Canada's Nuclear Regulator

Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2017

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Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2017

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Cover images
From left to right:

Weighing of uranium concentrate drums before processing
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. The report outlines the safety performance of uranium and nuclear substance processing facilities in Canada for the 2017 calendar year and, where applicable, includes trends and comparisons with results in previous years.

The report 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.

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. CNSC staff confirm that, in 2017, the uranium and nuclear substance processing facilities in Canada continued to operate safely. With one exception, the performance of all uranium and nuclear substance processing facilities was rated as "satisfactory" or better for all 14 SCAs.

The one exception was a "below expectations" rating for the management system SCA for the Cameco Port Hope Conversion Facility (PHCF), due to deficiencies identified in the PHCF's management system following a release event in 2017. Over an unspecified time, Cameco failed to verify whether work was being performed correctly and according to approved procedures as outlined in the Cameco PHCF licence conditions handbook. To deter recurrence and promote future compliance, a CNSC designated officer issued an administrative monetary penalty to Cameco.

Overall, CNSC staff's compliance 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 remaining SCAs required to ensure that 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 2017, the licensees covered in this report made adequate provision for the health and safety of workers as well as the protection of the

public and the environment, and for meeting Canada's international obligations on the peaceful use of nuclear energy.

The full report is available on the CNSC public website and the documents referenced in it 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.

CNSC staff report to the Commission annually on the safety performance of the uranium and nuclear substance processing facilities in Canada regulated by the CNSC in the form of a regulatory oversight report. The 2017 report contains information on the licensees' compliance with the legal requirements of the *Nuclear Safety and Control Act* (NSCA) [1] and its associated regulations made under the NSCA, as well as with each facility's licence conditions handbook (LCH) and any other applicable standards and regulatory documents.

The information provided in this report covers the 2017 calendar year and, where applicable, includes trends and comparisons with previous years. The report focuses on three SCAs – radiation protection, environmental protection, and conventional health and safety – as they provide a good overview of the safety performance for the facilities. In addition, the document highlights a discussion of licensee's 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.

In addition, the report includes a list of references, a list of acronyms and their definitions, a glossary and 11 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 regarding radiation protection, environmental monitoring and releases, and health and safety data, including annual trends. New to this year's report is appendix G, which provides the total annual releases of radionuclides for each facility during 2017. Appendix I lists the licensees' websites and appendix J summarizes any significant changes made to the licences and LCHs in 2017. Appendix K provides a list of all compliance verification inspections conducted during the calendar year for each facility.

1.1 Canada's uranium and nuclear substance processing facilities

This report summarizes the CNSC staff assessment of the safety performance of the following licensees, all of which are 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.00/2025)
  - Best Theratronics Ltd. (BTL) in Ottawa (NSPFOL-14.01/2019)

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 resources are appropriately allocated and controls are applied based on the complexity of the facility, as well as the hazards and magnitude of the potential risks associated with the activities at the facility.

To ensure that each licensee is operating safely, CNSC staff apply a risk-informed approach to the compliance oversight of a facility. CNSC staff establish compliance plans for each facility, determining the type and level of review, inspection and testing to be conducted in a manner that is consistent with the potential risks posed by the regulated activities.

CNSC staff continuously review 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 2017, CNSC staff conducted 29 onsite inspections at uranium and nuclear substance processing facilities in Canada. The inspections covered various aspects of the SCAs. A breakdown of the number of inspections is provided in each industry's respective section (chapters 2 and 7) and summarized in appendix K.

While some inspections focus on specific SCAs, CNSC inspectors strive to ensure that they cover aspects of the radiation protection, environmental protection, and conventional health and safety SCAs in every inspection. This is done to continually 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, facility visits and meetings with the licensees.

1.3 Safety and Control Area Framework

CNSC staff use the SCA Framework in evaluating 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)

Full definitions of the four ratings are provided in appendix B. Ratings are listed for each applicable SCA. The ratings are derived from the compliance 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 these cases, the CNSC staff rating input consists of the information provided in CNSC staff's 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 due to the licensee's licensed activities. The licensees submit the results of these monitoring programs to the CNSC to ensure compliance with applicable guidelines and limits, 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. The IEMP involves taking samples from public areas around the facilities, then measuring and analyzing the amounts of radioactive and hazardous substances in those samples and comparing the results against relevant guidelines, limits and objectives.

In 2017, CNSC staff conducted independent environmental monitoring at BRR, PHCF and CFM. The 2017 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 there are no expected adverse environmental or health effects as a result of site operations.

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

The CNSC is committed to ongoing engagement and relationship building with interested Indigenous communities. In this regard, Indigenous communities with interest in Canada's uranium and nuclear substance processing facilities were provided a copy of this report. Through its Participant Funding Program (PFP), the CNSC also made available financial support for participation in the review of this report. In addition, during 2017, CNSC staff provided interested Indigenous communities with updates on sampling campaigns under the IEMP at uranium and nuclear substance processing operations.

In 2017, uranium and nuclear processing facility licensees began, continued, or strengthened communications and engagement activities with Indigenous communities and organizations interested in their facilities. Activities included meetings with Indigenous leaders, facility tours, financial and volunteer support for sporting and cultural events, and community forum invites. CNSC staff and licensees also responded in writing to issues of interest or concern raised by the Algonquins of Ontario (AOO) in their intervention to the Commission in relation to the *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2016*. The AOO was the only Indigenous group that submitted an intervention.

CNSC staff continue to ensure that each licensee's communications and engagement activities with Indigenous communities are consistent and appropriate. CNSC staff also continue to develop a structured, formalized approach to ensure routine engagement and information sharing with all interested Indigenous communities and organizations in relation to the CNSC-regulated facilities.

More detailed information on the licensees' activities relating to Indigenous communities and organizations can be found in the facility-specific performance sections.

1.6 Overall conclusions

CNSC staff concluded that uranium processing facilities and nuclear substance processing facilities in Canada operated safely during the 2017 calendar year. This assessment is based on CNSC staff's verification of licensee activities that included 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 2017, the performance ratings in all 14 SCAs for the facilities were as follows:

- with the exception of a "below expectations" rating for the management system SCA for the PHCF, uranium processing facilities were rated as "satisfactory" or better
- nuclear substance processing facilities were rated as "satisfactory" or better

CNSC staff's compliance 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 2017. Appendix B includes a definition of the rating methodology and ratings.

CNSC staff concluded that, in 2017, the licensees covered in this report made adequate provision for the health and safety of workers as well as 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

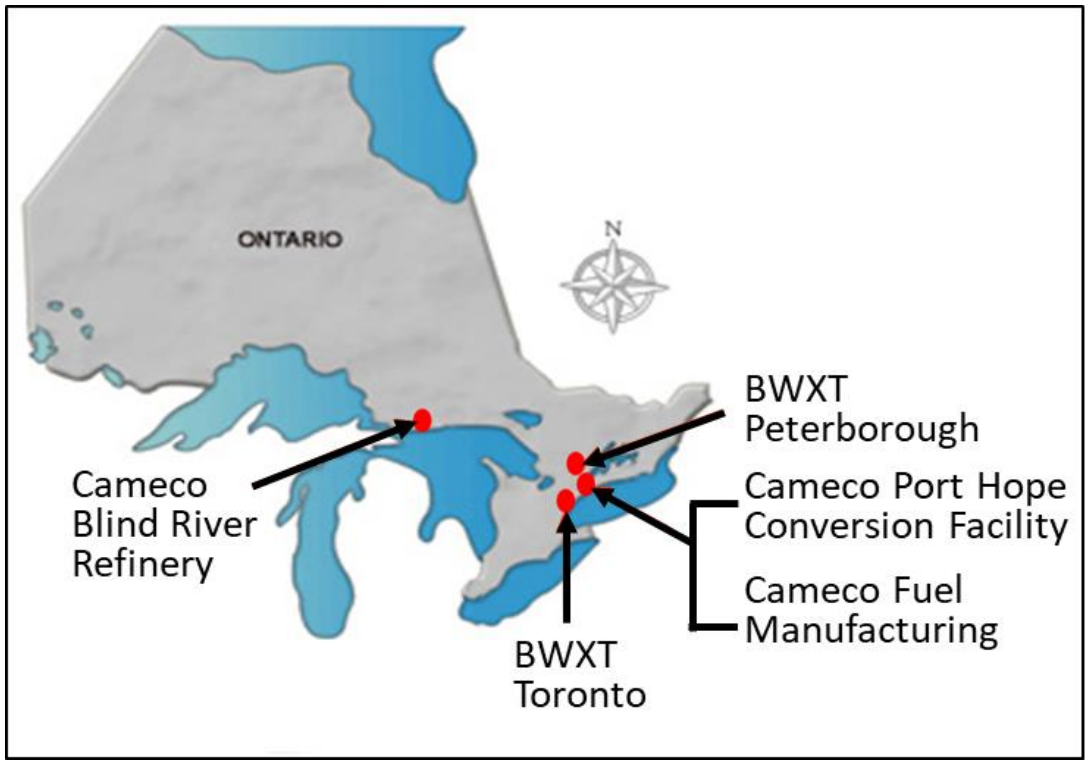
2 Overview

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 2017. Table 2-1 presents the licensing and compliance efforts from CNSC staff for these facilities throughout 2017.

Table 2-1: CNSC regulatory oversight licensing and compliance activities, uranium processing facilities, 2017

Facility	Number of onsite inspections	Person-days for compliance	Person-days for licensing activities
BRR	4	223	16
PHCF	5	301	23
CFM	4	295	11
BWXT Toronto and Peterborough	5	214	78

In 2017, CNSC staff performed 18 onsite inspections at Canada's uranium processing facilities. All the findings resulting from these onsite inspections were provided to the licensees in detailed inspection reports. All resulting regulatory enforcement actions were recorded in the CNSC Regulatory Information Bank to ensure that they are tracked to completion. Appendix K lists the CNSC inspections conducted for each facility in 2017.

In accordance with the licence and respective LCH, all uranium processing facility licensees must submit annual compliance reports on the operations of their respective 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 2017, CNSC staff rated all but two of the SCAs as "satisfactory". The exceptions were:

- BRR's performance in the conventional health and safety SCA, which was rated as "fully satisfactory"
- PHCF's performance in the management systems SCA, which was rated as "below expectations"

Additional information about these SCA ratings can be found in the facility-specific sections. Appendix C contains the SCA ratings from 2013 to 2017 for each facility.

Table 2-2: SCA performance ratings, uranium processing facilities, 2017

SCA	BRR	PHCF	CFM	BWXT Toronto and Peterborough
Management system	SA	BE	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, which CNSC staff review and approve. Each plan 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 2017, unchanged from the previous year.

Ratings for the radiation protection SCA, uranium processing facilities, 2017

BRR	PHCF	CFM	BWXT Toronto and Peterborough
SA	SA	SA	SA

SA = satisfactory

Application of ALARA

During 2017, 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.

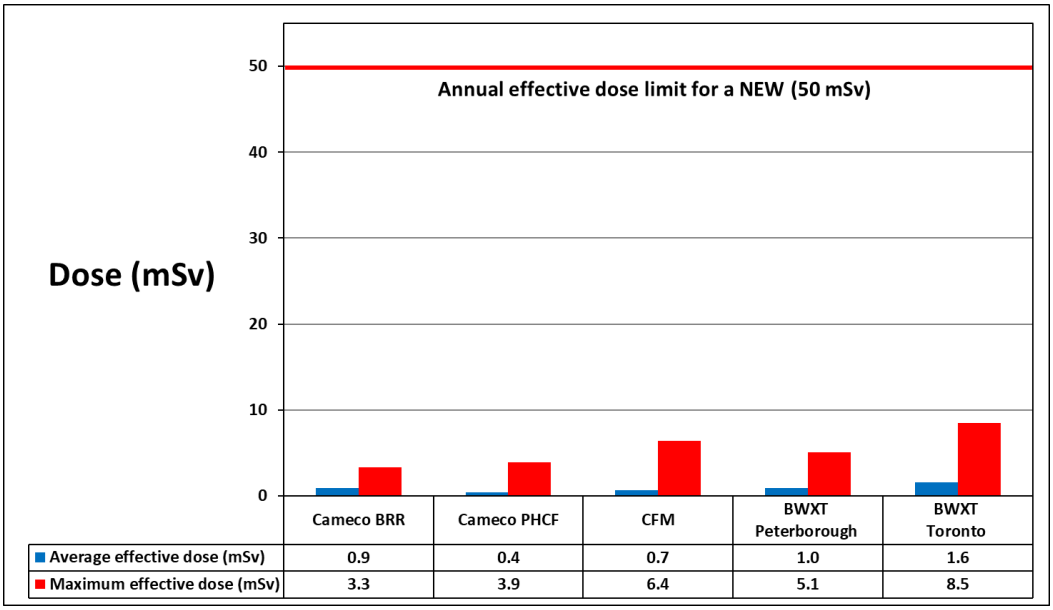
Worker dose control

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. Taking into consideration the inherent differences in the design of radiation protection programs among

licensees, the dose statistics provided in this report are primarily for NEWs. Additional information on the total number of monitored persons, including workers, contractors and visitors, is provided in the facility-specific sections.

The maximum and average effective doses for NEWs at uranium processing facilities are shown in figure 2-2. In 2017, the maximum individual effective dose received by a NEW at all facilities ranged from 3.3 millisieverts (mSv) to 8.5 mSv, which is 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, 2017



	Cameco BRR	Cameco PHCF	CFM	BWXT Peterborough	BWXT Toronto
Average effective dose (mSv)	0.9	0.4	0.7	1.0	1.6
Maximum effective dose (mSv)	3.3	3.9	6.4	5.1	8.5

During 2017, all licensees of 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 during 2017 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 action to restore the effectiveness of the radiation protection program. It is important to note that occasional 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 2017, there were two radiological action level exceedances across all uranium processing facility licensees. The exceedances were at the BRR and CFM facilities, and are further discussed in sections 3.2 and 5.2. Cameco reported the action level exceedances to the CNSC, investigated the exceedances and established corrective actions to the satisfaction of CNSC staff.

Radiological hazard control

CNSC staff verified that, in 2017, 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. All these licensees continued to implement their 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 by using monitoring results from air emissions, liquid effluent releases and fenceline gamma monitoring. The CNSC's requirement to apply the ALARA principle ensures that licensees 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 2013 to 2017 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, 2013–17

Facility	2013	2014	2015	2016	2017	Regulatory Limit
BRR	0.012	0.005	0.005	0.005	0.005	**1 mSv/year**
PHCF	0.021	0.012	0.006	0.020	0.153*	
CFM	0.013	0.018	0.025	0.023	0.022	
BWXT Toronto	0.0006	0.0055**	0.010	0.0007	0.0175	
BWXT Peterborough	<0.001	<0.001	<0.001	<0.001	<0.001	

*In 2016, the 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 look higher than in previous years', but there has not been an actual increase in emissions/dose from the PHCF. The results actually represent a much more conservative estimate of dose to the public. This is because gamma monitoring at the facility fenceline has now been added to the calculations. As such, 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, in 2017, 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 2017, unchanged from the previous year.

Ratings for the environmental protection SCA, uranium processing facilities, 2017

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 2017 in the uranium fuel processing sector. Information on the total annual release of relevant facility-specific radionuclides in emissions to the atmosphere and in effluent released to surface waters is provided in appendix G.

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.

Exceeding an action level does not mean non-compliance. Indeed, the 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 a 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 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 2017, the uranium processing facility licensees established and implemented EMSs in compliance with the CNSC regulatory requirements.

Assessment and monitoring

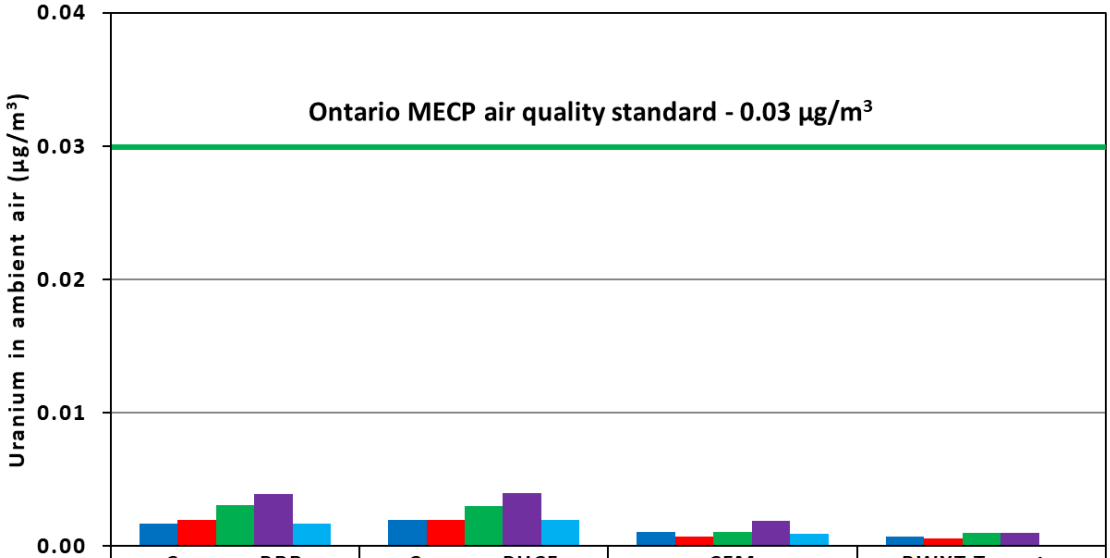
Each uranium processing facility licensee has environmental monitoring programs at each of its facilities to monitor releases of radioactive and hazardous substances, and to characterize the quality of the environment associated with the licensed facility. These programs include the monitoring of uranium 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 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 (µg/m^3).

The results from the high-volume air samplers with the highest values near a facility (maximum annual average) for 2013 through 2017 are shown in figure 2-3. These values are measured as the total suspended particulate representing the total amount of uranium in air. As shown in figure 2-3, 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, 2013–17



	Cameco BRR	Cameco PHCF	CFM	BWXT Toronto
2013	0.0017	0.0020	0.0011	0.0007
2014	0.0020	0.0020	0.0007	0.0006
2015	0.0031	0.0030	0.0011	0.0010
2016	0.0039	0.0040	0.0019	0.0010
2017	0.0017	0.0020	0.0009	0.0000

Uranium in soil

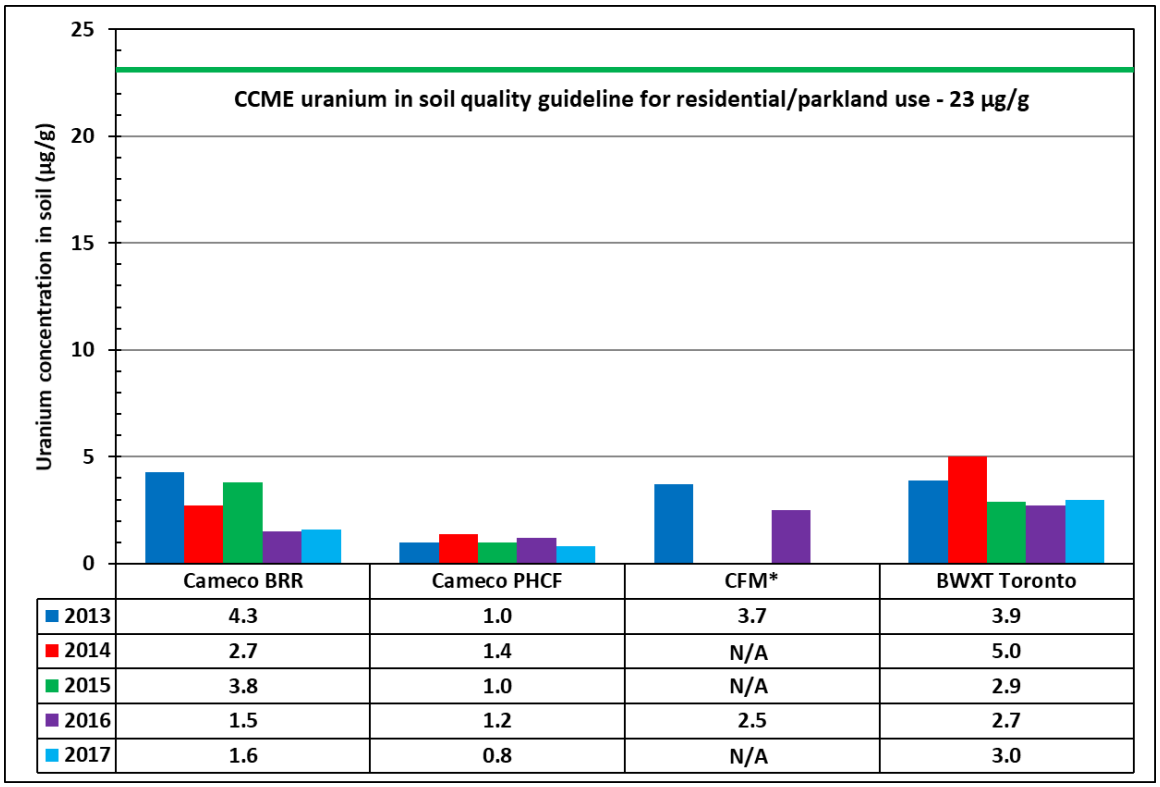
The three Cameco facilities and BWXT Toronto have soil monitoring programs to monitor the long-term effects of air emissions and to determine whether there is accumulation of uranium in soil around the facility. Sampling takes place every three years at the CFM facility and annually at the other facilities. The uranium in the soil at the CFM facility is a result of historic uranium contamination, which is common to the Port Hope area.

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 described in the previous subsection, BWXT monitors the stack to confirm that releases to air remain low.

CNSC staff evaluated the results of licensees' soil sampling programs for 2017 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 2013 through 2017. 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) soil quality guideline for residential and parkland use.

Figure 2-4: Uranium concentration in soil (annual average), uranium processing facilities, 2013–17



	Cameco BRR	Cameco PHCF	CFM*	BWXT Toronto
2013	4.3	1.0	3.7	3.9
2014	2.7	1.4	N/A	5.0
2015	3.8	1.0	N/A	2.9
2016	1.5	1.2	2.5	2.7
2017	1.6	0.8	N/A	3.0

*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 hazardous substances released from their facilities. Licensees use effluent and environmental monitoring programs to verify that releases of hazardous substances do not result in environmental concentrations that may affect public health. CNSC staff receive reports of discharges to the environment through reporting requirements outlined in the licence and the LCH. Based on reviews of the programs at the uranium processing facilities, CNSC staff concluded that the public continues to be protected from facility emissions of hazardous substances.

Environmental risk assessment

Environmental risk assessments (ERAs) are used 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. The uranium processing facility licensees currently have acceptable environmental programs in place to ensure the protection of the public and the environment.

In 2014, CNSC staff requested that the uranium processing facilities implement CSA standard N288.6-12 *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3], in order to align with the design, implementation and management of an ERA program that incorporates best practices used in Canada and internationally. CSA N288.6-12 has now been implemented at all uranium processing facilities.

As outlined in REGDOC-3.2.1, *Public Information and Disclosure*, published in May 2018, if a licensee is required to conduct an ERA, the ERA must be posted on the licensee's website. Licensees are developing implementation plans for uranium processing facilities, which will include the date by which the regulatory document must be implemented. Section 2.4 provides more details on the implementation status of regulatory documents for the uranium processing facilities.

Conclusion on environmental protection

CNSC staff concluded that the uranium processing facility licensees implemented their environmental protection programs satisfactorily during 2017. 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 personnel and equipment.

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 2017 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, 2017

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.

Licensees are required to report unsafe occurrences 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. 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 2017 and the actions taken.

Table 2-4: LTIs at uranium processing facilities, 2013–17

Facility	2013	2014	2015	2016	2017
BRR	0	0	0	0	0
PHCF	0	1	2	3	1
CFM	0	0	1	0	0
BWXT Toronto and Peterborough	0	1	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 2017 to verify compliance of the licensees' conventional health and safety programs with regulatory requirements. Through these regulatory oversight activities, CNSC staff determined 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.

Through conducting onsite inspections, CNSC staff are able to 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 2017. Their programs are effective in protecting the health and safety of persons working in the facilities.

2.4 Regulatory developments

In 2017, Cameco's operating licence for the PHCF was renewed by the Commission through a public hearing for a 10-year period expiring in February 2027. No amendments were made to the 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*, Version 2	February 2016	Implemented	Implementation expected by April 2019	Implementation expected by December 2018	Implemented
REGDOC-2.2.2, *Personnel Training*, Version 2	December 2016	Implemented	Implemented	Implemented	Implemented
REGDOC-3.1.2, *Reporting Requirements, Volume I: Non-Power Reactor Class I Nuclear Facilities and Uranium Mines and Mills*	January 2018	Implementation expected by January 2019	Implementation expected by January 2019	Implementation expected by January 2019	Implementation expected by February 2019
REGDOC-2.13.1, *Safeguards and Nuclear Material Accountancy*	February 2018	Implementation expected by September 2019	Implementation expected by September 2019	Implementation expected by September 2019	Implementation expected by January 2019
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 and standards, taking into consideration licensees' implementation plans. CNSC staff verify the implementation as part of ongoing compliance verification activities.

2.5 Public information and outreach

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 what type of facility information must be shared with the public (e.g., incidents, major changes to operations or periodic environmental performance reports), as well as details on how that information will be shared. This ensures that timely information is effectively communicated about the health, safety and security of persons and the environment, and about other issues associated with the lifecycle of the nuclear facilities.

In 2017, CNSC staff evaluated licensees' implementation of their public information and disclosure programs by reviewing communications activities such as public information sessions, facility tours, newsletters, and website and social media updates, and licensees' direct outreach to stakeholders in the community. CNSC staff determined that all uranium processing facility licensees were in compliance with REGDOC-3.1.2, *Reporting Requirements, Volume I: Non-Power Reactor Class I Nuclear Facilities and Uranium Mines and Mills*.

