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Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2016




Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

Canada

Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2016

Cat. No.: CC171-33E-PDF
ISSN: 2562-0010

Également publié en français sous le titre : Rapport de surveillance réglementaire installations de traitement de l'uranium et des substances nucléaires au Canada : 2016

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

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Publishing history

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

The operating performance of uranium and nuclear substance processing facilities regulated by the Canadian Nuclear Safety Commission (CNSC) is presented in this *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2016*. The report covers the 2016 calendar year and, when applicable, shows trends and compares information to previous years.

This report focuses on three safety and control areas (SCAs): "radiation protection", "environmental protection" and "conventional health and safety". Because these three SCAs reflect the overall effectiveness of the safety programs implemented by CNSC licensees, they provide a good indication of the overall safety performance of the facilities discussed in this report. The report also includes ratings for all 14 SCAs and highlights public information programs, reportable events, significant facility modifications and areas of increased regulatory focus.

Through regulatory oversight activities, CNSC staff confirmed that Canada's uranium and nuclear substance processing facilities continued to operate safely in 2016. These activities included onsite inspections, reviews of reports submitted by licensees, event and incident reviews, and general communication and exchanges of information with licensees. For the 2016 calendar year, the performance of all uranium and nuclear substance processing facilities was rated as "satisfactory" or better for all 14 SCAs.

CNSC staff's compliance activities confirmed 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 the environment
- conventional health and safety programs at all facilities continued to protect workers
- other programs in support of remaining SCAs required to ensure the protection of the health and safety of workers, the public and the environment continued to be effectively implemented

CNSC staff concluded that in 2016, each of the regulated facilities covered in this report made adequate provision for the health and safety of workers, the protection of the public and the environment, and Canada's international obligations.

The full report is available on the CNSC public website. The documents referenced in it are available to the public upon request.

1 Overview

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

Each year, CNSC staff assess the overall safety performance of Canada's uranium and nuclear substance processing facilities, looking at each industry as a whole and at the performance of each facility. The 2016 assessment, which is summarized in this report, aligns with the legal requirements of the *Nuclear Safety and Control Act* (NSCA) [1] and the regulations made under the NSCA, each facility's licence conditions handbook (LCH), and any other applicable standards and regulatory documents.

This report highlights areas of regulatory focus for CNSC staff, including information on regulatory requirements and expectations in selected areas. It also discusses significant events, licence changes, major developments and overall performance. It provides performance data on the safety and control areas (SCAs) of "radiation protection", "environmental protection" and "conventional health and safety", which collectively provide a good overall indication of the safety performance for the facilities discussed. The information covers the 2016 calendar year and, where appropriate, compares information to previous years.

Also included are 10 appendices, a glossary and a list of references. Appendices A, B and C provide general information related to the CNSC's regulatory oversight of uranium and nuclear substance processing facilities in Canada. Appendix D presents the financial guarantees for each facility. Appendices E, F and G provide performance data for each facility, including trends. Appendix H lists the licensees' websites, while appendix I summarizes any significant changes made to the licences and LCHs in 2016. New to this year's report is appendix J, which provides a list of all compliance verification inspections conducted during the calendar year for each facility.

Documents referenced in this report are available to the public upon request.

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 Ontario:

- uranium processing facilities
    - Cameco Corporation Blind River Refinery in Blind River, ON (FFOL-3632.00/2022)

  - Cameco Corporation Port Hope Conversion Facility in Port Hope, ON (FFOL-3631.00/2027)
  - Cameco Fuel Manufacturing Inc. in Port Hope, ON (FFOL-3641.00/2022)
  - BWXT Nuclear Energy Canada Inc. (formerly GE Hitachi Nuclear Energy Canada Inc.) in Peterborough, ON (FFOL-3620.01/2020)
  - BWXT Nuclear Energy Canada Inc. (formerly GE Hitachi Nuclear Energy Canada Inc.) in Toronto, ON (FFOL-3620.01/2020)
- nuclear substance processing facilities
  - SRB Technologies (Canada) Inc. in Pembroke, ON (NSPFOL-13.00/2022)
  - Nordion (Canada) Inc. in Ottawa, ON (NSPFOL-11A.00/2025)
  - Best Theratronics Ltd. in Ottawa, ON (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 in order 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.

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 risks posed by the regulated activities. Compliance plans are continuously reviewed to take into consideration events, facility modifications, changes in licensee performance, and lessons learned.

Onsite inspections conducted in 2016 covered various aspects of the SCAs. In 2016, CNSC staff conducted 22 onsite inspections at uranium and nuclear substance processing facilities in Canada. A breakdown of the number of inspections is provided in each industry's respective section and summarized in appendix J.

While some inspections focus on specific SCAs, CNSC inspectors strive to ensure that aspects of radiation protection, environmental protection, and conventional health and safety are covered in every inspection. This is done to continually ensure that:

- radiation protection measures are effective and radiation doses to workers remain as low as reasonably achievable (ALARA), taking into account social and economic factors

- the environmental protection programs are effective and releases remain ALARA
- 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, which are supplemented through presentations, facility visits and meetings with the licensees.

CNSC staff's regulatory focus will continue to provide assurance that the uranium and nuclear substance processing facilities in Canada are operated in a manner that protects the health and safety of workers and the public; security; and the environment. CNSC staff's continuous improvement in regulatory oversight includes:

- ensuring the implementation of new or updated regulatory requirements, including CSA Group standards and CNSC regulatory documents
- implementing CNSC licence improvement initiatives, including licensing modernization and LCH standardization

1.3 Safety and Control Area Framework

CNSC staff use the SCA Framework in evaluating each licensee's safety performance. SCAs are comprehensive technical topics that, taken together, cover all aspects of licensees' systems, structures and programs used for safety. CNSC staff use SCAs across all regulated facilities and activities to assess, evaluate, review, verify and report on regulatory requirements and performance. The SCA Framework includes 14 SCAs, each subdivided into specific areas that define that SCA's key components. See appendix A for more details about the CNSC's SCA Framework.

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 for these four ratings are provided in appendix B. Ratings are provided for each applicable SCA. The ratings are derived on an annual basis from the compliance verification activities conducted by CNSC staff.

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. Performance in each SCA is continually assessed by CNSC staff. 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 in the area during the year. In these cases, the rating input is based on CNSC staff review of the information provided by the licensees in their annual compliance reports and through desktop reviews of other performance reports submitted by licensees to the CNSC.

The three SCAs of focus in this report – radiation protection, environmental protection, and conventional health and safety – have key metrics to demonstrate a licensee's performance. These include the radiation dose to workers and the public, releases to the environment, and the number of lost-time injuries.

1.4 CNSC Independent Environmental Monitoring Program

Under the NSCA, the CNSC requires each nuclear facility licensee to develop, implement and maintain an environmental monitoring program to demonstrate that the public and the environment are protected from emissions related to the facility's nuclear activities. The results of these monitoring programs are submitted to the CNSC to ensure compliance with the guidelines and limits set out in regulations that oversee Canada's nuclear industry.

The CNSC implements its Independent Environmental Monitoring Program (IEMP) to verify that the public and the environment around licensed nuclear facilities are safe. It is a regulatory tool that complements the CNSC's ongoing compliance verification program. The IEMP involves CNSC staff taking samples from publicly accessible areas around the facilities, then measuring and analyzing the level of radiological and hazardous (non-radiological) substances in those samples.

Samples may be taken for air, water, soil, sediment, vegetation and some food (such as meat and produce). Highly qualified scientists using best industry practices at the CNSC's state-of-the art laboratory analyze these samples, which are measured for both radiological and hazardous contaminants related to the activities of the nuclear facility (as identified in the site-specific environmental risk assessment). Contaminant levels are compared with those in applicable guidelines or natural background levels to confirm that there is no impact on health or the environment.

In 2016, CNSC staff conducted independent environmental monitoring at the BWXT facility in Toronto and at the Nordion facility in Ottawa. The 2016 IEMP results (which can be found on the CNSC's IEMP Web page) indicate that the public and the environment surrounding these facilities are protected and safe.

1.5 Overall conclusions

CNSC staff concluded that uranium processing facilities and nuclear substance processing facilities operated safely during 2016. This conclusion is based on CNSC staff's assessments of licensee activities that included site inspections, reviews of reports submitted by licensees, and event and incident reviews, supported by follow-up and general communication with the licensees.

For 2016, the performance in all 14 SCAs for the facilities was as follows:

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

CNSC staff's compliance activities confirmed that:

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

CNSC staff will continue to provide regulatory compliance oversight to all licensed facilities to ensure that they continue to make adequate provision to protect the health, safety and security of workers, Canadians and the environment; and continue to implement Canada's international obligations on the peaceful use of nuclear energy.

Part I: Uranium processing facilities

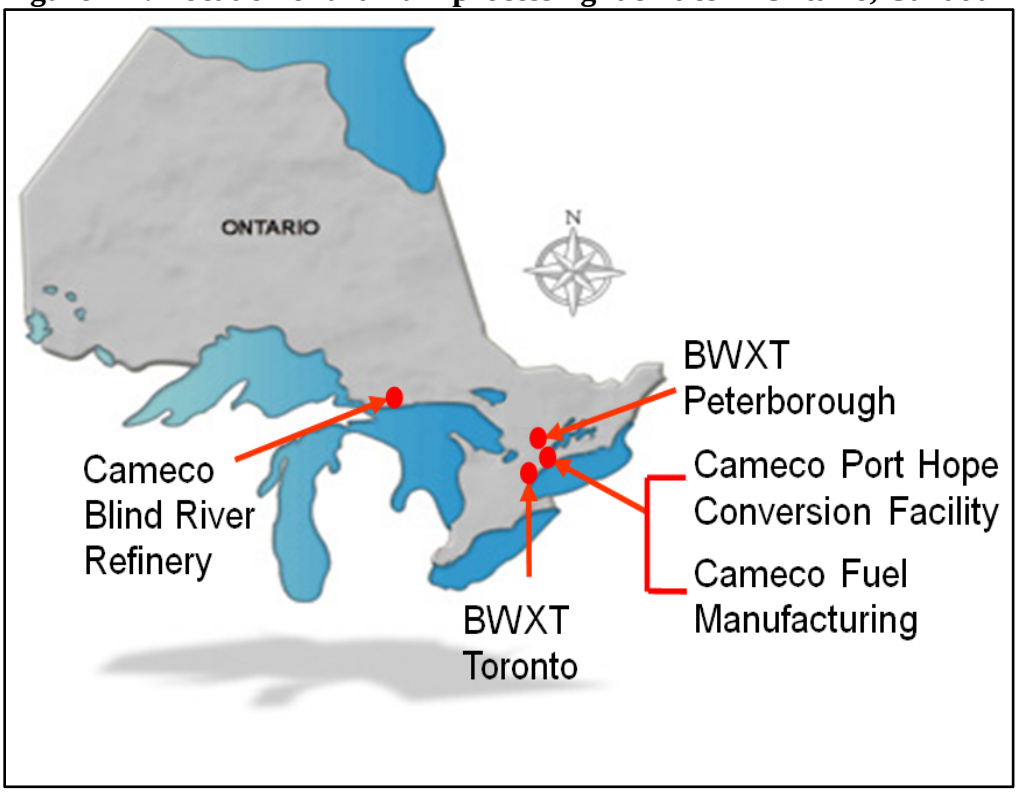
2 Overview

This section of the report focuses on the five uranium processing facilities in Canada:

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

All five facilities are located in Ontario, as shown in figure 2-1. In November 2016, a public Commission proceeding was held in Port Hope, ON, regarding the renewal of Cameco's PHCF operating licence. The Commission renewed the licence for PHCF in March 2017 with the licence expiring 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 January 2011 and expires in December 2020.

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



CNSC staff conducted consistent and risk-informed regulatory oversight activities at Canada's uranium processing facilities in 2016. Table 2-1 presents the licensing and compliance efforts from CNSC staff for these facilities throughout 2016.

Table 2-1: CNSC regulatory oversight licensing and compliance activities, uranium processing facilities, 2016

Facility	Number of onsite inspections	Person-days for compliance	Person-days for licensing activities
Blind River Refinery	4	236	10
Port Hope Conversion Facility	4	438	672
Cameco Fuel Manufacturing Inc.	3	280	9
BWXT Toronto and Peterborough	3	223	47

In 2016, CNSC staff performed 14 onsite inspections at Canada's uranium processing facilities. All of the findings resulting from these onsite inspections were provided to the licensees in detailed inspection reports. All regulatory enforcement actions arising from the findings were recorded in the CNSC Regulatory Information Bank to ensure that they are tracked to completion. Appendix J lists the CNSC inspections conducted for each facility in 2016.

The CNSC requires each uranium processing facility licensee to submit an annual compliance report by March 31 every year (per its operating licence). These reports contain facility performance information, such as annual production volumes; improvements to programs in all safety and control areas (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 normal regulatory compliance oversight 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, provided in appendix H.

The SCA performance ratings of uranium processing facilities are presented in table 2-2. For 2016, CNSC staff rated all but one of the individual SCAs as "satisfactory" for the uranium processing facilities. The exception was BRR, which was given a "fully satisfactory" rating in the conventional health and safety SCA. Additional information about this SCA rating can be found in the facility-specific section on BRR. Appendix C contains the SCA ratings from 2012 to 2016 for each facility.

Table 2-2: Safety and control area performance ratings, uranium processing facilities, 2016

Safety and control area	Blind River Refinery	Port Hope Conversion Facility	Cameco Fuel Manufacturing	BWXT Toronto and Peterborough
Management system	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA
Physical design	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA
Conventional health and safety	FS	SA	SA	SA
Environmental protection	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA
Waste management	SA	SA	SA	SA
Security	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA

FS = fully satisfactory; SA = satisfactory

The CNSC requires each facility to develop a decommissioning plan, which is reviewed and approved by CNSC staff. Each plan is accompanied by a financial guarantee that provides the funding necessary to complete the future decommissioning work. The financial guarantees for each facility are listed in appendix D.

One area of continuous improvement for the uranium processing licensees is acquiring lessons learned from the International Atomic Energy Agency's Fuel Incident Notification and Analysis System (FINAS). The main objective of the FINAS is to provide timely feedback on safety-related events to help prevent the occurrence or reoccurrence of such incidents or accidents.

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 2016. This was unchanged from the previous year.

Ratings for the radiation protection SCA, uranium processing facilities, 2016

Blind River Refinery	Port Hope Conversion Facility	Cameco Fuel Manufacturing Inc.	BWXT Toronto and Peterborough
SA	SA	SA	SA

SA = satisfactory

Application of ALARA

Throughout 2016, all uranium processing facility licensees continued to implement radiation protection measures to keep radiation exposures and doses to persons ALARA, while taking into account social and economic factors. The CNSC requirement to apply the ALARA principle has consistently resulted in doses to persons being well below regulatory dose limits.

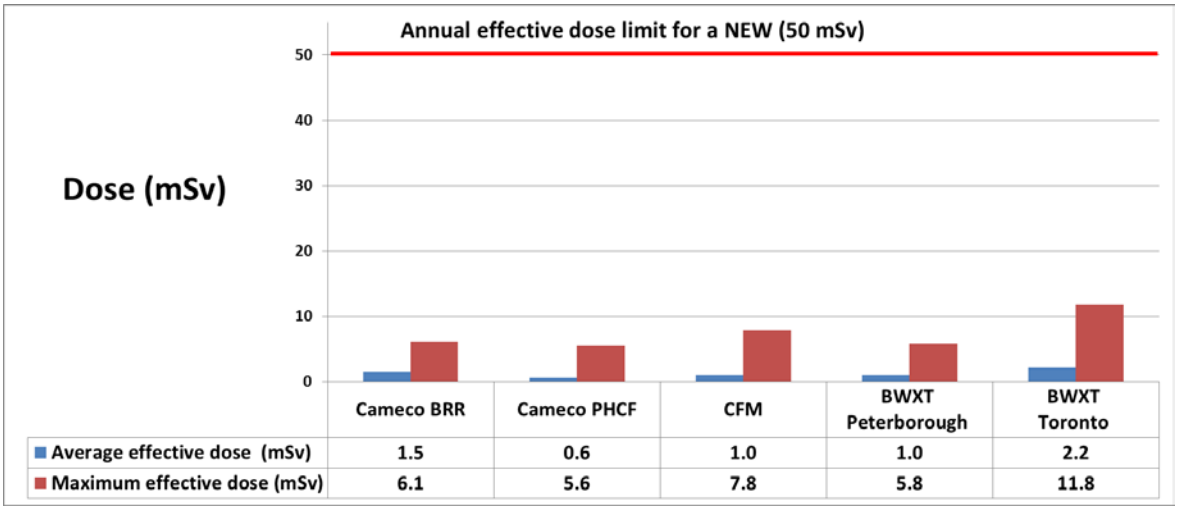
Worker dose control

The design of radiation protection programs, including the dosimetry methods and the determination of workers who are identified as nuclear energy workers (NEWs), differs depending on the radiological hazards present and the expected magnitude of doses received by workers. Radiological hazards in the uranium processing facilities vary due to the complex and differing work environments. This means that direct comparison of doses received by NEWs among facilities does not necessarily provide an appropriate measure of how effective the licensee is in implementing its radiation protection program.

During 2016, all uranium processing facility licensees monitored and controlled the radiation exposures and doses received by all persons present at their licensed facilities, including workers, contractors and visitors. 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 is provided in the facility-specific write-ups on the total number of monitored persons, including workers, contractors and visitors.

The maximum and average effective doses for NEWs at uranium processing facilities are provided in figure 2-2. In 2016, the maximum individual effective dose received by a NEW at all facilities ranged from 5.6 millisieverts (mSv) to 11.8 mSv, which is well below the regulatory dose limit of 50 mSv/year for a NEW. These results are further discussed in the respective sections for each facility.

Figure 2-2: Average and maximum effective doses to nuclear energy workers, uranium processing facilities, 2016



Radiation protection program performance

CNSC staff conducted regulatory oversight activities at all uranium processing facilities during 2016 to verify that licensees' radiation protection programs were in compliance with regulatory requirements. This regulatory oversight consisted of desktop reviews and radiation protection-specific compliance verification activities, including onsite inspections. Through these oversight activities, CNSC staff confirmed that all uranium processing facility licensees have effectively implemented their radiation protection programs to help control occupational exposures to workers.

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 program that represent timely indicators of potential losses of control of the program. As a result, action levels are licensee-specific and can change over time depending on operational and radiological conditions.

If an action level is reached, the licensee must establish the cause, notify the CNSC and, if applicable, take action to restore the effectiveness of the program. Occasional exceedances indicate that the action level chosen is likely an adequately sensitive indicator of a potential loss of control of the radiation protection program. Action levels that are never exceeded may not be sensitive enough to detect a potential loss of control. For this reason, licensee performance is not judged solely on the number of action level exceedances in a given period but rather on how the licensee responds and identifies corrective actions to enhance program performance and prevent reoccurrence.

In 2016, there was one radiological action level exceedance across all uranium processing facility licensees. This exceedance occurred at the BWXT Toronto facility and is further discussed in section 6.2. BWXT reported the action level exceedance to the CNSC, performed an investigation and established corrective actions to the satisfaction of CNSC staff.

Radiological hazard control

CNSC staff verified that, in 2016, all uranium processing facility licensees continued to implement adequate measures to monitor and control radiological hazards in their facilities. These measures include delineation of zones for contamination control purposes and, for certain facilities, in-plant air-monitoring systems. All uranium processing facility licensees continued to implement their workplace monitoring programs to protect workers. They also demonstrated that, in 2016, levels of radioactive contamination were controlled within their facilities.

Estimated dose to the public

The maximum dose to the public from licensed activities at each uranium processing facility is calculated using monitoring results from air emissions, liquid effluent releases and fence-line gamma monitoring. The CNSC's requirements to apply ALARA principles ensure 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 2012 to 2016 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, 2012–16

Facility	Year					Regulatory limit
	2012	2013	2014	2015	2016	
Blind River Refinery	0.012	0.012	0.005	0.005	0.005	**1 mSv/year**
Port Hope Conversion Facility	0.029	0.021	0.012	0.006	0.020	
Cameco Fuel Manufacturing	0.031	0.013	0.018	0.025	0.023	
BWXT Toronto	0.0011	0.0006	*0.0055	0.010	0.0007	
BWXT Peterborough	<0.001	<0.001	<0.001	<0.001	<0.001	

mSv = millisievert
*Beginning in 2014, BWXT Toronto (then GE Hitachi Nuclear Energy Canada Inc.) implemented environmental gamma-exposure monitoring using licensed dosimeters and began to include this result in its estimated annual public dose.

Conclusion on radiation protection

CNSC staff concluded that, throughout 2016, 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, 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 of the uranium processing facilities for the environmental protection SCA as "satisfactory" in 2016, unchanged from the previous year.

Ratings for the environmental protection SCA, uranium processing facilities, 2016

Blind River Refinery	Port Hope Conversion Facility	Cameco Fuel Manufacturing Inc.	BWXT Toronto and Peterborough
SA	SA	SA	SA

SA = satisfactory

Effluent and emissions control (releases)

To protect the environment, the CNSC imposes release limits on radioactive and hazardous substances at licensee facilities. Controls on environmental releases are also established to provide further protection to the environment. To provide assurance that facility release limits will not be exceeded, licensees set action levels to allow for early indication of a potential loss of control of part of the environmental protection program. Action levels are facility-specific and are used to ensure that licensees demonstrate adequate control of their facility based on their approved facility design and environmental protection programs. Through compliance verification activities in 2016, CNSC staff confirmed that releases from the uranium processing facilities were within their licensed limits.

In 2016, there was one environmental action level exceedance across all uranium processing facility licensees. This exceedance occurred at the CFM facility and is further discussed in section 5.3. Cameco reported the action level exceedance to the CNSC, performed an investigation and established corrective actions to the satisfaction of CNSC staff.

Environmental management system

The CNSC requires licensees to develop and maintain an environmental management system (EMS) that provides a framework for integrated activities related to environmental protection. The details of each licensee's EMS are described in their approved environmental management programs and include activities such as establishing annual environmental objectives and targets. Licensees conduct internal audits of their programs at least once per year. CNSC staff, as part of their compliance verification activities, review and assess these objectives, goals and targets. CNSC staff determined that, in 2016, the uranium processing facility licensees established and implemented an EMS in compliance with CNSC regulatory requirements.

