium concentration (µg/g)	2.1	2.1	0.7	1.6	< 1.0
CCME guidelines (µg/g)*	**23**				

CCME = Canadian Council of Ministers of the Environment; µg/g = microgram per gram
*CCME, *Soil Quality Guidelines for the Protection of Environmental and Human Health*

SRB Technologies (Canada) Inc.

Table F-15: Atmospheric emissions monitoring results, 2014–18

Parameter	2014	2015	2016	2017	2018	Licence limit (TBq/year)
Tritium as tritium oxide (HTO) (TBq/year)	10.71	11.55	6.29	7.19	10.74	**67**
Total tritium as HTO + HT (TBq/year)	66.16	56.24	28.95	24.82	33.18	**448**

TBq = terabecquerel; HTO = hydrogenated tritium oxide; HT = tritium gas

Table F-16: Liquid effluent monitoring results for release to sewer, 2014–18

Parameter	2014	2015	2016	2017	2018	Licence limit (TBq/year)
Tritium-water soluble (TBq/year)	0.013	0.007	0.005	0.007	0.010	**0.200**

TBq = terabecquerel

Nordion (Canada) Inc.

Table F-17: Air emissions monitoring results, 2014–18

Parameter	2014	2015	2016	2017	2018	Licence limit (DRL) (GBq/year)
Cobalt-60	0.005	0.005	0.006	0.0034	0.002	250
Iodine-125	0.14	0.12	0.21	0.0012	0	952
Iodine-131	0.46	0.15	0.35	0.0008	0.006	686
Xenon-133	15,018	11,916	7,277	0	0	677,000,000
Xenon-135	13,075	8,237	4,299	0	0	102,000,000
Xenon-135m	18,170	10,758	5,421	0	0	69,000,000

DRL = derived release limit; GBq = gigabecquerel

Table F-18: Liquid effluent monitoring results for release to sewer, 2014–18

Parameter	2014	2015	2016	2017	2018	Licence limit (DRL) (GBq/year)
β < 1 MeV	0.209	0.191	0.222	0.212	0.243	763
β > 1 MeV	0.050	0.044	0.051	0.048	0.055	35,000
Iodine-125	0.051	0.111	0.144	0.145	0.146	1,190
Iodine-131	0.006	0.006	0.006	0.006	0.007	389
Molybdenum-99	0.055	0.060	0.052	0.049	0.055	10,200
Cobalt-60	0.018	0.019	0.026	0.022	0.027	35.4
Niobium-95	0.0007	0.0010	0.0010	0.0010	0.0010	3,250
Zirconium-95	0.0005	0.0010	0.0015	0.0020	0.0017	2,060
Cesium-137	0.0004	0.0004	0.0007	0.0007	0.0007	24.8

β < 1 MeV = beta particles less than 1 megaelectronvolt; DRL = derived release limit; GBq = gigabecquerel

G. Total annual releases of radionuclides directly to the environment

During the December 2018 Commission meeting, CNSC staff made a commitment to provide an annual update to the Commission in keeping with the decision on radionuclide reporting in the National Pollutant Release Inventory (NPRI). The CNSC is making radionuclide release data more readily accessible to the public as part of its commitment to open government and its mandate to disseminate this information to the public; this appendix reflects the continued commitment to provide data, within the regulatory oversight reports, on the total annual release of radionuclides.

In addition, the CNSC and the NPRI are working together to establish active links between the CNSC and NPRI websites. A stakeholder sub-group consisting of environmental non-governmental organizations (ENGOs) and industry is completing active beta testing of the links between the NPRI site and existing CNSC data products (such as this regulatory oversight report). The CNSC has also begun to develop downloadable digital databases of radionuclide releases, further supplementing the range of CNSC environmental data products linked to the NPRI website. The downloadable databases are expected to become part of the active beta testing activities in the latter part of 2019.

Uranium processing facilities

Direct releases of radionuclides to the environment from uranium fuel refinery, manufacturing and conversion facilities are primarily limited to uranium released to the atmosphere. As uranium is more chemically toxic than radiologically toxic, releases are monitored as total uranium. As a result, the annual load is reported in kilograms. Of these facilities, only Cameco’s Blind River Refinery has direct releases to surface water; the relevant radionuclides are uranium and radium-226.

Table G-1: Total annual load of relevant radionuclides released to atmosphere or surface waters for uranium processing facilities, 2013–18

Facility and year	Annual uranium release to air (kg)	Annual uranium released in liquid effluent to surface waters (kg)	Total radium-226 released in liquid effluent to surface waters (MBq)
BRR			
2013	4.1	3.6	1.93
2014	1.5	4.0	1.81
2015	1.3	2.6	1.06
2016	1.0	1.2	0.92
2017	0.8	1.9	1.04
2018	1.2	1.9	1.05
PHCF			
2013	68.4	N/A	N/A
2014	33.4	N/A	N/A
2015	38.7	N/A	N/A
2016	34.3	N/A	N/A
2017	31.5	N/A	N/A
2018	34.1	N/A	N/A
CFM			
2013	0.51	N/A	N/A
2014	0.41	N/A	N/A
2015	0.46	N/A	N/A
2016	0.73	N/A	N/A
2017	0.58	N/A	N/A
2018	1.26	N/A	N/A
BWXT Toronto			
2013	0.0104	N/A	N/A
2014	0.0109	N/A	N/A
2015	0.0108	N/A	N/A
2016	0.0108	N/A	N/A
2017	0.0074	N/A	N/A
2018	0.0063	N/A	N/A
BWXT Peterborough			
2013	0.000013	N/A	N/A
2014	0.000003	N/A	N/A
2015	0.000003	N/A	N/A
2016	0.000004	N/A	N/A
2017	0.000002	N/A	N/A
2018	0.000002	N/A	N/A