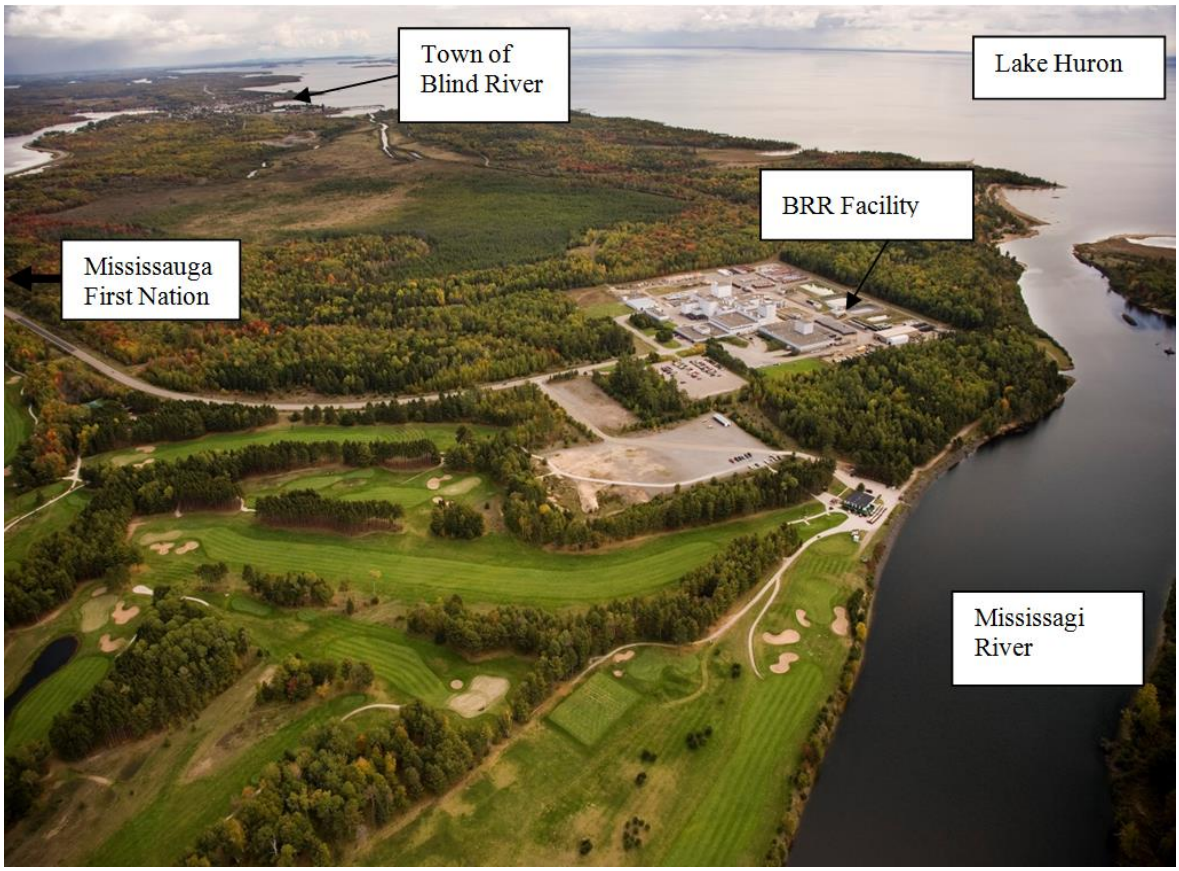
CNSC staff concluded that, in 2017, licensees operating uranium processing facilities implemented their public information programs satisfactorily and issued information in accordance with their public disclosure protocols. Their programs are effective at communicating information about the health, safety and security of persons and the environment, and other issues associated with the facilities. Furthermore, all licensees publish their annual compliance reports on their websites.

More detailed engagement activities and information shared with the public with respect to each facility are outlined in the licensee-specific performance sections.

3 Cameco Blind River Refinery

Cameco Corporation owns and operates the Blind River Refinery (BRR) facility in Blind River, Ontario, under an operating licence that expires in February 2022. The BRR 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 the BRR facility



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 the PHCF.

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

3.1 Overall performance

For 2017, CNSC staff rated the BRR facility's performance as "satisfactory" in all but one of the SCAs. The exception was conventional health and safety, which was rated as "fully satisfactory". The performance ratings for the BRR facility from 2013 to 2017 are shown in table C-1 of appendix C.

Cameco continued to operate the BRR facility safely throughout 2017. The facility underwent two planned shutdowns during the year to conduct routine maintenance activities and implement facility upgrades. Cameco ensured that the BRR site was maintained according to the facility's licensing basis.

The BRR facility experienced four events that were reported to CNSC staff in 2017, in accordance with Cameco's regulatory reporting requirements.

Three of the four events were related to transport, while the fourth was a CNSC radiological action level exceedance. Two of the transport events involved damage to drums coming to the BRR facility from a foreign producer. There was no loss of material from any of the damaged drums. The third transport event involved damage to one drum going from the BRR facility to Cameco's Key Lake Mine.

While there was a small release of calcined product onto the floor of the truck trailer, there was no effect on the environment or the health and safety of persons.

The fourth event, exceedance of a CNSC radiological action level, is discussed in section 3.2.

For each event, Cameco completed an investigation and established corrective actions. CNSC staff reviewed this information to ensure that Cameco's corrective actions were effective to prevent recurrence.

In 2017, CNSC staff conducted four onsite inspections at the BRR facility to ensure compliance with the NSCA [1] and its associated regulations, Cameco's operating licence and the programs used to meet regulatory requirements. A list of these inspections can be found in table K-1 in appendix K. The inspections focused on the following SCAs: management system, human performance management, operating performance, fitness for service, radiation protection, conventional health and safety, and security. Seven 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.

CNSC staff note that Cameco, in relation to the BRR facility, provided information and engaged with Indigenous communities and organizations with an interest in the BRR site activities in 2017, including meetings with the Chief of the Mississauga First Nation (MFN) and tours for representatives of the Métis Nation of Ontario and the Sagamok First Nation. In the interest of reconciliation and relationship-building based on openness and trust with Indigenous peoples in Canada, CNSC staff continue to ensure that all issues of interest or concern in relation to the BRR facility are identified, recorded, considered and addressed, where appropriate.

Cameco continued to communicate with all target audiences about its facility in 2017 and regularly updates its website with safety and environmental information about its licensed activities. Cameco posts a safety report on its website, along with waste management information and quarterly compliance reports. The licensee meets yearly with community leaders and Indigenous groups and also conducts meetings with public stakeholders interested in the facility. Cameco is in compliance with RD/GD-99.3, the predecessor of REGDOC-3.2.1, *Public Information and Disclosure* [7], and implementation plans for REGDOC-3.2.1 are expected to be completed in 2019.

3.2 Radiation protection

Compliance ratings for the radiation protection SCA, BRR facility, 2013–17

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA
For 2017, CNSC staff continued to rate the radiation protection SCA at the BRR facility as "satisfactory". Cameco has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations* [2]. At the BRR 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 BRR 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

Cameco established radiation protection objectives and targets at the BRR facility in 2017 that focused on initiatives to reduce worker doses and airborne uranium concentrations. Cameco's objectives included improvements to the respiratory protection program and gamma spectroscopy equipment. Cameco's site management team reviewed the status of the radiation protection objectives and targets and allocated resources accordingly in order to achieve them. Cameco also continued to use an ALARA Committee that is responsible for making recommendations for improving radiation protection at the BRR facility.

Worker dose control

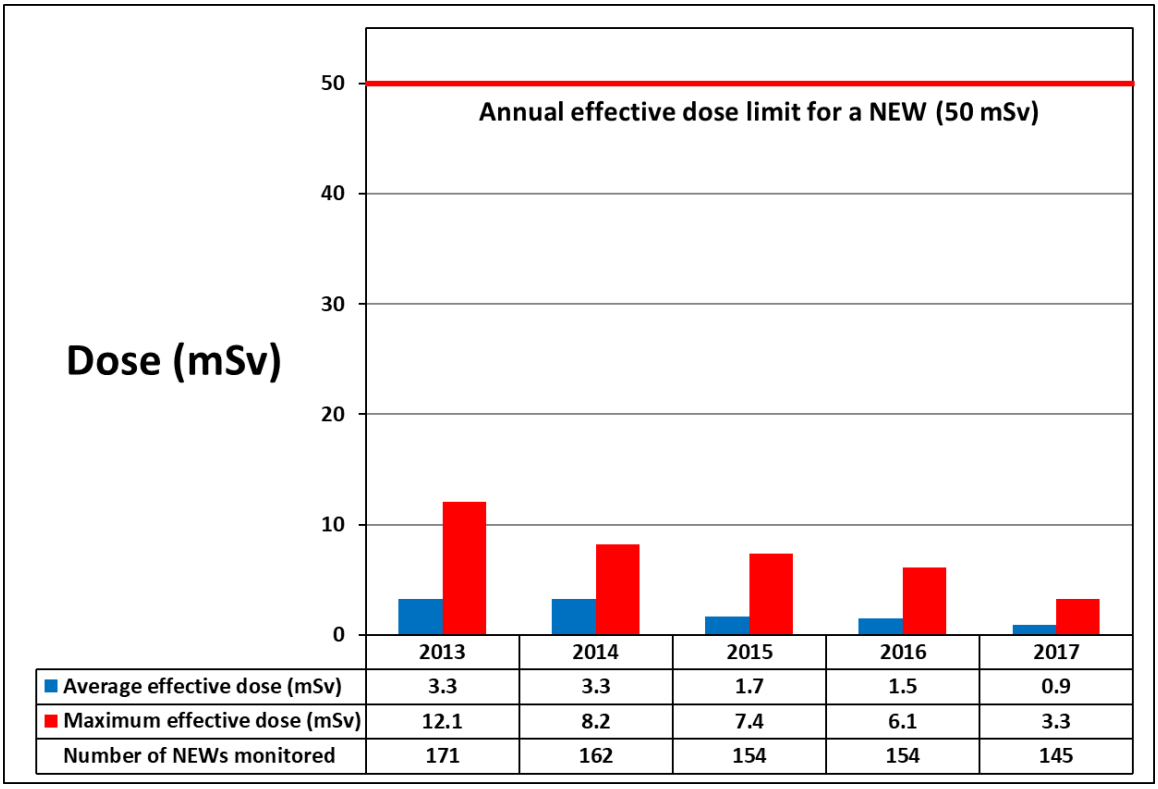
Radiation exposures at the BRR facility are monitored to ensure compliance with the CNSC's regulatory dose limits and to keep radiation doses ALARA. In 2017, radiation exposures at the BRR facility were well below the CNSC regulatory dose limits.

Cameco ascertains external doses by using whole-body and extremity dosimetry. For internal radiological exposures, Cameco's Fuel Services Division holds a CNSC dosimetry service licence, which authorizes Cameco to provide in-house internal dosimetry services at the BRR facility. Internal dose is assessed and assigned at the BRR facility through two programs: urine analysis and lung counting, a method in which a radiation detector is used to measure radiation emitted from radioactive material collected in a person's lung.

All Cameco employees at the BRR facility are identified as NEWs. BRR contractors may also be identified as NEWs depending on the nature of their work activities. In 2017, total effective dose was assessed for 145 NEWs at the BRR facility, consisting of 130 Cameco employees and 15 contractors. The maximum effective dose received by a NEW in 2017 was 3.3 mSv, which is approximately 7% 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 the BRR facility from 2013 to 2017. The average and maximum total effective doses in 2017 are the lowest over this five-year period.

Figure 3-3: Average and maximum effective doses to NEWs, BRR facility, 2013–17



	2013	2014	2015	2016	2017
Average effective dose (mSv)	3.3	3.3	1.7	1.5	0.9
Maximum effective dose (mSv)	12.1	8.2	7.4	6.1	3.3
Number of NEWs monitored	171	162	154	154	145

Annual average and maximum equivalent (extremity) and equivalent (skin) dose results from 2013 to 2017 are shown in tables E-1 and E-7 in appendix E. In 2017, the maximum individual skin dose received by a NEW at the BRR facility was 16.2 mSv, which is approximately 3% 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 the BRR facility was 13.6 mSv, 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 steady 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 the BRR facility. In 2017, the maximum individual effective dose received by a site visitor/contractor who was not a NEW was 0.1 mSv, which is well below the CNSC regulatory dose limit of 1 mSv/year for a person who is not a NEW.

Radiation protection program performance

In 2017, CNSC staff assessed the performance of Cameco's radiation protection program at the BRR facility through various CNSC staff compliance activities. Overall, Cameco's compliance with the *Radiation Protection Regulations* [2] and the CNSC licence requirements at the BRR facility was found to be acceptable.

Action levels for radiological exposures are established as part of the radiation protection program. 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 2017, there was one exceedance of the BRR facility's action level for whole-body dose reported to the CNSC. Cameco's investigation revealed that the reported exposure was non-personal in nature. Cameco requested that a correction be made to the official dose of record in the National Dose Registry for the employee, in accordance with the CNSC-established process. The dose change request was reviewed by CNSC staff and approved in December 2017.

Radiological hazard control

Cameco has radiation and contamination control programs at the BRR facility to control and minimize radiological hazards and the spread of radioactive contamination. Methods of control include radiation zone controls and monitoring to confirm the effectiveness of the programs. Cameco staff at the BRR facility conducted in-plant air monitoring, contamination monitoring and radiation dose rate surveys in 2017, and did not identify any adverse trends.

Estimated dose to the public

The maximum dose to the public from licensed activities at the BRR facility is calculated by using monitoring results of air emissions, water discharges and gamma radiation. Table 3-1 shows the 2013 to 2017 maximum effective doses to a member of the public. Doses to the public remain well below the CNSC regulatory dose limit of 1 mSv/year.

Table 3-1: Maximum effective dose to a member of the public, BRR facility, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory dose limit
Maximum effective dose (mSv)	0.012	0.005	0.005	0.005	0.005	**1 mSv/year**

3.3 Environmental protection

Compliance ratings for the environmental protection SCA, BRR, 2013–17

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA
For 2017, CNSC staff continued to rate the environmental protection SCA at Cameco's BRR facility as "satisfactory". Uranium releases to the environment continue 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 are controlled in accordance with the MECP applicable regulations and certificates of approval. The measured releases to the environment in 2017 were well below regulatory limits. Groundwater monitoring, surface water monitoring, soil sampling and ambient air data indicate that the public and the environment continue to be protected from facility releases.				

SA = satisfactory

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 demonstrate that atmospheric emissions from the facility continued to be effectively controlled, as they remained consistently well below their respective licence limits from 2013 to 2017.

Table 3-2: Air emissions monitoring results (annual averages), BRR facility, 2013–17

Parameter	2013	2014	2015	2016	2017	Licence limit
Dust collection and exhaust ventilation stack: uranium (kg/h)	0.00004	0.00005	0.00005	0.00005	0.00004	**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)	3.4	2.0	2.5	1.6	1.7	**56.0**
Particulate (kg/h)	0.014	0.009	0.006	0.006	0.008	**11.0**

HNO_3 = nitric acid; kg/h = kilogram per hour; NO_2 = nitrogen dioxide; NO_x = nitrogen oxides
Note: Results below the detection limit are denoted as "<".

In addition to licence limits, the BRR facility implemented 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 2017.

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, before discharge into Lake Huron. Cameco monitors uranium, radium-226, nitrates and pH levels in liquid effluents to demonstrate compliance with their respective licence limits.

Table 3-3 summarizes the average monitoring results from 2013 to 2017. For 2017, the liquid discharges from the facility continued to be below their respective licence limits.

Table 3-3: Liquid effluent monitoring results (annual averages), BRR facility, 2013–17

Parameter	2013	2014	2015	2016	2017	Licence limit
Uranium (mg/L)	0.01	0.02	0.02	0.01	0.01	**2**
Nitrates (mg/L)	26	17	13	11	14	**1,000**
Radium-226 (Bq/L)	0.01	0.01	<0.01	0.01	0.01	**1**
pH (min)	7.1	7.1	7.2	7.3	7.3	**Min 6.0**
pH (max)	8.4	8.4	8.4	8.6	8.2	**Max 9.5**

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

In addition to licence limits, the BRR facility has action levels that are used to provide assurance that the licence limits will not be exceeded. No action levels for liquid effluents were exceeded at any time in 2017.

Environmental management system

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 facility. Cameco's EMS for the BRR facility is described in the facility's Environmental Management Program Manual.

The EMS includes annual environmental objectives and targets set by Cameco, which are reviewed and assessed by CNSC staff through compliance verification activities. Cameco completed four out of five of its environmental objectives set for 2017. These completed objectives were related to a review of the action levels, reduction of legacy waste on site, review of the storm water lagoon pumping system and assessment of the internal recycling of liquid effluent streams. The fifth objective was to assess an alternate location for the incinerator sampling point. However, Cameco cancelled this objective, after determining that the original sampling point was appropriate and did not require relocation based on current operations.

Cameco holds an annual safety meeting during which environmental protection issues are discussed and documented. CNSC staff, as part of their compliance verification activities, review these documents and follow up with Cameco staff on any outstanding issues. The results of these compliance verification activities demonstrate that Cameco conducted an annual management review in accordance with the CNSC requirements and that identified issues are being properly addressed. CNSC staff are satisfied that Cameco is conducting effective reviews and adequately addressing identified issues.

Assessment and monitoring

Cameco's environmental monitoring programs serve 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 public dose limit of 1 mSv and is ALARA. The principal monitoring activities, described below, focus on monitoring air, groundwater, surface water, soil, and gamma radiation around the BRR site.

In addition, the CNSC conducts periodic monitoring under its IEMP to verify that the public and the environment around nuclear facilities are protected.

Uranium in ambient air

Cameco's sampling network around the facility revealed that the concentrations of uranium in the ambient air continued to be low. In 2017, the highest measured annual average concentration (among the sampling stations) of uranium in ambient air was 0.0017 $\mu g/m^3$, which is well below the MECP annual 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 a total of 43 monitoring wells: 17 wells located inside the fenceline and 26 outside of it.

Based on the groundwater sampling data presented in Cameco's annual compliance reports, the BRR operations are not causing any adverse impact to groundwater quality. The average uranium concentration in groundwater decreased in 2017 from 2016. The maximum sampled uranium concentration in the groundwater was 11.0 micrograms per litre (μg/L) in 2017, which is below the maximum acceptable concentration of 20 μg/L in Health Canada's *Guidelines for Canadian Drinking Water Quality* (GCDWQ) [8]. The groundwater in the area is not used for drinking water purposes. Groundwater monitoring results are shown in table F-1 of appendix F.

Surface water monitoring

Cameco continues to monitor surface water for uranium, nitrate, radium and pH at the location of the BRR's outfall diffuser in Lake Huron. The concentrations of uranium, nitrate, radium and the pH levels in the lake remain well below the CCME guidelines. Surface water monitoring results are shown in table F-2 of appendix F.

Soil monitoring

Cameco collects soil samples annually to monitor uranium concentrations in an upper layer of surface soil (15 cm) to demonstrate that there are no long-term effects of air emissions on soil quality due to deposition of airborne uranium on soil around the BRR facility. The 2017 soil monitoring results remained consistent with the respective concentrations detected in previous years, as shown in table F-3 of appendix F. The maximum uranium soil concentrations measured near the facility continued to trend downward, with the 2017 result at 2.8 µg/g slightly above natural background levels (between 1.9 and 2.1 µg/g) at both the MFN and Blind River communities. In addition, the uranium soil concentrations are well below 23 µg/g, which is the most restrictive soil quality guideline for uranium (for residential and parkland land use) set by the CCME. Uranium soil concentrations are not increasing in the area surrounding the facility.

These data demonstrate that the current BRR operations do not contribute to accumulation of uranium in surrounding soil. No adverse consequences to human and environmental receptors are expected.

Gamma monitoring

A significant portion of radiological public dose in Blind River that can be attributed to the BRR operations is due to gamma radiation sources. Consequently, monitoring gamma radiation effective dose rates at the fenceline of the BRR main site and at a nearby golf course north of the BRR site is essential to ensuring that levels of potential gamma radiation exposure are safe and maintained ALARA. The land immediately outside the fenceline continues to be owned and controlled by Cameco. The critical receptor location for the gamma component of dose to the public is the neighbouring golf course. Therefore, Cameco sets an action level for gamma dose rates of 1.0 µSv/h (microsieverts per hour) at the north fence only. The effective dose rates for gamma radiation are measured with environmental dosimeters.

In 2017, the monthly average of fenceline gamma measurements at the BRR facility were 0.38 µSv/h (east), 0.24 µSv/h (north), 0.43 µSv/h (south) and 1.10 µSv/h (west). All north fence results in 2017 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 in the Blind River area in 2013, 2014 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 BRR site are protected from facility emissions.

Since 2014, CNSC staff and the MFN have been holding regular meetings to discuss Cameco's licensing and compliance activities for the BRR facility. As a continuation of these meetings, CNSC staff held a meeting with the MFN on February 2, 2016, to discuss the MFN's air quality sampling program and air monitoring results. Also discussed were the MFN's concerns regarding previous IEMP sampling locations and the changes to Ontario's ambient air quality standard for uranium. Following the meeting, CNSC and MFN staff discussed ideas for future sampling campaigns that would include MFN traditional lands. CNSC staff made a commitment to continue the dialogue and explore opportunities with the MFN to inform the sampling campaign and increase the MFN's understanding of the results.

On July 5, 2016, CNSC staff met with MFN staff to develop an IEMP sampling plan on MFN lands. The CNSC's PFP provided financial support to the MFN for all these meetings. A sampling plan meeting both the IEMP objectives and the MFN objectives was subsequently developed and executed in October 2017. The CNSC shared the IEMP results with the MFN and indicated that the community is protected from the operations of the facility.

Another IEMP campaign was completed in October 2018 at the BRR facility and, similar to previous years, involved ongoing communications and support from the MFN. The results from the campaign will be made available to the public once the samples have been analyzed by the CNSC's laboratory.

Protection of the public

The CNSC receives reports of discharges to the environment in accordance with the reporting requirements outlined in the BRR facility licence and LCH. CNSC staff's review of hazardous discharges from the BRR facility to the environment in 2017 indicates that no significant risks to the public or environment occurred during that period.

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

Environmental risk assessment

In November 2016, Cameco submitted an ERA for the BRR facility to the CNSC. CNSC staff reviewed Cameco's responses to staff comments and concluded that the current version of the ERA for the BRR facility is in compliance with CSA N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [7]. CNSC staff expect Cameco to address several technical comments before or in the next iteration of the ERA (due in 2021), as appropriate, to improve the quality of the ERA.

ERA conclusions and recommendations, as well as guidance outlined in 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], have been incorporated into Cameco's environmental programs for the BRR facility to ensure the protection of the public and the environment.

REGDOC-3.2.1, *Public Information and Disclosure*, which was published in May 2018, stipulates that if a licensee is required to conduct an ERA, the ERA must be posted on the licensee's website. Cameco is currently developing implementation plans for its uranium processing facilities, which will include the date by which REGDOC-3.2.1 must be implemented.

3.4 Conventional health and safety

Compliance ratings for the conventional health and safety SCA, BRR facility, 2013–17

2013	2014	2015	2016	2017
FS	FS	FS	FS	FS
For 2017, CNSC staff continued to rate the conventional health and safety SCA at the BRR facility as "fully satisfactory". Overall, the compliance verification activities conducted by CNSC staff at the BRR facility confirmed that Cameco continues to view conventional health and safety as an important consideration. Cameco has demonstrated a fully satisfactory ability to keep its workers safe from occupational injuries: No lost-time injuries (LTIs) have occurred at the facility in the past 11 years.				

FS = fully satisfactory

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. Cameco continues to develop and maintain a comprehensive conventional health and safety management program for the BRR facility. This program at the BRR facility incorporates various elements, including accident reporting and investigation, hazard prevention, preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response.

A key performance measure for the conventional health and safety SCA is the number of LTIs that occur per year. Table 3-4 shows that the number of LTIs remained at zero in 2017. Cameco has not had an LTI at the BRR facility in the past 11 years.

Table 3-4: LTIs, BRR facility, 2013–17

	2013	2014	2015	2016	2017
LTIs	0	0	0	0	0

Practices

Cameco's activities and operations at the BRR facility must comply with 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 facility's entrance. Cameco uses audits, inspections, evaluations, reviews, benchmarking, training and employee engagement to evaluate the effectiveness of conventional health and safety practices at the facility.

Cameco has a Facility Health and Safety Committee that inspects the workplace and meets monthly to resolve and track any safety issues. All reported conventional health and safety incidents are tracked and managed through the Cameco Incident Reporting System database. CNSC staff review the committee meeting minutes and any associated corrective actions to verify that issues are promptly resolved.

Awareness

Workers are made aware of the conventional health and safety program, as well as workplace hazards, through training and ongoing internal communications with Cameco. Cameco holds monthly safety meetings for all employees at the BRR facility on various safety topics, including radiation protection, environmental protection and fire protection. Attendance is tracked at the safety meetings as an indicator for safety performance. Cameco workers at the BRR facility also attend daily toolbox meetings where they are notified of any concerns or ongoing maintenance in their area. Cameco also undertook a safety initiative in 2017, 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. The PHCF is located at two sites in the Municipality of Port Hope, as seen in figure 4-1. Aerial photographs of the two PHCF sites (Site 1 and Site 2) are shown in figure 4-2 and figure 4-3.