Assessment and monitoring

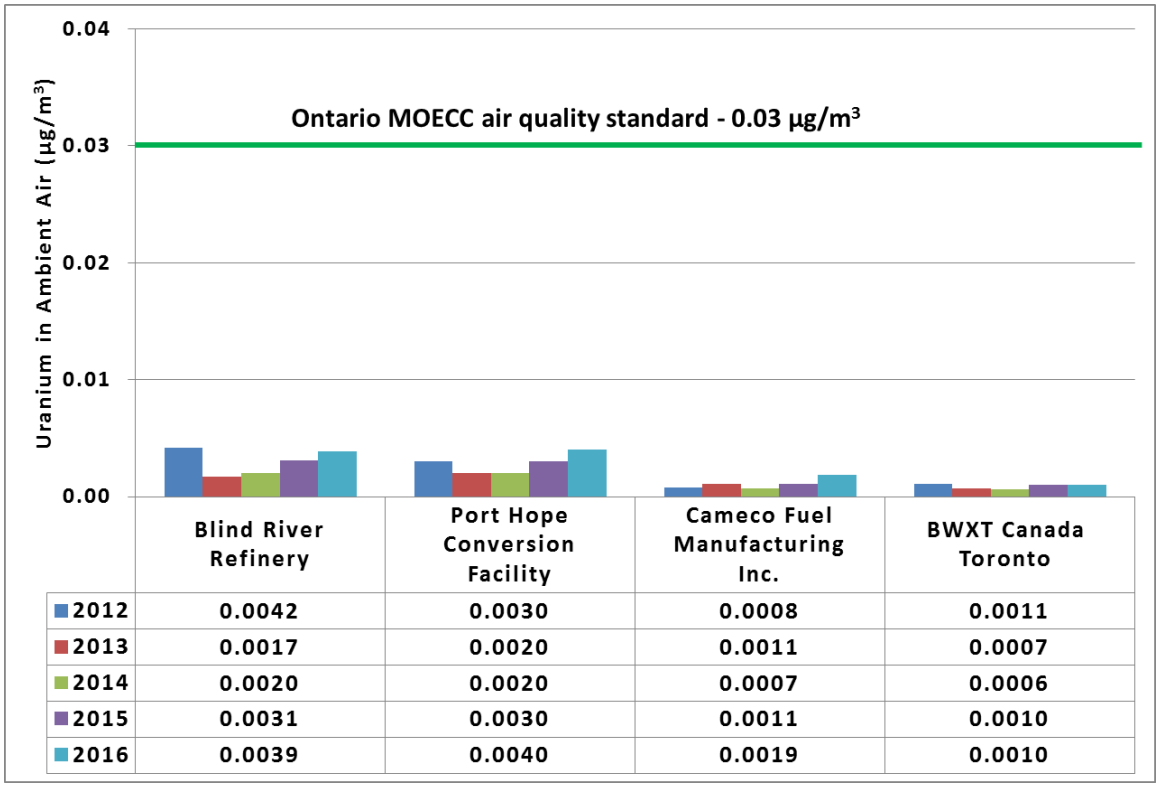
Each uranium processing facility licensee has environmental monitoring programs to monitor releases of radiological and hazardous substances, and to characterize the quality of the environment associated with the licensed facility. These programs include the monitoring of uranium in ambient air and uranium 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. All three Cameco facilities and BWXT Toronto operate high-volume air samplers at the perimeter of their facilities. As stack emissions at the point of release already meet the Ontario Ministry of the Environment and Climate Change (MOECC) air standard for uranium (0.03 µg/m^3) at BWXT Peterborough, it does not use fence-line air samplers.

The results from the high-volume air samplers with the highest values near a facility (maximum annual average) for 2012 through 2016 are provided in figure 2-3. These values are measured as total suspended particulate representing the total amount of uranium in the air. As shown in figure 2-3, the maximum annual average concentration of uranium in ambient air is well below the newest MOECC air standard for uranium, which took effect in 2016.

Figure 2-3: Uranium concentration in ambient air (maximum annual average), uranium processing facilities, 2012–16



	Blind River Refinery	Port Hope Conversion Facility	Cameco Fuel Manufacturing Inc.	BWXT Canada Toronto
2012	0.0042	0.0030	0.0008	0.0011
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

Uranium in soil

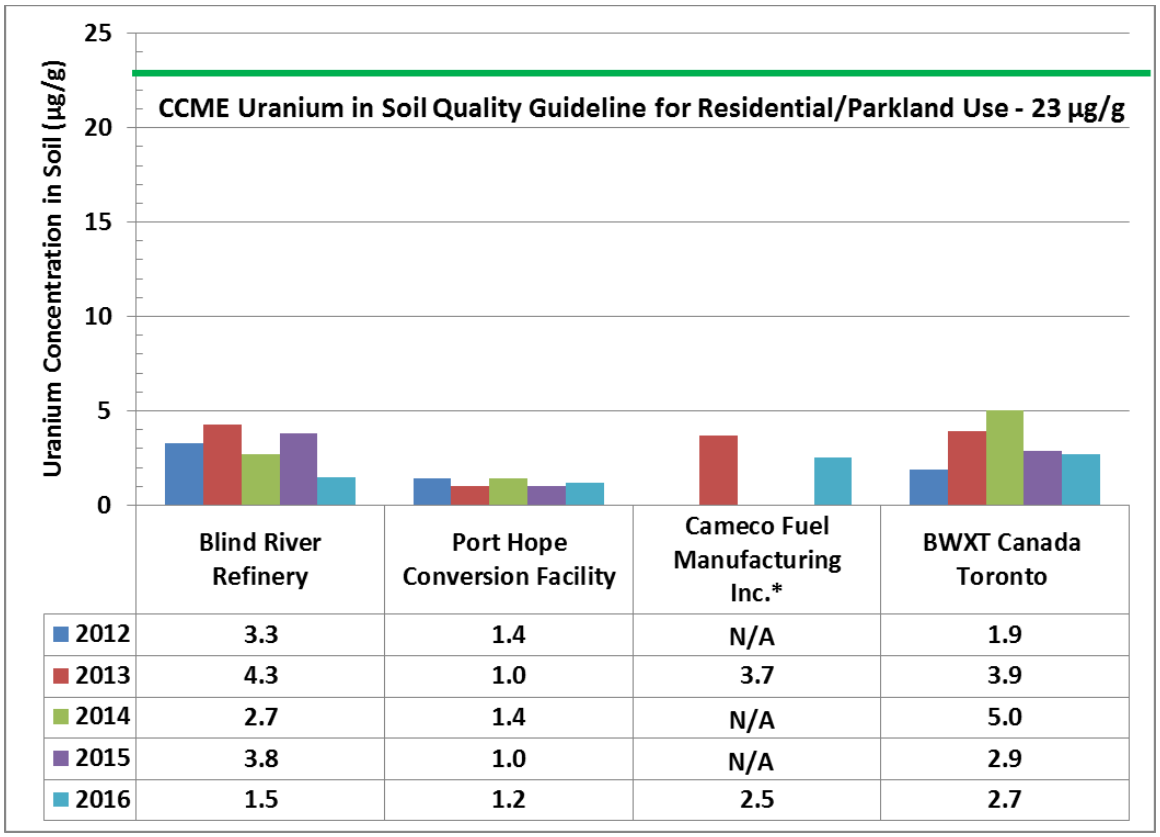
All three Cameco facilities and BWXT Toronto have soil monitoring programs that monitor the long-term effects of air emissions to determine whether there is accumulation of uranium in the soil surrounding the facility. The sampling frequency at CFM is every three years and annually at the other facilities.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

BWXT Peterborough does not conduct uranium-in-soil monitoring because uranium releases from that facility are negligible, given that the fuel pellets received from the Toronto facility are in solid form, leading to very low uranium releases to air. BWXT monitors the stack to confirm that releases to air remain low.

CNSC staff evaluated the results of licensees' soil sampling programs for 2016 and compared them with previous years. The results continue to indicate that there is no accumulation of uranium in the facilities' 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 2012 through 2016. In Ontario, natural background concentrations of uranium in soil are generally below 2.5 µg/g. The annual average concentrations of uranium in soil at uranium processing facilities are similar to natural background levels. They are also well below the applicable guideline value (23 µg/g) as described by the Canadian Council of Ministers of the Environment (CCME) soil quality guideline for residential and parkland land use.

Figure 2-4: Uranium concentration in soil (annual average), uranium processing facilities, 2012–16



	Blind River Refinery	Port Hope Conversion Facility	Cameco Fuel Manufacturing Inc.*	BWXT Canada Toronto
2012	3.3	1.4	N/A	1.9
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

* N/A indicates that a value is not available because 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 licence conditions handbook (LCH).

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

Environmental risk assessment

Environmental risk assessments are used to analyze the risks associated with contaminants in the environment as a result of licensed activities. These assessments provide the basis for the scope and complexity of the uranium processing facilities' environmental monitoring programs. The licensees currently have acceptable 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 N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3], to ensure that they design, implement and manage their environmental risk assessment programs in a way that aligns with the best practices used in Canada and internationally. Work is underway to transition the uranium processing facilities to CSA N288.6-12. CNSC staff expect that all licensees will fully implement CSA N288.6-12 by the end of 2017. CNSC staff will continue to review the licensees' respective documentation to address the compliance requirements of the new standard.

Conclusion on environmental protection

CNSC staff concluded that the uranium processing facility licensees implemented their environmental protection programs satisfactorily during 2016. The licensees' programs are effective in protecting the health and safety of both 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 of all but one of the uranium processing facilities for the conventional health and safety SCA as "satisfactory" in 2016. 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, 2016

Blind River Refinery	Port Hope Conversion Facility	Cameco Fuel Manufacturing Inc.	BWXT Toronto and Peterborough
FS	SA	SA	SA

FS = fully satisfactory; SA = satisfactory

Performance

The regulation of conventional health and safety at uranium processing facilities involves both Employment and Social Development Canada (ESDC) and the CNSC. 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 must include serious illnesses and injuries incurred or possibly incurred as a result of licensed activity. The number of recordable lost-time injuries 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 appendix G.

Table 2-4: Lost-time injuries, uranium processing facilities, 2012–16

Facility	2012	2013	2014	2015	2016
Blind River Refinery	0	0	0	0	0
Port Hope Conversion Facility	1	0	1	2	3
Cameco Fuel Manufacturing Inc.	0	0	0	1	0
BWXT Toronto and Peterborough	1	0	1	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 2016 to verify that the licensees' conventional health and safety programs were in compliance with regulatory requirements. Through these regulatory oversight activities, CNSC staff determined that the uranium processing facility licensees met all regulatory requirements for this specific area.

Awareness

Licensees are responsible for ensuring that workers are able 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.

By conducting onsite inspections, CNSC staff were able to verify that workers at all of the facilities are trained to identify hazards. 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 2016. Their programs are effective in protecting the health and safety of persons working in the facilities.

2.4 Public information and disclosure programs

Uranium processing facility licensees are required to maintain and implement public information and disclosure programs per RD/GD-99.3, *Public Information and Disclosure* [6]. These programs are supported by disclosure protocols that outline what types of facility information and activities must be shared with the public (e.g., incidents, major changes to operations, periodic environmental performance reports), as well as how that information will be shared. This ensures that timely information is effectively communicated about the health, safety and security of people and the environment, and about other issues associated with the lifecycle of the nuclear facilities.

In 2016, CNSC staff evaluated licensees' implementation of their public information and disclosure programs, and determined that all licensees were in compliance with RD/GD-99.3. CNSC staff reviewed the communications activities during this period and noted that licensees used a variety of methods to share information with the public, including public information sessions, facility tours, participation in community events, regular updates to elected officials, newsletters, and ongoing website and social media updates.

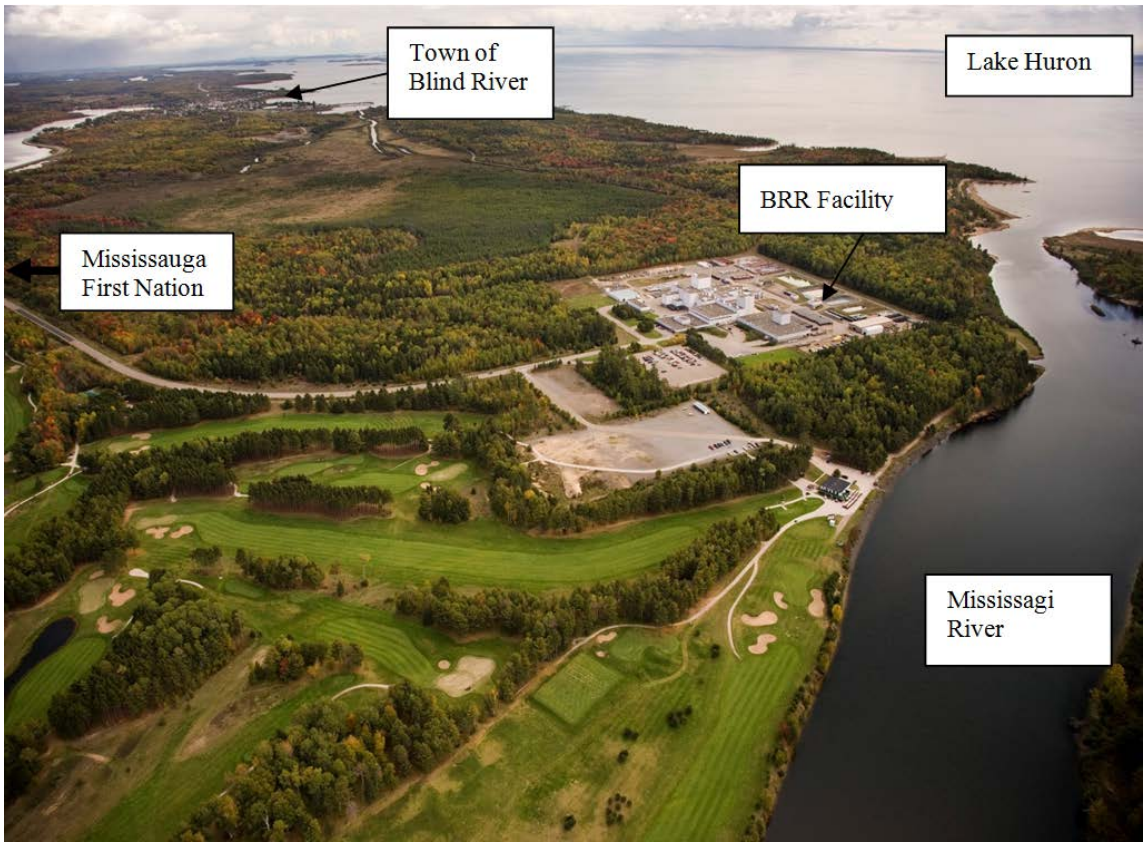
Licensees also issued information in accordance with their public disclosure protocols. Licensees' followed their public disclosure protocols to disclose information and reports of interest to the public, including routine and non-routine situations, events and activities. In 2016, Cameco posted event reports and information on the licence renewal for PHCF on its website. BWXT posted event reports on its website, as well as information on its acquisition of GE-Hitachi Nuclear Energy Canada Inc. In addition, all licensees publish their annual compliance reports on their websites.

CNSC staff concluded that in 2016 the uranium processing facility licensees implemented their public information and disclosure programs satisfactorily. Their programs are effective at communicating information about the health, safety and security of people and the environment, and other issues associated with the facilities.

3 Cameco Blind River Refinery

Cameco Corporation owns and operates the Blind River Refinery (BRR) in Blind River, Ontario, under an operating licence that expires in February 2022. BRR is located about 5 kilometres west of the town of Blind River, as shown in figure 3-1. The Mississauga First Nation (MFN) is the closest community to BRR, located approximately one kilometre from the facility.

Figure 3-1: Aerial view of the Blind River Refinery



BRR 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 Port Hope Conversion Facility (PHCF). Figure 3-2 shows shipping totes that are used to transfer UO_3 from BRR to PHCF.

Figure 3-2: Shipping totes used to transfer uranium trioxide from the Blind River Refinery to the Port Hope Conversion Facility

3.1 Performance

For 2016, CNSC staff rated BRR's performance as "satisfactory" in all but one of the safety and control areas (SCAs). The exception was conventional health and safety, which was rated as "fully satisfactory". The performance ratings for BRR from 2012 to 2016 are provided in table C-1 of appendix C.

Cameco continued to operate BRR safely throughout 2016. 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 its licensing basis.

Cameco completed the implementation of REGDOC-2.12.3, *Security of Nuclear Substances: Sealed Sources* [7], in 2016. CNSC staff conducted an inspection in June 2017 to verify compliance with REGDOC-2.12.3.

BRR experienced five events that were reported to CNSC staff in 2016, in accordance with Cameco's regulatory reporting requirements. Four of the five events were related to transport, while the fifth was a worker injury requiring medical treatment that did not result in lost time. Three of the transport events were minor traffic accidents where there was no personal injury or damage to the packages being transported.

The fourth transport-related event pertained to a traffic accident in Saskatchewan, where a vehicle transporting uranium concentrates, originating from Heathgate Resources PTY Ltd. in Australia, drifted onto the shoulder of the road and was then overturned. No other vehicle was involved in the accident. CNSC staff reported the incident to the Commission on January 28, 2016, as an event initial report (EIR) in Commission member document (CMD) 16-M8. On April 6, 2017, CNSC staff updated the Commission on the actions taken by Cameco and CNSC staff in response to this incident. CNSC staff concluded that the event had no radiological impact on the health and safety of workers, the public or the environment.

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

In 2016, CNSC staff conducted four onsite inspections at BRR to ensure compliance with the *Nuclear Safety and Control Act* (NSCA) [1] and its regulations, Cameco's operating licence and the programs used to meet regulatory requirements. A list of these inspections can be found in table J-1 in appendix J. The inspections focused on the following SCAs: management system, emergency management and fire protection, radiation protection, environmental protection, conventional health and safety, and security. Sixteen enforcement actions were raised as a result of the inspections. The findings from these inspections posed a low risk to the achievement of regulatory objectives and CNSC expectations.

3.2 Radiation protection

Overall compliance ratings for the radiation protection SCA, Blind River Refinery, 2012–16

2012	2013	2014	2015	2016
SA	SA	SA	SA	SA
For 2016, CNSC staff continued to rate the radiation protection SCA at BRR as "satisfactory". Cameco has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations* [2].				

SA = satisfactory

Application of ALARA

In 2016, Cameco established radiation protection objectives and targets for BRR that focused on initiatives to reduce worker dose and airborne uranium concentrations. Cameco's objectives included improvements to the respiratory protection program and implementation of additional continuous air monitors in work areas. Cameco's site management team reviewed the status of the objectives and targets and allocated resources, as required, to achieve them. Cameco also continued to use an ALARA Committee that makes recommendations for improving radiation protection at BRR.

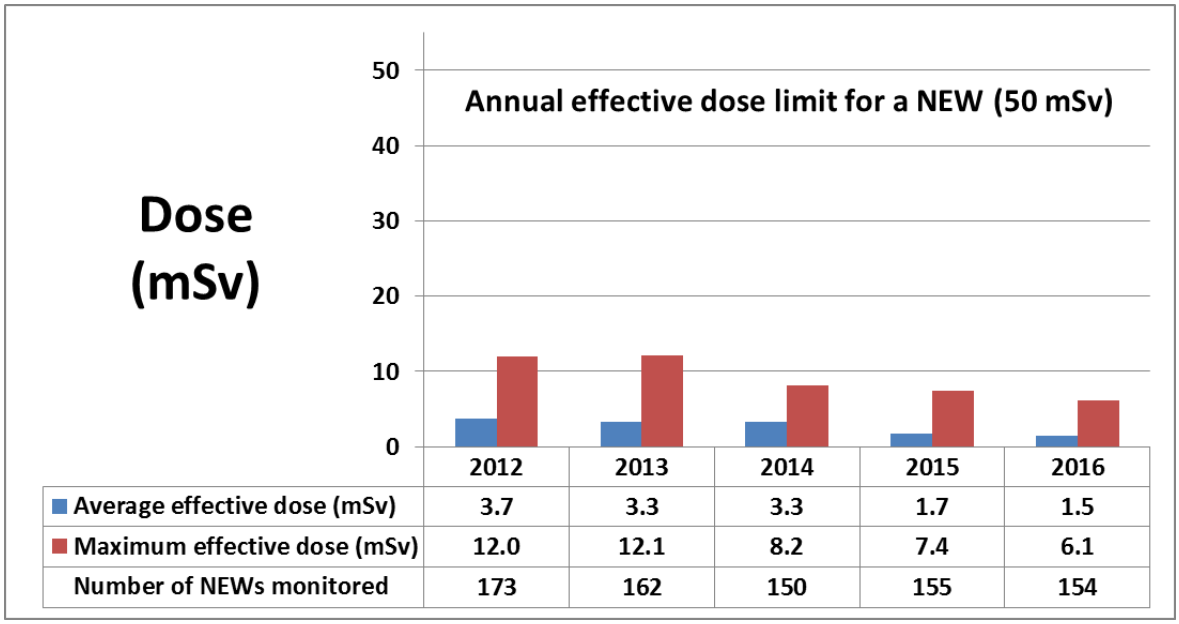
Worker dose control

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

All Cameco employees at BRR are identified as nuclear energy workers (NEWs). BRR contractors may also be identified as NEWs, if the nature of their work activities and time spent onsite present a reasonable probability of them receiving an occupational dose greater than 1 millisievert (mSv) per year. In 2016, total effective dose was assessed for 154 NEWs at BRR, consisting of 138 Cameco employees and 16 contractors. The maximum effective dose received by a NEW in 2016 was 6.1 mSv, which is approximately 12% of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period.

Figure 3-3 provides the average and maximum effective doses to NEWs at BRR between 2012 and 2016.

Figure 3-3: Average and maximum effective doses to nuclear energy workers, Blind River Refinery, 2012–16



	2012	2013	2014	2015	2016
Average effective dose (mSv)	3.7	3.3	3.3	1.7	1.5
Maximum effective dose (mSv)	12.0	12.1	8.2	7.4	6.1
Number of NEWs monitored	173	162	150	155	154

Average and maximum effective doses at BRR show a decreasing trend, likely due to the decrease in UO_3 production over these years.

Annual average and maximum equivalent (skin) and equivalent (extremity) dose results from 2012 to 2016 are provided in tables E-7 and E-1 in appendix E. In 2016, the maximum skin dose received by a NEW at BRR was 26 mSv, which is approximately 5% of the regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. The maximum extremity dose received by a NEW at BRR was 10.6 mSv, which is approximately 2% of the regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. The average and maximum equivalent doses at BRR were relatively stable between 2012 and 2014, and thereafter show a decreasing trend, again likely due to the decrease in UO_3 production over these years.