MBq = megabecquerel; N/A = not applicable

Nuclear substance processing facilities

SRBT

Direct releases to the environment for SRBT are limited to atmospheric releases of tritium. There are no direct releases to surface waters.

Table G-2: Total annual load of relevant radionuclides released to atmosphere, SRBT, 2013–18

Year	Tritium	
	Tritiated water or HTO (GBq)	Elemental tritium or T_2 (GBq)
2013	1.78E+04	6.11E+04
2014	1.07E+04	5.48E+04
2015	1.15E+04	4.47E+04
2016	6.29E+03	2.27E+04
2017	7.20E+03	1.76E+04
2018	1.07E+04	2.24E+04

GBq = gigabecquerel; HTO = hydrogenated tritium oxide; HT = tritium gas

Nordion

Direct radionuclide releases to the environment at Nordion are limited to atmospheric releases.

Table G-3: Total annual load of relevant radionuclides released to the atmosphere, Nordion, 2013–18

Year	Cobalt-60 (GBq)	Iodine-125 (GBq)	Iodine-131 (GBq)	Xenon-133 (GBq)	Xenon-135 (GBq)	Xenon-135m (GBq)
2013	0.005	0.23	0.39	30,735	28,193	43,383
2014	0.005	0.14	0.46	15,018	13,075	18,170
2015	0.005	0.12	0.15	11,916	8,237	10,758
2016	0.006	0.21	0.35	7,277	4,299	5,421
2017	0.0034	0.0012	0.0008	0	0	0
2018	0.002	0	0.006	0	0	0

GBq = gigabecquerel

BTL

BTL does not have any airborne or liquid radiological releases.

H. Lost-time injuries in 2018

Table H-1: LTIs, PHCF, 2018

LTI	Action taken by licensee
On May 15, 2018, during offsite confined-space training, an emergency response team (ERT) member was crawling through a confined-space tunnel prop. The employee failed to stop at the tunnel transition and fell into the next tunnel approximately 4 feet below. The individual was wearing all required PPE at the time of the incident. They were transported to the site to be evaluated by the site nurse and put on restricted duties. The employee continued to work under the restrictions, but was later instructed by their doctor to cease work. The lost time began on June 19, 2018, and the individual remained off work until July 26, 2018.	During training, place a spotter at the transition, to stop the entrant before the change in elevation. Create a confined-space rescue plan for the training prop and treat it like a site rescue. The 4-foot fall is a hazard that would need to be effectively mitigated to prevent injuring a rescuer.
On September 7, 2018, while exiting their vehicle, a contracted truck driver stepped down onto rig mats in the loading area on Centre Pier. The driver's foot landed in a gap between the boards of the rig mat. Consequently the driver rolled and sprained their ankle. The driver was transported to the hospital for assessment. There it was determined that they would not be able to return to work until September 13. This resulted in the lost-time injury.	The rig matting was pulled up so that it would no longer pose a risk.

Table H-2: LTIs, BTL, 2018

LTI	Action taken by licensee
An employee's coverall was caught on a grinder and pulled, causing cuts and abrasion to the right side of the stomach area. This resulted in one day of lost time.	The employee received medical attention, the wound was sterilized and cleaned, and gauze was applied. The employee was reminded to use the proper guard when performing the work.
An employee applied an upward force to a large pipe wrench and experienced lower back strain. This resulted in 11 days of lost time.	The employee visited a chiropractor for treatment. This was deemed to be an isolated incident as the work has not been performed since. The employee was put on light-duty work upon return.

I. Links to licensee websites

Licensee	Website	2018 annual compliance reports
Cameco BRR	cameco.com/fuel_services/blind_river_refinery	2018 Annual Compliance Report
Cameco PHCF	cameco.com/fuel_services/port_hope_conversion	2018 Annual Compliance Report
Cameco CFM	cameco.com/fuel_services/fuel_manufacturing	2018 Annual Compliance Report
BWXT Toronto and Peterborough	nec.bwxt.com	2018 Annual Compliance Report
SRBT	srbt.com	2018 Annual Compliance Report
Nordion	nordion.com	2018 Annual Compliance Report
BTL	theratronics.ca	2018 Annual Compliance Report

J. Significant changes to licence and licence conditions handbook

There were no significant changes to licences or LCHs in uranium and nuclear substance processing facilities in 2018.