Figure 4-1: PHCF Site 1 and Site 2 properties, located in the Municipality of Port Hope, ON

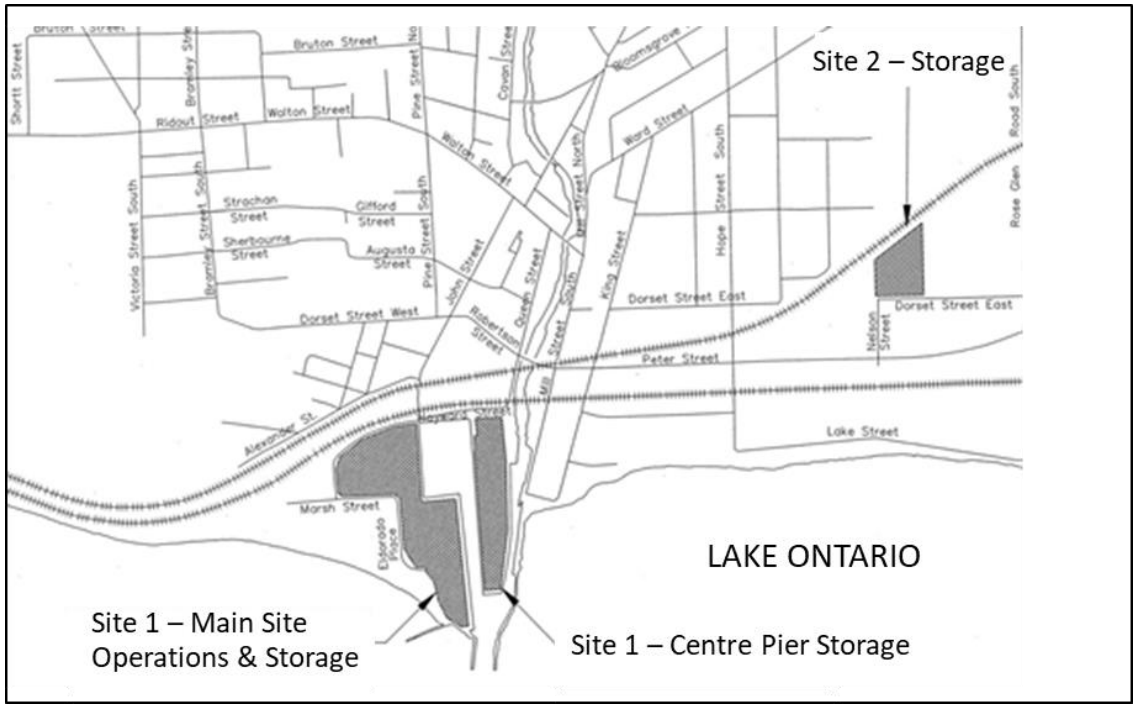


Figure 4-2: Aerial view of Site 1 of the PHCF

Figure 4-3: Aerial view of Site 2 of the PHCF

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

Vision in Motion (VIM) is the name of Cameco's project to clean up legacy waste inherited from historic operations and to renew the PHCF. The project is being carried out under Cameco's operating licence for the facility. In 2017, Cameco's work included repackaging legacy waste to further prepare conditions for cleanup and remediation expected to start in 2018.

In 2017, the Commission renewed Cameco's operating licence via a public hearing. Cameco's PHCF licence covers 10 years, expiring on February 28, 2027.

4.1 Overall performance

For 2017, CNSC staff rated the PHCF's performance as "satisfactory" in all but one of the SCAs. The exception was the management system, which received a rating of "below satisfactory". The performance ratings for the PHCF from 2013 to 2017 are shown in table C-2 of appendix C.

In 2017, Cameco ensured that the PHCF site was maintained according to the PHCF's licensing basis. During the summer of 2017, the UO_2 and UF_6 plants underwent scheduled shutdowns to allow for planned maintenance activities.

On May 5, 2017, Cameco reported a small release of hydrogen fluoride (HF) at its UF_6 plant. During the night shift, an employee was performing maintenance work and HF gas was released. The emergency ventilation system was activated by a local HF detector. Upon arriving to the affected area, Cameco's emergency response team secured the connection to the impulse line. The employee was directed to Cameco's medical department where he received precautionary medical attention due to exposure to HF. The worker was not injured and there were no environmental impacts as a result of this event.

In accordance with the CNSC reporting regulatory requirement, Cameco reported the incident to the CNSC duty officer and carried out a detailed investigation of this reportable event. Cameco submitted a final report for review by CNSC staff. Based on Cameco's investigation into the event, CNSC staff determined that the required work clearance and permits had not been obtained by the junior technician before the start of the maintenance work. Furthermore, Cameco determined that the junior and senior technicians had been performing this maintenance activity for an unspecified period of time without the necessary work clearances and permits.

This practice was known to the UF_6 production supervisor. CNSC staff had previously identified non-adherence to this procedure in a 2014 inspection and noted non-compliance with Cameco's management system since 2014. CNSC staff assessed the release event and Cameco's compliance history with respect to procedural adherence and determined that Cameco had failed to verify whether work was being performed correctly and according to approved procedures, as required by Cameco's management system.

An administrative monetary penalty (AMP) was issued to Cameco by a CNSC designated officer on September 6, 2017, in accordance with section 6(1)(b) of the *Canadian Nuclear Safety Commission's Administrative Monetary Penalties Regulations* [9]. Specifically, it was issued because Cameco had failed to comply with licence condition 2.1, that "licensees shall implement and maintain a management system" in accordance with paragraph 48(c) of the NSCA. The purpose of issuing the AMP was to promote compliance with Cameco's licensing basis documents, which are part of its management system, and to deter future violations.

Cameco requested a review of the AMP by the Commission. The review was held in March 2018 and the Commission rendered its decision in May 2018, determining that Cameco had committed the violation. Additional details on the AMP are provided on the CNSC website.

In 2017, Cameco reported nine events at the PHCF to the CNSC. Cameco reported these events in accordance with its regulatory reporting requirements and, of the nine events, one was an LTI notification. All the events are further discussed in section 4.4.

In 2017, CNSC staff conducted five onsite inspections at the PHCF to verify compliance with the NSCA [1], its associated regulations, Cameco's operating licence and the programs used to meet regulatory requirements. A list of these inspections can be found in table K-2 of appendix K. These planned onsite inspections focused on the following SCAs: radiation protection, conventional health and safety, packaging and transport, physical design, management system, fitness for service, emergency management, and human performance management. CNSC staff raised 22 enforcement actions 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 noted that Cameco, in relation to the PHCF, invited Indigenous communities and organizations with a potential interest in its activities to public forums in 2017. In the interest of reconciliation and relationship-building based on openness and trust with Indigenous peoples in Canada, CNSC staff continue to ensure that all issues of interest or concern to Indigenous communities and organizations in relation to the PHCF are identified, recorded, considered and addressed, where appropriate.

Cameco maintained the commitments of its public information program in 2017 by holding a joint community forum for stakeholders and key audiences on the PHCF and CFM activities, and by hosting two media events. The media events announced Cameco's involvement in the world's supply of cobalt-60 to produce medical isotopes. Local media covered these events, which were attended by federal and provincial parliamentary representatives, as well as the mayors of Port Hope and Cobourg, and other dignitaries.

Cameco gave facility tours to the public, students and industry organizations at the PHCF. Cameco also updated health and safety information on its website, and conducted public opinion polling in accordance with its public information program. The licensee is in compliance with RD/GD-99.3, the predecessor of REGDOC-3.2.1, *Public Information and Disclosure* [7], and implementation plans for REGDOC-3.2.1 are expected to be completed in 2019.

4.2 Radiation protection

Compliance ratings for the radiation protection SCA, PHCF, 2013–17

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA
For 2017, 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 PHCF, 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 PHCF. 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

Cameco established radiation protection objectives and ALARA targets at the PHCF for parameters such as radiation doses, radiation protection training and contamination monitoring. All ALARA targets for radiation doses were met in 2017. The radiation protection subcommittee of the Conversion Safety Steering Committee also continued to provide support for radiation protection improvement initiatives at the PHCF.

Worker dose control

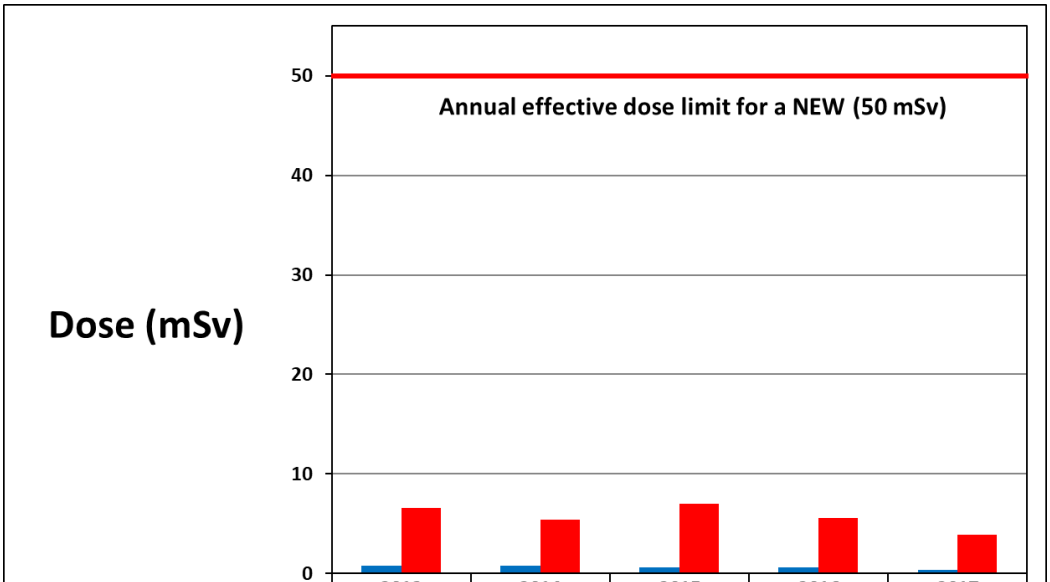
Radiation exposures at the PHCF are monitored to ensure compliance with the CNSC regulatory dose limits and to keep radiation doses ALARA. In 2017, radiation exposures at the PHCF were well below the CNSC regulatory dose limits.

Cameco ascertains external doses by using whole-body dosimetry. For internal radiological exposures, Cameco's Fuel Services Division holds a CNSC dosimetry service licence, which authorizes Cameco to provide in-house internal dosimetry services at the PHCF. Internal dose is assessed and assigned at the PHCF through two programs: urine analysis and lung counting, a method in which a radiation detector is used to measure radiation emitted from radioactive material collected in a person's lung.

Workers (including contractors) who conduct work activities that present a reasonable probability of receiving an annual occupational dose greater than 1 mSv are identified as NEWs at the PHCF. In 2017, total effective dose was assessed for 808 NEWs, consisting of 444 employees and 364 contractors, at the PHCF. The maximum individual effective dose received by a NEW in 2017 was 3.9 mSv, which is approximately 8% of the CNSC regulatory effective dose limit of 50 mSv in a one-year dosimetry period.

Figure 4-4 provides the average and maximum effective doses to NEWs at Cameco's PHCF from 2013 to 2017. The average total effective doses over this five-year period have been stable, and the maximum individual total effective dose is the lowest over this five-year period.

Figure 4-4: Average and maximum effective doses to NEWs, PHCF, 2013–17



	2013	2014	2015	2016	2017
Average effective dose (mSv)	0.8	0.8	0.6	0.6	0.4
Maximum effective dose (mSv)	6.6	5.4	7.0	5.6	3.9
Number of NEWs monitored	793	780	862	830	808

Annual average and maximum equivalent (skin) dose results from 2013 to 2017 are shown in table E-8 of appendix E. In 2017, the maximum individual skin dose received by a NEW at the PHCF was 13.7 mSv, which is approximately 3% of the CNSC regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. Average skin doses have been steady since 2013, and the maximum individual skin dose is the lowest it has been since 2015.

Site visitors and those contractors who are not considered as NEWs are issued dosimeters to monitor their radiological exposures while at the PHCF. In 2017, the maximum individual effective dose received by a site visitor/contactor who was not a NEW was 0.2 mSv, which is well below the CNSC regulatory dose limit of 1 mSv/year for a member of the public.

Radiation protection program performance

In 2017, CNSC staff assessed the performance of Cameco's radiation protection program at the PHCF through various CNSC staff compliance activities. Overall, Cameco's compliance with the *Radiation Protection Regulations* [2] and the CNSC licence requirements at the PHCF was found to be acceptable.

Action levels for radiological exposures are established as part of the radiation protection program implemented at the PHCF. In 2017, there were no instances at the PHCF where an action level was reached.

Radiological hazard control

Cameco has radiation and contamination control programs at the 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 the PHCF conducted in-plant air monitoring, contamination monitoring and radiation dose-rate surveys in 2017 and did not identify any adverse trends.

Estimated dose to the public

The operating release level (ORL) is based on the releases of uranium and external gamma radiation to the environment that ensure the dose to the public from the PHCF is below 0.3 mSv/year, with the air and water components each being less than 0.05 mSv/year and gamma component being 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/year.

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

These changes included calculating dose to the public from facility discharges to the sanitary sewer. They also included a fenceline monitoring location closer to the operating facility than previously used. Also new were calculations for 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. The amounts in 2017 look higher than in previous years', but there has not been an actual increase in emissions/dose from the PHCH. The results actually represent a much more conservative estimate of dose to the public. This is because gamma monitoring at the facility fenceline has now been added to the calculations. Due to these significant changes, the results beginning in 2017 cannot be compared with those of previous years.

Table 4-1 shows the 2013 to 2017 maximum effective doses to a member of the public. Table 4-2 shows the 2017 doses to a member of the public for Sites 1 and 2. Doses to the public are well below the ORL of 0.3 mSv/year and the CNSC regulatory dose limit for a member of the public of 1 mSv/year.

Table 4-1: Maximum effective dose to a member of the public, PHCF, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory dose limit
Maximum effective dose (mSv)	0.021	0.012	0.006	0.020	0.153	**1 mSv/year**

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

	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**

4.3 Environmental protection

Compliance ratings for the environmental protection SCA, PHCF, 2013–17

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA

For 2017, CNSC staff continued to rate the environmental protection SCA at the PHCF as "satisfactory". Uranium releases to the environment continue 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 are controlled in accordance with the MECP applicable requirements. Measured releases to the environment in 2017 were well below regulatory limits. Fenceline gamma measurements, groundwater monitoring, soil sampling, vegetation and ambient air data indicate that the public and the environment continue 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 the PHCF. The monitoring data in table 4-3 demonstrate that the atmospheric emissions from the facility continued to be effectively controlled, as they remained consistently below their respective licence limits from 2013 to 2017.

Table 4-3: Air emissions monitoring results (annual averages), PHCF, 2013–17

Location	Parameter	2013	2014	2015	2016	2017	Licence limit
UF_6 plant	Uranium (kg/h)	0.0051	0.0012	0.0017	0.0012	0.0011	**0.280**
	Fluorides (kg/h)	0.0190	0.0130	0.0170	0.0100	0.0210	**0.650**
UO_2 plant	Uranium (kg/h)	0.0013	0.0012	0.0012	0.0010	0.0005	**0.240**
	Ammonia (kg/h)	2.0	2.2	2.4	1.7	1.4	**58**

UO_2 = uranium dioxide; UF_6 = uranium hexafluoride

In addition to the licence limits, Cameco has action levels at the PHCF that are used to provide assurance that the licence limits will not be exceeded. No action levels for air emissions were exceeded at any time in 2017.

Liquid effluent

Cameco's operating licence does not allow the discharge of any process waste water effluent from the PHCF. In 2017, there were no process liquid discharges

from the 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 the 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 relicensing process, a daily sanitary sewage discharge action level of 100 µg/L and a monthly average licence limit of 275 µg/L were developed and accepted. The sanitary sewage action level was exceeded on multiple occasions between May and October 2017. This was attributed to the unusually high Lake Ontario water elevations and associated groundwater infiltration into the sanitary sewer system due to significant precipitation.

Cameco has implemented corrective actions in relation to the action level exceedances. Investigation work is underway at the UO_2 and UF_6 plants to determine whether infiltration exists, and the sewer system will be upgraded as part of the Vision in Motion project. CNSC staff concluded that, in 2017, Cameco met its licence requirement not to discharge process waste water effluent and that the sanitary sewer discharges were below their respective licence limit.

Environmental management system

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 set by Cameco, which are reviewed and assessed by CNSC staff through compliance verification activities. Cameco implemented

- CSA N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [10]
- CSA N288.5-11, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* [11]
- CSA N292.0-14, *General principles for the management of radioactive waste and irradiated fuel* [12]
- CSA N292.3-14, *Management of low and intermediate radioactive waste* [13]

Cameco also met its objective related to the deployment of waste management projects to dispose of contaminated materials at licensed hazardous facilities.

The EMS is verified through the licensee's annual management review, where minutes and follow-up to outstanding issues are documented. CNSC staff, as part of their compliance verification activities, review these documents and follow up with Cameco staff on any outstanding issues as appropriate.

The results of these compliance verification activities demonstrate that, in 2017, Cameco conducted an annual management review in accordance with the CNSC requirements and addressed identified issues properly.

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 public dose limit of 1 mSv and is ALARA. The principal monitoring activities, described below, focus on monitoring the air, groundwater, surface water, soil, vegetation and gamma radiation around the PHCF site.

In addition, the CNSC conducts periodic monitoring under its IEMP to verify that the public and the environment around nuclear facilities are protected.

Uranium in ambient air

Cameco measures uranium in the ambient air 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 2017, the measurements showed that the highest annual average uranium concentration in ambient air (as suspended particulate) among the sampling stations was 0.002 $\mu g/m^3$, well below the MECP annual standard for uranium in ambient air of 0.03 $\mu g/m^3$.

Groundwater monitoring

Currently, the groundwater quality at the PHCF is assessed 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
- 15 monitoring wells in the bedrock on an annual basis

CNSC staff found that the groundwater monitoring program, including the pump-and-treat wells, has been performing as expected. The pump-and-treat wells have been significantly reducing the mass of contaminants reaching 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 is sampled at two depths (just below the water surface and just above the harbour sediment layer), at each of the 13 locations in the harbour. Annual average and maximum concentrations of uranium, fluoride, nitrate and ammonia monitored in the harbour water from 2013 to 2017 are shown in table F-5 of appendix F.

Surface water concentrations continue to be stable, protective of human health and generally below CCME water quality guidelines for the protection of aquatic life.

Soil monitoring

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

The measured average uranium-in-soil concentrations in 2017 resulting from the current PHCF operations have remained similar to past years, without increasing. This suggests that uranium emissions from the current PHCF operations do not contribute to accumulation of uranium in soil. Soil sampling results are shown in table F-6 of appendix F. The results have been well below the most restrictive CCME soil quality guidelines for the protection of environmental and human health for residential and parkland land use (23 μg/g) and within the range of the natural background levels for Ontario (between 1.9 and 2.1 μg/g).

Cameco has made a commitment to maintain the existing five soil monitoring locations and report results to the CNSC annually. 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 the PHCF on the environment is determined each growing season (April 15 to October 15). At that time, samples of fluoride-sensitive vegetation are collected and then analyzed for fluoride content. In 2017, the vegetation sampling program was modified and included the standardization of sampling locations, where tree clusters were sampled as composite samples as opposed to single location sampling. The results in 2017 continued to be well below the MECP's Upper Limit of Normal Guideline of 35 parts per million (ppm). Details are provided in table F-7 of appendix F.

Gamma monitoring

A significant portion of the low radiological public dose in Port Hope resulting from the 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 safe and maintained ALARA. The gamma radiation effective dose rates for both sites are measured with environmental dosimeters supplied by a licensed dosimeter service. In accordance with the 2016 ORL, dose to the public is calculated for both Sites 1 and 2 at 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. For updates to the ORL, see the subsection "Estimated dose to the public" in section 4.2 above.

The specific gamma fenceline monitoring locations used included results from station 2 (Site 1 and Site 2), station 13 (Site 1) and station 21 (Site 2). Table F-9 in appendix F includes the results from the gamma fenceline monitoring.

The 2013 to 2017 annual averages of public doses for gamma are shown in table F-8 of appendix F, and the 2017 maximum monthly public dose for gamma is shown in table F-9. 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 are protected. The next IEMP campaign at the PHCF is scheduled for 2020.

Protection of the public

The CNSC receives reports of discharges to the environment in accordance with the reporting requirements outlined in the PHCF licence and LCH. CNSC staff's review of Cameco's reports of hazardous discharges from the PHCF to the environment in 2017 indicated that no significant risks to the public or environment occurred during that period.

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

Environmental risk assessment

In January 2016, Cameco submitted the revised ERA for the PHCF for CNSC staff's review. CNSC staff reviewed the ERA and concluded that it is in compliance with CSA N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3]. CNSC staff recommendations on the ERA, as well as guidance outlined in 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], have been incorporated into Cameco's environmental programs for the PHCF to ensure the protection of the public and the environment.

4.4 Conventional health and safety

Compliance ratings for the conventional health and safety SCA, PHCF, 2013–17

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA
For 2017, CNSC staff continued to rate the conventional health and safety SCA at the PHCF as "satisfactory". Overall, compliance verification activities conducted by CNSC staff at the facility confirmed that Cameco continues 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 PHCF is monitored through CNSC staff's onsite inspections and event reviews. Cameco continues to develop and maintain a comprehensive occupational health and safety management program for the PHCF. This program at the PHCF incorporates various elements, including accident reporting and investigation, hazard prevention, preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response.

A key performance measure for the conventional health and safety SCA is the number of LTIs that occur per year. Table 4-3 outlines the number of LTIs over the past five years at the PHCF.

Cameco reported one LTI in 2017. An employee sustained a muscle injury while removing a drum from a conveyor in the UO_2 plant. The drum weighed approximately 17 kg. It was lifted off the conveyor, at shin height, and over a safety cable, at waist height, before being placed on the floor. After the event, the employee continued to work, but with restrictions, and received surgery in July. Doctors instructed the employee to take time off after the surgery, resulting in six days lost time.

Cameco conducted an investigation and implemented corrective actions. One action was to instruct its employees to convey drums around the conveying system to the designated drum removal location without lifting the drums. Employees were also instructed to remove/relocate two obstructing buttons and shorten the safety cable, in order to provide an opening for drum removal without lifting. CNSC staff reviewed the corrective actions and were satisfied with the actions taken by Cameco to prevent recurrence.

Table 4-3: LTIs, PHCF, 2013–17

	2013	2014	2015	2016	2017
LTIs	0	1	2	3	1

Practices

Cameco's activities and operations at the 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 the PHCF.

The Conversion Safety Steering Committee supports conventional health and safety efforts at the PHCF. This joint committee, created in 2013, conducts monthly workplace inspections and meets three times per month to improve the safety performance of the site through review of issues, increasing employee involvement in safety, and development of new processes to follow up on injuries, among other activities. In addition, the committee promotes continuous improvement.

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

Awareness

Workers are made aware of the conventional health and safety program, as well as workplace hazards, through training and ongoing internal communications with Cameco. Cameco holds monthly safety meetings for all employees at the PHCF on various safety topics, including radiation protection, environmental protection and fire protection. Attendance is tracked at the safety meetings as an indicator for safety performance. Cameco workers at the PHCF also attend daily "toolbox meetings" where they are 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 the 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 2017, CNSC staff rated Cameco's performance at the CFM facility as "satisfactory" in all SCAs. The performance ratings for the CFM facility from 2013 to 2017 are shown in table C-3 of appendix C.

Cameco continued to operate the CFM facility safely throughout 2017. The facility underwent two planned shutdowns during the year to conduct routine maintenance activities and implement facility upgrades. Cameco ensured that the CFM site was maintained according to the CFM licensing basis.

In 2017, Cameco submitted an updated preliminary decommissioning plan with a revised decommissioning cost estimate of $21 million, an increase from the previous amount of $19.5 million. The document was submitted in accordance with the CNSC guidance documents G-219, *Decommissioning Planning for Licensed Activities* [14], and G-206, *Financial Guarantees for the Decommissioning of Licensed Activities* [15]. CNSC staff reviewed the submission and recommended that the Commission accept a revised financial guarantee of $21 million. The revised financial guarantee was presented in writing to the Commission during a Commission hearing in October 2017 [16]. The Commission accepted the proposed financial guarantee for the CFM facility in November 2017 [17].

Cameco reported four events to the CNSC in 2017:

- In August, an action level associated with a whole-body quarterly dose was exceeded; this is discussed further in section 5.2.
- In November, an action level associated with the quarterly fenceline gamma dose was exceeded; this is discussed further in section 5.3.
- In December, a fire occurred around the weld prep machines in the Assembly Area due to zirconium buildup within an extraction hose. The fire was promptly extinguished and Cameco made changes to the extraction system to prevent zirconium buildup in the future.
- In December, a false fire alarm was set off because a smoke sensor was activated by exhaust fumes from an idling truck. Cameco reported these events in accordance with its regulatory reporting requirements.

In 2017, CNSC staff conducted four 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. A list of these inspections can be found in table K-3 of appendix K. These inspections focused on the following SCAs: management system, human performance management (training), security, radiation protection, conventional health and safety, environmental protection, operating performance, and emergency management and fire protection. Fifteen enforcement actions were raised as a result of the inspections conducted.

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 the CFM in 2017, CNSC staff performed desktop compliance verification of the various SCAs by reviewing Cameco's compliance reporting submissions (e.g., annual and quarterly compliance monitoring reports) and specific program documents.

CNSC staff note that Cameco, in relation to the CFM facility, invited Indigenous communities and organizations with a potential interest in its activities to public forums in 2017. In the interest of reconciliation and relationships based on openness and trust with Indigenous peoples in Canada, CNSC staff continue to ensure that all issues of interest or concern to Indigenous communities and organizations in relation to the CFM facility are identified, recorded, considered and addressed, where appropriate.

CNSC staff confirmed that Cameco upheld the commitments of its program throughout the year. Cameco held a joint community forum for the PHCF and CFM stakeholders and key audiences, as well as two media events announcing Cameco's involvement in the supply of cobalt-60 for the production of medical isotopes. Cameco participates in regular community activities, such as the local fair and career days at local schools. Cameco gave facility tours to members of industry, elected officials, students and international audiences. Cameco also posted updated health and safety information on its website and conducted public opinion polling in accordance with its public information program. The licensee was in compliance with RD/GD-99.3, the predecessor of REGDOC-3.2.1, *Public Information and Disclosure* [7], and implementation plans for REGDOC-3.2.1 are expected to be completed in 2019.

5.2 Radiation protection

Compliance ratings for the radiation protection SCA, CFM, 2013–17

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA
For 2017, CNSC staff continued to rate the radiation protection SCA at the CFM facility as "satisfactory". Cameco has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations* [2]. At the CFM facility, workers handle natural uranium in the production of ceramic-grade UO_2 pellets and nuclear fuel bundle. 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 the CFM 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

Cameco established ALARA initiatives and ALARA dose targets for the CFM facility in 2017. Key performance indicators to track radiation protection program performance were also used for parameters such as radiation dose, training and contamination monitoring. In 2017, the Radiation Protection Subcommittee replaced the ALARA Committee at the CFM facility. The subcommittee identifies opportunities for ALARA and reviews radiological data and information, including in-plant air monitoring and radiological exposure results.