Site visitors and contractors considered non-NEWs may be issued dosimeters. In 2016, the maximum individual effective dose received by a monitored non-NEW was 0.1 mSv and the average dose to monitored non-NEWs was less than 0.1 mSv; both results are well below the annual regulatory dose limit of 1 mSv for a member of the public.

Radiation protection program performance

In 2016, CNSC staff assessed the performance of the BRR radiation protection program through various CNSC staff compliance activities, which included a focused inspection on radiation protection. Overall, Cameco's compliance with the *Radiation Protection Regulations* [2] and CNSC licence requirements at BRR was found to be acceptable. Cameco established corrective actions to address CNSC staff's findings and areas requiring improvement. Cameco's corrective actions included updating and documenting practices and procedures supporting the radiation protection program, as well as improving the posting of radiation warning signage in radiation areas and the labelling of radiation devices. CNSC staff evaluated Cameco's corrective actions and are satisfied that Cameco adequately addressed CNSC staff's findings.

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 2016, there were no instances at BRR where an action level was reached.

Radiological hazard control

Cameco has radiation and contamination control programs at BRR to control and minimize radiological hazards and the spread of radioactive contamination. Methods of control include radiological zone controls and monitoring to confirm the effectiveness of the program. Cameco staff at BRR conducted in-plant air monitoring, contamination monitoring and radiation dose rate surveys in 2016, and did not identify any adverse trends. CNSC staff are satisfied with Cameco's radiological hazard control.

Estimated dose to the public

The maximum dose to the public from licensed activities at BRR is calculated using monitoring results. The 2012 to 2016 maximum effective doses to a member of the public are shown in table 3-1. Dose to the public remains well below the regulatory dose limit of 1 mSv/year.

Table 3-1: Maximum effective dose to a member of the public, Blind River Refinery, 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory dose limit
Maximum effective dose (mSv)	0.012	0.012	0.005	0.005	0.005	**1 mSv/year**

mSv = millisievert

3.3 Environmental protection

Overall compliance ratings for the environmental protection SCA, Blind River Refinery, 2012–16

2012	2013	2014	2015	2016
SA	SA	SA	SA	SA
For 2016, CNSC staff rated the "environmental protection" SCA at Cameco's BRR 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 Ontario Ministry of the Environment and Climate Change's (MOECC) applicable regulations and certificates of approval. The measured releases to the environment were well below regulatory limits in 2016. 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)

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 staff to effectively develop, implement and maintain their environmental protection programs.

Atmospheric emissions

Cameco monitors uranium, nitrogen oxides, nitric acid 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 were consistently well below their respective licence limits between 2012 and 2016.

Table 3-2: Blind River Refinery, air emissions monitoring results (annual averages), 2012–16

Parameter	2012	2013	2014	2015	2016	Licence limit
Dust collection and exhaust ventilation stack: uranium (kg/h)	0.00006	0.00004	0.00005	0.00005	0.00005	**0.1**
Absorber stack: uranium (kg/h)	0.00001	<0.00001	<0.00001	0.00001	0.00001	**0.1**
Incinerator stack: uranium (kg/h)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	**0.01**
NO_X + HNO_3 (kg NO_2/h)	3.3	3.4	2.0	2.5	1.6	**56.0**
Particulate (kg/h)	0.024	0.014	0.009	0.006	0.006	**11.0**

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

In addition to licence limits, BRR has action levels that are used to provide assurance that licence release limits will not be exceeded. 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 for atmospheric emissions were exceeded at any time in 2016.

Liquid effluent

There are three sources of allowable liquid effluent from the BRR facility: plant effluent, storm water runoff and sewage treatment plant effluent. These effluents are collected in lagoons and treated, as required, prior to discharge into Lake Huron. Cameco monitors uranium, radium-226, nitrates and pH in liquid effluents to demonstrate compliance with their respective licensed limits. The average monitoring results from 2012 to 2016 are summarized in table 3-3. For 2016, the liquid discharges from the facility continued to be below their respective licensed limits.

Table 3-3: Blind River Refinery, liquid effluent monitoring results (annual averages), 2012–16

Parameter	2012	2013	2014	2015	2016	Licence limit
Uranium (mg/L)	0.01	0.01	0.02	0.02	0.01	**20**
Nitrates (mg/L)	28	26	17	13	11	**1,000**
Radium-226 (Bq/L)	<0.01	0.01	0.01	<0.01	0.01	**11**
pH (min)	7.2	7.1	7.1	7.2	7.3	**Min 6.0**
pH (max)	8.2	8.4	8.4	8.4	8.6	**Max 9.5**

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

In addition to licence limits, BRR has action levels that are used to provide assurance that the licence release limits will not be exceeded. No action levels for liquid effluents were exceeded at any time in 2016.

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 BRR is described in the facility's Environmental Management Program Manual. It includes activities such as establishing annual environmental objectives and targets that are reviewed and assessed by CNSC staff through compliance verification activities. Cameco completed five out of six of its environmental objectives set for 2016. These completed objectives are related to liquid effluent discharge volume reduction, shredded drum disposal, an update of site EMS documentation, floor sump evaluation and an absorbent materials assessment. The sixth objective was carried over to 2017 and is related to the identification and implementation of a suitable shielding replacement for shredded drums.

Cameco 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 Cameco staff at BRR on any outstanding issues. The results of these compliance verification activities demonstrate that Cameco conducted an annual management review in accordance with CNSC requirements and that identified issues are being addressed properly. CNSC staff are satisfied that Cameco is conducting effective reviews and addressing identified issues properly.

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 dose limit of 1 mSv and is ALARA. The principal monitoring activities, described below, are focused on monitoring the air, groundwater, surface water, soil, and gamma radiation around the BRR site.

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

Uranium in ambient air

The concentrations of uranium in the ambient air as monitored by Cameco's sampling network around the facility continue to be consistently low. In 2016, the highest annual average concentration (among the sampling stations) of uranium in ambient air measured was 0.0039 $\mu g/m^3$, which is well below the MOECC standard for uranium in ambient air of 0.03 $\mu g/m^3$.

Groundwater monitoring

A total of 43 monitoring wells exist in and around the BRR site: 17 wells located inside the perimeter fence and 26 wells outside it.

Based on the groundwater sampling data presented in Cameco's annual compliance reports, BRR operations are not causing any adverse impact to groundwater quality. The average uranium concentration in groundwater decreased in 2016 when compared with 2015 data. The maximum sampled uranium concentration in the groundwater was 14.0 µg/L in 2016, which is below the maximum acceptable concentration of 20 µg/L in Health Canada's *Guidelines for Canadian Drinking Water Quality*. Although the groundwater in the area is not used for drinking water, CNSC staff encourage the licensee to apply the ALARA principle, where technology is available, to eliminate offsite impacts as much as possible. Groundwater monitoring results are provided 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 BRR's outfall diffuser in Lake Huron. The concentration of uranium in the lake remains well below published federal guidelines. Surface water monitoring results are provided in table F-2 of appendix F.

Soil monitoring

Cameco collects soil samples on an annual basis to monitor uranium concentrations in an upper layer (15 cm) of surface soil to demonstrate that there are no long-term effects of air emissions on soil quality due to deposition of airborne uranium on soil in the vicinity of the BRR facility. The 2016 soil monitoring results remained consistent with the respective concentrations detected in previous years (as seen in table F-3, appendix F). The maximum uranium soil concentrations measured near the facility continued to be slightly above Ontario's natural background level of 2.5 µg/g, in the range of natural background level at both the MFN and Blind River communities, and well below 23 µg/g, which is the most restrictive soil quality guideline for uranium (for residential and parkland land use) set by the Canadian Council of Ministers of the Environment. Uranium soil concentrations do not appear to increase in the area surrounding the facility. These data demonstrate that current BRR operations do not contribute to accumulation of uranium in surrounding soil, and that no adverse consequences to relevant human and environmental receptors are expected.

Gamma monitoring

A significant portion of radiological public dose in Blind River attributable to BRR operations is due to gamma radiation sources. Consequently, monitoring gamma radiation effective dose rates at the fenceline of the BRR main site and the nearby golf course (a critical receptor location) is essential to ensuring that levels of potential gamma radiation exposure are safe and maintained ALARA. The land immediately outside the perimeter fence continues to be owned and controlled by Cameco. Therefore, Cameco sets an action level for gamma dose rates of 1.0 µSv/h at the north fence only, because the critical receptor location for the gamma component of dose to the public is the neighbouring golf course north of the BRR site. The effective dose rates for gamma radiation are measured using environmental dosimeters. In 2016, the monthly average of fenceline gamma measurements at BRR were 0.49 µSv/h (east), 0.30 µSv/h (north), 0.55 µSv/h (south) and 1.69 µSv/h (west). All north fence results in 2016 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 and 2014. 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 and safe.

Since 2014, CNSC staff and the MFN have been holding regular meetings to discuss Cameco's licensing and compliance activities for BRR. 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 staff and the MFN 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. A sampling plan that is representative of both parties' needs was subsequently developed. The CNSC's Participant Funding Program provided financial support to the MFN for all of these meetings.

While this regulatory oversight report was in production, another IEMP campaign took place in October 2017 and included the sampling plan developed with the MFN. A subsequent campaign is scheduled for 2019.

Protection of the public

The licensee is required to demonstrate that adequate provisions are made for protecting the health and safety of the public from exposures to hazardous (non-radiological) substances released from the facility. The effluent and environmental monitoring programs currently conducted by the licensee are used to verify that releases of hazardous substances do not result in environmental concentrations that may affect public health.

The CNSC receives reports of discharges to the environment through the reporting requirements outlined in the BRR licence and licence conditions handbook. CNSC staff's review of hazardous discharges from BRR to the environment in 2016 indicates that no significant risks to the public or environment occurred during this period.

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

Environmental risk assessment

Cameco currently has acceptable environmental programs in place to ensure the protection of the public and the environment. Cameco indicated that, by the end of 2017, it would implement the three environmental protection standards: CSA N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [8]; CSA N288.5-11, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* [9]; and CSA N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3].

Cameco submitted the BRR environmental risk assessment to the CNSC at the end of 2016. CNSC staff have reviewed Cameco's responses and conclude that

the current version of the ERA for BRR is in compliance with CSA standard N288.6-12, and that the ERA conclusions are generally valid. CNSC staff expect Cameco to address several technical issues prior to or in the next iteration of the ERA, as appropriate, to improve the quality of the ERA.

3.4 Conventional health and safety

Overall compliance ratings for the conventional health and safety SCA, Blind River Refinery, 2012–16

2012	2013	2014	2015	2016
SA	FS	FS	FS	FS
For 2016, CNSC staff continued to rate the conventional health and safety SCA at BRR as "fully satisfactory". Overall, the compliance verification activities conducted by CNSC staff at BRR confirmed that Cameco continues to view conventional health and safety as an important consideration. Cameco has implemented an effective occupational health and safety management program, which has helped to keep its workers safe from occupational injuries: no lost-time injuries (LTIs) have occurred at the facility for more than 10 years.				

FS = fully satisfactory; SA = satisfactory

Performance

Cameco's performance related to conventional health and safety at BRR is monitored by CNSC staff using onsite inspections and event reviews. Cameco continues to develop and maintain a comprehensive conventional health and safety management program for BRR. 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 the conventional health and safety SCA is the number of LTIs that occur per year. An LTI is an injury that takes place at work and results in the worker being unable to return to work and carry out their duties for a period of time. Per table 3-4, the number of LTIs remained at zero in 2016. Cameco has not had an LTI at BRR in the past 10 years.

Table 3-4: Lost-time injuries, Blind River Refinery, 2012–16

	2012	2013	2014	2015	2016
Lost-time injuries	0	0	0	0	0

Cameco also met its 2016 internal targets and objectives related to conventional health and safety at BRR. In recognition of Cameco's effective implementation of its conventional health and safety program at BRR, CNSC staff continued to rate

Cameco's overall performance for the conventional health and safety SCA at BRR as "fully satisfactory".

Practices

Cameco's activities and operations at BRR must comply with not only the NSCA [1] and its associated regulations, but also with Part II of the *Canada Labour Code* [5]. Cameco's commitment to safety is captured in a safety charter signed by each employee and displayed at the entrance of the facility. Cameco uses audits, inspections, evaluations, reviews, benchmarking, training and employee engagement to evaluate the effectiveness of conventional health and safety practices at BRR.

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 BRR 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 BRR 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 which it held a "safety stand-down" for the workers upon return to work after the summer and Christmas shutdown periods.

4 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 kilometres east of Toronto. Aerial photographs of the two PHCF sites are shown in figure 4-1 and figure 4-2.

Figure 4-1: Aerial view of Site 1 of the Port Hope Conversion Facility

Figure 4-2: Aerial view of Site 2 of the Port Hope Conversion Facility

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

In 2015, Cameco submitted an application to renew its operating licence for PHCF. The licence renewal hearing was held from November 9 to 10, 2016, in Port Hope. The Commission subsequently announced its decision to renew Cameco's operating licence for a 10-year period. It will expire on February 28, 2027.

4.1 Performance

For 2016, CNSC staff continued to rate PHCF's performance as "satisfactory" in all safety and control areas (SCAs). The performance ratings for PHCF from 2012 to 2016 are provided in table C-2 of appendix C.

In 2016, Cameco ensured that the PHCF site was maintained according to the PHCF's licensing basis. During the summer of 2016, the UO_2 and UF_6 plants underwent scheduled shutdowns to allow for planned maintenance activities.

Vision in Motion (VIM) is the name of Cameco's project to clean up and renew PHCF. The project is being carried out under Cameco's operating licence for the facility. In 2016, Cameco carried out work to further prepare conditions for full cleanup and remediation expected to start in 2018. Cameco also completed the demolition of building 42 on the centre pier, which was no longer in use.

Cameco completed the implementation of REGDOC-2.2.2, *Personnel Training* [10], in 2016. CNSC staff scheduled an inspection for November 2017 to verify compliance with REGDOC-2.2.2.

Cameco experienced 11 events at PCHF that were reported to CNSC staff in 2016. Cameco reported these events in accordance with its regulatory reporting requirements. Of the 11 events, three were lost-time injury (LTI) notifications. These are further discussed in section 4.4. In April 2016, CNSC staff provided a verbal update to the Commission on another event, a nitric acid spill at PCHF. In August 2016, CNSC staff provided additional information regarding this event in a memo to the Commission. For each event, Cameco completed an investigation and established corrective actions to the satisfaction of CNSC staff. CNSC staff concluded that none of the events compromised the health and safety of persons or the environment.

In 2016, CNSC staff conducted four onsite inspections at PHCF to verify compliance with the *Nuclear Safety and Control Act* (NSCA) [1], its regulations, Cameco's operating licence and the programs used to meet regulatory requirements. A list of these inspections can be found in table J-2 of appendix J. These planned onsite inspections focused on the following SCAs: radiation protection, environmental protection, emergency management and fire protection, and security. Nineteen enforcement actions were raised as a result of the inspections. The findings were of low safety significance and did not affect the

health and safety of workers, the public or the environment, or the safe operation of the facility. CNSC staff concluded that the findings from these inspections posed a low risk to the achievement of regulatory objectives and CNSC expectations.

While this regulatory oversight report was in production, a CNSC designated officer issued an administrative monetary penalty to Cameco for events at PHCF that occurred in 2017. This does not change CNSC staff's findings for 2016.

4.2 Radiation protection

Overall compliance ratings for the radiation protection SCA, Port Hope Conversion Facility, 2012–16

2012	2013	2014	2015	2016
SA	SA	SA	SA	SA
For 2016, 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].				

SA = satisfactory

Application of ALARA

In 2016, Cameco established radiation protection objectives and ALARA targets for PHCF that focused on initiatives to reduce worker dose and airborne uranium concentrations. Key performance indicators to track radiation protection program performance were also used for parameters such as radiation dose, training and contamination monitoring. Cameco also used a "top five" approach in order to regularly follow up on the five workers with the highest year-to-date doses in each dose component – an approach that was effective in helping to achieve Cameco's annual ALARA targets. A radiation protection subcommittee of the Conversion Safety Steering Committee also provided support for radiation protection improvement initiatives at PHCF.

Worker dose control

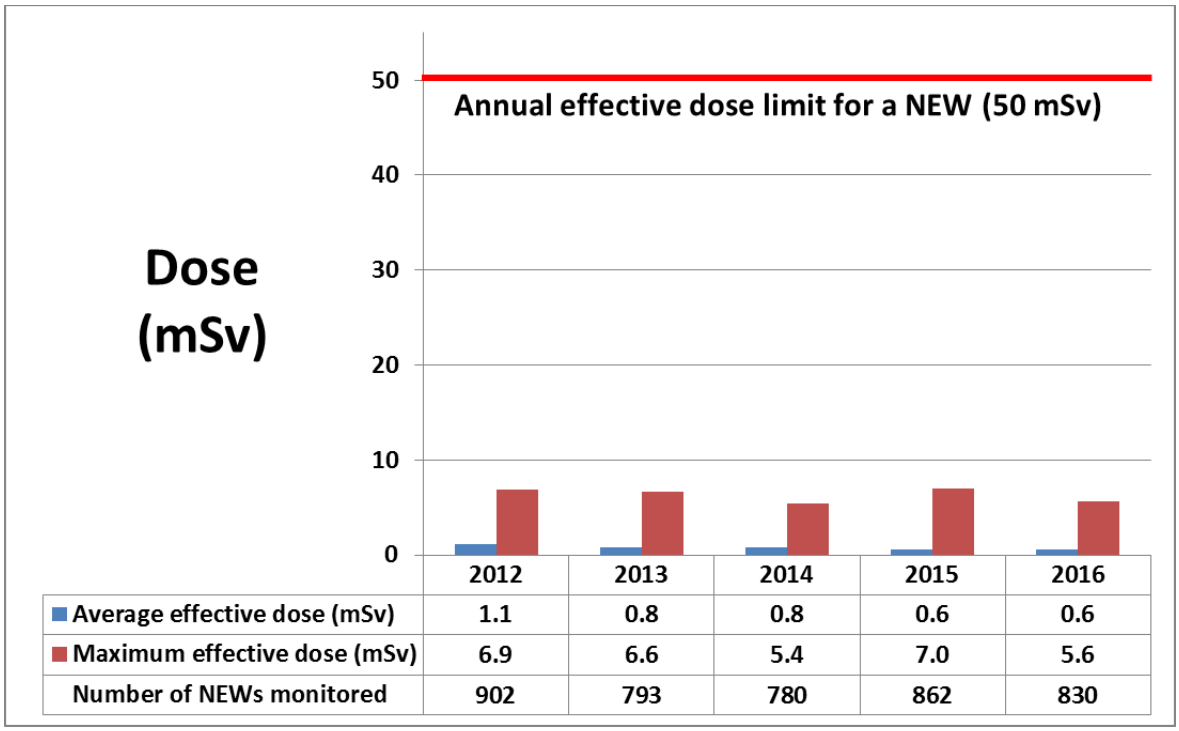
Radiation exposures at PHCF are monitored to ensure compliance with regulatory dose limits and with keeping radiation doses ALARA. In 2016, radiation exposures at PHCF, as reported by Cameco, were well below regulatory dose limits.

Cameco ascertains external doses using whole-body dosimetry. In 2016, Cameco did not use extremity dosimetry, which is used on a case-by-case basis dependent on the work activities being carried out. 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 PHCF. Internal dose is assessed and assigned at PHCF through two programs: urinalysis and lung counting.

Workers (including contractors) conducting work activities that present a reasonable probability of receiving an annual occupational dose greater than 1 millisievert (mSv) are identified as nuclear energy workers (NEWs) at PHCF. In 2016, total effective dose was assessed for 830 NEWs (433 employees and 397 contractors) at PHCF. The maximum effective dose received by a NEW in 2016 was 5.6 mSv, or approximately 11% of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period.

Figure 4-3 provides the average and maximum effective doses to NEWs at Cameco's PHCF between 2012 and 2016. The average and maximum effective doses at PHCF were relatively stable between 2012 and 2016.

Figure 4-3: Average and maximum effective doses to nuclear energy workers, Port Hope Conversion Facility, 2012–16



	2012	2013	2014	2015	2016
Average effective dose (mSv)	1.1	0.8	0.8	0.6	0.6
Maximum effective dose (mSv)	6.9	6.6	5.4	7.0	5.6
Number of NEWs monitored	902	793	780	862	830

Annual average and maximum equivalent (skin) dose results from 2012 to 2016 are provided in table E-8 of appendix E. In 2016, the maximum skin dose received by a NEW at PHCF was 16.9 mSv, which is approximately 3% of the regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period.

Site visitors and contractors considered as non-NEWs may be issued dosimeters. In 2016, the maximum individual effective dose received by a non-NEW was 0.21 mSv and averaged less than 0.1 mSv, both of which are well below the annual regulatory dose limit of 1 mSv for a member of the public.

Radiation protection program performance

In 2016, CNSC staff assessed the performance of Cameco's radiation protection program at PHCF through various CNSC staff compliance activities, including a focused inspection on radiation protection. Overall, Cameco's compliance with the *Radiation Protection Regulations* [2] and CNSC licence requirements at

PHCF was found to be acceptable. Cameco established corrective actions to address areas requiring improvement. These included administrative aspects of the management of external dosimetry, the maintenance of fume hoods and dust collection systems, and the use of contamination monitoring equipment and instrumentation.

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 2016, there were no instances at PHCF where an action level was reached.

Radiological hazard control

Cameco has radiation and contamination control programs at PHCF to control and minimize radiological hazards and the spread of radioactive contamination. Methods of control include the use of radiation zone controls and monitoring to confirm the effectiveness of the programs. Cameco staff at PHCF conducted in-plant air monitoring, contamination monitoring and radiation dose-rate surveys in 2016 and did not identify any adverse trends, and the results were consistent with expected radiological conditions. CNSC staff are satisfied with Cameco's radiological hazard control.

Estimated dose to the public

The maximum dose to the public from licensed activities at PHCF is calculated using monitoring results. The 2012 to 2016 maximum effective doses to a member of the public are shown in table 4-1. Doses to the public are well below the PHCF operating release level of 0.3 mSv/year. The regulatory dose limit for a member of the public is 1 mSv/year.

Table 4-1: Maximum effective dose to a member of the public, Port Hope Conversion Facility, 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory dose limit
Maximum effective dose (mSv)	0.029	0.021	0.012	0.006	0.020	**1 mSv/year**

mSv = millisievert

4.3 Environmental protection

Overall compliance ratings for the environmental protection SCA, Port Hope Conversion Facility, 2012–16

2012	2013	2014	2015	2016
SA	SA	SA	SA	SA
For 2016, CNSC staff rated the environmental protection SCA at 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 Ontario Ministry of the Environment and Climate Change's (MOECC) applicable requirements. Measured releases to the environment in 2016 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)

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 staff to effectively develop, implement and maintain their environmental protection programs.