K. CNSC inspections

CNSC inspections: Uranium processing facilities

Table K-1: Inspections, BRR, 2018

Inspection title	Safety and control areas covered	Inspection report sent date
CAMECO-BRR-2018-01	Environmental protection	April 25, 2018
CAMECO-BRR-2018-02	Management systems	May 16, 2018
CAMECO-BRR-2018-03	Waste management	July 11, 2018
CAMECO-BRR-2018-04	Emergency management and fire protection	May 6, 2019
CAMECO-BRR-2018-05	Radiation protection	January 11, 2019

Table K-2: Inspections, PHCF, 2018

Inspection Title	Safety and control areas covered	Inspection report sent date
CAMECO-PHCF-2018-01	Fitness for Service	May 25, 2018
CAMECO-PHCF-2018-02	Waste management, management system	June 12, 2018
CAMECO-PHCF-2018-03	Radiation protection, environmental protection, waste management	October 19, 2018
CAMECO-PHCF-2018-04	Emergency management and fire protection	December 18, 2018
CAMECO-PHCF-2018-05	Environmental protection, waste management	December 21, 2018
CAMECO-PHCF-2018-06	Management system	January 25, 2019

Table K-3: Inspections, CFM, 2018

Inspection title	Safety and control areas covered	Inspection report sent date
CAMECO-CFM-2018-01	Emergency management and fire protection	July 3, 2018
CAMECO-CFM-2018-02	Waste management, conventional health and safety	March 11, 2019

Table K-4: Inspections, BWXT Toronto and Peterborough, 2018

Inspection title	Safety and control areas covered	Inspection report sent date
BWXT-2018-01	Operating performance, fitness for service, radiation protection, conventional health and safety, environmental protection	April 9, 2018
BWXT-2018-02	Emergency management and fire protection	June 12, 2018
BWXT-2018-03	Environmental protection	November 27, 2018
BWXT-2018-04	Emergency management and fire protection	January 25, 2019

CNSC inspections: Nuclear substance processing facilities

Table K-5: Inspections, SRBT, 2018

Inspection title	Safety and control areas covered	Inspection report sent date
SRBT-2018-01	Security	March 16, 2018
SRBT-2018-02	Packaging and transport	April 5, 2018

Note: Security inspection reports contain sensitive information and will not be made public.

Table K-6: Inspections, Nordion, 2018

Inspection title	Safety and control areas covered	Inspection report sent date
NORDION-2018-01	Management system	May 7, 2018
NORDION-2018-02	Conventional health and safety, operating performance, fitness for service, radiation protection, environmental protection, waste management	February 1, 2019

Table K-7: Inspections, BTL, 2018

Inspection title	Safety and control areas covered	Inspection report sent date
BT-2018-01	Radiation protection, operating performance, fitness for service, human performance management, conventional health and safety, physical design	December 14, 2018

L. CNSC fuel cycle ratings definitions and examples

	Radiation protection		Environmental protection		Conventional health and safety	
Safety significance	**Definition**	**Fuel cycle facility-specific examples**	**Definition**	**Fuel cycle facility-specific examples**	**Definition**	**Fuel cycle facility-specific examples**
High	Exposures to multiple workers in excess of regulatory limits. Widespread contamination to several persons or to a place.	Incident that results in, or has reasonable potential for, a worker exceeding regulatory limits. Examples: ▪ nuclear energy worker (NEW) exceeding 50 millisieverts (mSv)/year or 100 mSv/five years ▪ Non-NEW exceeding 1 mSv	Radiological or hazardous substances being released to the environment exceeding regulatory limits (including public exposure) or resulting in significant impact to the environment.	Incident that results in, or has reasonable potential to have, a significant or moderate impact or extensive future remediation. Examples: ▪ impairment of ecosystem functions ▪ effluent licence limit exceedance ▪ spill into fish-bearing water ▪ fish kill	Work-related fatality due to failures in the conventional safety program.	Fatality or serious injury.
Medium	An incident that would result in a licensee exceeding action level. Limited contamination that could affect a few persons or a limited area.	Incident that results in or has reasonable potential to exceed an action level. Example: ▪ doses to workers of 1 mSv/week or 5 mSv/quarter	Radiological or hazardous substances being released to the environment exceeding action levels (including public exposure) or resulting in an impact to	Incident that results in, or has reasonable potential to have, a minor impact, or that requires some future remediation. Examples: ▪ effluent action level exceedance ▪ spills to environment	Work-related lost-time accident due to failures in the conventional safety program.	Lost-time accident or serious injury causing permanent disability that would not allow the worker to return to work

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			the environment outside the licensing basis.	(including atmosphere) with short-term or seasonal impacts		for an extended period of time or ever.
Low	Increased dose, but below reportable limits. Contamination that could affect a worker.	Incident that results in, or has reasonable potential to exceed, the highest administrative level.	Release of radiological or hazardous substances to the environment, but below regulatory limits.	Incident that results in, or has reasonable potential to have, a negligible impact. Examples: ▪ administrative-level effluent exceedance ▪ spills to the environment (including atmosphere), with no future impacts	Minor injury due to failures in the conventional safety program.	Minor injury (cuts, scrapes, bumps, soreness).