Worker dose control

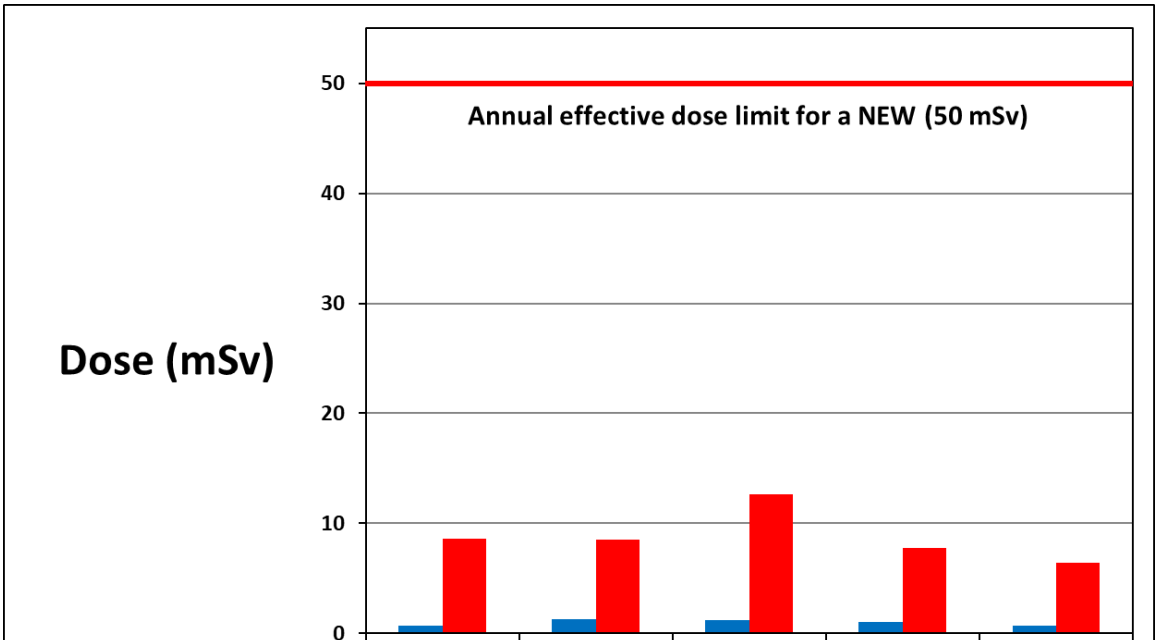
Radiation exposures at the CFM facility are monitored to ensure compliance with the CNSC regulatory dose limits and to keep radiation doses ALARA. In 2017, radiation exposures at the CFM facility were well below the CNSC regulatory dose limits.

Cameco ascertains external doses by using whole-body and extremity dosimetry at the CFM facility. For internal radiological exposures, Cameco's Fuel Services Division holds a CNSC dosimetry service licence, which authorizes Cameco to provide in-house internal dosimetry services at the CFM facility. Internal dose is assessed and assigned at the CFM facility by lung counting, a method in which a radiation detector is used to measure radiation emitted from radioactive material collected in a person's lung.

At the CFM facility, all employees are identified as NEWs. Contractors at the CFM facility may also be identified as NEWs depending on their work activities. In 2017, the total effective dose was assessed for 270 NEWs, consisting of 234 Cameco employees and 36 contractors at the CFM facility. The maximum individual effective dose received by a NEW in 2017 was 6.4 mSv, which is approximately 13% 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 the CFM facility from 2013 to 2017. The average and maximum total effective doses in 2017 are the lowest over this five-year period.

Figure 5-2: Average and maximum effective doses to NEWs, CFM, 2013–17



	2013	2014	2015	2016	2017
Average effective dose (mSv)	0.7	1.3	1.2	1.0	0.7
Maximum effective dose (mSv)	8.6	8.5	12.6	7.8	6.4
Number of NEWs monitored	330	317	336	278	270

Annual average and maximum equivalent (extremity) and equivalent (skin) dose results from 2013 to 2017 are shown in tables E-2 and E-9 of appendix E. In 2017, the maximum skin dose received by a NEW at the CFM facility was 88.1 mSv, which is approximately 18% 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 the CFM facility was 59 mSv, approximately 12% of the CNSC regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period.

The average and maximum equivalent doses for 2017 are the lowest over the last five-year period.

Visitors are not considered as NEWs, but are issued dosimeters to monitor their radiological exposures while at the CFM facility. In 2017, there were no measurable doses recorded on dosimeters issued to visitors.

Radiation protection program performance

In 2017, CNSC staff assessed the performance of Cameco's radiation protection program at the CFM facility through various CNSC staff compliance activities. Overall, Cameco's compliance with the *Radiation Protection Regulations* [2] and the CNSC licence requirements at the CFM facility was found to be acceptable.

Action levels for radiological exposures are established as part of the radiation protection program implemented at the CFM facility. 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 2017, there was one exceedance of the CFM facility's action level for whole-body dose reported to the CNSC. Cameco's investigation revealed that the worker had undergone a therapeutic radiation treatment, and that the treatment was the primary contributor of the dose recorded on the worker's dosimeter (which is used to monitor occupational exposures). Corrective actions were implemented at the CFM facility. They include new steps in internal processes to prevent exposure of a worker's dosimeter when the worker receives a medical treatment involving a radioisotope. In this way, the dosimeter is restricted to monitoring occupational exposures.

Radiological hazard control

Cameco has radiation and contamination control programs at the CFM facility to control and minimize radiological hazards and the spread of radioactive contamination. Methods of control include radiation zone controls and monitoring to confirm the effectiveness of the programs. In 2017, Cameco staff at the CFM facility conducted in-plant air monitoring, as well as contamination monitoring and radiation dose-rate surveys, and did not identify any adverse trends.

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 2013 to 2017 effective doses to a member of the public. The doses are well below the CNSC regulatory dose limit of 1 mSv/year for a member of the public.

Table 5-1: Maximum effective dose to a member of the public, CFM, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory dose limit
Maximum effective dose (mSv)	0.013	0.018	0.025	0.023	0.022	**1 mSv/year**

mSv = millisievert

5.3 Environmental protection

Compliance ratings for the environmental protection SCA, CFM, 2013–17

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA
For 2017, CNSC staff continued to rate the environmental protection SCA at the CFM facility as "satisfactory". Uranium and hazardous substance releases from the facility to the environment continue 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 continue to be protected from facility releases.				

SA = satisfactory

Effluent and emissions control (releases)

Atmospheric emissions

Cameco monitors uranium released as gaseous emissions from the CFM facility. The monitoring data in table 5-2 demonstrate that stack and building exhaust ventilation emissions from the facility in 2017 continued to be effectively controlled as they remained consistently well below their licence limits.

Table 5-2: Air emissions monitoring results, CFM, 2013–17

Parameter	2013	2014	2015	2016	2017	Licence limit
Total uranium discharge through stacks (kg/year)	0.03	0.01	0.01	0.03	0.01	**14**
Total uranium discharge through building exhaust ventilation (kg/year)	0.48	0.40	0.45	0.70*	0.57*	**14**

kg = kilogram
*In 2016 and 2017, the annual value was calculated by adding the quarterly results whereas 2013, 2014 and 2015 used the annual average.

In addition to the licence limits, Cameco has action levels at the CFM facility 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 2017.

Liquid effluent

Liquid effluent generated from the production process is collected and treated to remove the majority of the uranium by using an evaporator process. The condensed liquid is sampled and analyzed before 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 demonstrate that liquid effluent from the facility in 2017 remained consistently well below the licence limit and continued to be effectively controlled.

Table 5-3: Liquid effluent monitoring results, CFM, 2013–17

Parameter	2013	2014	2015	2016	2017	Licence limit
Total uranium discharge to sewer (kg/year)	0.83	1.58	1.24	0.85	0.64	**475**

kg = kilogram

In addition to the licence limits, the CFM facility has action levels that are used to provide assurance that licence limits will not be exceeded. No action levels for liquid effluents were exceeded at any time in 2017.

Environmental management system

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 facility. The EMS is described in Cameco's Radiation & Environmental Protection Manual. It includes annual environmental objectives and targets set by Cameco, which are reviewed and assessed by CNSC staff through compliance verification activities. Cameco met its environmental objectives in 2017 by:

- ensuring compliance with CSA N288.4-10 [10] and CSA N288.5-11 [11]
- changing the high-volume sample analysis method from alpha counting to inductively coupled plasma mass spectrometry (ICP-MS)
- implementing faster turnaround of sewer samples
- designing and testing an environmental tracking database
- continuing environmental monitoring in accordance with the CFM environmental monitoring program
- revising procedures according to site documentation review requirements

Cameco holds an annual management review meeting at which environmental protection issues are discussed and documented. CNSC staff, as part of their compliance verification activities, review these documents and follow up with CFM staff on any outstanding issues.

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 resulting from Cameco's CFM operations is below the annual regulatory public dose limit of 1 mSv and is ALARA. The principal monitoring activities, described below, focus on monitoring the air, groundwater, surface water, soil, and gamma radiation around the CFM site.

In addition, the CNSC conducts periodic monitoring under its IEMP to verify that the public and the environment around nuclear facilities are safe.

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 2017, the results from these samplers showed that the highest annual average concentration of uranium in ambient air (among the sampling stations) was 0.0009 $\mu g/m^3$. This is well below the MECP annual standard for uranium in ambient air of 0.03 $\mu g/m^3$.

Due to the advantages offered by ICP-MS, the CFM facility has decided to cease alpha counting in 2018 and move to analyzing the high-volume filters exclusively

with the use of the ICP-MS method. The ICP-MS method allows results to be reported directly through the Cameco database system.

Groundwater monitoring

As of the end of 2017, the CFM facility has a network of 74 groundwater monitoring wells located both within and outside the site. These wells are screened within the overburden (soil) and some are within the underlying bedrock. The groundwater monitoring results confirmed that current operations are not adversely impacting the groundwater within, or outside of, the facility, or the quality of surface water outside.

Uranium concentrations among the 74 groundwater monitoring wells sampled in 2017 all met the MECP's Full Depth Generic Site Condition Standards in a Non-Potable Ground Water Condition (MECP table 3 Standards, which is 420 µg/L for uranium), except for three monitoring wells near the northeast corner of the CFM plant. The exceedances of the MECP table 3 standards at these locations were due to the past practice of storing contaminated material on the ground surface. The practice was discontinued in 2008 and the contaminated soil was cleaned, although some uranium still remains in the overburden and shallow groundwater.

Through reviews of the CFM's annual compliance reports, CNSC staff are monitoring the soil and groundwater quality changes at the site. All concentrations of uranium in groundwater at offsite monitoring locations were below the MECP table 3 standard. The 2017 data are consistent with results from previous years.

Surface water monitoring

In 2017, Cameco collected surface water samples at nine locations in April, six locations in August and eight in October. The sample locations were on and adjacent to the facility, and were analyzed for uranium.

Uranium concentrations in all surface water samples collected in 2017 met the applicable CCME water quality guidelines for the protection of aquatic life. The short-term exposure guideline (33 µg/L) was applied to the locations in the intermittent drainage feature, and the long-term exposure guideline (15 µg/L) was applied to the locations in the Gages Creek tributary. The highest uranium concentration was collected at SW-9 (24 µg/L in October) 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 continue to oversee Cameco's monitoring at locations around the vicinity of the CFM facility to confirm whether 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 2.1 µg/g as stated in table F-10 in appendix F.

The maximum concentrations detected are attributable to historic contamination in Port Hope, which has long been recognized and continues to be the focus of environmental studies and cleanup activities. These concentrations are not representative of soil quality as opposed to the statistically significant average values. Nevertheless, the results for all samples were below the CCME soil quality guidelines for the protection of environmental and human health of 23 µg/g for parkland and residential use. This is the most restrictive guideline; therefore, no adverse consequences to human and environmental receptors are expected. A comparison of 2017 results with those of previous years shows that uranium emissions from the facility are not resulting in an accumulation of uranium in soil.

Gamma monitoring

A significant portion of radiological public dose in Port Hope attributable to the CFM operations is due to gamma radiation sources. Consequently, monitoring gamma radiation effective dose rates at the fenceline of the CFM site is essential to ensuring that levels of potential gamma radiation exposure are safe and maintained ALARA. The gamma radiation effective dose rates for the site are measured with environmental dosimeters supplied by a licensed dosimeter service.

In 2017, the annual average of fenceline gamma measurements at the CFM site was 0.12 µSv/h. The CFM facility 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, the CFM facility has action levels for the critical receptor and other locations. These levels are used to provide assurance that the licence limits will not be exceeded.

One exceedance of the action level occurred at Location #12 (located directly behind the Fuel Storage Building) during the third quarter in 2017. The quarterly result was 1.11 µSv/h, which exceeded the action level of 1.0 µSv/h for this specific monitoring location. Cameco investigated the situation and determined that more fuel was being stored in the building starting in the fourth quarter of 2016.

To reduce the gamma dose rate at this location, a soil berm was installed behind the Fuel Storage Building between the fenceline and the building in December 2017. The gamma level measured at Location #12 for the first quarter of 2018 was 0.36 µSv/h, indicating the soil berm has been effective.

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 CFM facility are protected from facility emissions. The next IEMP campaign at the CFM facility is scheduled for 2020.

Protection of the public

The CNSC receives reports of discharges to the environment in accordance with the reporting requirements outlined in the CFM licence and LCH. CNSC staff's review of hazardous discharges from the CFM facility to the environment in 2017 indicated that no significant risks to the public or environment occurred during that period.

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

Environmental risk assessment

To ensure the protection of the public and the environment, Cameco has incorporated CSA N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3], into its environmental program. In 2017, CNSC staff reviewed the ERA for the CFM facility and concluded that Cameco is in compliance with CSA N288.6-12 and that the ERA conclusions regarding potential risk to human health and the environment at the CFM facility are valid. Meaningful human health or ecological effects resulting from current CFM operations are unlikely. Cameco currently has acceptable environmental programs in place to ensure protection of the public and the environment.

5.4 Conventional health and safety

Compliance ratings for the conventional health and safety SCA, CFM, 2013–17

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA
For 2017, CNSC staff continued to rate the conventional health and safety SCA at the CFM facility as "satisfactory". Overall, compliance verification activities conducted by CNSC staff at the facility confirmed that Cameco continues 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. Cameco continues to maintain a comprehensive occupational health and safety management program for the CFM facility. This program at the CFM facility incorporates various elements, including accident reporting and investigation, hazard prevention, preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response.

A key performance measure for the conventional health and safety SCA is the number of LTIs that occur per year. As indicated in table 5-4, there were no LTIs at the CFM facility in 2017.

Table 5-4: LTIs, CFM, 2013–17

	2013	2014	2015	2016	2017
LTIs	0	0	1	0	0

Practices

Cameco's activities and operations at the CFM facility 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 the CFM facility.

Cameco maintains a Joint Health and Safety Committee at the CFM facility, which investigates all safety-related incidents in the facility, including not only events that resulted in injuries but also all near misses. All reported conventional health and safety incidents are tracked and managed as part of the Cameco Incident Reporting System database. In addition, the committee conducts monthly inspections of the workplace and provides input into all new and revised health and safety policies, procedures and programs. Cameco emphasizes proactive safety measures by regularly performing risk analyses of various operations throughout the facility and by implementing alternate strategies to reduce the risk to workers. CNSC staff review health and safety documentation to verify that any issues identified are promptly resolved.

Awareness

Workers are made aware of the conventional health and safety program, as well as workplace hazards, through training and ongoing internal communications with Cameco. Cameco holds monthly safety meetings for all employees at the CFM facility on various safety topics, including radiation protection, environmental protection and fire protection. Attendance is tracked at the safety meetings as an indicator for safety performance. Cameco workers at the CFM facility also attend daily "toolbox meetings" where they are notified of any concerns or ongoing maintenance in their area.

6 BWXT Nuclear Energy Canada Inc.

The BWXT Nuclear Energy Canada Inc. (BWXT) facility (formerly known as GE-Hitachi Nuclear Energy Canada Inc.) produces nuclear fuel bundles used by Ontario Power Generation's (OPG) Pickering and Darlington Nuclear Power 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 by 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 Peterborough facility also processes beryllium, which poses inhalation hazards. 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 facility operations have low environmental releases. All releases are controlled, monitored and reported. Figure 6-1 shows the BWXT Toronto facility.

Figure 6-1: BWXT Toronto facility

The current reporting period was the first full year of operation for the BWXT Toronto and Peterborough facilities under the transferred Class IB licence (FFOL-3620.01/2020) issued by the Commission in December 2016. The licence was transferred from GE-Hitachi Nuclear Energy Canada (GEH-C) to BWXT Nuclear Energy Canada Inc. During the reporting period, no significant changes to the 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 either. The current licence expires in December 2020.

6.1 Overall performance

For 2017, CNSC staff rated BWXT's performance as "satisfactory" in all SCAs. The performance ratings for the BWXT facilities from 2013 to 2017 are shown in table C-4 in appendix C.

In May 2017, BWXT notified the CNSC that Mr. John MacQuarrie had been appointed to the position of President of BWXT. During this reporting period, BWXT also made management changes overseeing licensed activity to align the two facilities' operations under new management. This included creation of a new role, Director – Fuel Operations, as well as a new Manager – Shop Operations, in Toronto. BWXT provided the CNSC with a detailed organizational chart including appointments and reporting structure in accordance with requirements in section 15 of the *General Nuclear Safety and Control Regulations* [4].

BWXT conducted 28 internal audits to maintain an effective management system and ensure continuous improvement. Management system program improvements included an updated non-conformance and corrective action program, an improved change control program and a revised critical-to-safety (CTS) list as a result of the beryllium occupational exposure exceedance event, described below.

In June 2017, BWXT transitioned to a new training tracker tool. As well, several programs were updated in compliance with BWXT's implementation of its systematic approach to training (SAT). These updates included training on respiratory protection awareness, transportation of dangerous goods, security awareness, radiation protection, and emergency response.

In 2017, improvements to plant equipment and processes included lighting replacements at the Peterborough fuel shop floor, Peterborough kit program relocation and installation of an emergency operations centre trailer in Toronto. All changes were made through BWXT's change control system to ensure that they were within the licensing basis and have no impact to health and safety of personnel and the environment. CNSC staff reviewed these changes and concluded that they were minor and did not alter the licensing basis, and that no changes needed to be made to the facility safety analysis reports for this reporting period. BWXT also completed all preventive maintenance scheduled for 2017, with 99% and 97% of the tasks completed within 14 days of the target completion date for Toronto and Peterborough, respectively.

In January 2017, BWXT reported a minor hydrogen fire at a furnace in Toronto. BWXT submitted an investigative report that detailed corrective actions which

included replacing the union joints of the hydrogen lines of the furnace and conducting leak tests to confirm a secure connection. CNSC staff subsequently reviewed and accepted BWXT's corrective actions.

In April 2017, BWXT reported an error in calibration of air flow meters that resulted in minor corrections to internal dose and uranium-in-air emissions. BWXT submitted a detailed tap root investigation report with corrective actions including the implementation of work instructions for assessing, accepting and filing calibration certificates for CTS equipment procedures and the provision of refresher training on the updated procedures. As part of an inspection in February 2018, CNSC staff reviewed the corrective actions and their implementation and found them acceptable.

In July 2017, BWXT reported activation of a fire sprinkler at the Toronto facility that resulted in release of fire water inside the plant. There was no external release of water from the facility and the fire water was collected, treated and released by the facility's water treatment system with no impact to the public or the environment. BWXT submitted a detailed investigation report as well as a third-party review of the subsequent modifications to the sprinkler system. CNSC staff reviewed the corrective actions, as part of a March 2018 fire inspection, and found them effective and acceptable.

In August 2017, BWXT reported an occupational exposure limit (OEL) exceedance for beryllium, which became the subject of an event initial report to the Commission in October 2017. The event occurred at BWXT's facility in Peterborough. Additional details of this event, corrective actions and subsequent CNSC staff actions are detailed in CMD 17-M53, *BWXT Nuclear Energy Canada Inc. – Peterborough: Beryllium Occupational Exposure Level Exceedance for Two Workers*. BWXT has implemented several corrective actions related to procurement of filters subsequent to this event and has proposed several improvements to its management systems to prevent recurrence of such an event.

There were no action level exceedances related to radiation protection and environmental protection, and no LTIs were reported for 2017.

CNSC staff note that, in 2017, BWXT developed a Canada-wide company policy for Indigenous relations, joined the Canadian Council for Aboriginal Business (CCAB) in 2017, and was working to become certified by the CCAB for having Progressive Aboriginal Relations (PAR). BWXT also joined the Indigenous relations supplier network established by Bruce Power during this reporting period.

In the interest of reconciliation and relationship-building based on openness and trust with Indigenous peoples in Canada, CNSC staff continue to ensure that all issues of interest or concern to Indigenous communities and organizations in relation to the BWXT facilities are identified, recorded, considered and addressed, where appropriate.

BWXT successfully communicated the facilities' activities to members of the public in 2017. The licensee was active on social media throughout the year and continued to respond to public inquiries. BWXT updated its website with health and safety performance information, as well as environmental monitoring results. BWXT continued to focus on community engagement and met regularly with members of the community through its Community Liaison Committee. Facility tours were also conducted with elected officials, as well as interested stakeholders. The licensee was in compliance with RD/GD-99.3, the predecessor of REGDOC-3.2.1, *Public Information and Disclosure* [7], and implementation plans for REGDOC-3.2.1 are expected to be completed in 2019.

In 2017, CNSC staff conducted four planned Type II inspections at BWXT's two facilities, focusing them on security, management systems, training and waste management to verify licensee compliance with the NSCA and its associated regulations, the operating licence and LCH. CNSC staff also conducted one inspection in October 2017, in response to the beryllium OEL exceedance. BWXT has addressed all the enforcement actions from these inspections in 2017.

In March 2017, CNSC staff issued eight notices of non-compliance to BWXT related to the effectiveness and implementation of the Toronto facility's emergency response program. The enforcement actions were based on CNSC staff observations from a major exercise conducted at the Toronto facility in conjunction with Toronto Fire Services in 2016. BWXT submitted a detailed plan addressing CNSC staff observations from this exercise and, in 2018, implemented a revised emergency response program that meets the CNSC requirements as listed in REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response* [18]. The enforcement actions were raised as a result of simulated scenarios that tested several aspects of the emergency response program for a worst-case design-basis accident.

Overall performance of the BWXT emergency response program was satisfactory in real events that occurred at the facility in 2017, such as the minor hydrogen fire and fire sprinkler activation events mentioned above. CNSC staff continue to rate BWXT's performance in the emergency preparedness and fire protection SCA as satisfactory.

6.2 Radiation protection

Compliance ratings for the radiation protection SCA, the BWXT Toronto and Peterborough facilities, 2013–17

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA
For 2017, 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 in 2017. 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 2017, no worker's radiation exposure exceeded the CNSC's regulatory dose limits.

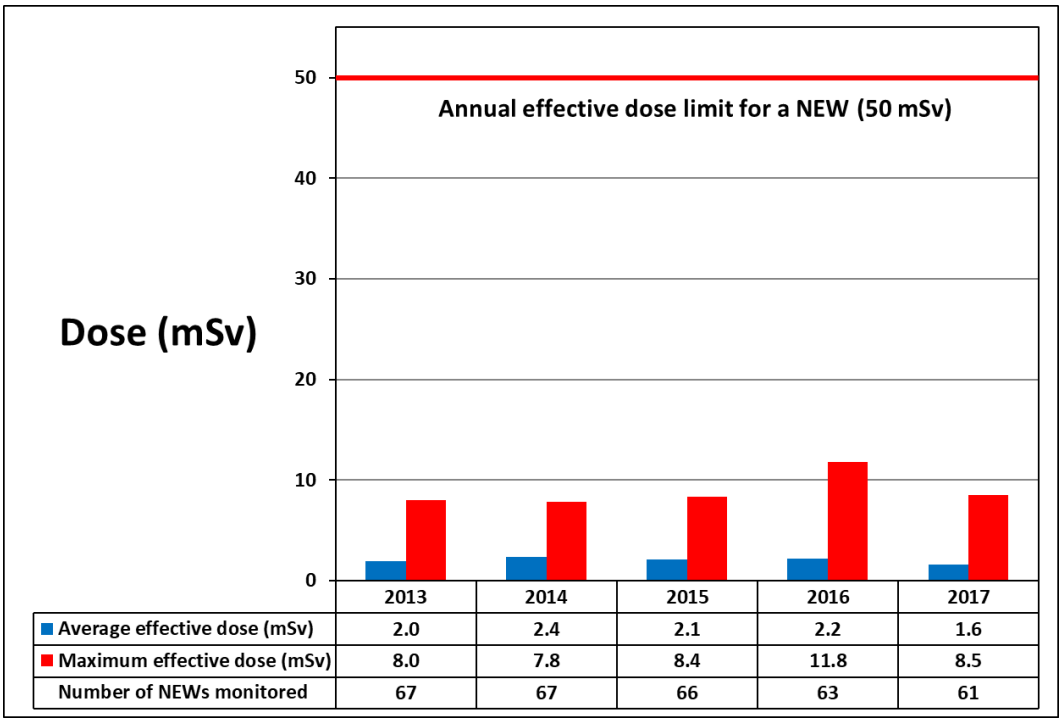
BWXT's workers are exposed externally to UO_2 pellets. At the Toronto facility, workers have the potential to be exposed internally to UO_2 powder. External whole-body and equivalent doses are ascertained with the use of dosimeters. Internal dose is assessed and assigned at the BWXT Toronto facility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

At BWXT, most employees are classified as NEWs.

The maximum effective dose received by a NEW in 2017 at the Toronto facility was 8.5 mSv, or approximately 17% of the CNSC regulatory effective dose limit of 50 mSv in a one-year dosimetry period.

Figure 6-2 provides the average and maximum effective doses to NEWs at BWXT's Toronto facility from 2013 to 2017.