Atmospheric emissions

Cameco monitors uranium, fluorides and ammonia released from stacks at the PHCF facility. The monitoring data in table 4-2 demonstrate that the atmospheric emissions from the facility continued to be effectively controlled, as they remained consistently below their respective licence limits from 2012 to 2016.

Table 4-2: Air emissions monitoring results (annual averages), Port Hope Conversion Facility, 2012–16

Location	Parameter	2012	2013	2014	2015	2016	Licence limit
UF_6 plant	Uranium (kg/h)	0.0042	0.0051	0.0012	0.0017	0.0012	**0.290**
	Fluorides (kg/h)	0.0160	0.0190	0.0130	0.0170	0.0100	**0.650**
UO_2 plant	Uranium (kg/h)	0.0012	0.0013	0.0012	0.0012	0.0010	**0.150**
	Ammonia (kg/h)	1.9	2.0	2.2	2.4	1.7	**58**

UO_2 = uranium dioxide; UF_6 = uranium hexafluoride

In addition to the licence limits, Cameco has action levels at PHCF that are used to provide assurance that the licence release limits will not be exceeded. 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 for air emissions were exceeded at any time in 2016.

Liquid effluent

Cameco's operating licence does not allow the discharge of any process waste water effluent from PHCF. For 2016, there were no process liquid discharges from PHCF. Cameco continues to collect and evaporate rather than discharge process liquid effluent.

Cameco does discharge non-process liquid effluent, such as cooling water and sanitary sewer discharges, from PHCF. Cameco monitors these releases in compliance with the requirements of other regulators that have jurisdiction. CNSC staff reviewed these monitoring results and found them to be acceptable, and concluded that Cameco met its licence requirement not to discharge process waste water effluent.

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, and includes annual environmental objectives and targets that are reviewed and assessed by CNSC staff through compliance verification activities. Cameco met its objectives related to reviewing its environmental protection program against CSA standards N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [8] and N288.5-11, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* [9]. It also met objectives related to the deployment of waste management projects to dispose of contaminated materials at licensed hazardous facilities.

The EMS is verified through the annual licensee's 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 on any outstanding issues with Cameco staff as appropriate. The results of these compliance verification activities demonstrate that, in 2016, Cameco conducted an annual management review in accordance with CNSC requirements, and that identified issues were addressed 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 to ensure that the public exposure resulting from Cameco's PHCF operations is below the annual regulatory dose limit of 1 mSv

and ALARA. The principal monitoring activities, as described below, are focused 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 Independent Environmental Monitoring Program (IEMP) to verify that the public and the environment around nuclear facilities are safe.

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 2016, the measurements showed that the highest annual average uranium concentration in ambient air (as suspended particulate) among the sampling stations was 0.004 $\mu g/m^3$, well below the MOECC standard for uranium in ambient air of 0.03 $\mu g/m^3$.

Groundwater monitoring

Currently, the groundwater quality at PHCF is assessed using samples from:

- 12 active pumping wells on a monthly basis
- 66 monitoring wells in the overburden 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 of concern 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 2012 to 2016 are provided in table F-5 of appendix F. Surface water concentrations continue to be stable, protective of human health and generally below Canadian Council of Ministers of the Environment guidelines for protection of aquatic life.

Soil monitoring

Cameco's soil monitoring program consists of five monitoring locations in Port Hope. 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 changes as compared to previous sample results.

The measured average uranium-in-soil concentrations in 2016 attributable to current PHCF operations have remained similar to past years, without increasing. This suggests that uranium emissions from current PHCF operations do not contribute to accumulation of uranium in soil. Soil sampling results are provided in table F-6 of appendix F. The results have been well below the most restrictive CCME soil quality guideline for residential and parkland land use (23 µg/g) and within the range of the natural background levels for Ontario.

Cameco recognizes that, in the coming years, the Port Hope Area Initiative will provide a unique opportunity to locate soil monitoring stations in clean fill following the cleanup of the low-level radioactive waste throughout the Port Hope community. Cameco will review its soil monitoring program within the community at that time. In the interim, Cameco maintains the existing five soil monitoring locations at an annual frequency.

Fluoride monitoring

The impact of fluoride emissions from PHCF on the environment is determined each growing season (April 15–October 15). At that time, samples of fluoride-sensitive vegetation are collected and then analyzed for fluoride content. The results in 2016 continued to be well below the MOECC's Upper Limit of Normal guideline of 35 parts per million. Details are provided in table F-7 of appendix F.

Gamma monitoring

A significant portion of the low radiological public dose in Port Hope attributable to 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 using environmental dosimeters supplied by a licensed dosimeter service. The annual average of fenceline gamma measurements at Site 1 was 0.005 µSv/h in 2016. For Site 1, Cameco has a licensed limit for fenceline gamma dose rates of 0.14 µSv/h at the critical receptor located at station 14, opposite 125 Mill Street. The annual average of fenceline gamma measurements at Site 2 (on Dorset Street) was 0.054 µSv/h in 2016. Site 2 has a licensed limit of 0.40 µSv/h at the fenceline. Details are provided in table F-8 of appendix F. 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 and 2015. 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 and safe. Further independent environmental monitoring campaigns at PHCF were scheduled for May 2017 and for 2020.

Protection of the public

The licensee is required to demonstrate that adequate provisions are made to protect the health and safety of the public from exposures to hazardous (non-

radiological) substances released from the facility. The effluent and environmental monitoring programs currently conducted by the licensee are used to verify that releases of hazardous substances do not result in environmental concentrations that may affect public health.

The CNSC receives reports of discharges to the environment through the reporting requirements outlined in the PHCF licence and licence conditions handbook. CNSC staff's review of hazardous discharges from PHCF to the environment in 2016 indicated that no significant risks to the public or environment occurred during this period.

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

Environmental risk assessment

Cameco submitted the revised environmental risk assessment for PHCF on January 8, 2016, for CNSC staff review and concurrence. CNSC staff reviewed the ERA and concluded that it complies in general with CSA N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3]. 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* [8], and CSA N288.5-11, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* [9], will be incorporated into the PHCF Environmental Monitoring Plan and the PHCF Environmental Inspection and Test Plan by December 31, 2017. Cameco currently has acceptable environmental programs in place to ensure the protection of the public and the environment.

4.4 Conventional health and safety

Overall compliance ratings for the conventional health and safety SCA, Port Hope Conversion Facility, 2012–16

2012	2013	2014	2015	2016
SA	SA	SA	SA	SA
For 2016, CNSC staff continued to rate the conventional health and safety SCA at 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 at PHCF related to conventional health and safety is monitored by CNSC staff using onsite inspections and event reviews. Cameco continues to develop and maintain a comprehensive occupational health and

safety management program for PHCF. Cameco's conventional health and safety program at 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. An LTI is an injury that takes place at work and results in the worker being unable to return to work to carry out their duties for a period of time. Table 4-3 outlines the number of LTIs over the past five years at PHCF. Cameco reported three LTIs in 2016, and all three involved minor finger and ankle injuries, with workers returning to work in five days or less. For each LTI, Cameco conducted an investigation and implemented corrective actions, which are summarized in table G-1 of appendix G. CNSC staff reviewed the corrective actions and are satisfied with the actions taken by Cameco to prevent reoccurrence.

Table 4-3: Lost-time injuries, Port Hope Conversion Facility, 2012–16

	2012	2013	2014	2015	2016
Lost-time injuries	1	0	1	2	3

Practices

Cameco's activities and operations at PHCF must comply with not only the NSCA [1] and its associated regulations, but also with Part II of the *Canada Labour Code* [5]. Cameco uses audits, inspections, evaluations, reviews, benchmarking, training and employee engagement to evaluate the effectiveness of conventional health and safety practices at PHCF.

The Conversion Safety Steering Committee supports conventional health and safety efforts at PHCF. This joint committee, created in 2013, inspects the workplace and meets monthly to improve the safety performance of the site and promote continuous improvement.

All reported conventional health and safety incidents 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 are promptly resolved.

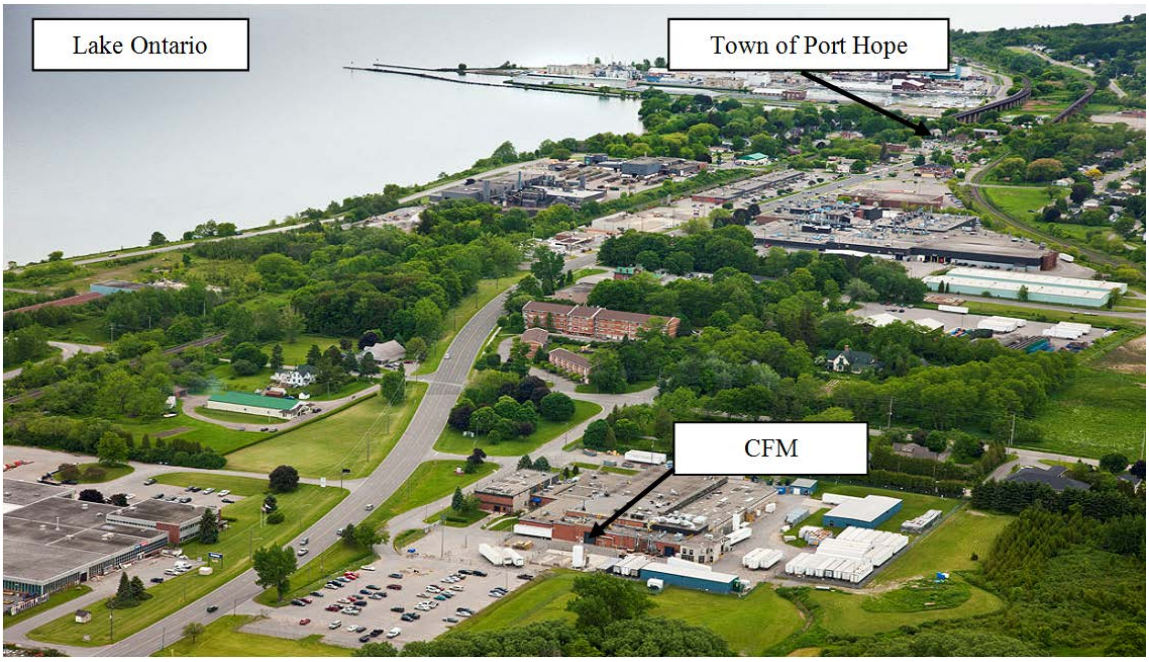
Awareness

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 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 PHCF also attend daily "toolbox meetings" where they are notified of any concerns or ongoing maintenance in their area.

5 Cameco Fuel Manufacturing Inc.

Cameco Fuel Manufacturing Inc. (CFM) is a wholly owned subsidiary of Cameco Corporation that operates two facilities: a nuclear fuel fabricating facility licensed by the CNSC in Port Hope, Ontario; and a metals manufacturing facility in Cobourg, ON, which manufactures zircaloy tubes. 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 Performance

For 2016, CNSC staff rated Cameco's performance at CFM as "satisfactory" in all safety and control areas (SCAs). The performance ratings for CFM from 2012 to 2016 are found in table C-3 of appendix C.

Cameco continued to operate CFM safely throughout 2016. 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 CFM's licensing basis.

In 2016, Cameco completed the implementation of REGDOC-2.12.3, *Security of Nuclear Substances: Sealed Sources* [7]. CNSC staff conducted an inspection in June 2017 to verify compliance with REGDOC-2.12.3.

CFM experienced two events in 2016 that were reported to CNSC staff. In June, a shipment of contaminated ductwork from CFM to the Port Hope Conversion Facility was incorrectly classified and therefore shipped in packaging that was not in accordance with requirements of the *Packaging and Transport of Nuclear Substances Regulations* [11]. In September, an action level associated with atmospheric release from a process stack was exceeded; this is discussed further in section 5.3. Cameco reported both of these events in accordance with its regulatory reporting requirements.

In 2016, CNSC staff conducted three onsite inspections to verify compliance with the *Nuclear Safety and Control Act* (NSCA) [1] and its regulations, Cameco's operating licence and the programs used to meet regulatory requirements. A list of these inspections can be found in table J-3 of appendix J. These inspections focused on the following SCAs: radiation protection, environmental protection, and emergency management and fire protection. Twenty-two enforcement actions were raised as a result of the inspections conducted. CNSC staff concluded that the findings from these inspections posed a low risk to the achievement of regulatory objectives and CNSC expectations.

5.2 Radiation protection

Overall compliance ratings for the radiation protection SCA, Cameco Fuel Manufacturing Inc., 2012–16

2012	2013	2014	2015	2016
SA	SA	SA	SA	SA
For 2016, CNSC staff continued to rate the radiation protection SCA at CFM as "satisfactory". Cameco has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations* [2].				

SA = satisfactory

Application of ALARA

In 2016, Cameco established ALARA initiatives and dose targets for the CFM facility. These objectives and targets addressed worker dose reduction initiatives and other projects that examined ways to reduce airborne uranium concentrations, such as by installing continuous air monitors in work areas, and by enclosing and automating uranium powder processes. Key performance indicators to track radiation protection program performance were also used for parameters such as radiation dose, training and contamination monitoring. In addition, a joint worker–management ALARA committee, whose main goal is to implement initiatives meant to lower worker radiological exposures, continues to support Cameco in its dose reduction efforts at CFM.

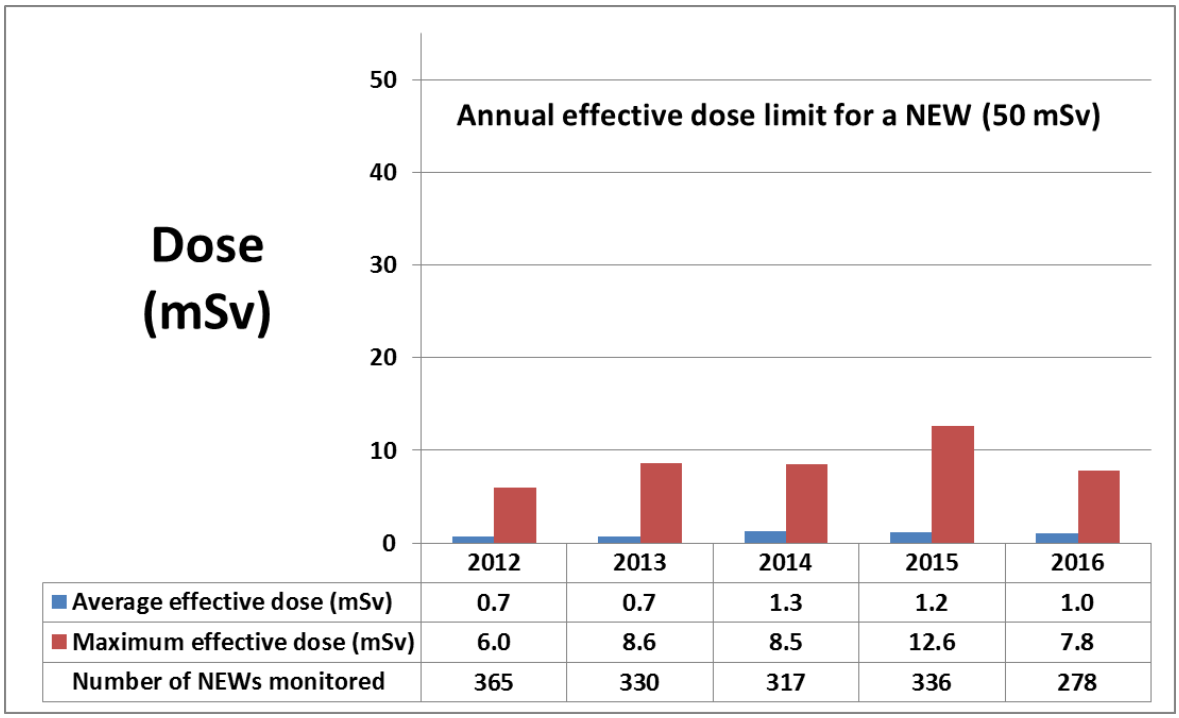
Worker dose control

Radiation exposures at CFM are monitored to ensure compliance with regulatory dose limits and with keeping radiation doses ALARA. In 2016, radiation exposures at CFM, as reported by Cameco, were well below regulatory dose limits.

Cameco ascertains external doses using whole-body and extremity dosimetry at CFM. 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 CFM. Internal dose is assessed and assigned at CFM by lung counting.

At CFM, all employees are identified as nuclear energy workers (NEWs). Contractors at CFM may also be identified as NEWs if the nature of their work activities will require the time spent in the facility to be more than 80 hours per year. In 2016, the total effective dose was assessed for 278 NEWs (227 Cameco employees and 51 contractors) at CFM. The maximum effective dose received by a NEW in 2016 was 7.8 millisieverts (mSv), approximately 16% of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period. Figure 5-2 provides the average and maximum effective doses to NEWs at CFM between 2012 and 2016.

Figure 5-2: Average and maximum effective doses to nuclear energy workers, Cameco Fuel Manufacturing Inc., 2012–16



	2012	2013	2014	2015	2016
Average effective dose (mSv)	0.7	0.7	1.3	1.2	1.0
Maximum effective dose (mSv)	6.0	8.6	8.5	12.6	7.8
Number of NEWs monitored	365	330	317	336	278

The maximum total effective dose in 2016 was lower than that in the previous three years. Average effective dose has been relatively stable since 2014, when the method of determining internal dose through lung counting was implemented.

Annual average and maximum equivalent (skin) and equivalent (extremity) dose results from 2012 to 2016 are provided in tables E-9 and E-2 of appendix E. In 2016, the maximum skin dose received by a NEW at CFM was 95.7 mSv, which is approximately 19% of the regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. The maximum extremity dose received by a NEW at CFM was 98.4 mSv, approximately 20% of the regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. Average and maximum equivalent doses to workers were relatively stable between 2012 and 2016.

All visitors to CFM are issued dosimeters. In 2016, there were no measurable doses recorded on dosimeters issued to non-NEWs.

Radiation protection program performance

In 2016, CNSC staff assessed the performance of Cameco's radiation protection program at CFM through various compliance activities, including an onsite inspection in January 2016. Based on the findings of the inspection, CNSC staff concluded that Cameco is in overall compliance with CNSC regulatory requirements. However, the inspection identified areas requiring improvement, including the need to develop and document all key processes to adequately support the implementation of CFM's internal dosimetry program. These deficiencies do not compromise the health and safety of workers, although improvements are needed to support and improve the management of suspected and confirmed abnormal intakes of uranium by Cameco workers at CFM. Cameco continues to work toward implementing corrective actions to adequately address all of the findings of CNSC staff. CNSC staff will continue to track and evaluate Cameco's corrective actions to ensure that they are satisfactory.

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 2016 there were no action level exceedances associated with the radiation protection program.

Radiological hazard control

Cameco has radiation and contamination control programs at CFM to control and minimize radiological hazards and the spread of radioactive contamination. Methods of control include radiological zone controls and monitoring to confirm the effectiveness of the program. In 2016, Cameco staff at CFM conducted in-plant air monitoring as well as contamination monitoring and radiation dose-rate surveys, and did not identify any adverse trends. CNSC staff are satisfied with Cameco's radiological hazard control.

Estimated dose to the public

The maximum dose to the public from licensed activities at CFM is calculated using monitoring results. The maximum 2012 to 2016 effective doses to a member of the public are shown in table 5-1. The doses are well below the 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, Cameco Fuel Manufacturing Inc., 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory dose limit
Maximum effective dose (mSv)	0.031	0.013	0.018	0.025	0.023	**1 mSv/year**

mSv = millisievert

5.3 Environmental protection

Overall compliance ratings for environmental protection SCA, Cameco Fuel Manufacturing Inc., 2012–16

2012	2013	2014	2015	2016
SA	SA	SA	SA	SA
For 2016, CNSC staff rated the environmental protection SCA at CFM as "satisfactory". Uranium and hazardous substance releases from CFM 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)

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 staff to effectively develop, implement and maintain their environmental protection programs.

Atmospheric emissions

Cameco continues to monitor uranium released as gaseous emissions from the facility. The monitoring data in table 5-2 demonstrate that stack and building exhaust ventilation emissions from the facility in 2016 continued to be effectively controlled as they remained consistently well below their licence limits.

Table 5-2: Air emissions monitoring results, Cameco Fuel Manufacturing Inc., 2012–16

Parameter	2012	2013	2014	2015	2016	Licence limit
Total uranium discharge through stacks (kg/year)	0.02	0.03	0.01	0.01	0.03	**14**
Total uranium discharge through building exhaust ventilation (kg/year)	0.57	0.48	0.40	0.45	0.70*	

kg = kilogram
* In 2016, Cameco changed how it calculated the annual building exhaust value. It was calculated by adding the quarterly results, causing the value to be higher than in previous years due to the number of weeks used in the calculation (i.e., 52 vs. 44).

In addition to the licence limits, Cameco has action levels at CFM that are used to provide assurance that licence release 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.

There was one action level exceedance with respect to stack emissions at CFM in the third quarter of 2016. The action level exceedance occurred in the stack servicing the new automated grinder. The measured value was 9.52 micrograms of uranium per cubic meter (µg U/m^3) compared to the action level of 2.0 µg U/m^3. Cameco completed an investigation of the event and implemented corrective actions accordingly. Cameco's ambient air monitoring conducted around the facility at the time of this event confirmed that uranium concentrations remained far below levels associated with potential risk to the public. CNSC staff are satisfied that the corrective actions implemented by Cameco will be effective in preventing reoccurrence of this event.

Liquid effluent

Liquid effluent generated from the production process is collected and treated to remove the majority of the uranium using an evaporator process. The condensed liquid is sampled and analyzed prior to a controlled release to the sanitary sewer line. Cameco continues to monitor uranium released as liquid effluent from the facility. The monitoring data in table 5-3 demonstrate that liquid effluent from the facility in 2016 remained consistently well below the licence limit and continued to be effectively controlled.

Table 5-3: Liquid effluent monitoring results, Cameco Fuel Manufacturing Inc., 2012–16

Parameter	2012	2013	2014	2015	2016	Licence limit
Total uranium discharge to sewer (kg/year)	0.95	0.83	1.58	1.24	0.85	**475**

kg = kilogram

In addition to the licence limits, CFM has action levels that are used to provide assurance that licence release limits will not be exceeded. No action levels for liquid effluents were exceeded at any time in 2016.

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 CFM. The EMS is described in Cameco's Radiation & Environmental Protection Manual and includes activities such as establishing annual environmental objectives and targets, which are reviewed and assessed by CNSC staff through compliance verification activities. Cameco met its objectives related to improved environmental sampling and monitoring, as well as the implementation of its multi-year waste reduction initiative.

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

Assessment and monitoring

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

In addition, the CNSC conducts periodic monitoring under its Independent Environmental Monitoring Program (IEMP) to verify that the public and the environment around nuclear facilities 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 2016, the results from these samplers showed that the highest annual average concentration of uranium in ambient air (among the sampling stations) was 0.0019 $\mu g/m^3$, well below the Ontario Ministry of the Environment and Climate Change's standard for uranium in ambient air of 0.03 $\mu g/m^3$.

Groundwater monitoring

As of the end of 2016, CFM has a network of 75 groundwater monitoring wells located both within (59) and outside (16) 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 contributing to the concentrations of uranium in groundwater on the licensed property.

Surface water monitoring

In 2016, Cameco collected surface water samples at six locations in June, eight locations in August and eight locations 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 2016 met the applicable Canadian Council of Ministers of the Environment (CCME) water quality guidelines for the protection of aquatic life. The CCME uranium guideline for short-term exposure (33 μg/L) was met for the two sample locations situated in intermittent drainage features. The CCME uranium guideline for long-term exposure (15 μg/L) was met for the six sample locations situated at the tributary of Gages Creek. The highest uranium concentration was collected at SW-4 (23 μg/L in August) and was below the applicable CCME guideline for short-term exposure. Sampling station SW-4 is located onsite at the drainage ditch leading to the creek. Uranium concentrations were measured at one offsite location (immediately downstream of CFM) and were well below the applicable CCME guideline for each round of sampling.

CNSC staff will continue to oversee Cameco's monitoring at locations around the vicinity of CFM to confirm whether uranium concentrations remain at safe levels in surface water.

Soil monitoring

On a three-year frequency, 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 CFM are just slightly above the Ontario natural background level of 2.5 μg/g (table F-9, 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 23 µg/g, which is the most restrictive CCME soil quality guideline for uranium for residential and parkland land use and, therefore, no adverse consequences to human and environmental receptors are expected. A comparison of 2016 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 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 using environmental dosimeters supplied by a licensed dosimeter service. In 2016, the annual average of fenceline gamma measurements at the CFM site was 0.010 µSv/h. CFM has a licensed limit for fenceline gamma dose rates of 0.2 µSv/h at the monitoring station corresponding to the critical receptor. These measurements indicate that gamma dose rates are effectively controlled and that the public is protected.

CNSC Independent Environmental Monitoring Program

CNSC staff conducted independent environmental monitoring in the Port Hope area in 2014 and 2015. The results are available on the CNSC's IEMP Web page. The IEMP results indicate that the public and the environment surrounding CFM are protected and safe. The next independent environmental monitoring campaigns at CFM were scheduled to take place in May 2017 and in 2020.

Protection of the public

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

The CNSC receives reports of discharges to the environment through the reporting requirements outlined in the CFM licence and licence conditions handbook. CNSC staff's review of hazardous discharges from CFM to the environment in 2016 indicated that no significant risks to the public or environment occurred during this period.

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

Environmental risk assessment

In 2015, Cameco indicated that, by the end of 2017, it would implement the three environmental protection standards: CSA N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [8]; CSA N288.5-11, *Effluent monitoring programs at Class I nuclear facilities and*

uranium mines and mills [9]; and CSA N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3]. Recently, CNSC staff reviewed the environmental risk assessment for CFM and concluded that Cameco is in compliance with CSA 288.6-12 and that its conclusions regarding potential risk to human health and the environment at CFM are valid. Cameco currently has acceptable environmental programs in place to ensure protection of the public and the environment.

5.4 Conventional health and safety

Overall compliance ratings for the conventional health and safety SCA, Cameco Fuel Manufacturing Inc., 2012–16

2012	2013	2014	2015	2016
SA	SA	SA	SA	SA
For 2016, CNSC staff continued to rate the conventional health and safety SCA at CFM 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 CFM is monitored by CNSC staff using onsite inspections and event reviews. Cameco continues to develop and maintain a comprehensive occupational health and safety management program for CFM. Cameco’s conventional health and safety program at CFM 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 lost-time injuries (LTIs) that occur per year. An LTI is an injury that takes place at work and results in the worker being unable to return to work to carry out their duties for a period of time. As indicated in table 5-4, there were no LTIs at CFM in 2016.

Table 5-4: Lost-time injuries, Cameco Fuel Manufacturing Inc., 2012–16

	2012	2013	2014	2015	2016
Lost-time injuries	0	0	0	1	0

Practices

Cameco's activities and operations at CFM must comply with not only the NSCA [1] and its associated regulations, but also 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 CFM.

Cameco maintains a Joint Health and Safety Committee at CFM, 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 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 CFM 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 CFM also attend daily "toolbox meetings" where they are notified of any concerns or ongoing maintenance in their area.

6 BWXT Nuclear Energy Canada Inc.

BWXT Nuclear Energy Canada Inc., formerly known as GE Hitachi Nuclear Energy Canada Inc. (GEH-C), produces nuclear fuel bundles used by Ontario Power Generation's Pickering and Darlington nuclear generating stations. BWXT operates in three locations in Ontario: Arnprior, Toronto and Peterborough. The Arnprior facility is not licensed by the CNSC and is not discussed further in this report. The Toronto and Peterborough facilities are Class IB nuclear facilities operating under a licence issued by the CNSC. BWXT's licence authorizes it to operate and modify its nuclear fuel facility to produce natural and uranium dioxide (UO_2) pellets in Toronto, and to produce and test fuel bundles in Peterborough. The Peterborough facility is also authorized to receive, repair, modify and return contaminated equipment from offsite nuclear facilities. BWXT's licence expires in December 2020.

Figure 6-1 shows the BWXT Toronto facility and figure 6-2 shows the BWXT Peterborough facility.

Figure 6-1: Aerial view of the BWXT Toronto facility

Figure 6-2: Side view of the BWXT Peterborough facility

During the reporting period, BWXT completed its acquisition of GEH-C. The Commission approved the transfer of GEH-C's operating licence to BWXT [12] following an application by GEH-C in August 2016. No significant changes to the operations, management and personnel occurred at either facility as a result of this acquisition. As part of the licence transfer, the Commission also approved a new financial guarantee to the sum of $52,371,600. For the purpose of this report, the licensee will be referred to as BWXT for the remainder of this section.

The changes to BWXT's licence and licence conditions handbook (LCH) are described in tables I-1 and I-2 of appendix I.

6.1 Performance

For 2016, CNSC staff rated BWXT's performance in all SCAs as "satisfactory". The performance ratings for BWXT from 2012 to 2016 are found in table C-4 of appendix C.

In 2016, several changes took place in management personnel accountable for licenced activities. In December 2016, the licensee organization structure was revised to integrate BWXT with other operations of BWXT Canada Ltd.

In 2016, production operations at both BWXT facilities continued safely, without any significant changes. Both sites had shutdowns related to engineering projects and equipment maintenance. BWXT ensured that both facilities were maintained according to their licensing bases.

BWXT experienced four events that were reported to CNSC staff in 2016 in accordance with its regulatory reporting requirements. In April, a suspicious package was received at the BWXT Toronto facility, which was later deemed benign following response by licensee staff and first responders. Also in April, a dedicated shipment from the Peterborough facility to the Toronto facility containing a single stack of uranium pellets and a zircaloy tube was incorrectly

labelled as empty. In May, BWXT reported a radiation protection action level exceedance, which is further discussed in section 6.2. In September, BWXT reported a worker injury that did not result in a lost-time injury (LTI). For each event, BWXT completed an investigation and implemented corrective actions to the satisfaction of CNSC staff.

In 2016, CNSC staff conducted three inspections at BWXT's two facilities to verify licensee compliance with the *Nuclear Safety and Control Act* (NSCA) [1] and its regulations, the operating licence and the programs used to meet regulatory requirements. A list of these inspections can be found in table J.4 of appendix J. The inspections focused on the following SCAs: conventional health and safety, waste management, safety analysis, emergency management and fire protection, fitness for service, and radiation protection. Thirteen enforcement actions were raised as a result of the inspections. CNSC staff concluded that the findings from these inspections posed a low risk to the achievement of regulatory objectives and CNSC expectations.

6.2 Radiation protection

Overall compliance ratings for the radiation protection SCA, BWXT, 2012–16

2012	2013	2014	2015	2016
SA	SA	SA	SA	SA
For 2016, 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].				

SA = satisfactory

Application of ALARA

In 2016, BWXT established radiation protection goals and initiatives to keep worker doses ALARA at its Toronto and Peterborough facilities. BWXT has an ALARA Committee that met quarterly and set annual ALARA goals focused on reducing worker dose and surface contamination throughout the facilities. BWXT met all of its ALARA goals for 2016 at both sites.

Worker dose control

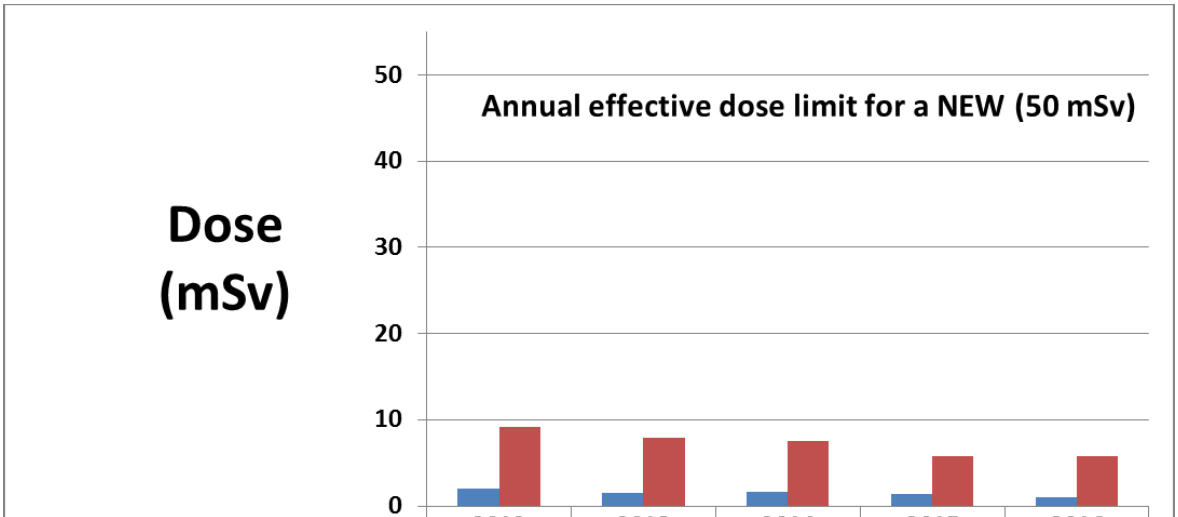
Radiation exposures at BWXT are monitored to ensure compliance with regulatory dose limits and to maintain radiation doses ALARA. In 2016, no worker's radiation exposure, as reported by BWXT, exceeded regulatory dose limits.

BWXT's workers are exposed externally to uranium dioxide pellets. At the Toronto facility, workers have the potential to be exposed internally to uranium dioxide powder. External whole-body and equivalent doses are ascertained using dosimeters. Internal dose is assessed and assigned at BWXT Toronto through a uranium-in-air breathing zone monitoring program. At BWXT, most employees are classified as nuclear energy workers (NEWs).

The maximum effective dose received by a NEW in 2016 at the Peterborough facility was 5.82 millisieverts (mSv), approximately 12% of the regulatory limit for an effective dose of 50 mSv in a one-year dosimetry period.

Figure 6-3 provides the average and maximum effective doses to NEWs at BWXT's Peterborough facility between 2012 and 2016.

Figure 6-3: Average and maximum effective doses to nuclear energy workers, BWXT Peterborough facility, 2012–16

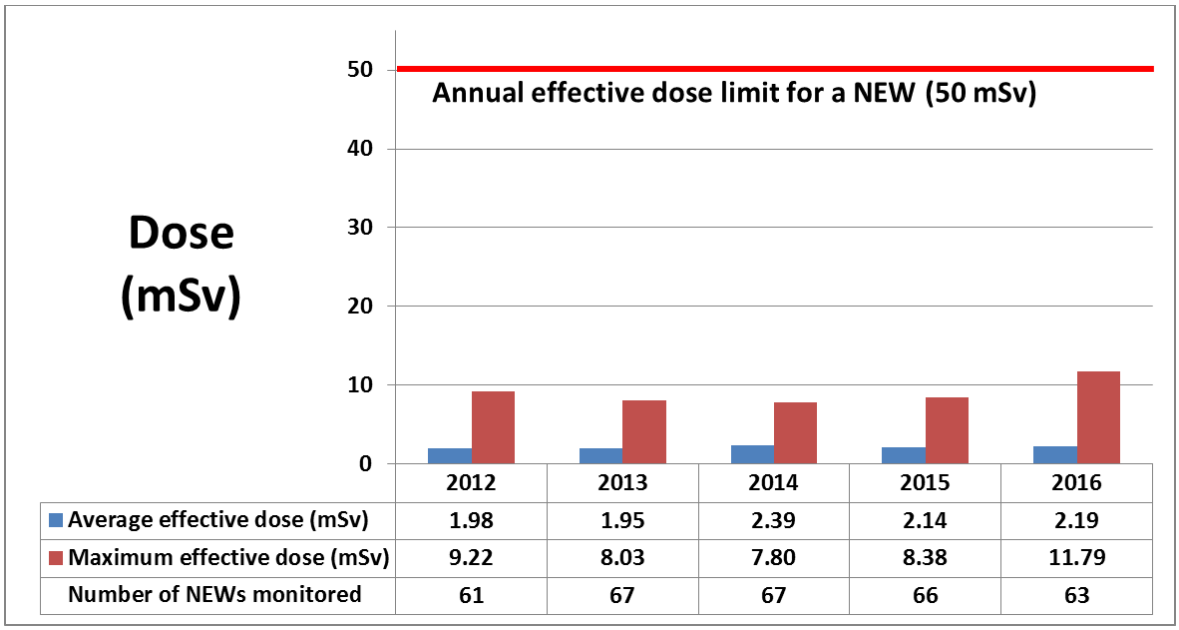


	2012	2013	2014	2015	2016
Average effective dose (mSv)	1.97	1.54	1.67	1.35	0.96
Maximum effective dose (mSv)	9.16	7.96	7.55	5.77	5.82
Number of NEWs monitored	76	82	78	75	88

The maximum effective dose received by a NEW in 2016 at the Toronto facility was 11.79 mSv, approximately 24% of the regulatory limit for an effective dose of 50 mSv in a one-year dosimetry period.

Figure 6-4 provides the average and maximum effective doses to NEWs at BWXT's Toronto facility between 2012 and 2016.

Figure 6-4: Average and maximum effective doses to nuclear energy workers, BWXT Toronto facility, 2012–16



	2012	2013	2014	2015	2016
Average effective dose (mSv)	1.98	1.95	2.39	2.14	2.19
Maximum effective dose (mSv)	9.22	8.03	7.80	8.38	11.79
Number of NEWs monitored	61	67	67	66	63

For both the Peterborough and Toronto 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 public dose limit of 1 mSv/year.

Annual average and maximum equivalent (skin) and equivalent (extremity) dose results from 2012 to 2016 are provided in tables E-3, E-4, E-10 and E-11 of appendix E. In 2016, the maximum equivalent skin dose for both facilities was 74.26 mSv (occurring in Toronto), which is approximately 15% of the regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. The maximum equivalent extremity dose was 119.47 mSv (occurring in Toronto), approximately 24% of the 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 when compared with the Toronto facility, where direct pellet handling 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

Action levels for radiological exposures, urinalysis results and contamination control are established as part of the BWXT radiation protection program. If an action level is reached, BWXT staff must establish the cause and, if applicable, restore the effectiveness of the radiation protection program. In 2016, there was one action level exceedance at BWXT Toronto, pertaining to a urinalysis result of 13 µg/L, which exceeded the 10 µg/L action level. BWXT provided the CNSC with an investigation report and identified six corrective actions, all of which

were reviewed and accepted by CNSC staff. BWXT determined that the potential cause for the elevated urinalysis result was most likely a contaminated sample, with exposure due to ingestion not completely ruled out. CNSC staff calculated the committed effective dose to the affected worker as a result of this event to be approximately 0.2 mSv.

Radiological hazard control

BWXT has radiation contamination controls at its facilities 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 2016, the number of swipe locations remained relatively constant and no adverse trends were identified in monitoring results. CNSC staff are satisfied with BWXT's radiological hazard control.

Estimated dose to the public

The maximum dose to the public from licensed activities at BWXT is calculated using monitoring results. The 2012 and 2016 maximum effective doses to members of the public are shown in table 6-1 for BWXT's Toronto facility. BWXT's Peterborough facility has consistently reported doses to members of the public of 0 mSv between 2012 and 2016. These effective doses are well below the regulatory dose limit of 1 mSv/year.

Table 6-1: Maximum effective dose to a member of the public, BWXT Toronto, 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory limit
Maximum effective dose (mSv)	0.0011	0.0006	***0.0055	0.0101	0.0007	1 mSv/year

mSv = millisievert.
*In 2014, BWXT Toronto (then GEH-C) started implementing environmental gamma exposure monitoring using licensed dosimeters and began to include this result in the estimated annual public dose.

6.3 Environmental protection

Overall compliance ratings for the environmental protection SCA, BWXT, 2012–16

2012	2013	2014	2015	2016
FS	FS	FS	SA	SA
For 2016, CNSC staff rated the environmental protection SCA at the BWXT facilities as "satisfactory". All uranium and hazardous substance releases from BWXT facilities to the environment continue to be well below the regulatory limits during 2016. Fenceline gamma measurements, soil sampling and ambient air data indicate that the public and the environment continue to be protected from facility releases.				

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 staff to effectively develop, implement and maintain their environmental protection programs.

Atmospheric emissions

To ensure compliance with licence limits, air from the BWXT facilities is filtered and sampled prior to its release into the atmosphere. In 2016, the annual releases of uranium from the BWXT facilities in Toronto and Peterborough were 0.011 kg and 0.000004 kg, respectively. BWXT's annual uranium emissions from the Toronto and Peterborough facilities from 2012 to 2016 are provided in tables F-10 and F-14 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 BWXT facilities.

In addition to licence limits, BWXT facilities in Toronto and Peterborough have action levels that are used to provide assurance that licence release limits will not be exceeded. No action levels were exceeded at any time in 2016.

Liquid effluent

To ensure compliance with licence limits, waste water from BWXT facilities is collected, filtered and sampled prior to its release into sanitary sewers. In 2016, the annual releases of uranium from the BWXT Toronto and Peterborough facilities were 0.65 kg and 0.0001 kg, respectively. BWXT's annual uranium effluent releases from the BWXT Toronto and Peterborough facilities for 2012 to 2016 are provided in tables F-10 and F-14 of appendix F. In 2016, the releases continued to be well below the licence limit. The results demonstrate that liquid effluent releases are being controlled effectively at the BWXT facilities.

In addition to licence limits, BWXT facilities in Toronto and Peterborough have action levels that are used to provide assurance that licence release limits will not be exceeded. No action levels were exceeded at any time in 2016.

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 facility. BWXT's EMS is described in its Environmental Management Program Manual, and includes activities such as establishing annual environmental objectives and targets that are reviewed and assessed by CNSC staff through compliance verification activities. In 2016, BWXT met its objectives related to improved environmental sampling and monitoring, emissions reduction and the completion of a noise-abatement project.

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 on any outstanding

issues with BWXT staff. The results of these compliance verification activities demonstrate that BWXT conducted an annual management review in accordance with CNSC requirements and that identified issues are being addressed properly.

Assessment and monitoring

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

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

Uranium in ambient air

BWXT Toronto operates five high-volume air samplers to measure the airborne concentrations of uranium at points of impingement of stack plumes. The results from these samplers show that the annual average concentration of uranium (among the sampling stations) in ambient air measured around the facility in 2016 was 0.001 µg/m^3, well below the Ontario Ministry of the Environment and Climate Change (MOECC) standard for uranium in ambient air of 0.03 µg/m^3. Air monitoring results for BWXT Toronto are provided in table F-11 of appendix F.

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

Soil monitoring

BWXT conducts soil sampling at its Toronto facility as part of its environmental program. In 2016, 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 2016, the average soil concentration of uranium for residential locations was 0.5 µg/g, while the maximum concentration of uranium in soil for these locations was 0.7 µg/g. These values are in the range of natural background levels for Ontario and well below the most restrictive Canadian Council of Ministers of the Environment soil quality guidelines for uranium of 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 provided in tables F-12 and F-13 of appendix F.

Gamma monitoring

For both the BWXT Toronto and Peterborough 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 using environmental dosimeters. The estimated effective dose as a result of gamma radiation during 2016 was 0 mSv, for a total estimated critical receptor dose of 0.0007 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 using environmental dosimeters. The estimated effective dose as a result of gamma radiation during 2016 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 and safe. The next IEMP campaigns at the BWXT facilities are scheduled for 2018 (Peterborough) and 2019 (both facilities).

Protection of the public

The licensee is required to demonstrate that adequate provisions are made to protect the health and safety of the public from exposures to hazardous (non-radiological) substances released from the facility. The effluent and environmental monitoring programs currently conducted by BWXT are used to verify that releases of hazardous substances do not result in environmental concentrations that may affect public health.

The CNSC receives reports of discharges to the environment through the reporting requirements outlined in the BWXT licence and LCH. Review of hazardous discharges to the environment for BWXT in 2016 indicated that these discharges would not pose significant risks to the public or the environment during this period.

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

Environmental risk assessment

BWXT currently has acceptable environmental programs in place to ensure the protection of the public and the environment. In 2016, BWXT worked to achieve compliance for both its facilities by the end of the year with the three environmental protection standards: CSA N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [8]; CSA N288.5-11, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* [9]; and CSA N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3]. BWXT has submitted environmental risk assessments for both facilities, to comply with the requirements of CSA N288.6-12. CNSC staff are reviewing these submissions to ensure that they are in full compliance with the requirements of CSA N288.6-12 and that their conclusions are valid. CNSC staff will be conducting compliance verification activities to confirm BWXT's implementation of the new standards.