Figure 6-2: Average and maximum effective doses to NEWs, BWXT Toronto facility, 2013–17

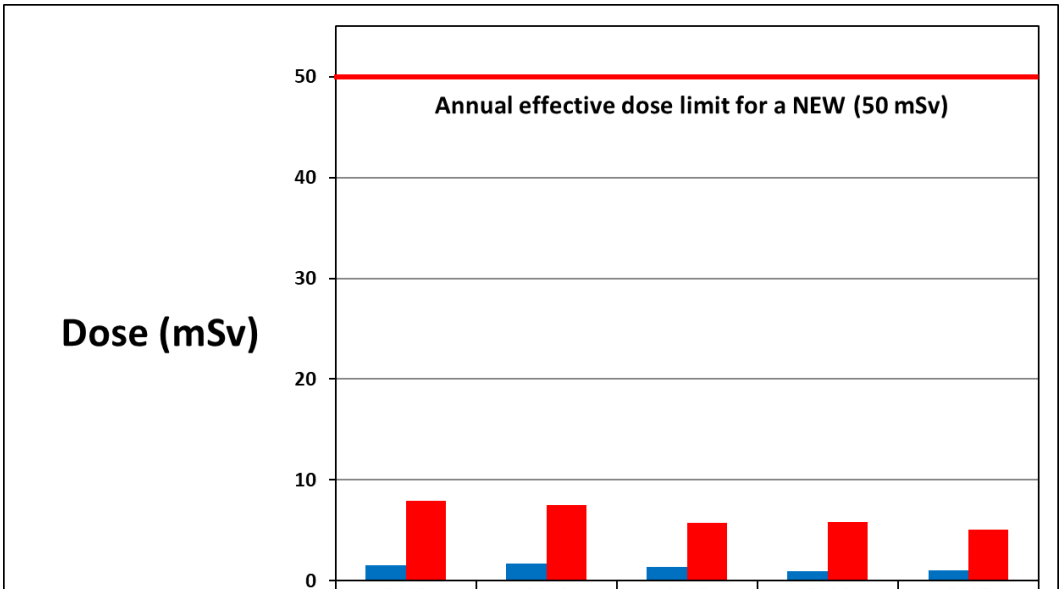


	2013	2014	2015	2016	2017
Average effective dose (mSv)	2.0	2.4	2.1	2.2	1.6
Maximum effective dose (mSv)	8.0	7.8	8.4	11.8	8.5
Number of NEWs monitored	67	67	66	63	61

The maximum effective dose received by a NEW in 2017 at the Peterborough facility was 5.1 mSv, or approximately 10% 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 at the BWXT Peterborough facility from 2013 to 2017. Overall, average external whole-body doses have been trending downward at the BWXT Peterborough facility. This has been due to ongoing efforts to improve ALARA awareness, as well as recent improvements to ergonomics and shielding for workers.

Figure 6-3: Average and maximum effective doses to NEWs, BWXT Peterborough facility, 2013–17



	2013	2014	2015	2016	2017
Average effective dose (mSv)	1.5	1.7	1.4	1.0	1.0
Maximum effective dose (mSv)	8.0	7.6	5.8	5.8	5.1
Number of NEWs monitored	82	78	75	88	77

For both the Toronto and Peterborough facilities, non-NEWs and contractors (who are all considered non-NEWs) are not directly monitored. Doses are estimated 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.

Annual average and maximum equivalent dose results from 2013 to 2017 are also shown in appendix E. In 2017, the maximum individual equivalent skin dose for both facilities was 54.27 mSv (Toronto, table E-10), while the maximum individual equivalent extremity dose was 115.07 mSv (Toronto, table E-4). These maximum individual equivalent doses are approximately 11% and 23%, 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 and extremity doses 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 2017, CNSC staff assessed the performance of BWXT's radiation protection programs at the Toronto and Peterborough facilities through various CNSC staff compliance activities. Overall, BWXT's compliance with the *Radiation Protection Regulations* [2] and the CNSC licence requirements was found 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 2017, there were no action level exceedances reported by BWXT at its two facilities.

Radiological hazard control

Radiation contamination controls have been established at BWXT to control and minimize the spread of radioactive contamination. Methods of contamination control include the use of a radiation zone control program and monitoring by using surface contamination swipes to confirm the effectiveness of the program. In 2017, the number of swipe locations remained relatively constant, and no adverse trends were identified in monitoring results at the BWXT facilities.

Estimated dose to the public

Table 6-1 shows the 2013 to 2017 annual effective doses to members of the public for BWXT's Toronto facility. BWXT's Peterborough facility has consistently reported doses of 0 mSv to members of the public from 2013 to 2017. Effective doses to members of the public are 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 facility, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Maximum effective dose (mSv)	0.0006	0.0055*	0.0101	0.0007	0.0175	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 Toronto and Peterborough facilities, 2013–17

2013	2014	2015	2016	2017
FS	FS	SA	SA	SA
For 2017, CNSC staff continued to rate the environmental protection SCA at the BWXT facilities as "satisfactory". All uranium and hazardous substance releases from the BWXT facilities to the environment continued to be well below the regulatory limits during 2017. Fenceline gamma measurements, soil sampling and ambient air data indicate that the public and the environment continue to be protected from the facilities 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 before being released into the atmosphere. In 2017, the annual releases of uranium from the BWXT facilities in Toronto and Peterborough were 0.00744 kg and 0.000002 kg, respectively. BWXT's annual uranium emissions from the Toronto and Peterborough facilities from 2013 to 2017 are shown in tables F-11 and F-16 of appendix F. The annual uranium emissions remained well below the licence limits for both facilities. The results demonstrate that air emissions of uranium are being controlled effectively at both facilities.

In addition to licence limits, the BWXT facilities in Toronto and Peterborough have action levels that are used to provide assurance that licence limits will not be exceeded. No action levels were exceeded at any time in 2017.

Liquid effluent

To ensure compliance with licence limits, waste water from the BWXT facilities is collected, filtered and sampled before being released into sanitary sewers. In 2017, the annual releases of uranium from the BWXT Toronto and Peterborough facilities were 0.941 kg and 0.00011 kg, respectively. BWXT's annual uranium effluent releases from the two facilities for 2013 to 2017 are shown in tables F-11 and F-16 of appendix F. In 2017, the releases continued to be well below the licence limits referenced in the appendices. The results demonstrate that liquid effluent releases are being controlled effectively at the BWXT facilities.

In addition to licence limits, both BWXT facilities have action levels that are used to provide assurance that licence limits will not be exceeded. No action levels were exceeded at any time in 2017.

Environmental management system

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 in Toronto and Peterborough. BWXT's EMS is described in its Environmental Management Program Manual. The EMS includes annual environmental objectives and targets set by BWXT, which CNSC staff review and assess through compliance verification activities. In 2017, BWXT met its objectives related to investigating the feasibility of recycling zirconium skeletons to reduce beryllium hazardous waste, implementing preventive maintenance for significant environmental aspects of nuclear services, reducing air emissions and water effluent, reducing onsite chemical inventory, and completing awareness training on manufacturing-area hazards to the site.

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

Assessment and monitoring

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

In addition, the CNSC conducts periodic monitoring under its IEMP to verify that the public and the environment around nuclear facilities are safe.

Uranium in ambient air

The BWXT Toronto facility 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 2017 was below the minimum detection limit. This demonstrates that the results are well below the MECP annual standard for uranium in ambient air of 0.03 $\mu g/m^3$. Air monitoring results for the BWXT Toronto facility are shown in table F-12 of appendix F.

The BWXT Peterborough facility does not monitor uranium in ambient air, since the atmospheric emissions discharged from the facility already meet the MECP annual standard of 0.03 $\mu g/m^3$ at the point of release.

Soil monitoring

BWXT conducts soil sampling at its Toronto facility as part of its environmental program. In 2017, samples were taken from 49 locations and analyzed for uranium content. The samples were collected on the BWXT site, on commercial property located along the south border of the site and in the nearby residential neighbourhood. In 2017, the average soil concentration of uranium for residential locations was 1.0 µg/g, while the maximum concentration of uranium in soil for these locations was 1.6 µg/g. These values are in the range of natural background levels for Ontario (between 1.9 and 2.1 µg/g) and well below most CCME soil quality guidelines for the protection of environmental and human health for uranium (23 µg/g for residential and parkland land use).

These data demonstrate 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. Soil sampling results are shown in tables F-13, F-14 and F-15 of appendix F.

Gamma monitoring

For both the BWXT facilities, a portion of radiological public dose is due to gamma radiation sources. Consequently, monitoring gamma radiation effective dose rates at the fenceline of the Toronto site and at the Peterborough plant boundary is essential to ensuring that levels of potential gamma radiation exposure are safe and maintained ALARA.

Since 2014, the gamma radiation effective dose rate for the BWXT Toronto site has been measured with environmental dosimeters. The estimated effective dose as a result of gamma radiation during 2017 was 0 mSv, for a total estimated critical receptor dose of 0.00049 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 been measured with environmental dosimeters. The estimated effective dose as a result of gamma radiation during 2017 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 around both facilities in 2014 and outside the Toronto facility in 2016. 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 are protected from facility emissions. An IEMP campaign for both BWXT facilities was completed in June 2018. The next IEMP campaign is scheduled for 2020.

Protection of the public

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 of hazardous discharges to the environment for BWXT in 2017 indicated that these discharges did not pose significant risks to the public or the environment during this period.

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

Environmental risk assessment

BWXT currently has acceptable environmental programs in place to ensure the protection of the public and the environment. BWXT submitted an ERA for both facilities, to comply with the requirements of CSA N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3]. CNSC staff reviewed the ERA and concluded that it is consistent with the overall methodology and complies with all the applicable requirement clauses of CSA N288.6-12, and that the ERA conclusions and recommendations are valid.

ERA conclusions and recommendations, as well as guidance outlined in 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], have been incorporated into BWXT's environmental programs to ensure the protection of the public and the environment.

CNSC staff will be conducting compliance verification activities to confirm BWXT's implementation of the new standards.

6.4 Conventional health and safety

Compliance ratings for the conventional health and safety SCA, BWXT Toronto and Peterborough facilities, 2013–17

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA
For 2017, CNSC staff continue to rate the conventional health and safety SCA at BWXT Toronto and Peterborough as "satisfactory". BWXT reported a beryllium OEL exceedance at the Peterborough facility during this reporting period. This event was reported to the Commission through an event initial report. However, compliance verification activities conducted by CNSC staff at the facility confirmed that BWXT continues 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 conventional health and safety program incorporates 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, change control and preventive maintenance, industrial hygiene, chemical management, ergonomics, lock-out tag-out, and environmental defences. 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).

For 2017, the Toronto facility reported zero LTIs (table 6-2), 14 near-miss events and 11 first-aid responses. Of the 11 first-aid responses, nine involved injury to the hand or fingers. The Peterborough facility reported zero LTIs (table 6-3), one injury that required medical aid, 23 near-miss events and 10 first-aid responses. The most common event categories were industrial hygiene, safety, waste and water for the Toronto facility; and safety, radiation protection and environmental for the Peterborough facility.

Table 6-2: LTIs, the BWXT Toronto facility, 2013–17

	2013	2014	2015	2016	2017
LTIs	0	1	0	0	0

Table 6-3: LTIs, the BWXT Peterborough facility, 2013–17

	2013	2014	2015	2016	2017
LTIs	0	0	0	0	0

BWXT has implemented several corrective actions due to the beryllium exposure event. For example, BWXT procured filters and proposed several improvements to prevent recurrence of such an event. Through the Regulatory Information Bank, CNSC staff continue to track open actions related to commitments made by BWXT related to this event.

Practices

BWXT's program practices in this reporting period included improvements and updates to the Workplace Hazardous Material Information System (WHMIS) to comply with the Globally Harmonized System of Classification and labelling of Chemicals for specified controlled or hazardous products. Several improvement practices were also implemented as part of the corrective actions related to the beryllium OEL exceedance, including training under the SAT methodology for respiratory protection awareness, Part II of the *Canada Labour Code* [5], B3 Area Donning and Doffing (Peterborough), and external/internal radiation hazard monitoring (Toronto). BWXT continues to comply with the NSCA [1] and its associated regulations, and with Part II of the *Canada Labour Code.* BWXT also maintains three committees under its conventional health and safety program: the Health and Safety Policy Committee, the WSC and the Ergonomics Committee.

Awareness

In 2017, at its Toronto facility, BWXT conducted a combined total of 40 investigations and inspections in accordance with its health and safety program. This activity included WSC inspections; staff safety inspections; and near-miss, incident and injury investigations. These investigations and inspections, excluding staff safety inspections, led to 135 actions being identified and tracked to closure. The most common finding categories from WSC inspections at the Toronto facility included housekeeping, radiation safety, unsafe condition, chemicals and personal protective equipment.

In 2017, at its Peterborough facility, BWXT conducted a combined total of 71 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 255 actions logged and tracked to closure. The top five finding categories at the Peterborough facility were housekeeping, chemical management, emergency equipment, safety, and walking/working surfaces.

BWXT management regularly reviews performance metrics for each facility, and these metrics are summarized in the licensee's annual compliance report. CNSC staff continue to monitor the effectiveness of BWXT's programs through onsite inspections.

Part II: Nuclear substance processing facilities

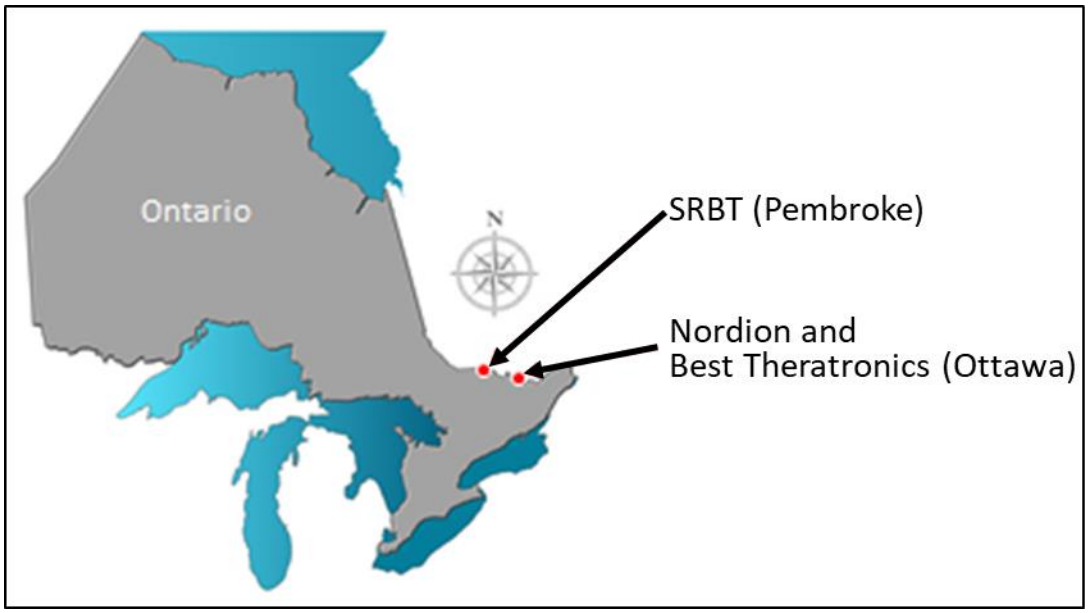
7 Overview

This part of the report outlines the performance of three nuclear substance processing facilities in Canada, all of which are located in the province of 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 July 2014 and expires in June 2019.

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 2017. Table 7-1 presents the licensing and compliance effort from CNSC staff for these facilities throughout the year.

Table 7-1: CNSC regulatory oversight licensing and compliance activities, nuclear substance processing facilities, 2017

Facility	Number of onsite inspections	Person-days for compliance	Person-days for licensing activities
SRBT	2	105	13
Nordion	5	198	5
BTL	4	106	5

In 2017, CNSC staff conducted 11 onsite inspections at the above-listed 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 that they are tracked to completion. Appendix K includes a complete list of the CNSC inspections conducted in 2017.

In accordance with the licence and respective LCH, all nuclear substance processing facility licensees must submit an annual compliance report on the operations of their respective 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, as 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 the nuclear substance processing facilities. For 2017, CNSC staff rated all but two SCAs as "satisfactory". The exceptions were:

- SRBT's performance in the fitness for service SCA, which was 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 2013 to 2017 for each of the three facilities.

Table 7-2: SCA performance ratings, nuclear substance processing facilities, 2017

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	SA	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 a preliminary decommissioning plan for each of their respective facilities, which CNSC staff review and approve. Each plan 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 2017, unchanged from the previous year.

Ratings for the radiation protection SCA, nuclear substance processing facilities, 2017

SRBT	Nordion	BTL
SA	SA	SA

SA = satisfactory

Application of ALARA

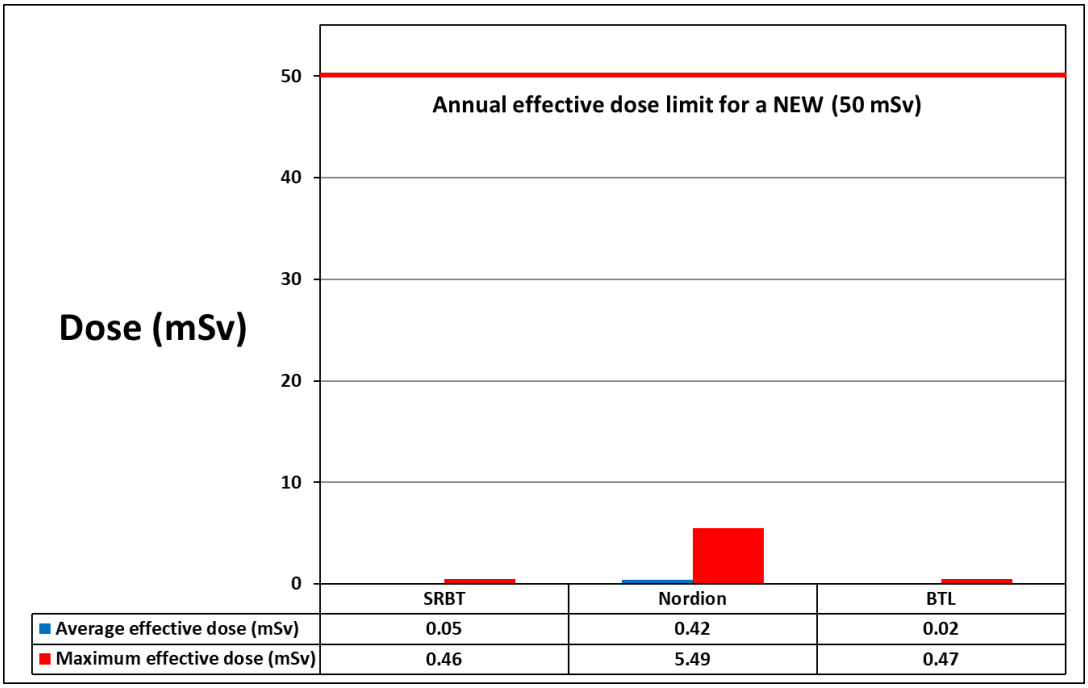
In 2017, the nuclear substance processing facility licensees continued to implement radiation protection measures to keep radiation exposures and doses to persons ALARA. The CNSC's requirement for licensees to follow the ALARA principle has consistently resulted in these doses staying well below regulatory dose limits.

Worker dose control

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

The maximum and average effective doses for NEWs at nuclear substance processing facilities are shown in figure 7-2. In 2017, the maximum individual effective dose received by a NEW at all facilities ranged from 0.46 mSv to 5.49 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, 2017



	SRBT	Nordion	BTL
Average effective dose (mSv)	0.05	0.42	0.02
Maximum effective dose (mSv)	0.46	5.49	0.47

In 2017, all licensees of nuclear substance processing facilities 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 during 2017 to verify that the radiation protection programs of the licensees 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 2017, there were no action level exceedances reported by nuclear substance processing licensees.

Radiological hazard control

CNSC staff verified that, in 2017, 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. All these licensees continued to implement their 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 defined as 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. 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. The CNSC's requirement to follow the ALARA principle ensures that licensees monitor their facilities and keep doses to the public below the annual public dose limit of 1 mSv/year.

Table 7-3 compares the estimated public doses from 2013 to 2017 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, 2013–17

Facility	Year					Regulatory limit
	2013	2014	2015	2016	2017	
SRBT	0.0068	0.0067	0.0068	0.0046	0.0033	**1 mSv/year**
Nordion	0.022	0.010	0.0056	0.0021	0.000052	
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 2017 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, as well as 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 2017 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, 2017

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 2017 for the nuclear substance processing sector. Information on total annual release of relevant facility-specific radionuclides in emissions to the atmosphere and in effluent released to surface waters is provided in appendix G.

As outlined in REGDOC-3.2.1, *Public Information and Disclosure*, published in May 2018, if a licensee is required to conduct an ERA, the ERA must be posted on the licensee's website. Licensees are developing implementation plans for nuclear substance processing facilities, which will include the date by which the regulatory document must be implemented. Section 7.4 provides more details on the implementation status of regulatory documents for nuclear substance processing facilities.

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 parameter 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 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.

Exceeding an action level does not mean non-compliance. Indeed, the 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 demonstrates due diligence and a 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.

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 personnel and equipment.

It encompasses the following specific areas:

- performance
- practices
- awareness

Based on regulatory oversight activities at nuclear substance processing facilities, CNSC staff rated the performance of the SRBT, Nordion and BTL facilities for the conventional health and safety SCA as "satisfactory" in 2017. Due to the increase in the number of LTIs from zero in 2016 to three in 2017, the SRBT facility was rated "satisfactory" compared with a "fully satisfactory" rating in previous years. CNSC staff reviewed the corrective actions taken by SRBT and were satisfied with their implementation.

Ratings for the conventional health and safety SCA, nuclear substance processing facilities, 2017

SRBT	Nordion	BTL
SA	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, CNSC staff consult with ESDC staff.

Licensees are required to report unsafe occurrences 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. Table 7-4 summarizes the number of recordable LTIs reported by nuclear substance processing facilities from 2013 to 2017. Further information is provided in facility-specific sections, as well as appendix H, which lists all LTIs reported in 2017 and the actions taken.

Table 7-4: LTIs at nuclear substance processing facilities, 2013–17

Facility	2013	2014	2015	2016	2017
SRBT	0	0	0	0	3
Nordion	1	3	0	3	0
BTL	N/A*	1	1	3	1

N/A = not applicable
*BTL was not required to report LTI statistics before 2014 under its previous licence.

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 2017. The programs are effective in protecting the health and safety of persons working in these facilities.

7.4 Regulatory developments

There were no amendments to the SRBT and Nordion licences in 2017. The Commission amended the BTL licence condition for financial guarantees (CMD 17-H103.A, *Best Theratronics Limited Financial Guarantee*).

The CNSC continues 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 and 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*, Version 2	February 2016	Implemented	Implemented	Implemented
REGDOC-2.2.2, *Personnel Training*, Version 2	December 2016	Implemented	Implemented	Implemented
REGDOC-3.1.2, *Reporting Requirements, Volume I: Non-Power Reactor Class I Nuclear Facilities and Uranium Mines and Mills*	January 2018	Implemented	Implemented	Implementation expected by January 2019
REGDOC-2.13.1, *Safeguards and Nuclear Material Accountancy*	February 2018	N/A	Implemented	Implementation expected by January 2019
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

N/A = not applicable

CNSC staff are updating the LCHs for each nuclear substance processing facility are being updated to reflect these regulatory documents and standards, 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 what type of facility information must be shared with the public (e.g., incidents, major changes to operations, or periodic environmental performance reports), as well as details on how that information will be shared. This ensures that timely information is effectively communicated about the health, safety and security of persons and the environment, and about other issues associated with the lifecycle of the nuclear facilities.

In 2017, CNSC staff evaluated licensees' implementation of their public information and disclosure programs by reviewing communication activities such as public information sessions, facility tours, newsletters, website and social media updates, and licensees' direct outreach to stakeholders in the community. CNSC staff determined that all nuclear substance processing facility licensees were in compliance with REGDOC-3.1.2, *Reporting Requirements, Volume I: Non-Power Reactor Class I Nuclear Facilities and Uranium Mines and Mills*.

CNSC staff concluded that, in 2017, licensees operating Class IB nuclear substance processing facilities implemented their public information programs satisfactorily and issued information in accordance with their public disclosure protocols. Their programs are effective at communicating information about the health, safety and security of persons and the environment, and other issues associated with the facilities. Furthermore, all licensees publish their annual compliance reports on their websites.

More detailed engagement activities and information shared with the public with respect to each facility are outlined in the licensee-specific performance sections that follow.

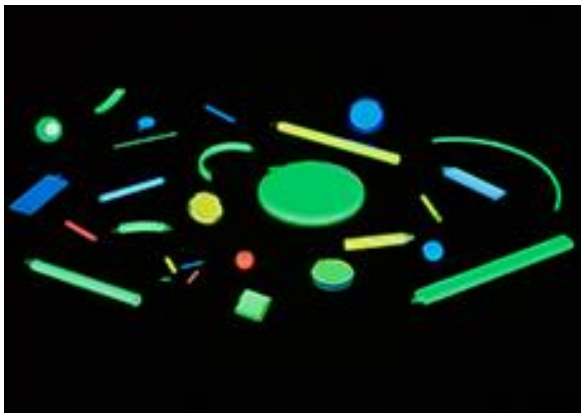
8 SRB Technologies (Canada) Inc.

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 NSPFOL-13.00/2022. This licence 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 radiation devices in varying shapes, sizes and colours such as signs, markers and tactical devices. The SRBT facility distributes its products in Canada and internationally. Figure 8-2 shows examples of GTLS exit signs and other markers manufactured at the SRBT facility.

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



8.1 Overall performance

For 2017, CNSC staff rated the SRBT facility's performance as "satisfactory" in all but one of the SCAs. The exception was the fitness for service SCA, which was rated as "fully satisfactory" because SRBT has implemented highly effective measures. SRBT conducts preventive maintenance activities as outlined in its maintenance plan, tracks corrective maintenance activities and identifies trends. In 2017, no safety-significant equipment failures occurred at the SRBT facility, indicating the effectiveness of the maintenance program. SRBT promptly addressed and reported any arising problems in accordance with regulatory requirements. As a result, CNSC staff rated SRBT's performance in the fitness for service SCA as "fully satisfactory". The SRBT facility performance ratings for all SCAs for 2013 to 2017 are shown in table C-5 of appendix C.

At the renewal hearing of the SRBT facility'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 [19]. In 2017, the SRBT facility processed 32,968,695 gigabecquerels (GBq) of tritium, resulting in 970 shipments of self-luminous products to customers in 23 countries, including Canada. The SRBT facility also receives expired self-luminous products for reuse and disposal. In 2017, the facility received 539 consignments composed of returned devices which contained 5,049 terabecquerels (TBq) of tritium activity. The majority of returned devices are sent to a licensed waste management facility at Chalk River Laboratories, while a small number are reused in other applications. In 2017, a total of 4,506.67 TBq of tritium activity from expired GTLS was transferred as low-level waste material, which represents a decrease of 2,149.96 TBq compared with the quantity in 2016.

In 2017, 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. The inspections are listed in table K-5 of appendix K. The inspections focused on the radiation protection and the management system SCAs. Three notices of non-compliance were raised as a result of these inspections. CNSC staff have reviewed and were satisfied with the corrective actions taken by SRBT. All actions have now been closed by CNSC staff.

Based on CNSC staff's compliance activities, SRBT continued to operate the tritium processing facility safely throughout 2017 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 2017.

The SRBT facility experienced two events in 2017 that were reported to the CNSC in accordance with the regulatory reporting requirements. The first event occurred in June 2017 and involved an excepted package containing self-luminous safety signs. The package appeared to have been punctured in transit before reaching the consignee and was returned to the SRBT facility where it was assessed for contamination. No contamination was identified and the products were intact. The second event occurred in November 2017, when a package of self-luminous safety signs went missing in transit to an international customer. Three weeks later, SRBT was notified that the package had been located and was in good condition. SRBT staff submitted complete reports for both events to CNSC staff and made the reports available to the public in accordance with SRBT's public information program. CNSC staff accepted the reports and corrective actions in response to the events. These actions have now been closed.

CNSC and SRBT staff responded to the issues and concerns raised in the intervention by the Algonquins of Ontario (AOO) regarding issues and concerns raised in the AOO's intervention to the Commission on the *Uranium and Nuclear Processing Facilities Regulatory Oversight Report: 2016*. Issues of concern or interest raised by the AOO, and responses provided by CNSC and/or SRBT staff, included:

- fulfillment of regulatory standards to maintain environmental protection
- establishment of communication protocols
- meaningful engagement and participation by the AOO in environmental monitoring and protection programs
- reporting of dose exceedances or abnormalities
- archaeological assessment
- Indigenous knowledge, land use and occupancy study
- notifications of non-compliance
- accessibility of compliance verification and enforcement program information

- radiation exposure from transportation accidents and spills

CNSC staff are aware of SRBT's commitment to the AOO for ongoing communication and engagement with respect to SRBT's facility and related activities.

In the interest of reconciliation and relationships based on openness and trust with Indigenous peoples in Canada, CNSC staff will continue to work with SRBT staff to engage with Indigenous communities and organizations to ensure that all issues of interest or concern to Indigenous communities and organizations in relation to the SRBT facility are identified, recorded, considered and addressed, where appropriate.

SRBT continues to implement its commitment to open and transparent communication with its key audiences. The licensee expanded its social media presence in 2017, adding two additional channels. SRBT continues to conduct quarterly sampling from public wells and provides that information directly to the public. Communication products related to environmental findings, as well as general facility information were updated, and facility tours were provided to members of the public, local suppliers, and interested institutions. The licensee was in compliance with RD/GD.99.3, the predecessor of REGDOC-3.2.1, *Public Information and Disclosure* [7], and implementation plans for REGDOC-3.2.1 are expected to be completed in 2019.

8.2 Radiation protection

Compliance ratings for the radiation protection SCA, SRBT, 2013–17

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA
For 2017, CNSC staff continued to rate the radiation protection SCA at the SRBT facility as "satisfactory". The SRBT facility has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations* [2]. Tritium is handled in the form of tritium gas, which presents an internal radiological hazard to workers through ingestion, inhalation and absorption. This radiological hazard was effectively controlled at the SRBT 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 2017, SRBT continued to implement radiation protection measures at its facility to keep radiation exposures and doses to persons ALARA. These measures led to a 31% decrease in collective dose in 2017, despite the fact that the total amount of tritium processed by SRBT was similar to previous years. SRBT attributes the improved performance to a number of items, including increased use of portable tritium-in-air monitors, implementation of a new valve design on tritium traps, and

improvements to radiation protection training of workers. SRBT's Health Physics Committee continues to meet regularly to discuss various aspects of the radiation protection program, including tracking of worker doses against ALARA targets, radiological-hazard monitoring results and internal audit results.

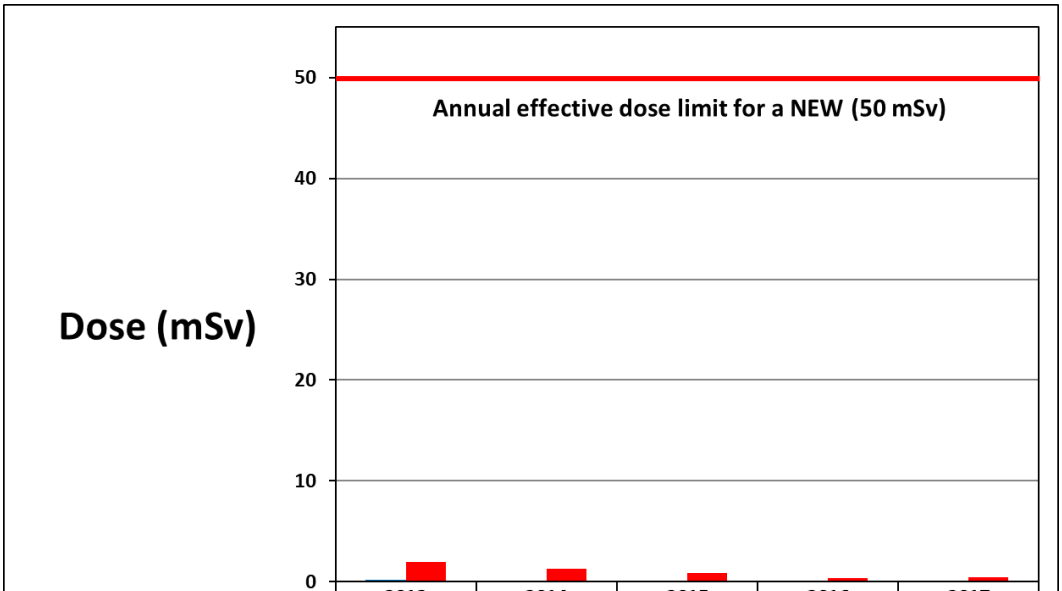
Worker dose control

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 2017, 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 2017 was 0.46 mSv, approximately 0.9% 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 2013 to 2017. 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, 2013–17



	2013	2014	2015	2016	2017
Average effective dose (mSv)	0.21	0.10	0.07	0.05	0.05
Maximum effective dose (mSv)	1.93	1.29	0.87	0.34	0.46
Number of NEWs monitored	38	48	47	45	45

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 2017, no contractors received a recordable dose due to work activities performed at the SRBT facility.

Radiation protection program performance

In 2017, CNSC staff assessed the performance of SRBT's radiation protection program, through various CNSC staff compliance verification activities, including a focused inspection on radiation protection. Overall, SRBT's compliance with the *Radiation Protection Regulations* [2] and the CNSC licence requirements was acceptable. SRBT established corrective actions to address areas requiring improvement, which were related to procedural non-compliance in the area of dosimetry.

Action levels for effective doses to workers and urine bioassays are established as part of SRBT's radiation protection program. There were no action level exceedances reported by SRBT in 2017.

Radiological hazard control

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 2017, 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 the SRBT facility is calculated by using monitoring results. Table 8-1 shows the maximum effective doses to a member of the public from 2013 to 2017. Doses to the public remain well below the CNSC regulatory dose limit of 1 mSv/year.

Table 8-1: Maximum effective dose to a member of the public, SRBT, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Maximum effective dose (mSv)	0.0068	0.0067	0.0068	0.0046	0.0033	**1 mSv/year**

mSv = millisievert

8.3 Environmental protection

Compliance ratings for the environmental protection SCA, SRBT, 2013–17

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA
For 2017, CNSC staff continued to rate the environmental protection SCA at the SRBT facility as "satisfactory". SRBT's radioactive releases to the environment continue to be controlled and monitored to comply with the regulatory requirements and the conditions of the operating licence. Throughout 2017, the measured releases of radioactive substances to the environment were below regulatory limits and there were no releases of hazardous substances from the SRBT facility that would pose a risk to the environment or the public. Monitoring of ambient air, groundwater, precipitation, runoff, surface water, produce and milk data around the facility indicates that the public and the environment continue 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 2013 through 2017 (shown in table F-17 of appendix F) demonstrate 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 limits will not be exceeded. No action levels were exceeded at any time in 2017.

The fluctuations in total tritium released to air from 2013 to 2017 are mostly due to respective changes in tritium processing at SRBT during the same period. They are also partly due to effective emission reduction initiatives, such as the improved tritium trap valves.

Liquid effluent

SRBT continues to monitor and control tritium released as liquid effluent from the facility. The monitoring data for 2013 through 2017 (shown in table F-18 of appendix F) demonstrate 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 limits will not be exceeded. No action levels were exceeded at any time in 2017.

Tritium liquid effluent releases increased from 5.18 GBq in 2016 to 6.85 GBq in 2017. The increase was due to the precipitation levels that were above normal levels, thus resulting in higher humidity and increased concentration of tritium in the dehumidifier drain water. Additionally, the increase was due to the growth in manufacturing of the miniature light source, specifically when water-submersion testing is used to assess for integrity. CNSC staff determined that this increase does not pose harm to the environment or members of the public.

Environmental management system

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 annual environmental objectives and targets set by SRBT, which are reviewed and assessed by CNSC staff 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, as part of their compliance verification activities, review these documents and follow up on any outstanding issues with SRBT staff as appropriate. The results of these compliance verification activities demonstrate that SRBT conducted an annual management review (in accordance with CNSC requirements) and that identified issues are being addressed properly.

SRBT made a commitment to complete a gap analysis of its environmental monitoring program and effluent monitoring program, respectively against REGDOC-2.9.1, *Environmental Protection Policies, Programs and Procedures* [20]; 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].

In addition, CNSC staff reviewed SRBT's effluent monitoring program against CSA N288.5-11. SRBT submitted its gap analysis and received comments from CNSC staff based on their review. SRBT addressed those comments and submitted revised documents in 2017. CNSC staff have since reviewed and accepted SRBT's submissions.

In 2017, CNSC staff reviewed SRBT's newly developed groundwater monitoring program and procedures, and Groundwater Protection Program documents and verified that they are aligned with CSA N288.7-15 *Groundwater protection programs at Class I nuclear facilities and uranium mines and mills* [21].

Assessment and monitoring

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

In addition, the CNSC conducts periodic monitoring under its 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 2017 air monitoring results from these samplers demonstrated that tritium levels in ambient air near SRBT remain low.

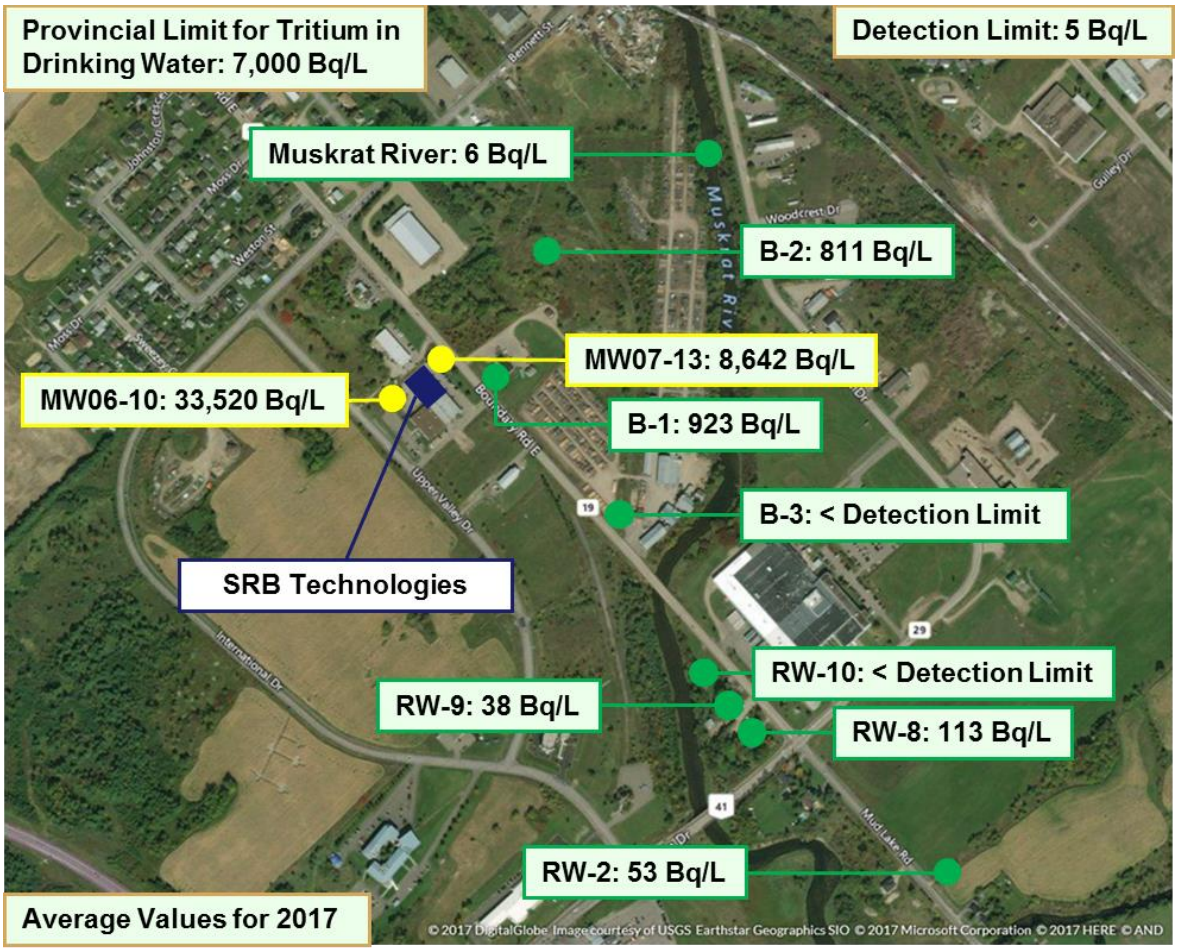
Groundwater monitoring

Groundwater is currently sampled from 34 monitoring wells around the facility plus 15 residential and business wells. Out of all 49 groundwater monitoring wells, two showed tritium concentrations exceeding the Ontario drinking water quality standard of 7,000 becquerel per litre (Bq/L) in 2017. The highest tritium concentration was found in well MW06-10, which is located near the SRBT stacks, averaging 33,520 Bq/L in 2017. The wells exceeding 7,000 Bq/L (MW06-10 and MW07-13) are restricted to a small area adjacent to the SRBT building and are not used for drinking water. Figure 8-4 shows these average tritium concentrations and the results for the adjacent Muskrat River.

Tritium concentrations decrease significantly at locations farther away from SRBT. In 2017, the highest tritium concentration in a potential drinking water well was found in residential well RW-08. It averaged 113 Bq/L in 2017, a slight decrease from 2016 (175 Bq/L), far below Ontario's drinking quality standard of 7,000 Bq/L. Overall, CNSC staff concluded that 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, which includes SRBT's 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 historic tritium emissions through the groundwater system.

Figure 8-4: Annual average tritium concentrations in groundwater and the Muskrat River, SRBT, 2017



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 2017 monitoring data for these items are very low and consistent with previous years. This monitoring complements the principal monitoring activities, which focus on air and groundwater.

CNSC Independent Environmental Monitoring Program

CNSC staff conducted independent environmental monitoring at SRBT in 2013, 2014 and 2015. The results are available on the CNSC's IEMP Web page and indicate that the public and the environment surrounding SRBT are protected from facility emissions. An IEMP sampling campaign at SRBT was completed in September 2018. The next IEMP campaign at SRBT is scheduled for 2020.

Protection of the public and estimated dose to the public

In 2017, there were no releases of hazardous substances to the environment from SRBT that would pose a risk to the public or environment.

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

Environmental risk assessment

On January 15, 2016, SRBT submitted its gap analysis and action plan for several environmental protection standards, including CSA N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3]. SRBT has indicated that it will conduct an ERA in advance of its next licence renewal application, expected in 2020. CNSC staff found the gap analysis conducted by SRBT for 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 N288.6-12 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, SRBT, 2013–17

2013	2014	2015	2016	2017
FS	FS	FS	FS	SA
As a result of the increase to three LTIs in 2017, CNSC staff rated the conventional health and safety SCA for 2017 at SRBT as "satisfactory" compared with "fully satisfactory" in previous years. CNSC staff were satisfied with SRBT's corrective actions and determined that SRBT's implemented measures for conventional health and safety remain effective, despite the increase in LTIs. SRBT maintains an effective Workplace Health and Safety Committee and immediately addresses and reports any arising problems in accordance with regulatory requirements. The compliance verification activities conducted by CNSC staff confirmed that SRBT continues to view conventional health and safety as an important consideration.				

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. SRBT continues to develop and maintain a comprehensive occupational health and safety management program for its facility.

SRBT's conventional health and safety 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.

A key performance measure for this SCA is the number of LTIs that occur in a given year. Table 8-2 outlines the number of LTIs over the past five years at SRBT. In 2017, three LTIs occurred at SRBT.

The first LTI involved an employee who lacerated their hand during an assembly operation, requiring medical attention. As a result there were two days lost time. SRBT's investigation determined that the worker had not been adequately guarding the cutting blade. SRBT organized a safety stand-down meeting with supervisors to discuss the event and to ensure that expectations when handling sharp items were emphasized with the employees. SRBT's Workplace Health and Safety Committee investigated the event and procured alternative tooling to reduce the hazard when the assembly work is being performed.

The other two LTIs resulted from ergonomic injuries. In one, an employee injured their back when attempting to pick up an item. In the other, an employee experienced sudden shoulder pain.

In response to the three LTIs that occurred in 2017, SRBT has implemented corrective actions to prevent recurrence as summarized in table H-2 of appendix H.

Table 8-2: LTIs, SRBT, 2013–17

	2013	2014	2015	2016	2017
LTIs	0	0	0	0	3

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 2017, this committee met nine times. CNSC staff review the meeting minutes and any associated corrective actions through onsite inspections to ensure that all issues are promptly addressed and resolved.

Awareness

SRBT continues to maintain a comprehensive conventional health and safety program. Workers are made aware of the conventional health and safety program, and workplace hazards, through training and ongoing internal communications with SRBT.

9 Nordion (Canada) Inc.

Nordion (Canada) Inc. (Nordion) 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 expires in October 2025. Figure 9-1 shows an aerial view of the Nordion facility.

Figure 9-1: Aerial view of the Nordion facility

At this facility, Nordion processes unsealed radioisotopes (such as iodine-131) for health and life sciences applications. It also manufactures sealed radiation sources 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.

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

9.1 Overall performance

For 2017, CNSC staff rated Nordion's performance as "satisfactory" in all but two SCAs. The exceptions were environmental protection and security, which were rated as "fully satisfactory". The performance ratings for the Nordion facility from 2013 to 2017 are shown in table C-6 of appendix C.

In 2017, 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; the licensee completed upgrades to existing systems and equipment as part of facility maintenance and continuous improvement.

No action levels or regulatory limits were exceeded in 2017. 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 NSCA [1], its associated regulations and Nordion's licence, Nordion submitted reports to the CNSC on events or incidents that occurred in 2017. CNSC staff reviewed these reports, 16 in all, and concluded that none of the events or incidents compromised the health or safety of persons or the environment. Ten of the events or incidents were related to packaging and transport and consisted of 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 temporarily misplaced packages that were subsequently located.

The remaining six reports included an LTI originally sustained in 2016 (reported in the 2016 regulatory oversight report), an alarm for a safety system having been triggered, a misplaced low-activity, non-production sealed source, and non-compliance with export requirements. CNSC staff have reviewed and are satisfied with the corrective actions taken by Nordion for all the reports submitted in 2017.

In 2017, CNSC staff conducted five inspections at the Nordion facility to ensure compliance with the NSCA and its associated regulations, Nordion's licence and the programs used to meet regulatory requirements. A list of these inspections can be found in table K-6 of appendix K. The inspections focused on the following SCAs: radiation protection, environmental protection, conventional health and safety, security, human performance management, and emergency management and fire protection. Eight 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 the CNSC expectations.

In October 2017, CNSC staff issued a written notice to Nordion as a result of a non-compliance with a condition of an export licence. The non-compliance did not represent a risk to the health and safety of persons or the environment. Nordion responded to the written notice and has implemented corrective actions. CNSC staff are satisfied with the corrective actions taken by Nordion to address the non-compliance, and will continue to provide compliance oversight on this matter through desktop reviews of the export licences.

CNSC and Nordion staff responded to the issues and concerns raised in the intervention by the Algonquins of Ontario (AOO) to the Commission on the *Uranium and Nuclear Processing Facilities Regulatory Oversight Report: 2016.* Issues of concern or interest raised by the AOO, and responses provided by CNSC and/or Nordion staff, included:

- fulfillment of regulatory standards to maintain environmental protection
- establishment of communication protocols
- meaningful engagement and participation by the AOO in environmental monitoring and protection programs
- reporting of dose exceedances or abnormalities
- archaeological assessment
- Indigenous knowledge, land use and occupancy study
- notifications of non-compliance
- accessibility of compliance verification and enforcement program information
- radiation exposure from transportation accidents and spills

CNSC staff are aware of Nordion's commitment to the AOO for ongoing communication and engagement with respect to Nordion's facility and related activities. CNSC staff remain committed to working with the AOO to address any remaining issues of interest or concern.

In the interest of reconciliation and relationships based on openness and trust with Indigenous peoples in Canada, CNSC staff will continue to ensure that all issues of interest or concern to Indigenous communities and organizations in relation to Nordion's facility are identified, recorded, considered and addressed, where appropriate.

Nordion continued to meet the commitments made in its program by providing the public with updated information related to waste management initiatives, transport of nuclear substances, radiation protection and environmental monitoring. Nordion maintains an online survey to help improve its public disclosure and offers an online virtual tour of its facility to the public. The licensee is in compliance with RD/GD-99.3, the predecessor of REGDOC-3.2.1, *Public Information and Disclosure* [7], and implementation plans for REGDOC-3.2.1 are expected to be completed in 2019.

9.2 Radiation protection

Compliance ratings for the radiation protection SCA, Nordion, 2013–17

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA
For 2017, CNSC staff continued to rate the radiation protection SCA at the Nordion facility 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 Nordion 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 2017, 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.

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. External whole-body and equivalent doses are ascertained 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.

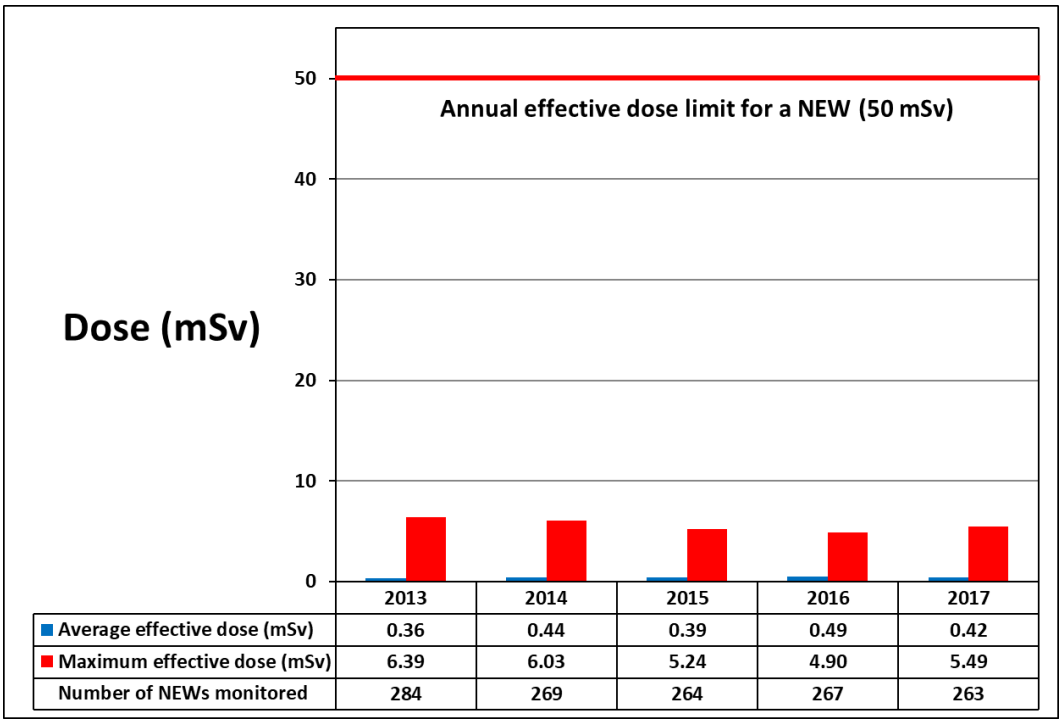
There are also provisions for whole-body counting and urinalysis in the event of elevated air or contamination monitoring results. There were no internal doses recorded in 2017.

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

In 2017, Nordion assessed the total effective dose for 263 NEWs, consisting of 141 workers working in the active area and 122 workers who work primarily in the non-active area but may perform some work duties in the active area. All the NEWs were Nordion employees. Nordion reported that the maximum effective dose received by a NEW in 2017 was 5.49 mSv, approximately 11% 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 2013 to 2017. Average and maximum effective doses have been relatively stable over these years.

Figure 9-3: Average and maximum effective doses to NEWs, Nordion, 2013–17



	2013	2014	2015	2016	2017
Average effective dose (mSv)	0.36	0.44	0.39	0.49	0.42
Maximum effective dose (mSv)	6.39	6.03	5.24	4.90	5.49
Number of NEWs monitored	284	269	264	267	263

Nordion identifies contractors as non-NEWs, as they may enter the active area but do not perform any radiological work. Nordion monitors contractors as required and provides relevant training to ensure that their doses are kept ALARA. In 2017, Nordion monitored 55 contractors. Nordion reported that the maximum effective dose received by a contractor was 0.2 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 contractors in 2017 was 0.02 mSv.