6.4 Conventional health and safety

Overall compliance ratings for the conventional health and safety SCA, BWXT, 2012–16

2012	2013	2014	2015	2016
FS	SA	SA	SA	SA
For 2016, CNSC staff continued to rate the conventional health and safety SCA at the BWXT facilities as "satisfactory". Overall, the compliance verification activities conducted by CNSC staff 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.				

FS = fully satisfactory; SA = satisfactory

Performance

BWXT's performance related to conventional health and safety is monitored by CNSC staff using onsite inspections and event reviews. BWXT continues to develop and maintain a comprehensive occupational health and safety management program for its facilities. This 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.

For 2016, the Toronto and Peterborough facilities reported zero LTIs. Tables 6-2 and 6-3 show the LTIs for BWXT Toronto and Peterborough between 2012 and 2016.

Table 6-2: Lost-time injuries, BWXT Toronto, 2012–16

	2012	2013	2014	2015	2016
Lost-time injuries	1	0	1	0	0

Table 6-3: Lost-time injuries, BWXT Peterborough, 2012–16

	2012	2013	2014	2015	2016
Lost-time injuries	0	0	0	0	0

Practices

BWXT's activities and operations must comply with not only the NSCA [1] and its associated regulations, but also with Part II of the *Canada Labour Code* [5]. BWXT's program practices in this reporting period included several improvements at the Peterborough facility, such as a single environmental health and safety permit system for improved hazard assessment; a standard methodology for chemical sweeps; and updated training for overhead cranes, fall arrest and fuel shop hazard awareness.

At the Toronto facility, several improvements were implemented to the emergency response respirator training programs and to operator training. BWXT continues to maintain three committees under its conventional health and safety program: the Health and Safety Policy Committee, the Workplace Safety Committee (WSC) and the Ergonomics Committee.

Awareness

BWXT's management regularly reviews performance metrics. In 2016, BWXT Peterborough conducted investigations and inspections, including WSC inspections, manager inspections, and near-miss and incident investigations. Findings were related to areas such as housekeeping, equipment safety, emergency response procedures, walking/working surfaces and chemical management compatibility/segregation. At its Toronto facility, BWXT conducted investigations and inspections, including WSC inspections as well as near-miss and incident investigations. Findings were related to areas such as housekeeping, chemicals, unsafe conditions and electrical. BWXT logs actions arising from investigations and inspections and tracks them to completion.

Part II: Nuclear Substance Processing Facilities

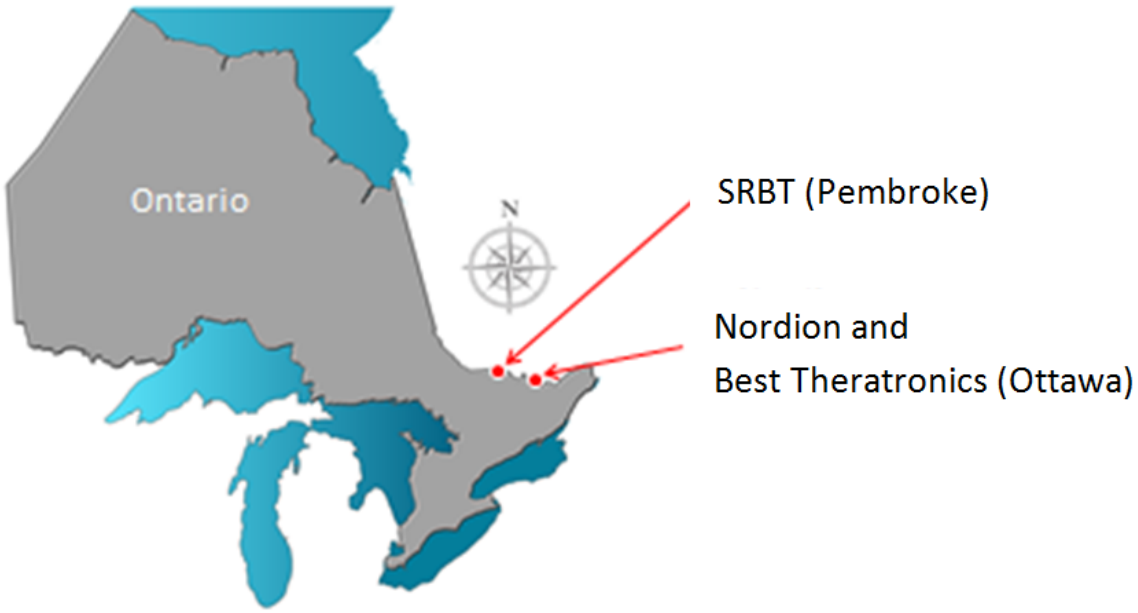
7 Overview

This section of the report deals with three nuclear substance processing facilities located in Canada:

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

All three facilities are located in the province of Ontario, as shown in figure 7-1. The licence for SRBT 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 consistent risk-informed regulatory oversight activities at each nuclear substance processing facility in 2016. 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, 2016

Facility	Number of onsite inspections	Person-days for compliance	Person-days for licensing activities
SRBT	1	102	11
Nordion	3	208	10
BTL	4	74	2

In 2016, CNSC staff performed eight onsite inspections at the nuclear substance processing facilities. All of the findings resulting from these onsite inspections were provided to the licensees in detailed inspection reports. All regulatory enforcement actions arising from the findings were recorded in the CNSC Regulatory Information Bank to ensure that they are tracked to completion. Appendix J lists each of the CNSC inspections conducted in 2016.

Each nuclear substance processing facility licensee is required to submit an annual compliance report on the operations of its facility by March 31 of each year. These reports 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 normal regulatory compliance oversight to verify that licensees are complying with regulatory requirements and operating safely. The full versions of these reports are available on the licensees' websites, as provided in appendix H of this report.

The safety and control area (SCA) performance ratings of nuclear substance processing facilities are presented in table 7-2. For 2016, CNSC staff rated most SCAs for SRBT, Nordion and BTL as "satisfactory" with the following exceptions:

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

Appendix C contains the SCA ratings between 2012 and 2016 for each facility.

Table 7-2: Safety and control area performance ratings, nuclear substance processing facilities, 2016

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

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

The CNSC requires each facility to develop a decommissioning plan, which is reviewed and approved by CNSC staff. Each plan is accompanied by a financial guarantee that provides the funding necessary to complete the future decommissioning work (see financial guarantees in appendix D).

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.

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 nuclear substance processing facilities for the radiation protection SCA as "satisfactory" in 2016, the same rating as in the previous year.

Ratings for the radiation protection SCA, nuclear substance processing facilities, 2016

SRBT	Nordion	BTL
SA	SA	SA

SA = satisfactory

Application of ALARA

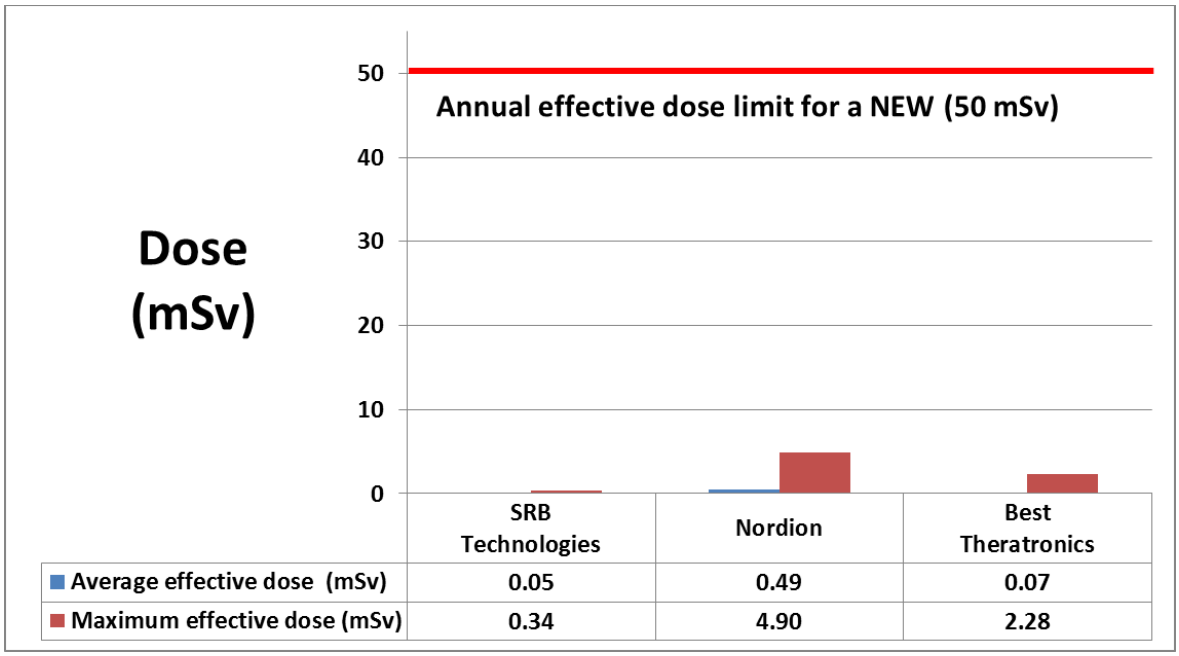
In 2016, all nuclear substance processing facility licensees continued to implement radiation protection measures to keep radiation exposures and doses to persons ALARA, while taking into account social and economic factors. As a result of the CNSC requirement to apply the ALARA principle, doses to persons have consistently been well below regulatory dose limits.

Worker dose control

The design of radiation protection programs, including the dosimetry methods and the determination of workers who are identified as nuclear energy workers (NEWs), varies 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 write-ups.

The maximum and average effective doses for NEWs at nuclear substance processing facilities are provided in figure 7-2. In 2016, the maximum individual effective dose received by a NEW at all facilities ranged from 0.34 mSv to 4.9 mSv, well below the regulatory dose limit of 50 mSv/year for a NEW.

Figure 7-2: Average and maximum effective doses to nuclear energy workers, nuclear substance processing facilities, 2016



During 2016, all nuclear substance processing facility licensees monitored and controlled the radiation exposures and doses received by all persons present at their licensed facilities, including workers, contractors and visitors. As radiological hazards vary across these facilities due to complex and differing work environments, direct comparison of doses to NEWs among facilities does not necessarily provide an appropriate measure of how effective the licensee is in implementing its radiation protection program.

Radiation protection program performance

CNSC staff conducted oversight activities at all nuclear substance processing facilities during 2016 to verify that the licensees' radiation protection programs were in compliance with regulatory requirements. This regulatory oversight consisted of desktop reviews and radiation protection-specific compliance verification activities, including onsite inspections. Through these oversight activities, CNSC staff confirmed that all these licensees have effectively implemented their radiation protection programs to help control occupational exposures to workers.

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 program that represent timely indicators of potential losses of control of the program. As a result, action levels are licensee-specific and can change over time depending on operational and radiological conditions.

If an action level is reached, the licensee must establish the cause, notify the CNSC and, if applicable, take action to restore the effectiveness of the 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 radiation protection program. Action levels that are never exceeded may not be sensitive enough to detect a potential loss of control. For this reason, licensee performance is not judged solely on the number of action level exceedances in a given period but rather on how the licensee responds and identifies corrective actions to enhance program performance and prevent reoccurrence. There were no action level exceedances reported by nuclear substance processing licensees during 2016.

Radiological hazard control

CNSC staff verified that in 2016, all nuclear substance processing facility licensees continued to implement adequate measures to monitor and control radiological hazards in their facilities. These measures include delineation of zones for contamination control purposes and, for certain facilities, in-plant air-monitoring systems. These licensees continued to implement their workplace monitoring programs to protect workers. They 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 SRBT is calculated using monitoring results; the maximum dose to the public from licensed activities at Nordion is calculated from derived release limits. Public dose estimates are not provided for BTL because its licensed activities involve sealed sources and there are no discharges to the environment. The CNSC's requirements to apply ALARA principles ensure 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 estimated public doses from 2012 to 2016 for the nuclear substance processing facility licensees. Estimated doses to the public from these licensees continued to be well below the regulatory annual public dose limit of 1 millisievert (mSv) per year.

Table 7-3: Public dose comparison table (mSv), nuclear substance processing facilities, 2012–16

Facility	Year					Regulatory limit
	2012	2013	2014	2015	2016	
SRBT	0.0049	0.0068	0.0067	0.0068	0.0046	**1 mSv/year**
Nordion	0.020	0.022	0.010	0.0056	0.0021	
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 2016 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 of all but one of the nuclear substance processing facilities for the environmental protection SCA as "satisfactory" in 2016. 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, 2016

SRBT	Nordion	BTL
SA	FS	SA

FS = fully satisfactory; SA = satisfactory

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 required to have trained and qualified staff to effectively develop, implement and maintain their environmental protection programs.

CNSC staff concluded that the nuclear substance processing facility licensees implemented their environmental programs satisfactorily in 2016. Their programs are effective in protecting the health and safety of the public and the environment. There were no exceedances of licence limits for any of these facilities during this year (see further information in the facility-specific sections).

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, CNSC staff rated the performance of all but one of the nuclear substance processing facilities for the conventional health and safety SCA as "satisfactory" in 2016. The exception was SRBT, which was given a "fully satisfactory" rating. This remains unchanged from the previous year.

Ratings for the conventional health and safety SCA, nuclear substance processing facilities, 2016

SRBT	Nordion	BTL
FS	SA	SA

FS = fully satisfactory; SA = satisfactory

Performance

The regulation of conventional health and safety at nuclear substance processing facilities involves both Employment and Social Development Canada (ESDC) and the CNSC. CNSC staff monitor compliance with regulatory reporting requirements and, when a concern is identified, CNSC staff consult with ESDC staff. 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. Table 7-4 summarizes the number of recordable lost-time injuries reported by nuclear substance processing facilities between 2012 and 2016. Further information is provided in facility-specific sections as well as appendix G.

Table 7-4: Lost-time injuries, nuclear substance processing facilities, 2012–16

Facility	2012	2013	2014	2015	2016
SRBT	0	0	0	0	0
Nordion	0	1	3	0	3
BTL	N/A*	N/A*	1	1	3

* BTL was not required to report lost-time injury statistics prior to 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 2016. Their programs are effective in protecting the health and safety of persons working in their facilities.

7.4 Public information and disclosure programs

Nuclear substance processing facility licensees are required to maintain and implement public information and disclosure programs per RD/GD-99.3, *Public Information and Disclosure* [6]. These programs are supported by disclosure protocols that outline what types of facility information and activities must be shared with the public (e.g., incidents, major changes to operations, periodic environmental performance reports), as well as 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 nuclear facilities.

In 2016, CNSC staff evaluated licensees' implementation of their public information and disclosure programs and determined that all licensees were in compliance with RD/GD-99.3. CNSC staff reviewed the communications activities during this period and noted that licensees used a variety of methods to share information with the public about their activities and licence renewal processes. Activities included public information sessions, facility tours, participation in community events, regular updates to elected officials, newsletters, and ongoing website and social media updates.

Licensees also issued information in accordance with their public disclosure protocols. Licensees followed these protocols to disclose information and reports of interest to the public, including routine and non-routine situations, events and activities. In 2016, SRBT posted information on its website about events and fire training on its website. Nordion posted information on its website about events, fire alarms, emergency training and a change in facility operations. BTL was in the process of updating its website to include an online survey to encourage feedback from the public. In addition, all licensees publish their annual compliance reports on their websites.

CNSC staff concluded that nuclear substance processing facility licensees implemented their public information and disclosure programs satisfactorily during 2016. Their programs are effective at communicating information about the health, safety and security of persons and the environment, as well as other issues associated with their facilities.

8 SRB Technologies (Canada) Inc.

SRB Technologies (Canada) Inc. (SRBT) is a gaseous tritium light source (GTLS) manufacturing facility located on the outskirts of Pembroke, Ontario, approximately 150 km northwest of Ottawa. The Class IB nuclear facility has been in operation since 1990. In 2015, the Commission renewed SRBT's operating licence, NSPFOL-13.00/2022, which expires in June 2022. Figure 8-1 shows an aerial view of the SRBT facility.

Figure 8-1: Aerial view of the SRBT facility

SRBT processes tritium gas to produce gaseous tritium light source (GTLS), and manufactures radiation devices such as signs, markers and tactical devices, which are distributed in Canada and internationally. Figure 8-2 shows examples of GTLS exit signs and other markers produced at SRBT.

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

8.1 Performance

For 2016, CNSC staff rated SRBT's performance in all but two of the safety and control areas (SCAs) as "satisfactory". The exceptions were the fitness for service and the conventional health and safety SCAs, which were rated as "fully satisfactory". SRBT has implemented highly effective measures for both SCAs, and SRBT's overall compliance in these SCAs has remained stable. For example, no lost-time injuries (LTIs) have occurred in the past five years, and SRBT promptly addresses and reports any arising problems in accordance with regulatory requirements. In addition, SRBT performs preventive maintenance activities according to its maintenance plan, tracks corrective maintenance and identifies trends. No safety-significant equipment failures occurred at the facility, indicating the effectiveness of SRBT's maintenance program. The SRBT performance ratings for all SCAs for 2012 to 2016 are provided in table C-5 of appendix C.

SRBT continued to operate the tritium processing facility safely throughout 2016 and made no significant changes to the processes that affect the safe operation of the facility. There were no exceedances of action levels and no occurrences of LTIs at SRBT in 2016.

As part of its decision to renew SRBT's operating licence in 2015, the Commission requested that CNSC staff "include in its annual reports more detailed information regarding, not only the number of shipments, but the volume of processed material as well as number of signs that had been received, and how much of that had been directed to waste" [13]. In 2016, SRBT processed 28,122,678 gigabecquerels (GBq) of tritium, resulting in 1,001 shipments of self-luminous products to customers in 18 countries, including Canada. SRBT also receives expired self-luminous products for reuse and disposal. In 2016, the facility received 562 consignments comprising 31,667 returned devices, containing 6,737 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 2016, a total of 6,656.63 TBq of tritium activity from expired GTLS was transferred as low-level waste material, which is an increase of 2,359.25 TBq from 2015.

As a follow-up to a 2015 inspection of SRBT's import and export licences, CNSC staff verified the implementation and effectiveness of SRBT's revised shipping and oversight procedures, as well as the implementation of corrective actions taken by SRBT related to CNSC staff's findings of non-compliance with the terms of SRBT's licence for exports to the European Union. These findings were previously reported in the 2015 regulatory oversight report. CNSC staff reviewed and accepted the corrective actions and additional information provided by SRBT, and determined that SRBT was compliant with the import and export licensing requirements.

In 2016, CNSC staff conducted one inspection at SRBT to ensure compliance with the *Nuclear Safety and Control Act* (NSCA) [1] and its regulations, SRBT's operating licence and the programs used to meet regulatory requirements. This inspection is listed in table J-5 of appendix J. The inspection focused on the

environmental protection and the conventional health and safety SCAs. One enforcement action was raised as a result of this inspection. CNSC staff concluded that this inspection's findings posed a low risk to the achievement of regulatory objectives and CNSC expectations.

SRBT experienced two events in 2016 that were reported to the CNSC in accordance with the regulatory reporting requirements. The first event was due to a false fire alarm that resulted from a malfunctioning compressor unit. The second event involved a stolen transport trailer containing expired tritium exit signs. The missing trailer was found abandoned approximately three weeks later with all packages intact and accounted for. For both events, SRBT submitted full reports that were reviewed and accepted by CNSC staff. SRBT made the reports available to the public in accordance with its public information program.

In 2016, there were no licence amendments for SRBT and no significant changes made to its licence condition handbook.

8.2 Radiation protection

Overall compliance ratings for the radiation protection SCA, SRB Technologies (Canada) Inc., 2012–16

2012	2013	2014	2015	2016
SA	SA	SA	SA	SA
For 2016, CNSC staff continued to rate the radiation protection SCA at SRBT as "satisfactory". SRBT has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations* [2].				

SA = satisfactory

Application of ALARA

In 2016, SRBT continued to implement radiation protection measures at its facility to keep radiation exposures and doses to persons ALARA, while taking into account social and economic factors. SRBT continues to make annual improvements to its radiation protection program. In 2016, it added remote display units, improved the tritium trap valve design, commissioned an upgraded power supply on the liquid scintillation counting equipment and implemented revised radiation protection program procedures. SRBT's Health Physics Committee meets regularly to discuss various aspects of the program, including worker doses, radiological-hazard monitoring results and internal audit results. The Health Physics Committee also tracks progress against ALARA targets for maximum effective dose to a worker and for collective dose, continuously working toward reducing the already very low doses to workers.

Worker dose control

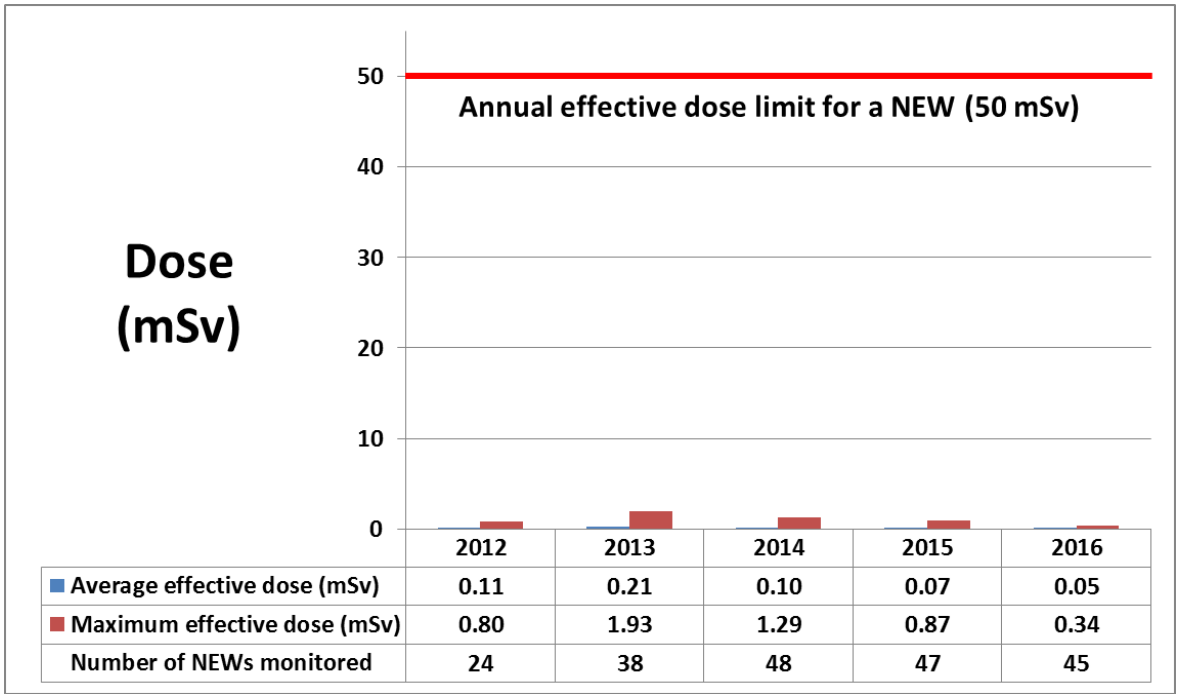
Inhalation, ingestion and absorption of tritium are the main radiological hazards faced by SRBT workers. SRBT ascertains internal tritium exposures through a urinalysis program that is part of its CNSC-licenced internal dosimetry service.