Annual average and maximum equivalent (extremity) and equivalent (skin) dose results from 2013 to 2017 are shown in tables E-5 and E-12 of appendix E. Nordion reported that the maximum equivalent skin dose for all NEWs monitored at Nordion in 2017 was 5.52 mSv, and that the maximum equivalent extremity dose for a worker in the active area was 16.4 mSv. These doses represent approximately 1% and 3% respectively of the CNSC's regulatory equivalent dose limits of 500 mSv in a one-year dosimetry period.

CNSC staff note that over the past five years, average equivalent extremity and skin doses at Nordion have been relatively stable, with the exception of the equivalent extremity dose in 2017. This dose is an increase from the previous four years (ranging from 7.4 mSv to 9.53 mSv). CNSC staff followed up with Nordion regarding this increase. Nordion explained that the same worker had received the maximum extremity dose to the hand from 2013 to 2017; Nordion attributed the increase in 2017 to production increases and a change in shift schedule. Nordion is currently investigating ways to lower the worker's dose in 2018. CNSC staff are satisfied with Nordion's explanation.

Radiation protection program performance

In 2017, CNSC staff assessed the performance of Nordion's radiation protection program through various compliance activities, including a focused inspection on radiation protection. Overall, CNSC staff found that Nordion's compliance with the *Radiation Protection Regulations* [2] and the CNSC licence requirements was acceptable. Nordion established corrective actions to address areas requiring improvement, which were primarily administrative.

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 2017.

Radiological hazard control

Nordion has radiation and contamination control programs 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 2017, 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 maximum effective doses to a member of the public over the years 2013 to 2017. In 2017, the dose to a member of the public was well below the regulatory dose limit of 1 mSv/year and decreased significantly from previous years due to the cessation of production molybdenum-99, iodine-125, iodine-131 and xenon-133.

Table 9-1: Maximum effective dose to a member of the public, Nordion, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory dose limit
Maximum effective dose (mSv)	0.022	0.010	0.0057	0.0021	0.000052	**1 mSv/year**

9.3 Environmental protection

Compliance ratings for the environmental protection SCA, Nordion, 2013–17

2013	2014	2015	2016	2017
FS	FS	FS	FS	FS
For 2017, CNSC staff continued to rate the environmental protection SCA at Nordion as "fully satisfactory". Nordion continues to implement and maintain a highly effective environmental protection program in accordance with regulatory requirements to control and monitor gaseous and liquid releases of radioactive substances from its facility into the environment. For the past five years, the gaseous emissions and liquid effluents have remained stable and well below the derived release limits (DRLs). No action levels were exceeded in 2017. Groundwater monitoring, soil sampling and gamma exposure measurements indicate that the public and the environment continue to be protected from facility releases. CNSC staff conducted a focused inspection on environmental protection in 2017 and no enforcement actions were raised.				

FS = fully satisfactory

Effluent and emissions control (releases)

Atmospheric emissions

Nordion continues to monitor and control the releases of radioactive materials from its facility to prevent unnecessary releases of radioisotopes to the atmosphere. Table F-19 of appendix F shows Nordion's radiological air emissions monitoring results from 2013 to 2017. The DRL values from the LCH were used to calculate dose to the public.

Nordion also presented DRL values to CNSC staff in 2016 by using Impact software and the most current version of the CSA N288.1-14, *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities* [22]. CNSC staff have reviewed these DRLs and agreed that the values calculated by the Impact software will apply for releases from Nordion starting in 2018. The monitoring data demonstrate that the radiological air emissions from the facility in 2017 continued to be effectively controlled as they were consistently well below the DRLs. In November 2016, Nordion ceased the production of molybdenum-99, iodine-125, iodine-131 and

xenon-133. This resulted in zero releases of noble gases and significant reductions in radioiodine releases from Nordion in 2017.

In addition to licence limits, Nordion has action levels that are used to provide assurance that licence limits will not be exceeded. An action level, if reached, provides early indication of a potential loss of control of part of the environmental protection program and triggers a requirement for specific action to be taken. No action levels were exceeded at any time in 2017.

Liquid effluent

Nordion continues to collect, sample and analyze all liquid effluent releases before their discharge into the municipal sewer system. Table F-20 of appendix F shows Nordion's monitoring results for radioactive liquid emissions from 2013 to 2017. The monitoring data demonstrate that the authorized radiological liquid effluent releases from the facility in 2017 were consistently well below the DRLs. Nor were any action levels for liquid effluent releases exceeded in 2017.

Environmental management system

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, which CNSC staff review and assess through compliance verification activities. Nordion's objectives during 2017 included: reducing non-hazardous waste to landfill; conducting an audit of a supplier whose goods and services could have a significant impact on the environment; reducing energy use; and reducing particulate matter air emissions. By the end of 2017, Nordion had met all its targets for these objectives except for the reduction of particulate matter air emissions. This objective is on hold until 2019 due to lack of production in Nordion's glass-blowing lab.

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

Assessment and monitoring

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 2013 are further described in the sections below.

In addition, the CNSC conducts periodic monitoring under its IEMP to verify that the public and the environment around nuclear facilities are protected.

Nordion made a commitment to complete a gap analysis of its environmental monitoring program and effluent monitoring program against 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], respectively. Nordion submitted its gap analysis and received comments from CNSC staff based on their review. Nordion addressed CNSC staff's comments and submitted revised documents in May 2017. CNSC staff have since reviewed and accepted Nordion's submission.

Groundwater monitoring

There are nine groundwater monitoring wells around the Nordion site. Since 2005, Nordion has been monitoring groundwater for hazardous substances such as ammonia, nitrate, dissolved organic carbon, total dissolved solids, iron and total petroleum hydrocarbons. Nordion's monitoring is conducted at least once a year to ensure that no significant changes have occurred since monitoring began. All monitoring results since 2005 have been near background levels or the detection limit.

Nordion began radiological sampling for groundwater in 2013. The results since then show that only naturally occurring radionuclides have been detected – that is, radionuclides that do not result from processing 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 Nordion facility have had no measurable impact on groundwater quality.

Soil sampling

Nordion performed soil sampling in 2012, 2014, 2016 and 2017, and did not detect any radioactive substances attributable to Nordion's licensed activities. The results of Nordion's sampling program are either below detection limits or at natural background levels, and indicate an absence of contamination. In 2017, Nordion started to conduct soil sampling annually to monitor concentrations of radioactive materials.

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 2017 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. 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 are protected from facility emissions. CNSC staff completed an IEMP campaign at Nordion in May 2018. The next IEMP campaign at Nordion is scheduled for 2020.

Protection of the public

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

Environmental risk assessment

Nordion currently has acceptable environmental programs in place to ensure the protection of the public and the environment. Nordion made a commitment to formalize and document its ERA in accordance with CSA N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3]. CNSC staff reviewed documentation submitted by Nordion in May 2017 and follow-up information submitted in October 2017.

CNSC staff are satisfied that Nordion has addressed their comments regarding the ERA and that the documents meet the requirements of CSA N288.6-12. CNSC staff have reviewed and accepted Nordion's ERA.

9.4 Conventional health and safety

Compliance ratings for the conventional health and safety SCA, Nordion, 2013–17

2013	2014	2015	2016	2017
FS	SA	SA	SA	SA
For 2017, CNSC staff continued to rate the conventional health and safety SCA at the Nordion facility as "satisfactory". Compliance verification activities confirmed that Nordion continues 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. Nordion continues to develop and maintain a comprehensive occupational health and safety management program for its facility.

Nordion's conventional health and safety program incorporates various elements, including 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 2017, including industrial hygiene monitoring, chemical awareness training, safety focus talks, and asbestos management. Nordion also made improvements to facility eyewash stations and chemical spill kits, as well as to its programs for respirator protection and hoisting safety.

A key performance measure for this SCA is the number of LTIs that occur per year. As table 9-4 shows, there were no LTIs at Nordion in 2017.

Table 9-4: LTIs, Nordion, 2013–17

	2013	2014	2015	2016	2017
LTIs	1	3	0	3	0

Practices

Nordion's activities and operations must comply with not only the NSCA [1] and its associated regulations, but also Part II of the *Canada Labour Code* [5]. Nordion's conventional health and safety program is under the oversight of its Workplace Health and Safety Committee, which met 11 times in 2017. CNSC staff review the meeting minutes and any associated corrective actions during onsite inspections to ensure that issues are promptly resolved.

Awareness

Nordion continues to develop and maintain a comprehensive occupational health and safety management program for its facility. Workers are made aware of the conventional health and safety program, as well as workplace hazards, through training and ongoing internal communications.

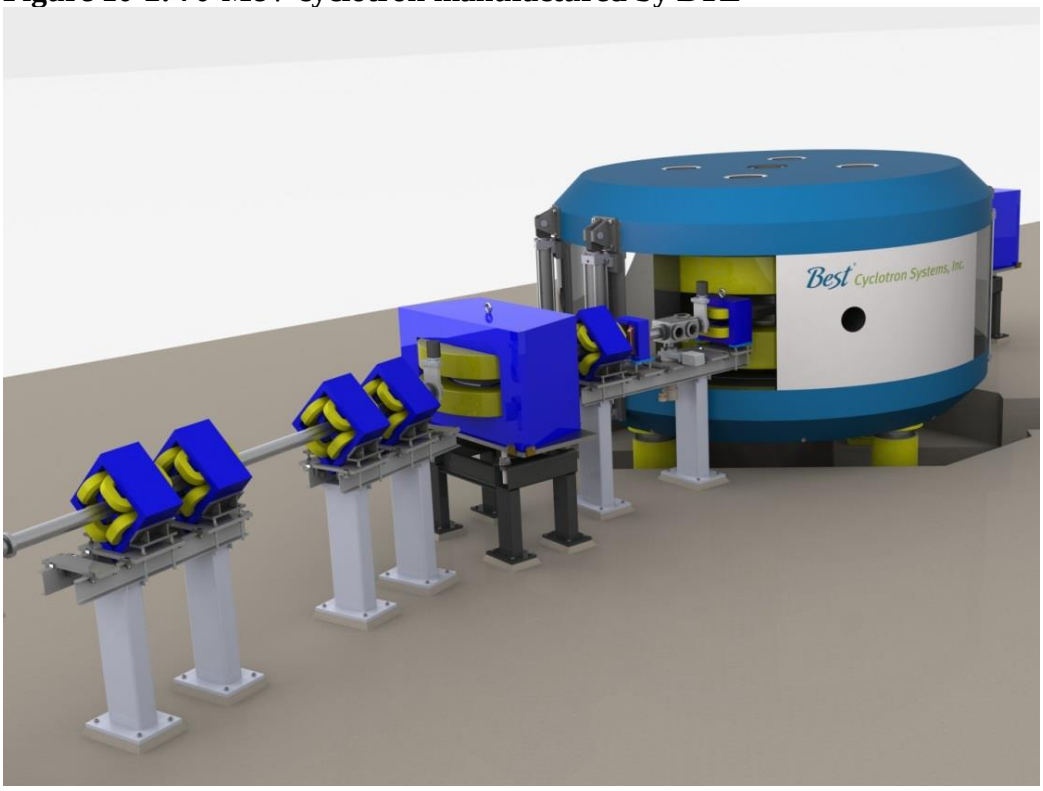
10 Best Theratronics Ltd.

Best Theratronics Ltd. (BTL) owns and operates a manufacturing facility in Ottawa, Ontario, under a Class IB operating licence that expires in June 2019. Figure 10-1 shows an aerial view of the BTL facility within the red rectangle.

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



BTL's licensed activities include the operation of a nuclear substance processing facility and a radioactive source teletherapy machine, and the use of a cyclotron greater than 1 MeV.

On August 24, 2015, a CNSC designated officer issued an order to BTL following BTL's failure to comply with a condition of Commission-issued licence NSPFOL-14.01/2019, which imposed requirements on BTL to provide an acceptable financial guarantee by April 31, 2015. The intent of the order was to ensure that sufficient funds are available for the future decommissioning of the BTL facility. BTL was granted an opportunity to be heard, and the Commission subsequently amended the order twice: on September 28, 2015 [23], and again on February 29, 2016 [24].

The order required BTL to dispose of or transfer all depleted uranium, sealed sources and prescribed equipment in its possession, cease all imports and increases to its current inventory of sealed sources and prescribed equipment containing radioactive sources or depleted uranium, and limit the operation of particle accelerators. As a result of the order, BTL reduced its inventory of nuclear substances.

BTL submitted a revised preliminary decommissioning plan to reflect the significant decrease in the number of sealed sources, prescribed equipment and depleted uranium at its facility, including a revised decommissioning cost estimate of $1.8 million. On July 14, 2017, the Commission accepted the financial guarantee [25], and BTL then submitted the financial guarantee to the full amount.

BTL is now in compliance with its financial guarantee licence condition, and the Commission has closed the order.

10.1 Overall performance

For 2017, CNSC staff rated BTL's performance as "satisfactory" in all SCAs. The performance ratings for BTL from 2015 to 2017 are shown in table C-7 of appendix C.

In 2017, CNSC staff conducted four onsite inspections 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. A list of these inspections can be found in table K-7 of appendix K. The inspections focused on management systems, security, emergency management, and packaging and transport SCAs. As a result of the inspections, 12 enforcement actions were raised. The findings from these inspections posed a low safety significance to the achievement of regulatory objectives and CNSC expectations.

There were no reportable action level exceedances in 2017. There was one LTI in 2017.

CNSC and BTL staff responded to the issues and concerns raised in the AOO's intervention by the Algonquins of Ontario (AOO) to the Commission on the *Uranium and Nuclear Processing Facilities Regulatory Oversight Report: 2016.* Issues of concern or interest raised by the AOO included:

- fulfillment of regulatory standards to maintain environmental protection
- establishment of communication protocols
- meaningful engagement and participation by the AOO in environmental monitoring and protection programs
- reporting of dose exceedances or abnormalities
- archaeological assessment
- Indigenous knowledge, land use and occupancy study
- notifications of non-compliance
- accessibility of compliance verification and enforcement program information
- radiation exposure from transportation accidents and spills

CNSC staff are aware of BTL's commitment to the AOO for ongoing communication and engagement with respect to BTL's facility and related activities and remain committed to working with the AOO to address any remaining issues of interest or concern.

In the interest of reconciliation and relationships based on openness and trust with Indigenous peoples in Canada, CNSC staff will continue to ensure that all issues of interest or concern to Indigenous communities and organizations in relation to BTL's facility are identified, recorded, considered and addressed, where appropriate.

BTL strives to be open and transparent with its stakeholders. BTL provides material on its website related to its licensed activities, discloses its annual compliance report online, and offers facility tours on a regular basis to local, national and international stakeholders. The licensee is in compliance with RD/GD-99.3, the predecessor of REGDOC-3.2.1, *Public Information and Disclosure* [7], and implementation plans for REGDOC-3.2.1 are expected to be completed in 2019.

10.2 Radiation protection

Compliance ratings for the radiation protection SCA, BTL, 2013–17

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA
For 2017, 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 BTL facility have no impact on doses to members of the public.				

SA = satisfactory

Application of ALARA

In 2017, 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. Dose data in 2017 include the doses received by manufacturing workers performing activities under the Class IB licence only. Before 2017, BTL's annual compliance report related to this licence included doses for both the manufacturing workers and service technicians performing work activities under a separate Class II servicing licence. In 2017, radiation exposures at BTL were well below the CNSC regulatory dose limits.

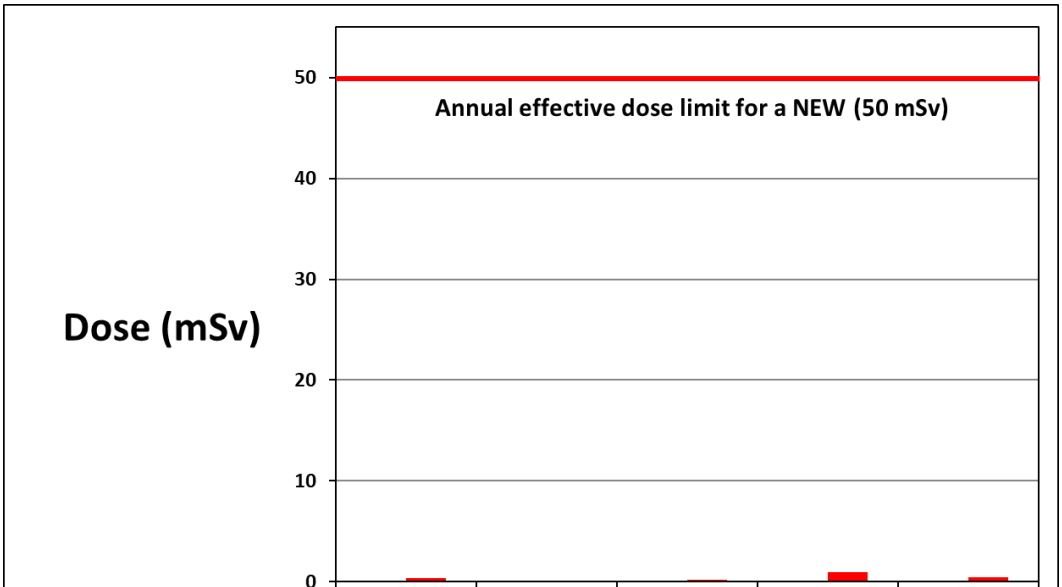
BTL workers are exposed externally to sealed sources of radiation. External whole-body and equivalent doses are ascertained with the use of dosimeters.

At BTL, employees are classified as NEWs if they are expected to have a reasonable probability of receiving an annual occupational dose greater than 1 mSv. Such workers include service technicians and source handlers. In 2017, the

maximum effective dose received by a NEW at BTL was 0.47 mSv, or approximately 1% 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 for NEWs at BTL from 2013 to 2017.

Figure 10-3: Average and maximum effective doses to NEWs, BTL, 2013–17



	2013	2014	2015	2016	2017
Average effective dose (mSv)	0.01	0.00	0.01	0.03	0.02
Maximum effective dose (mSv)	0.33	0.11	0.20	0.98	0.47
Number of NEWs monitored	58	61	62	60	68

Annual average and maximum equivalent dose results from 2013 to 2017 are shown in table E-6 of appendix E. The maximum equivalent extremity dose for 2017 was 0.50 mSv. Over the past five years, average extremity equivalent doses have been relatively stable, between approximately 0 mSv and 6.1 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.

BTL workers identified as non-NEWs, such as administrative staff, are restricted from accessing controlled areas where radioactive material is stored or areas where the public annual dose limit of 1 mSv may be exceeded. In 2017, non-NEWs did not receive any reportable doses.

Radiation protection program performance

Radiation protection program performance at BTL was assessed in 2017 through various CNSC staff compliance activities and desktop reviews. CNSC staff found that BTL's compliance with the *Radiation Protection Regulations* [2] and the CNSC licence requirements was 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 2017, there were no action level exceedances at BTL.

Radiological hazard control

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.

The majority of the 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 work place.

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/or too low to be measured.

10.3 Environmental protection

Compliance ratings for the environmental protection SCA, BTL, 2013–17

2014	2015	2016	2017
SA	SA	SA	SA
For 2017, CNSC staff continued to rate the environmental protection SCA at the 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 2017, there were no releases of hazardous 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 EMS to conform to CNSC REGDOC-2.9.1, *Environmental Protection Policies, Programs and Procedures* [20].			

SA = satisfactory

Effluent and emissions control (releases)

There are no radioactive releases (liquid or airborne) at the BTL facility that require controls or monitoring. The radioactive material used at the facility is limited to sealed sources and to depleted uranium that is used as shielding for the sealed sources.

There are no hazardous liquid releases that require controls. Hazardous liquid effluents from routine operations are collected, temporarily stored onsite and removed for disposal by a certified third-party contractor.

Airborne hazardous emissions from BTL are related to the exhausting of the lead pouring, paint booth, fire torching and sand blasting areas. Engineering controls, such as filters and ventilation, are in place to reduce or eliminate emissions generated during operations.

Environmental management system

In 2015, BTL implemented a new environmental management system (EMS) to conform to REGDOC-2.9.1, *Environmental Protection Policies, Programs and Procedures* [20], a requirement of its Class IB licence. CNSC staff have verified that BTL continues to meet the requirements outlined in this regulatory document. BTL's EMS considers environmental impacts from its activities with a commitment to pollution prevention and continuous improvement. If environmental issues are identified they are monitored, interpreted and acted upon to protect the environment and the health and safety of persons.

Assessment and monitoring

Since BTL manufacturing operations do not produce airborne or liquid radiological releases to the environment that require controls or monitoring, BTL does not conduct environmental monitoring around its facility.

Protection of 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. CNSC staff concluded that the public continues to be protected from facility emissions.

Environmental risk assessment

BTL included an ERA in its application for a Class IB licence in 2014, which included mitigation measures for identified risks such as filtration and ventilation for airborne hazardous emissions. CNSC staff reviewed BTL's submission and are satisfied with the measures BTL has put in place for the protection of the public and the environment.

In 2013, BTL contracted a third party to conduct modelling to support its Environmental Compliance Approval application to the MECP. The results indicated that emissions from the facility would not result in changes to local air quality that would affect the health and safety of the public or the environment.

10.4 Conventional health and safety

Compliance ratings for the conventional health and safety SCA, BTL, 2014–17

2014	2015	2016	2017
SA	SA	SA	SA
For 2017, CNSC staff continued to rate the conventional health and safety SCA at BTL as "satisfactory". The compliance verification activities conducted by CNSC staff 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. BTL continues to develop and maintain a comprehensive occupational health and safety management program for its facility. Its program incorporates various elements, including accident reporting and investigation, hazard prevention, preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response.

A key performance measure for this SCA is the number of LTIs that occur per year. As indicated in table 10-1, there was one LTI reported at the BTL facility in 2017. The LTI was due an injured finger when an employee cut their thumb on a sawmill when they moved a piece of material from the machine. The accident resulted in 22 days of lost time. For that LTI, BTL conducted an investigation and implemented corrective actions (which are summarized in table H-3 of appendix H). CNSC staff reviewed the corrective actions and are satisfied with the actions taken by BTL to prevent recurrence.

Table 10-1: LTIs, BTL, 2014–17

	2014	2015	2016	2017
LTIs	1	1	3	1

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 review the monthly meeting minutes of this committee and any associated corrective actions to ensure that issues 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

BTL continues to develop and maintain a comprehensive occupational health and safety management program for its facility. Workers are made aware of the conventional health and safety program, and 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 2017 calendar year. This assessment is based on CNSC staff's verification of licensee activities that included onsite inspections, reviews of reports submitted by licensees, and reviews of events and incidents, supported by follow-up and general communication activities with the licensees.

In 2017, the performance ratings in all 14 SCAs for the facilities were as follows:

- with the exception of a "below expectations" rating for the management system SCA for Cameco's PHCF, uranium processing facilities were rated as "satisfactory" or better
- nuclear substance processing facilities were rated as "satisfactory" or better

CNSC staff's compliance activities confirmed that:

- radiation protection programs at all facilities 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 2017, despite the "below expectations" rating discussed above.

CNSC staff concluded that, in 2017, the licensees discussed in this report made adequate provision for the health and safety of workers as well as 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] *(AA) Canada Labour Code*, R.S.C., 1985, c. L-2.

[6] CNSC, RD/GD-99.3, *Public Information and Disclosure*, Ottawa, Canada, 2012.

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

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

[9] *Administrative Monetary Regulations* (2013), SOR/2013-139.

[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] CSA Group, CSA N292.0-14, *General principles for the management of radioactive waste and irradiated fuel*, 2014.

[13] CSA Group, CSA N292.3-14, *Management of low and intermediate radioactive waste*, 2014.

[14] CNSC, G-219, *Decommissioning Planning for Licensed Activities*, Ottawa, Canada, June 2000.

[15] CNSC, G-206, *Financial Guarantees for the Decommissioning of Licensed Activities*, Ottawa, Canada, June 2000.

[16] CNSC, Notice of Hearing, Cameco Fuel Manufacturing Facility Financial Guarantee, September 25, 2017.

[17] CNSC, Record of Decision, In the Matter of Cameco Fuel Manufacturing Inc., Financial Guarantee for the Future Decommissioning of the Cameco Fuel Manufacturing Inc. Port Hope Facility, November 17, 2017.

[18] CNSC, REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*, Ottawa, Canada, 2016.

[19] 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.

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

[21] CSA Group, CSA N288.7-15, *Groundwater protection programs at Class I nuclear facilities and uranium mines and mills*, 2015.

[22] CSA Group, CSA N288.1-14, *Guidelines for calculating derived release limits for radioactive materials in airborne and liquid effluents for normal operation of nuclear facilities*, 2014.

[23] CNSC, Record of Proceedings, Including Reasons for Decision, In the Matter of Best Theratronics Ltd., *Review by the Commission of the Designated Officer Order Issued on August 24, 2015*, September 28, 2015.

[24] CNSC, Record of Proceedings, Including Reasons for Decision, In the Matter of Best Theratronics Ltd., *Redetermination, under subsection 43(3) of the Nuclear Safety and Control Act, of the Order issued by the Commission on September 28, 2015*, February 29, 2016.

[25] CNSC, Record of Decision, In the Matter of Best Theratronics Ltd., *Amendment under Section 25 of the Nuclear Safety and Control Act and Request for Acceptance of the Financial Guarantee*, July 14, 2017.

Acronyms and abbreviations

ALARA	as low as reasonably achievable, taking into account social and economic factors
AMP	administrative monetary penalty
AOO	Algonquins of Ontario
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
CCAB	Canadian Council for Aboriginal Business
CCME	Canadian Council of Ministers of the Environment
CFM	Cameco Fuel Manufacturing Inc.
Ci	curie
cm	centimetre
CMD	Commission member document
CNSC	Canadian Nuclear Safety Commission
CSA	Canadian Standards Association (now CSA Group)
CTS	critical-to-safety
DRL	derived release limit
EMS	environmental management system
ERA	environmental risk assessment
ESDC	Employment and Social Development Canada (formerly Human Resources and Skills Development Canada)
FFOL	fuel facility operating licence
FS	fully satisfactory
g	gram
GBq	gigabecquerel
GCDWQ	*Guidelines for Canadian Drinking Water Quality*
GEH-C	GE Hitachi Nuclear Energy Canada Inc.

GTLS	gaseous tritium light source
h	hour
HF	hydrogen fluoride
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
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
MFN	Mississauga First Nation
MECP	Ontario Ministry of Environment, Conversation and Parks
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
OEL	occupational exposure limit
ORL	operating release limit
OPEX	operating experience
OPG	Ontario Power Generation
PAR	Progressive Aboriginal Relations

PFP	Participant Funding Program
PHCF	Port Hope Conversion Facility
ppm	parts per million
RP	radiation protection
SA	satisfactory
SAT	systematic approach to training
SCA	safety and control area
SI	International System of Units
SRBT	SRB Technologies (Canada) Inc.
T_2	tritiated gas
TBq	terabecquerel
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

Glossary

action level	A specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee's radiation protection program or environmental protection program and triggers a requirement for specific action to be taken.
becquerel	The International System of Units (SI) unit of radioactivity. One becquerel (Bq) is the activity of a quantity of radioactive material in which one nucleus decays per second. In Canada, the Bq is used instead of the non-SI unit curie (Ci). 1 Bq = 27 μCi (2.7×10^{-11} Ci) and 1 Ci = 3.7×10^{10} Bq 1 megabecquerel (MBq) = 10^6 Bq 1 gigabecquerel (GBq) = 10^9 Bq 1 terabecquerel (TBq) = 10^{12} Bq
Canadian Nuclear Safety Commission (CNSC)	Canada's nuclear regulator, established under the *Nuclear Safety and Control Act* [1] to regulate the use of nuclear energy and materials to protect health, safety, security and the environment; to implement Canada's international commitments on the peaceful use of nuclear energy; and to disseminate objective scientific, technical and regulatory information to the public.
Commission	The Canadian Nuclear Safety Commission established by section 8 of the *Nuclear Safety and Control Act* [1]. The Commission consists of not more than seven members, appointed by the Governor in Council, to: • make independent, fair and transparent decisions on the licensing of nuclear-related activities • establish legally binding regulations • set regulatory policy direction on health, safety, security and environmental issues affecting the Canadian nuclear sector This term is not used when the intention is to refer to both Commission members and CNSC staff. (See also Canadian Nuclear Safety Commission.)
Commission member document	A document prepared for Commission hearings and meetings by CNSC staff, proponents and intervenors.
critical receptor	As defined in CSA N288.6, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3], "a critical receptor refers to the receptor receiving the greatest

	dose, which applies to both radiological and non-radiological risk assessments.”
cyclotron	A particle accelerator that speeds up particles in a circular motion until they hit a target at the perimeter of the cyclotron. Some cyclotrons are used to produce medical isotopes.
derived release limit (DRL)	As defined in the CSA N288.1, *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities*, “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.”
effective dose	The sum of the products, in sieverts, obtained by multiplying the equivalent dose of radiation received by and committed to each organ or tissue set out in column 1 of an item of schedule 1 of the *Radiation Protection Regulations* [2] by the weighting factor set out in column 2 of that item. Effective dose is a measure of the total detriment, or risk, due to an exposure to ionizing radiation. If the exposure to different organs or tissues is not uniform (as is the case when radionuclides are deposited in the body), the concept of effective dose is used. The basic idea is to express the risk from the exposure to a single organ or tissue in terms of the equivalent risk from an exposure to the whole body.
enforcement action	The set of activities associated with re-establishing compliance with regulatory requirements.
equivalent dose	The product, in sieverts, obtained by multiplying the absorbed dose of radiation of the type set out in column 1 of an item of schedule 2 of the *Radiation Protection Regulations* [2] by the weighting factor set out in column 2 of that item. Equivalent dose and effective dose are protection quantities used to reflect how radiation exposure can affect overall health of the human body. They specify dose values, which are derived from the body’s absorbed dose, for limiting the occurrence of stochastic health effects below acceptable levels and avoiding tissue reactions. The equivalent dose (multiplying the radiation type by its radiation weighting factor) is designed to reflect the amount of harm caused, regardless of the type of radiation. Values (expressed in sieverts) of equivalent dose to a specified tissue or organ from any type(s) of radiation can be compared directly.

lost-time injury	An injury or illness resulting in lost days beyond the date of injury as a direct result of an occupational injury or illness incident.
nuclear energy worker	A person who is required, in the course of the person's business or occupation in connection with a nuclear substance or nuclear facility, to perform duties in such circumstances that there is a reasonable probability that the person may receive a dose of radiation that is greater than the prescribed limit for the general public.
receptor	Any person or environmental entity that is exposed to radiation, a hazardous substance, or both. A receptor is usually an organism or a population, but it could also be an abiotic entity, such as surface water or sediment.
root-cause analysis	An objective, structured, systematic and comprehensive analysis for determining the underlying causes of a situation or event.
sealed source	A radioactive nuclear substance in a sealed capsule or in a cover to which the substance is bonded, where the capsule or cover is strong enough to prevent contact with or the dispersion of the substance under the conditions for which the capsule or cover is designed.

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 personnel and equipment.	▪ 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
	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, 2013–17

SCAs	2013 rating	2014 rating	2015 rating	2016 rating	2017 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, 2013–17

SCAs	2013 rating	2014 rating	2015 rating	2016 rating	2017 rating
Management system	SA	SA	SA	SA	BE
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, 2013–17

SCAs	2013 rating	2014 rating	2015 rating	2016 rating	2017 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, 2013–17

SCAs	2013 rating	2014 rating	2015 rating	2016 rating	2017 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	FS	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, 2013–17

SCAs	2013 rating	2014 rating	2015 rating	2016 rating	2017 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	FS	FS	FS	FS
Radiation protection	SA	SA	SA	SA	SA
Conventional health and safety	FS	FS	FS	FS	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	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, 2013–17

SCAs	2013 rating	2014 rating	2015 rating	2016 rating	2017 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, 2014–17

SCAs	2014 rating	2015 rating	2016 rating	2017 rating
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	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA
Emergency management and fire protection	SA	BE	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

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	$677,676
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 facility, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Average extremity dose (mSv)	14.1	5.4	1.5	1.2	1.0	**N/A**
Maximum individual extremity dose (mSv)	35.1	48.2	15.3	10.6	13.6	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table E-2: Equivalent (extremity) dose statistics for NEWs, CFM, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Average extremity dose (mSv)	14.3	15.5	15.5	13.2	10.6	**N/A**
Maximum individual extremity dose (mSv)	87.6	88.4	87.0	98.4	59.0	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table E-3: Equivalent (extremity) dose statistics for NEWs, BWXT Toronto, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Average extremity dose (mSv)	32.92	31.96	30.30	27.71	27.36	**N/A**
Maximum individual extremity dose (mSv)	143.59	102.44	109.62	119.47	115.07	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table E-4: Equivalent (extremity) dose statistics for NEWs, BWXT Peterborough, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Average extremity dose (mSv)	10.47	18.64	12.61	9.78	13.62	**N/A**
Maximum individual extremity dose (mSv)	76.03	98.98	39.34	32.84	43.18	**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, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Average extremity dose (mSv)	0.54	0.73	0.46	0.79	0.53	**N/A**
Maximum individual extremity dose (mSv)	7.4	9.5	9.3	8.3	16.4	**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, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Average extremity dose (mSv)	0.34	0.21	0.00	0.09	0.07	**N/A**
Maximum individual extremity dose (mSv)	6.10	3.70	0.00	1.10	0.50	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Skin doses: uranium processing facilities

Table E-7: Equivalent (skin) dose statistics for NEWs, BRR facility, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Average skin dose (mSv)	6.8	5.4	4.0	3.3	3.1	**N/A**
Maximum individual skin dose (mSv)	41.4	41.2	28.1	26.0	16.2	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table E-8: Equivalent (skin) dose statistics for NEWs, PHCF, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Average skin dose (mSv)	1.7	0.6	0.8	0.8	0.6	**N/A**
Maximum individual skin dose (mSv)	28.6	10.3	23.4	16.9	13.7	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table E-9: Equivalent (skin) dose statistics for NEWs, CFM, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Average skin dose (mSv)	7.3	8.1	6.3	6.6	5.5	**N/A**
Maximum individual skin dose (mSv)	88.4	108.4	95.6	95.7	88.1	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table E-10: Equivalent (skin) dose statistics for NEWs, BWXT Toronto, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Average skin dose (mSv)	10.29	11.08	9.89	10.23	7.85	**N/A**
Maximum individual skin dose (mSv)	52.84	51.67	54.99	74.26	54.27	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table E-11: Equivalent (skin) dose statistics for NEWs, BWXT Peterborough, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Average skin dose (mSv)	3.8	4.75	4.1	2.66	2.77	**N/A**
Maximum individual skin dose (mSv)	31.20	29.91	22.47	21.15	25.14	**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, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Average skin dose (mSv)	0.42	0.46	0.42	0.59	0.42	**N/A**
Maximum individual skin dose (mSv)	6.39	6.11	5.21	5.20	5.52	**500 mSv/year**

mSv = millisievert; N/A = not applicable

F. Environmental data

Blind River Refinery

Table F-1: Annual groundwater monitoring results, 2013–17

Parameter	2013	2014	2015	2016	2017	GCDWQ*
Average uranium concentration (µg/L)	0.5	0.6	1.7	1.3	1.2	**20**
Maximum uranium concentration (µg/L)	3.7	8.9	18.5	14.0	11.0	**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, 2013–17

Parameter	2013	2014	2015	2016	2017	CCME guidelines*
Average uranium concentration (µg/L)	0.4	<0.2	0.2	<0.8**	<0.8	**15**
Average nitrate concentration (mg/L as N)	0.3	0.2	0.2	0.2	0.2	**13**
Average radium-226 concentration (Bq/L)	<0.005	<0.005	<0.005	<0.005	<0.005	**N/A**
Average pH	7.2	7.6	7.3	8.0	7.3	**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 the Blind River Refinery in 2016.

Table F-3: Soil monitoring results, 2013–17

Parameter	2013	2014	2015	2016	2017	CCME guidelines*
Minimum uranium concentration (µg/g)	0.1	0.1	0.1	0.2	0.3	**23**
Average uranium concentration (µg/g) (within 1,000 m, 0–5 cm depth)	4.3	2.7	3.8	1.5	1.6	
Maximum uranium concentration (µg/g)	16.4	7.2	9.7	2.9	2.8	

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, 2013–17

Parameter	2013	2014	2015	2016	2017
Uranium	28.9	31.0	25.3	22.8	34.0
Fluoride	51.1	53.0	48.3	36.9	61.0
Ammonia	53.0	75.0	63.7	73.6	70.0
Nitrate	41.0	53.0	44.0	42.6	56.0
Arsenic	2.8	2.5	2.6	1.9	3.0

kg = kilogram

Table F-5: Harbour water quality, 2013–17

Parameter	Value	2013	2014	2015	2016	2017	CCME* guidelines
Uranium (µg/L)	Average	3.3	3.3	2.9	2.6	3.3	**15**
	Maximum	8.3	7.6	6.6	10	8.8	
Fluoride (mg/L)	Average	0.10	0.11	0.13	0.15	0.19	**0.12**
	Maximum	0.18	0.39	0.17	0.22	0.29	
Nitrate (mg/L)	Average	0.84	0.86	0.89	0.85	1.0	**13**
	Maximum	1.6	1.5	1.7	1.6	2.2	
Ammonia + Ammonium (mg/L)	Average	0.11	0.23	0.20	0.16	0.18	**0.3**
	Maximum	0.35	0.52	0.66	0.58	0.40	

CCME = Canadian Council of Ministers of the Environment; mg/L = milligrams per litre
*****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), 2013–17

Soil depth (cm)	2013	2014	Soil depth (cm)	2015	2016	2017	CCME guidelines*
0–2	1.0	1.4	**0–5**	1.0	1.2	0.8	**23**
2–6	0.9	1.2					
6–10	1.0	1.1	**5–10**	1.0	1.1	0.8	
10–15	1.0	1.1	**10–15**	1.2	1.0	0.9	
70 cm composite	1.5	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, 2013–17

Parameter	2013	2014	2015	2016	2017	MECP guidelines*
Fluoride in vegetation (ppm)	5.6	2.6	3.2	3.0	11.0	**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, 2013–16

Parameter	2013	2014	2015	2016	Licence limit
Site 1 (µSv/h)	0.007	0.003	0.007	0.005	**0.14**
Site 2 (Dorset Street) (µSv/h)	0.058	0.054	0.044	0.054	**0.40**

µSv = microsievert

Table F-9: Gamma monitoring results, maximum monthly, 2017

Station number and site	2017	Licence limit
Station 2 – Sites 1 and 2 (µSv/h)	0.25	**0.57**
Station 13 – Site 1 (µSv/h)	0.03	**0.40**
Station 21 – Site 2 (µSv/h)	0.08	**0.26**

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**

CCME = Canadian Council of Ministers of the Environment; µg/g = microgram per gram
*****CFM reverted to a three-year soil monitoring program and did not monitor soil in 2011, 2012, 2014 and 2015.
******CCME, *Soil Quality Guidelines for the Protection of Environmental and Human Health* (for residential and parkland land use)

BWXT Toronto

Table F-11: Air emission and liquid effluent monitoring results, 2013–17

Parameter	2013	2014	2015	2016	2017	Licence limit
Uranium discharged to air (kg/year)	0.0104	0.0109	0.0108	0.0108	0.00744	**0.76**
Uranium discharged to sewer (kg/year)	0.83	0.72	0.39	0.65	0.941	**9,000**

kg = kilogram
Note: The values for uranium discharge to air have been corrected from those reported in the *Regulatory Oversight Report for Nuclear Processing, Small Research Reactor and Class IB Accelerator Facilities: 2015*. The data reflect updated values provided by BWXT Nuclear Energy Canada Inc. to address a discrepancy in monitoring results caused by incorrect use of a flowmeter in 2016 when estimating the furnace exhaust stacks emissions from 2012 to 2015.

Table F-12: Uranium in boundary air monitoring results, 2013–17

Parameter	2013	2014	2015	2016	2017
Average concentration (µg/m^3)	0.0007	0.0006	0.0010	0.0010	<0.0001

µg = microgram
Note: Ontario standard for uranium in ambient air is 0.03 µg/m^3

Table F-13: Uranium in soil monitoring results, BWXT property, 2013–17

Parameter	2013	2014	2015	2016	2017
Number of samples	1	1	1	1	1
Average uranium concentration (µg/g)	2.3	2.3	1.4	1.2	1.7
Maximum uranium concentration (µg/g)	2.3	2.3	1.4	1.2	1.7
CCME guidelines (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-14: Uranium in soil monitoring results, industrial/commercial lands, 2013–17

Parameter	2013	2014	2015	2016	2017
Number of samples	24	34	30	34	34
Average uranium concentration (µg/g)	3.9	5.0	2.9	2.7	3.0
Maximum uranium concentration (µg/g)	24.9	22.1	8.7	13.6	20.6
CCME guidelines (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-15: Uranium in soil monitoring results, residential locations, 2013–17

Parameter	2013	2014	2015	2016	2017
Number of samples	24	14	18	14	14
Average uranium concentration (µg/g)	1.1	0.6	0.7	0.5	1.0
Maximum uranium concentration (µg/g)	3.1	2.1	2.1	0.7	1.6
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*

BWXT Peterborough

Table F-16: Air emissions and liquid effluent monitoring results, 2013–17

Parameter	2013	2014	2015	2016	2017	Licence limit
Uranium discharged to air (kg/year)	0.000013	0.000003	0.000003	0.000004	0.000002	**0.55**
Uranium discharged to sewer (kg/year)	0.0002	0.0001	0.0001	0.0001	0.00011	**760**

kg = kilogram

SRB Technologies (Canada) Inc.

Table F-17: Atmospheric emissions monitoring results, 2013–17

Parameter	2013	2014	2015	2016	2017	Licence limit (TBq/year)
Tritium as tritium oxide (HTO) (TBq/year)	17.82	10.71	11.55	6.29	7.19	**67**
Total tritium as HTO + HT (TBq/year)	78.88	66.16	56.24	28.95	24.82	**448**

TBq = terabecquerel; HTO = hydrogenated tritium oxide; HT = tritium gas

Table F-18: Liquid effluent monitoring results for release to sewer, 2013–17

Parameter	2013	2014	2015	2016	2017	Licence limit (TBq/year)
Tritium-water soluble (TBq/year)	0.009	0.013	0.007	0.005	0.007	**0.200**

TBq = terabecquerel

Nordion (Canada) Inc.

Table F-19: Air emissions monitoring results, 2013–17

Parameter	2013	2014	2015	2016	2017	Licence limit (DRL) (GBq/year)
Cobalt-60	0.005	0.005	0.005	0.006	0.0034	70.1
Iodine-125	0.23	0.14	0.12	0.21	0.0012	4,880
Iodine-131	0.39	0.46	0.15	0.35	0.0008	3,790
Xenon-133	30,735	15,018	11,916	7,277	0	61,200,000
Xenon-135	28,193	13,075	8,237	4,299	0	7,660,000
Xenon-135m	43,383	18,170	10,758	5,421	0	4,600,000

DRL = derived release limit; GBq = gigabecquerel

Table F-20: Liquid effluent monitoring results for release to sewer, 2013–17

Parameter	2013	2014	2015	2016	2017	Licence limit (DRL) (GBq/year)
β < 1 MeV	0.288	0.209	0.191	0.222	0.212	66,000
β > 1 MeV	0.065	0.050	0.044	0.051	0.048	210,000
Iodine-125	0.005	0.051	0.111	0.144	0.145	73,600
Iodine-131	0.009	0.006	0.006	0.006	0.006	23,300
Molybdenum-99	0.077	0.055	0.060	0.052	0.049	1,120,000
Cobalt-60	0.022	0.018	0.019	0.026	0.022	155,000
Niobium-95	0.0006	0.0007	0.0010	0.001	0.001	558,000
Zirconium-95	0.0006	0.0005	0.0010	0.0015	0.002	749,000
Cesium-137	0.0005	0.0004	0.0004	0.0007	0.0007	137,000

DRL = derived release limit; GBq = gigabecquerel; MeV = megaelectronvolt

G. Total annual releases of radionuclides directly to the environment

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 BRR has direct releases to surface water with the relevant radionuclides being uranium and radium-226.

Table G-1: Total annual load of relevant radionuclides released to atmosphere or surface waters for uranium processing facilities, 2013–17

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
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

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)
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
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
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

N/A = not applicable

Nuclear substance processing facilities

SRB Technologies (Canada) Inc.

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, 2013–17

Year	Hydrogenated tritium oxide (HTO in TBq)	Tritium gas (HT in TBq)
2013	17.82	61.06
2014	10.71	55.45
2015	11.55	44.69
2016	6.29	22.66
2017	7.19	17.63

TBq = terabecquerel; HTO = hydrogenated tritium oxide; HT = tritium gas

Nordion (Canada) Inc.

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, 2013–17

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

Best Theratronics Ltd.

BTL does not have any airborne or liquid radiological releases.

H. Lost-time injuries in 2017

Table H-1: LTIs, PHCF, 2017

LTI	Action taken
An employee injured a muscle in their right bicep while removing a drum from a conveyor in the UO_2 plant. The drum weighed approximately 17 kg. It was lifted off the conveyor, at shin height, and over a safety cable, at waist height, before being placed on the floor. After the event, the employee continued to work, but with restrictions, and received surgery in July. Doctors instructed the employee to take time off after the surgery, resulting in six days lost time.	Cameco instructed its employees to stop the practice of lifting drums over the obstructing buttons (tare scale zero button and tare label print button) mounted to the conveyor belt and a safety cable. Instead, employees should convey the unwanted drum around the conveying system to the designated drum removal location. In addition, Cameco removed two buttons as their function is now supported by a new interface and remote buttons are not required. Cameco also relocated the conveyor index button so it is not an obstacle to lifting the drum. Furthermore, Cameco shortened the safety cable to provide an opening for drum removal without lifting.

Table H-2: LTIs, SRBT, 2017

LTI	Action taken
An employee lacerated their hand during an assembly operation in January 2017. The worker received medical attention and required stitches at the Pembroke Regional Hospital. The doctors recommended that the worker take several days off before returning to work. Following an investigation into the event, it became apparent that the worker had not been adequately guarding the blade when changing it. This injury resulted in two days lost time.	SRBT organized a safety stand-down meeting with supervisors to discuss the event and to ensure that expectations when handling sharp items were emphasized with the employees. SRBT's Workplace Health and Safety Committee investigated the event and procured alternative tooling in collaboration with the workers, in order to reduce the hazard when the assembly work is being performed.
In August 2017, while kneeling down, an employee attempted to pick up an item on the floor and injured their back. The worker was subsequently transported to the local hospital and missed the following day of work due to the injury, resulting in one day lost time.	Upon returning to the workplace, the employee was advised on the proper methodology for lifting items, including avoiding twisting of the back when bending over.
In October 2017, an employee in the coating department experienced shoulder pain. The worker received medical attention and was advised by SRBT to take the week off work, resulting in four days lost time.	The worker returned to modified duties and SRBT highlighted expectations regarding job rotation to reduce injury risk as a result of repetitive movements.

Table H-4: LTIs, BTL, 2017

LTI	Action taken
An employee cut their thumb on a sawmill when moving a piece of material from the machine; this resulted in 22 days lost time.	The employee was retrained on the procedure and reminded of the safety precautions to take when using the machine. The employee has not been scheduled to work at the saw machine since returning to work and is also being monitored to follow safety procedures with all the other tools and machines on the shop floor.

I. Links to licensee websites

Licensee	Website
Cameco BRR	cameco.com/fuel_services/blind_river_refinery
Cameco PHCF	cameco.com/fuel_services/port_hope_conversion
Cameco CFM	cameco.com/fuel_services/fuel_manufacturing
BWXT Toronto and Peterborough	nec.bwxt.com
SRBT	srbt.com
Nordion	nordion.com
BTL	theratronics.ca

J. Significant changes to licence and licence conditions handbook

Table J-1: Changes to licences by the Commission

Facility	Date	Facility licence	Description of change
PHCF	March 2017	FFOL-3631.00/2027	First release of Cameco PHCF's LCH after the November 2016 relicensing hearing held in Port Hope. The Commission issued the PHCF's licence on February 27, 2017.
BTL	July 2017	Amended to: NSPFOL-14.02/2019	The Commission amended licence condition 1.3 to the following: "The licensee shall maintain a financial guarantee for decommissioning acceptable to the Commission." For additional details refer to CMD 17-H103.A, *Best Theratronics Limited Financial Guarantee.*

K. CNSC inspections

CNSC inspections: Uranium processing facilities

Table K-1: Inspections, BRR facility, 2017

Inspection title	Safety and control areas covered	Inspection report sent date
Type II Inspection Human Performance Management CAMECO-BRR-2017-01	Human performance management	May 4, 2017
Type II Operating Performance Inspection CAMECO-BRR-2017-02	Operating performance	May 26, 2017
Type II Security Inspection CAMECO-BRR-2017-03	Security	August 24, 2017
Type II General Inspection CAMECO-BRR-2017-04	Management system, fitness for service, radiation protection, conventional health and safety	November 16, 2017

Note: Security and safeguard inspection reports contain sensitive information and will not be made public.

Table K-2: Inspections, PHCF, 2017

Inspection Title	Safety and control areas covered	Inspection report sent date
CAMECO-PHCF-2017-01	Physical design, packaging and transport	April 26, 2017
CAMECO-PHCF-2017-02	Management system	May 23, 2017
CAMECO-PHCF-2017-03	Management system, fitness for service, radiation protection, conventional health and safety, packaging and transport	November 24, 2017
CAMECO-PHCF-2017-04	Emergency management	January 29, 2018
CAMECO-PHCF-2017-05	Human performance management	February 21, 2018

Table K-3: Inspections, CFM, 2017

Inspection title	Safety and control areas covered	Inspection report sent date
CFM Type II Inspection CAMECO-CFM-2017-01	Management system	March 15, 2017
CFM Type II Inspection CAMECO-CFM-2017-02	Human performance management	June 28, 2017
CFM Type II Inspection CAMECO-CFM-2017-03	Security	July 10, 2017
CFM Type II Inspection CAMECO-CFM-2017-04	Management system, fitness for service, operating performance, radiation protection, environmental protection, conventional Health and safety, emergency management and fire protection	February 16, 2018

Note: Security and safeguard inspection reports contain sensitive information and will not be made public.

Table K-4: Inspections, BWXT Toronto and Peterborough, 2017

Inspection title	Safety and control areas covered	Inspection report sent date
BWXT-2017-01	Security	March 3, 2017
BWXT-2017-02	Management system	June 6, 2017
BWXT-2017-03	Human performance management	July 25, 2017
BWXT-2017-04	Reactive inspection – beryllium OEL	January 10, 2018
BWXT-2017-05	Waste management	January 26, 2018

Note: Security and safeguard inspection reports contain sensitive information and will not be made public.

CNSC inspections: Nuclear substance processing facilities

Table K-5: Inspections, SRBT, 2017

Inspection title	Safety and control areas covered	Inspection report sent date
SRBT Type II Inspection SRBT-2017-01	Radiation protection	April 13, 2017
SRBT Type II Inspection SRBT-2017-02	Management system	May 12, 2017

Table K-6: Inspections, Nordion, 2017

Inspection title	Safety and control areas covered	Inspection report sent date
NORDION-2017-01	Security	February 24, 2017
NORDION-2017-02	Radiation protection	April 26, 2017
NORDION-2017-03	Environmental protection	June 1, 2017
NORDION-2017-04	Human performance management	September 26, 2017
NORDION-2017-05	Emergency management and fire protection	January 25, 2018

Note: Security and safeguard inspection reports contain sensitive information and will not be made public.

Table K-7: Inspections, BTL, 2017

Inspection title	Safety and control areas covered	Inspection report sent date
Security Inspection BT-2017-01	Security	August 14, 2017
Management Systems Inspection BT-2017-02	Management systems	August 11, 2017
Emergency Management Inspection BT-2017-03	Emergency management	December 14, 2017
Transport Inspection BT-2017-04	Packaging and transport	January 4 , 2018

Note: Security and safeguard inspection reports contain sensitive information and will not be made public.