All workers employed at SRBT are identified as nuclear energy workers (NEWs). While contractors are not generally identified as NEWs, given that they do not perform radiological work, they are monitored per regulatory requirements and provided with training to ensure that doses remain ALARA and below the dose limit of 1 millisievert (mSv) per year. In 2016, no contractors were classified as NEWs, and none received a recordable dose due to work activities performed at the SRBT facility.

In 2016, none of the radiation exposures reported by SRBT for NEWs exceeded regulatory dose limits. The maximum effective dose received by a NEW in 2016 was 0.34 mSv, approximately 0.7% of the 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 between 2012 and 2016. Since 2013, there has been a downward trend in the average effective dose and maximum effective dose at SRBT, demonstrating SRBT's continued improvements to its radiation protection program.

Figure 8-3: Average and maximum effective doses to nuclear energy workers, SRBT, 2012–16



	2012	2013	2014	2015	2016
Average effective dose (mSv)	0.11	0.21	0.10	0.07	0.05
Maximum effective dose (mSv)	0.80	1.93	1.29	0.87	0.34
Number of NEWs monitored	24	38	48	47	45

Due to the uniform distribution of tritium in the 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.

Radiation protection program performance

For 2016, CNSC staff assessed the performance of SRBT's radiation protection program, through various CNSC staff compliance verification activities and desktop reviews. SRBT's compliance with the *Radiation Protection Regulations* [2] and CNSC licence requirements was deemed acceptable.

Action levels for effective doses to workers and urine bioassay are established as part of SRBT's radiation protection program. If an action level is reached, SRBT must establish the cause, notify the CNSC and, if applicable, restore the effectiveness of the program. There were no action level exceedances reported by SRBT in 2016.

Improvements in the performance of SRBT's radiation protection program led to a 31% decrease in collective dose in 2016 despite the fact that the total amount of tritium processed by SRBT was relatively stable in 2016 compared with the amounts in 2015. 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 SRBT tritium traps, continuous oversight by the Health Physics Committee, and expansion and improvement of radiation protection training for staff.

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. CNSC staff did not identify any adverse trends in the monitoring results in 2016. CNSC staff are satisfied with SRBT's radiological hazard control.

Estimated dose to the public

The maximum dose to the public from licensed activities at SRBT is calculated using monitoring results. The 2012 to 2016 maximum effective doses to a member of the public are shown in table 8-1. Doses to the public remain well below the regulatory dose limit of 1 mSv/year.

Table 8-1: Maximum effective dose to a member of the public, SRBT, 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory limit
Maximum effective dose (mSv)	0.0049	0.0068	0.0067	0.0068	0.0046	**1 mSv/year**

mSv = millisievert

8.3 Environmental protection

Overall compliance ratings for the environmental protection SCA, SRB Technologies (Canada) Inc., 2012–16

2012	2013	2014	2015	2016
SA	SA	SA	SA	SA
For 2016, CNSC staff rated the environmental protection SCA at SRBT as "satisfactory". SRBT's radioactive releases to the environment continue to be controlled and monitored to comply with the conditions of the operating licence and regulatory requirements. Throughout 2016, the measured releases of radiological substances to the environment were well below regulatory limits and there were no releases of hazardous substances from SRBT that would pose a risk to the public or environment. Monitoring of ambient air, groundwater, precipitation, runoff, surface water, produce and milk data around the facility indicates that the public and environment continue to be protected from facility releases.				

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 staff to effectively develop, implement and maintain their environmental protection programs.

Atmospheric emissions

SRBT monitors tritium releases from the facility stacks and reports them on an annual basis. The monitoring data for 2012 through 2016 (provided in table F-15, appendix F) demonstrate that atmospheric emissions from the facility continued to be effectively controlled, as they remain consistently below the licence limits.

In addition to licence limits, SRBT has action levels in place that are used to provide assurance that licence release limits will not be exceeded. 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 2016 at SRBT.

The fluctuations in total tritium released to air between 2012 and 2016 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 2012 through 2016 (provided in table F-16, 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 release limits will not be exceeded. No action levels were exceeded at any time in 2016.

Tritium liquid effluent releases decreased from 6.5 GBq in 2015 to 5.18 GBq in 2016. The decrease was achieved by implementing process improvements, leading to a lower tritium-in-air concentration during the summer, thus reducing the concentration of tritium in the air conditioner and dehumidifier drain water.

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 activities such as establishing annual environmental objectives and targets, 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 was conducting an annual management review (in accordance with CNSC requirements) and that identified issues are being addressed properly.

In 2016, SRBT revised and implemented several programs and procedures to ensure alignment with new CSA standards and a CNSC regulatory guidance document. Specifically, SRBT revised its EMS to align with REGDOC-2.9.1, *Environmental Protection Policies, Programs and Procedures* [14], and CSA N288.4-10, *Environmental monitoring at Class I nuclear facilities and uranium mines and mills* [8], in accordance with its transition plan to the CSA N288 series of standards. SRBT also revised its derived release limits documentation according to CSA N288.1-14, *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities* [14], and implemented several procedures consistent with CSA N288.4-10. In addition, SRBT developed and implemented an effluent monitoring program in compliance with N288.5-11, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* [9]. CNSC staff reviewed the submitted documentation from SRBT and determined that they meet the requirements outlined in the relevant CSA standards and REGDOC-2.9.1.

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 dose limit of 1 mSv and is ALARA. The principal monitoring activities, described below, are focused 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 Independent Environmental Monitoring Program (IEMP) to verify that the public and the environment around nuclear facilities remain safe.

Tritium in ambient air

SRBT has 40 passive air samplers located within a 2-kilometre 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 2016 air monitoring results from these samplers demonstrated that tritium levels in ambient air near SRBT remain low and have decreased to 33.44 Bq/m^3, compared with 54.74 Bq/m^3 in 2015.

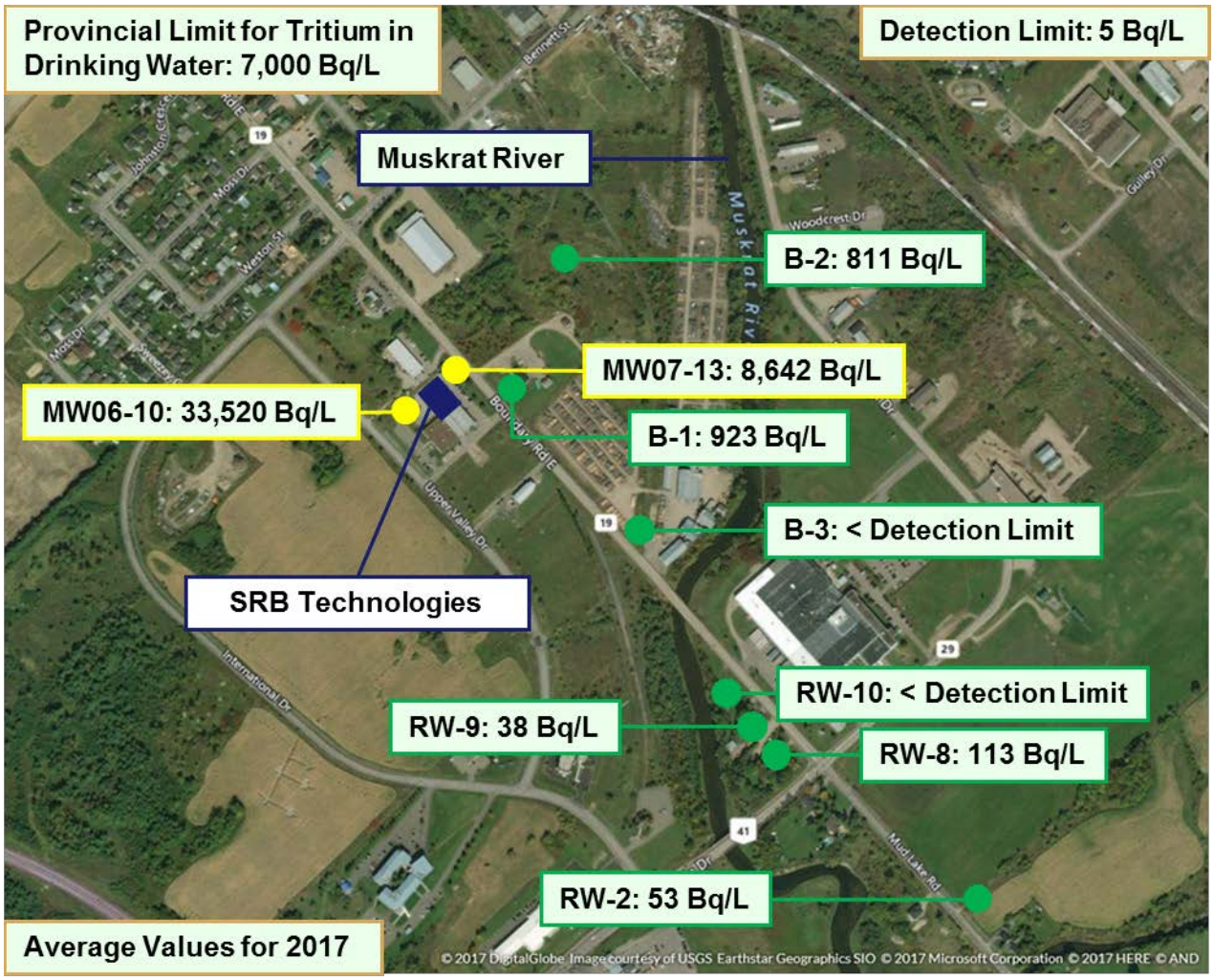
Groundwater monitoring

Groundwater is currently sampled from 34 monitoring wells around the facility plus an additional 15 residential and business wells. Out of all of the groundwater monitoring wells, two showed tritium concentrations exceeding 7,000 Bq/L at the conclusion of 2016. The highest tritium concentration was found in well MW06-10, which is located near the SRBT stacks, averaging 48,189 Bq/L in 2016. The wells exceeding 7,000 Bq/L 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.

Tritium concentrations decrease significantly at locations farther away from SRBT. In 2016, the highest tritium concentration in a potential drinking water well was found in residential well RW-08. It averaged 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, including the commissioning of improved tritium trap valves and remote display units, the real-time monitoring of gaseous effluent, and a reduction in the amount of failed leak tests of manufactured light sources. Along with the reduced emissions, the concentration of tritium in the groundwater is decreasing due to the natural decay of tritium and the flushing of historical tritium emissions through the groundwater system.

SRBT proactively conducted a gap analysis of its groundwater protection program against CSA N288.7-15, *Groundwater protection programs at Class I nuclear facilities and uranium mines and mills* [16], and consequently amended its groundwater protection program to meet the standard's requirements. SRBT identified gaps relating to the implementation of a groundwater protection program as part of the EMS, a groundwater monitoring program and a program outlining the maintenance and inspection of SRBT's groundwater monitoring wells. CNSC staff reviewed the submitted programs and determined that they meet the requirements set out in the outlined standards.

Figure 8-4: Annual average tritium concentrations in groundwater, SRBT, 2016



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 2016 monitoring data for these items are very low and consistent with previous years, with an average tritium concentration ranging between 3 Bq/L and 120 Bq/L for water runoff, surface water, milk and wine; and an average free-water tritium concentration of 72 Bq/kg for produce. 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 and safe. The next IEMP campaigns at SRBT are scheduled for 2018 and 2020.

Protection of the public

The licensee is required to demonstrate that adequate provisions are made to protect the health and safety of the public from exposures to hazardous (non-radiological) substances released from the facility. There were no releases of hazardous substances to the environment in 2016 from SRBT that would pose a risk to the public or environment.

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

Environmental risk assessment

In March 2015, CNSC staff informed SRBT that several environmental management standards would need to be included as part of the future licensing basis for the facility. CNSC staff requested that SRBT provide implementation dates, along with a gap analysis documenting the areas where SRBT's existing programs did not address the requirements of the standards.

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 environmental risk assessment in advance of its next licence renewal application, expected in 2020. In general, 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 Group requirements. SRBT currently has acceptable environmental programs in place to ensure the protection of the public and the environment.

8.4 Conventional health and safety

Overall compliance ratings for the conventional health and safety SCA, SRB Technologies (Canada) Inc., 2012–16

2012	2013	2014	2015	2016
FS	FS	FS	FS	FS

For 2016, CNSC staff continued to rate the conventional health and safety SCA at SRBT as "fully satisfactory". SRBT's implemented measures for conventional health and safety are highly effective, and overall compliance in this SCA remains stable. No LTIs have occurred in the past five years, and SRBT promptly addresses and reports any arising problems in accordance with regulatory requirements. SRBT also maintains an effective Workplace Health and Safety Committee. Overall, the compliance verification activities conducted by CNSC staff confirmed that SRBT continues to view conventional health and safety as an important consideration. SRBT has demonstrated the ability to keep its workers safe from occupational injuries.

FS = fully satisfactory

Performance

SRBT's performance related to conventional health and safety is monitored by CNSC staff using 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, 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 in a given year. An LTI is an injury that takes place at work and results in the worker being unable to return to work and carry out their duties for a period of time. Per table 8-2, no LTIs occurred at SRBT in 2016.

Table 8-2: Lost-time injuries, SRBT, 2012–16

	2012	2013	2014	2015	2016
Lost-time injuries	0	0	0	0	0

Practices

SRBT's activities and operations must comply with not only the NSCA [1] and its associated regulations, but also with Part II of the *Canada Labour Code* [5]. This means that SRBT is required to report incidents resulting in an injury to Employment and Social Development Canada. 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 2016, this committee met nine times. CNSC staff review the meeting minutes and any associated corrective actions through onsite inspections to ensure that issues were promptly resolved.

Awareness

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

9 Nordion (Canada) Inc.

Nordion (Canada) Inc. is located adjacent to industrial and residential property in Ottawa, Ontario, and is licensed to operate a Class IB nuclear substance processing facility. Nordion's licence 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 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.

Effective October 31, 2016, Nordion made the business decision to cease production and sale of iodine-125, iodine-131 and xenon-133. There was no impact to Nordion's environmental protection or to health and safety programs as a result of this change.

In its 2015 licence renewal application, Nordion indicated that it had historical neutron sources for which it could not find a disposal pathway. The Commission requested that Nordion provide updates on the disposal of these sources when a path forward had been determined. As reported in the 2015 regulatory oversight

report, Nordion was working with Energy Solutions, which was able to receive and dispose of these neutron sources. Nordion completed the shipment of the neutron sources to Canadian Nuclear Laboratories in July 2017. This Commission request is now closed.

Figure 9-2: Nordion personnel working with a hot cell manipulator

9.1 Performance

For 2016, CNSC staff rated all but two of Nordion's safety and control areas (SCAs) as "satisfactory". The exceptions were environmental protection and security, which were rated as "fully satisfactory". The performance ratings for the Nordion facility from 2012 to 2016 are provided in table C-6 of appendix C.

In 2016, Nordion ensured that its facility was maintained in accordance with the licensing basis. Nordion completed upgrades to existing systems and equipment as part of facility maintenance and continuous improvement.

No action levels or regulatory limits were exceeded in 2016. All measurable doses received by workers and the public were within the regulatory limits and no internal dose levels or limits were exceeded.

As required by the *Nuclear Safety and Control Act* (NSCA) [1], its associated regulations and Nordion's licence, Nordion submitted a total of 10 reports to the CNSC on events or incidents that occurred in 2016. CNSC staff reviewed these reports and concluded that none of the events or incidents compromised the health or safety of persons or the environment. Of the 10 reports, seven were related to packaging and transport (largely due to the fact that Nordion transports approximately 10,000 packages containing nuclear substances per year). These seven reports were related to low-risk items, such as incorrect shipping documents, errors in labelling, visible damage to Type A packages sustained in

transit, and incorrect activity listed on labels or documents. The remaining three event reports were also low risk, related to maintenance and shipping. CNSC staff have reviewed and are satisfied with the corrective actions taken by Nordion for all of the reports submitted in 2016.

In 2016, CNSC staff conducted three inspections at Nordion's facility to ensure compliance with the NSCA and its regulations, Nordion's operating licence and the programs used to meet regulatory requirements. A list of these inspections can be found in table J.6 of appendix J. The inspections focused on the following SCAs: operating performance, fitness for service, radiation protection, conventional health and safety, environmental protection, waste management, packaging and transport, and emergency management and fire protection. Seven enforcement actions were raised as a result of the inspections. CNSC staff concluded that the findings from these inspections posed a low risk to the achievement of regulatory objectives and CNSC expectations.

9.2 Radiation protection

Overall compliance ratings for the radiation protection SCA, Nordion, 2012–16

2012	2013	2014	2015	2016
SA	SA	SA	SA	SA
For 2016, CNSC staff continued to rate the radiation protection SCA at Nordion as "satisfactory". Nordion has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations* [2].				

SA = satisfactory

Application of ALARA

In 2016, Nordion continued to implement radiation protection measures at its facility to keep radiation exposures and doses to persons ALARA, while taking into account social and economic factors. Nordion's Environmental Health and Safety Committee meets regularly to discuss various aspects of the program, including worker doses, radiological-hazard monitoring results and internal audit results.

Worker dose control

Radiation exposures are monitored to ensure compliance with regulatory dose limits and with keeping radiation doses ALARA. In 2016, radiation exposures at Nordion were well below regulatory dose limits.

The main radiological hazards faced by workers 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 using dosimeters. For internal radiological exposures, Nordion has a screening program for routine thyroid monitoring of workers working with iodine-125 and

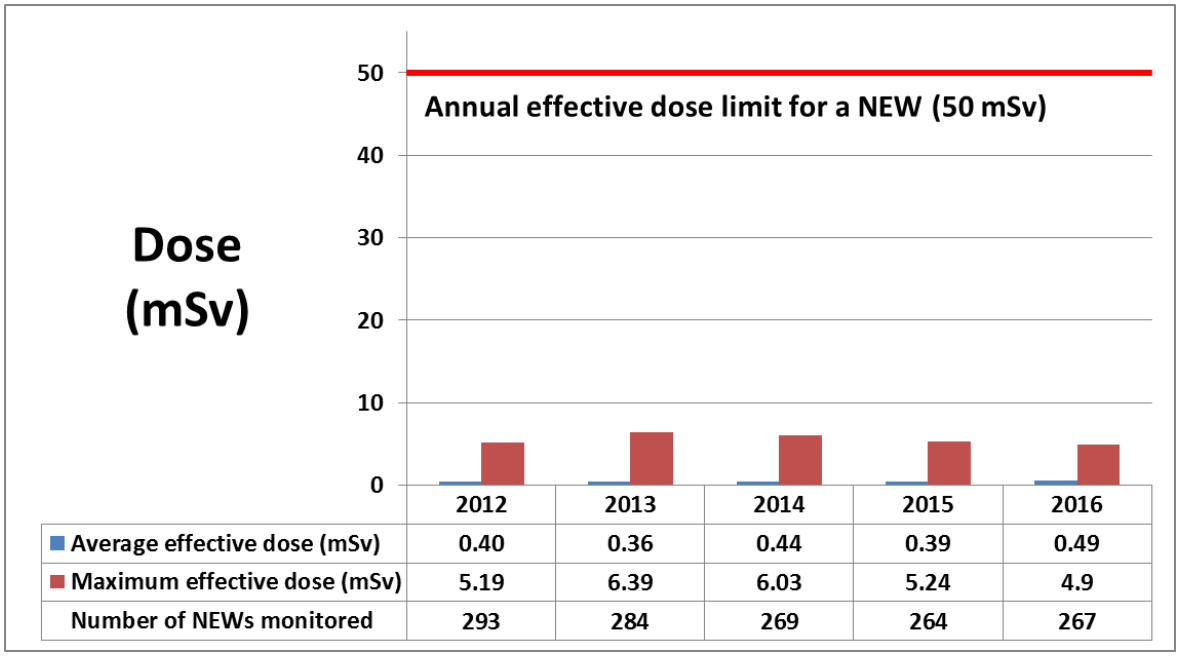
iodine-131. There are also provisions for whole-body counting and urinalysis in the event of elevated air or contamination monitoring results. There were no internal doses recorded in 2016.

All employees who work in or enter an area where radiological work is performed (such as the active area) have a reasonable probability of receiving an occupational dose greater than 1 millisievert (mSv) per year and are identified as nuclear energy workers (NEWs) per regulatory requirements. Radiation exposures are monitored for all NEWs to ensure compliance with regulatory dose limits and to maintain doses ALARA. Contractors are identified as non-NEWs, as they may enter the active area but do not perform any radiological work. They are monitored as required and provided with relevant training to ensure that doses remain less than the regulatory dose limit of 1 mSv/year and ALARA.

In 2016, the total effective dose was assessed for 267 NEWs at Nordion, consisting of 140 workers working in the active area and 127 workers who work primarily in the non-active area but may perform some work duties in the active area. All of the NEWs were Nordion employees. The maximum effective dose received by a NEW in 2016 was 4.9 mSv, approximately 10% of the 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 between 2012 and 2016. Average and maximum effective doses were relatively stable between 2012 and 2016.

Figure 9-3: Average and maximum effective doses to nuclear energy workers, Nordion, 2012–16



	2012	2013	2014	2015	2016
Average effective dose (mSv)	0.40	0.36	0.44	0.39	0.49
Maximum effective dose (mSv)	5.19	6.39	6.03	5.24	4.9
Number of NEWs monitored	293	284	269	264	267

Nordion also ascertained the total effective dose for contractors (non-NEWs) in 2016. Fifty-three contractors were monitored, and the maximum effective dose received by a contractor in 2016 was 0.36 mSv, 36% of the regulatory effective

dose limit of 1 mSv in a one-year dosimetry period. The average effective dose for contractors in 2016 was 0.07 mSv.

Annual average and maximum equivalent (skin) and equivalent (extremity) dose results from 2012 to 2016 are provided in tables E-12 and E-5 of appendix E. The maximum equivalent skin dose for all NEWs monitored at Nordion in 2016 was 5.2 mSv. The maximum equivalent extremity dose for workers in the active area was 8.3 mSv. These doses represent 1% and approximately 2% of the 500 mSv equivalent dose limits for the skin and extremities, respectively. Over the past five years, average equivalent extremity and skin doses have been relatively stable.

Radiation protection program performance

In 2016, CNSC staff assessed the performance of Nordion's radiation protection program through various compliance activities and desktop reviews. Nordion's compliance with the *Radiation Protection Regulations* [2] and CNSC licence requirements was acceptable.

Action levels (annual and by dosimetry period) are established as part of Nordion's radiation protection program. If an action level is reached, Nordion must establish the cause, notify the CNSC and, if applicable, restore the effectiveness of the program. No worker received a dose of radiation exceeding an action level during the year.

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. CNSC staff did not identify any adverse trends in the monitoring results in 2016 and are satisfied with Nordion's radiological hazard control.

Estimated dose to the public

The maximum dose to the public from licensed activities at Nordion is calculated using monitoring results. The 2012 to 2016 maximum effective doses to a member of the public are shown in table 9-1. In 2016, the dose to a member of the public was well below the regulatory dose limit of 1 mSv/year.

Table 9-1: Maximum effective dose to a member of the public, Nordion, 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory limit
Maximum effective dose (mSv)	0.020	0.022	0.010	0.0056	0.0021	**1 mSv/year**

mSv = millisievert

9.3 Environmental protection

Overall compliance ratings for the environmental protection SCA, Nordion, 2012–16

2012	2013	2014	2015	2016
FS	FS	FS	FS	FS
For 2016, 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 per 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 2016. Groundwater monitoring, soil sampling and gamma exposure measurements indicate that the public and the environment continue to be protected from facility releases.				

FS = fully 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 staff to effectively develop, implement and maintain their environmental protection programs.

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-17 of appendix F shows Nordion's radiological air emissions monitoring results from 2012 to 2016. The monitoring data demonstrate that the radiological air emissions from the facility in 2016 continued to be effectively controlled as they were consistently well below the DRLs prescribed in its operating licence.

In addition to licence limits, Nordion has action levels that are used to provide assurance that licence release 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 2016.

Nordion submitted a revised version of its DRLs document for review by CNSC staff to align with CSA N288.1-14, *Guidelines for calculating derived release limits for radioactive materials in airborne and liquid effluents for normal operation of nuclear facilities* [15]. CNSC staff have reviewed and accepted the updated DRLs for all atmospheric emissions (including xenon-135 and

xenon-135m). The updated DRLs will be included in Nordion's licence conditions handbook.

Liquid effluent

Nordion continues to collect, sample and analyze all liquid effluent releases prior to their discharge into the municipal sewer system. Table F-18 of appendix F shows Nordion's monitoring results of radiological liquid emissions from 2012 to 2016. The monitoring data demonstrate that the authorized radiological liquid effluent releases from the facility in 2016 continued to be effectively controlled as these releases were consistently well below the DRLs prescribed in Nordion's operating licence.

In addition to licence limits, Nordion has action levels that are used to provide assurance that licence release limits will not be exceeded. No action levels were exceeded in 2016.

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 Environmental Management System Manual and includes activities such as establishing annual environmental objectives and targets, which are reviewed and assessed by CNSC staff through compliance verification activities. Nordion's objectives during 2016 included reducing non-hazardous waste to landfill, reducing energy use and reducing particulate matter air emissions. By the end of 2016, Nordion had met or was in the process of meeting its targets for these objectives.

The EMS is verified through Nordion's 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 environmental health and safety objectives and targets, as well as any changing circumstances and recommendations for improvement. CNSC staff, as part of their compliance verification activities, review 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 (TLDs) 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 2012 are further described below.

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

Nordion made a commitment to complete a gap analysis of its environmental monitoring program against CSA N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [8], and CSA N288.5-11, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* [9], by May 31, 2016. Nordion completed its gap analysis and submitted it for CNSC review. 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. The 2005 results were all near background levels or the detection limit. Nordion's monitoring is conducted at least once per year to ensure that no significant changes have occurred since monitoring began. The monitoring results from 2012 to 2016 demonstrate that there were no significant changes to concentrations of hazardous substances in the groundwater (relative to 2005).

Nordion began radiological sampling for groundwater in 2013. The results since then have detected only naturally occurring radionuclides that are not processed at the Nordion facility. These results, which are either below detection limits or at natural background levels, indicate that releases of radioactive and hazardous substances from Nordion's facility have had no measurable impact on groundwater quality.

Soil sampling

Nordion conducts soil sampling every two years to monitor concentrations of radiological materials. Nordion performed soil sampling in 2012, 2014 and 2016 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.

Environmental thermoluminescent dosimeters program

Nordion monitors environmental gamma radiation by using TLDs. The dosimeters are deployed at locations to generally cover the points of a compass and preferentially to the east of the facility, which is the direction of the prevailing winds. TLDs are also placed in residences of Nordion employees located near the facility. The annual monitoring results for 2016 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 Independent Environmental Monitoring Program (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 and safe. The next IEMP campaigns at Nordion are scheduled for 2018 and 2020.

Protection of the public

The licensee is required to demonstrate that adequate provisions are made to protect the health and safety of the public from exposures to hazardous (non-radiological) substances released from the facility. There are no releases of hazardous substances to the environment from Nordion that would pose a risk to the public or environment.

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

Environmental risk assessment

Nordion 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 risk assessment in accordance with CSA N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3], by May 31, 2016. CNSC staff have reviewed and accepted Nordion's environmental risk assessment.

9.4 Conventional health and safety

Overall compliance ratings for the conventional health and safety SCA, Nordion (Canada) Inc., 2012–16

2012	2013	2014	2015	2016
FS	FS	SA	SA	SA
For 2016, CNSC staff continued to rate the conventional health and safety SCA at Nordion 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 by CNSC staff using 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 2016, including improvements to incident, near-miss and hazard

identification reporting; the development of a formal occupational health and safety manual; and quarterly safety focus talks with staff.

A key performance measure for this SCA is the number of lost-time injuries (LTIs) that occur per year. An LTI is an injury that takes place at work and results in the worker being unable to return to work to carry out their duties for a period of time. As indicated in table 9-4, there were three LTIs at Nordion in 2016. The LTIs included wasp stings as well as back and shoulder injuries, which combined resulted in 90.25 days of lost time. For each LTI that occurred, Nordion conducted an investigation and implemented corrective actions (summarized in table G-2, appendix G). CNSC staff reviewed the corrective actions and are satisfied with the actions taken by Nordion to prevent reoccurrence.

Table 9-4: Lost-time injuries, Nordion, 2012–16

	2012	2013	2014	2015	2016
Lost-time injuries	0	1	3	0	3

Practices

Nordion's activities and operations must comply with not only the NSCA [1] and its 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 10 times in 2016. CNSC staff review the meeting minutes and any associated corrective actions during onsite inspections to ensure that issues were 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.

BTL manufactures medical equipment, including cobalt-60 radiation therapy units and cesium-137 blood irradiators. Figure 10-2 shows an image of a teletherapy machine manufactured by BTL.

Figure 10-1: Aerial view of the BTL facility

Figure 10-2: Teletherapy machine 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 megaelectronvolt.

On August 24, 2015, a CNSC designated officer issued an order to BTL following its failure to comply with a condition of the Commission-issued licence NSPFOL-14.01/2019, which imposed requirements on BTL to provide an acceptable financial guarantee by July 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 [17], and again on February 29, 2016 [18].

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 [19], and BTL then submitted the financial guarantee to the full amount. BTL is now in compliance with its financial guarantee licence condition, and the order has been closed by the Commission.

There were no licence amendments in 2016 and no revisions to the licence conditions handbook.

10.1 Performance

For 2016, CNSC staff rated BTL's performance as "satisfactory" in all safety and control areas (SCAs). The performance ratings for BTL from 2015 to 2016 are provided in table C-7 of appendix C.

In 2016, CNSC staff conducted three onsite inspections at the BTL facility to verify compliance with the *Nuclear Safety and Control Act* (NSCA) [1] and its regulations, BTL's operating licence and the programs used to meet regulatory requirements. A fourth inspection was conducted to verify monthly reporting requirements as part of the order issued in August 2015. A list of these inspections can be found in table J-7 of appendix J. The inspections focused on the operating performance, fitness for service, radiation protection, conventional health and safety, and environmental protection SCAs. Thirteen enforcement actions were raised as a result of the inspections. CNSC staff concluded that the findings from these inspections posed a low risk to the achievement of regulatory objectives and CNSC expectations.

There were no reportable action level exceedances in 2016. There were three lost-time injuries (LTIs) in 2016.

10.2 Radiation protection

Overall compliance ratings for the radiation protection SCA, Best Theratronics Ltd., 2012–16

2012	2013	2014	2015	2016
SA	SA	SA	SA	SA
For 2016, 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].				

SA = satisfactory

Application of ALARA

In 2016, BTL continued to implement radiation protection measures to keep radiation exposures and doses to persons ALARA, while taking into account social and economic factors. 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.

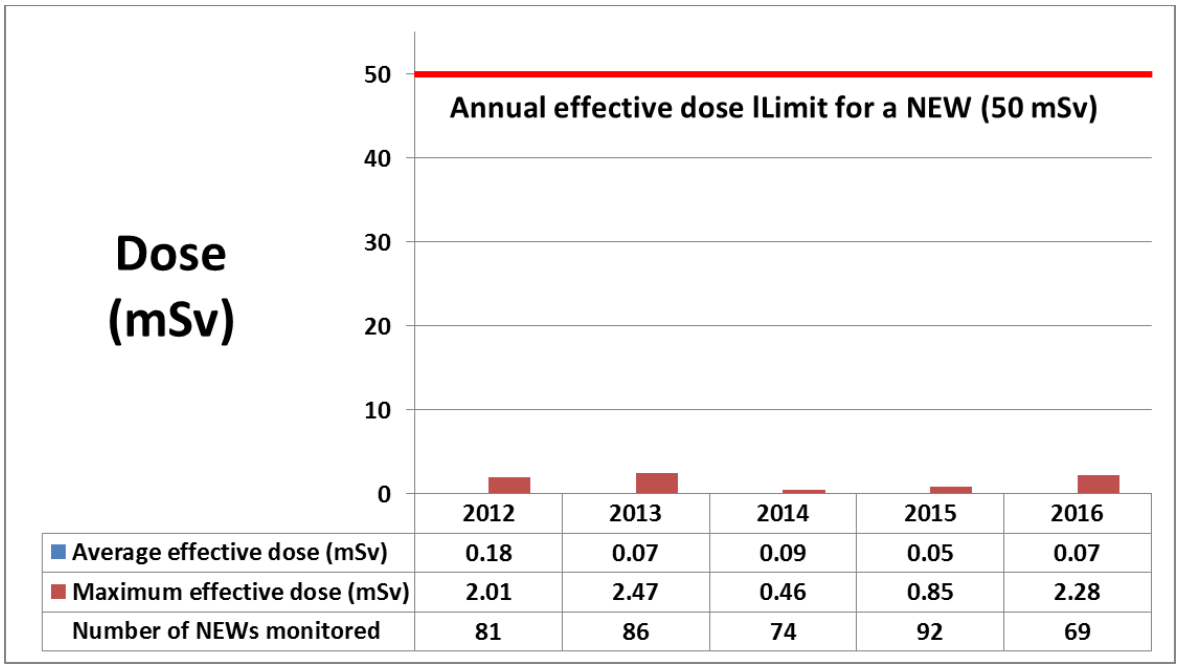
Worker dose control

Radiation exposures are monitored to ensure compliance with regulatory dose limits and with keeping radiation doses ALARA. In 2016, radiation exposures at BTL were well below regulatory dose limits.

BTL workers are exposed externally to sealed sources of radiation. At BTL, employees are classified as nuclear energy workers (NEWs) if they are expected to have a reasonable probability of receiving an occupational dose greater than 1 millisievert (mSv). Such workers include service technicians and source handlers. External whole-body and equivalent doses are ascertained using dosimetry. In 2016, the maximum effective dose received by a NEW at BTL was 2.28 mSv, approximately 4.6% of the regulatory limit for an 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 between 2012 and 2016. Over the past five years, annual effective doses at BTL have remained stable and very low.

Figure 10-3: Average and maximum effective doses to nuclear energy workers, BTL, 2012–16



	2012	2013	2014	2015	2016
Average effective dose (mSv)	0.18	0.07	0.09	0.05	0.07
Maximum effective dose (mSv)	2.01	2.47	0.46	0.85	2.28
Number of NEWs monitored	81	86	74	92	69

Annual average and maximum equivalent (extremity) dose results from 2012 to 2016 are provided in table E-6 of appendix E. The maximum equivalent extremity dose for 2016 was 29.9 mSv, which is well below the annual limit of 500 mSv/year, but higher than in previous years. BTL identified that two workers had elevated extremity doses. BTL performed an investigation into the elevated extremity doses and determined that the workers had performed a high volume of source loads with a particular piece of equipment in 2016. As a corrective measure, BTL has ensured that when such loadings are scheduled, no other installations or disposals will be scheduled in the same month. In addition, BTL recently lowered its radiation protection administrative and action levels as a result of a CNSC inspection. CNSC staff are satisfied with the corrective measures implemented by BTL.

Over the past five years, average extremity equivalent doses have been relatively stable, between approximately 0.2 mSv and 2 mSv. Equivalent skin doses are also ascertained; however, due to the nature of exposure, they are essentially equal to the effective dose and are therefore not included in this report.

BTL workers identified as non-NEWs, such as administrative staff, do not have access to active areas where radiation is present. As a result, they do not receive reportable doses and are not directly monitored.

Radiation protection program performance

In 2016, radiation protection program performance at BTL was assessed through various CNSC staff compliance activities and desktop reviews. BTL's compliance with the *Radiation Protection Regulations* [2] and CNSC licence requirements was acceptable.

Action levels for effective doses for various categories of workers have been established in order to alert BTL management of a potential loss of control of the radiation protection program. If an action level is reached, BTL staff must establish the cause and, if applicable, restore the effectiveness of the radiation protection program. In 2016, 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.

Because the majority of the radioisotopes in use at BTL are sealed sources, the potential for contamination is very low. Still, 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 also following any work where the potential for contamination exists. Routine contamination swipes at the BTL facility indicate no presence of contamination.

Monthly dose rate measurements are also performed in all radiation areas. In addition, fixed dose rate monitors are in place with set alarm thresholds in a variety of designated locations within the BTL facility. These measurements and alarm thresholds help to ensure a safe workplace. CNSC staff did not identify any adverse trends in the monitoring results in 2016 and are satisfied with BTL's radiological hazard control.

Estimated dose to the public

No activities that occur inside the BTL facility 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 impact to members of the public is insignificant and non-measurable.

10.3 Environmental protection

Overall compliance ratings for the environmental protection SCA, Best Theratronics Ltd., 2014–16

2014	2015	2016
SA	SA	SA
For 2016, 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 2016, there were no releases of hazardous (non-radiological) substances to the environment that would pose a risk to the public or the environment. Environmental monitoring is not conducted around the facility. BTL has implemented an environmental management system (EMS) to conform to CNSC REGDOC-2.9.1, *Environmental Protection Policies, Programs and Procedures* [14].		

SA = satisfactory

Effluent and emissions control (releases)

There are no radiological 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 shield 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 EMS to conform to REGDOC-2.9.1, *Environmental Protection Policies, Programs and Procedures* [14], a requirement of its Class IB licence. CNSC staff have verified that BTL continues to meet the requirements outlined in the regulatory document.

Assessment and monitoring

As there are no radiological releases that require controls or monitoring, BTL does not conduct environmental monitoring around its facility.

Protection of the public

The licensee is required to demonstrate that adequate provisions are made to protect the health and safety of the public from exposures to hazardous substances released from the facility. Because the BTL facility uses only sealed sources, the

risk of radiation exposure to members of the public from normal operations is very low.

Environmental risk assessment

BTL included an environmental risk assessment 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 environment.

In 2013, BTL contracted a third party to conduct modelling to support its Environmental Compliance Approval application to the Ontario Ministry of the Environment and Climate Change. 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

Overall compliance ratings for the conventional health and safety SCA, Best Theratronics Ltd., 2014–2016

2014	2015	2016
SA	SA	SA
For 2016, 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 by CNSC staff using onsite inspections and event reviews. BTL continues to develop and maintain a comprehensive occupational health and safety management program for its facility. BTL'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.

A key performance measure for this SCA is the number of LTIs that occur per year. An LTI is an injury that takes place at work and results in the worker being unable to return to work and carry out their duties for a period of time. As indicated in table 10-1, there were three LTIs reported at the BTL facility in 2016. The LTIs included injured fingers and a broken wrist, which resulted in a combined three days of lost time. For each LTI that occurred, BTL conducted an

investigation and implemented corrective actions (which are summarized in table G-3, appendix G). CNSC staff reviewed the corrective actions and are satisfied with the actions taken by BTL to prevent reoccurrence.

Table 10-1: Lost-time injuries, BTL, 2014–2016

	2014	2015	2016
Lost-time injuries	1	1	3

Practices

BTL's activities and operations must comply with not only the NSCA [1] and its regulations, but also 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 were 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 action.

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, as well as workplace hazards, through training and ongoing internal communications with BTL.

11 Overall conclusions

This report summarizes the CNSC staff assessment on the performance of uranium and nuclear substance processing facilities in Canada in 2016. CNSC staff concluded that these facilities operated safely during this reporting period. This conclusion is based on assessments of licensee activities that included site inspections, reviews of reports submitted by licensees, and event and incident reviews, supported by CNSC staff follow-up and general communication with the licensees.

For 2016, the performance in all 14 safety and control areas (SCAs) for the facilities were as follows:

- Uranium processing facilities were rated as “satisfactory” or better.
- Nuclear substance processing facilities were rated as “satisfactory” or better.

CNSC staff’s compliance activities confirmed 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 the environment
- conventional health and safety programs at all facilities continued to protect workers

CNSC staff will continue to provide regulatory compliance oversight to all licensed facilities. This will ensure that licensees continue to make adequate provision to protect the health, safety and security of workers, Canadians and the environment; and continue to implement Canada’s international obligations on the peaceful use of nuclear energy.

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Acronyms and abbreviations

ALARA	as low as reasonably achievable
BE	below expectations
Bq	becquerel
BRR	Blind River Refinery
BTL	Best Theratronics Ltd.
BWXT	BWXT Nuclear Energy Canada Inc.
Cameco	Cameco Corporation
CANDU	Canada Deuterium Uranium
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
COC	contaminants of concern
CSA	Canadian Standards Association (now CSA Group)
DRL	derived release limit
EMS	environmental management system
ESDC	Employment and Social Development Canada (formerly Human Resources and Skills Development Canada)
FINAS	Fuel Incident Notification and Analysis System
g	gram
GBq	gigabecquerel
GCQWQ	*Guidelines for Canadian Drinking Water Quality*
GEH-C	GE Hitachi Nuclear Energy Canada Inc.
GTLS	gaseous tritium light source
h	hour
HNO_3	nitric acid
IAEA	International Atomic Energy Agency
IEMP	Independent Environmental Monitoring Program
kg	kilogram

L	litre
LCH	licence conditions handbook
LTI	lost-time injury
m^3	cubic meters
MeV	megaelectronvolt
mg/L	milligram per litre
MFN	Mississauga First Nation
mSv	millisievert
MOECC	Ontario Ministry of the Environment and Climate Change
NEW	nuclear energy worker
NOx	nitrogen oxides
NO_2	nitrogen dioxide
Nordion	Nordion (Canada) Inc.
NSCA	*Nuclear Safety and Control Act*
PHCF	Port Hope Conversion Facility
ppm	parts per million
SA	satisfactory
SCA	safety and control area
SI	International System of Units
SRBT	SRB Technologies (Canada) Inc.
TBq	terabecquerel
TLD	thermolumisnescent dosimeters
UA	unacceptable
µg	microgram
µSv	microsievert
UF_6	uranium hexafluoride
UO_2	uranium dioxide
UO_3	uranium trioxide
VIM	Vision in Motion
WSC	Workplace Safety Committee

Glossary

action levels	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 Group standard 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 Group publication 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 seiverts) of equivalent dose to a specified tissue or organ from any type(s) of radiation can be compared

	directly.
lost-time injury	An occupational injury or illness incident resulting in lost days beyond the date of injury as a direct result of the injury or illness.
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 Canadian Nuclear Safety Commission (CNSC) evaluates how well licensees meet regulatory requirements and CNSC expectations for the performance of their programs in 14 safety and control areas (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
	Operating performance	Includes an overall review of the conduct of 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

Functional area	Safety and control area	Definition	Specific areas
			▪ 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 affect the ability of structures, systems and components to meet and maintain their design basis, given new information as it arises over time and taking changes in the external environment into account.	▪ Design governance ▪ Site characterization ▪ Facility design ▪ Structure design ▪ System design ▪ Component design
	Fitness for service	Covers activities that impact the physical condition of structures, systems and components to ensure that they remain effective. 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 the effects on the environment from facilities or as the result of licensed activities.	▪ Effluent and emissions control (releases) ▪ Environmental management system ▪ 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
	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	▪ Package design and maintenance

Functional area	Safety and control area	Definition	Specific areas
		licensed facility.	▪ 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

The ratings used to evaluate licensee performance in the Canadian Nuclear Safety Commission (CNSC) safety and control areas (SCAs) are defined as follows:

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 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 only 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 or applicant 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 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 an 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: Safety and control area ratings, Blind River Refinery, 2012–16

Safety and control areas	2012 rating	2013 rating	2014 rating	2015 rating	2016 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	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: Safety and control area ratings, Port Hope Conversion Facility, 2012–16

Safety and control areas	2012 rating	2013 rating	2014 rating	2015 rating	2016 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-3: Safety and control area ratings, Cameco Fuel Manufacturing Inc., 2012–16

Safety and control areas	2012 rating	2013 rating	2014 rating	2015 rating	2016 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: Safety and control area ratings, BWXT Nuclear Energy Canada Inc., 2012–16

Safety and control areas	2012 rating	2013 rating	2014 rating	2015 rating	2016 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	FS	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: Safety and control area ratings, SRB Technologies (Canada) Inc., 2012–16

Safety and control areas	2012 rating	2013 rating	2014 rating	2015 rating	2016 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	FS	FS	FS
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	N/A*	N/A	N/A	N/A	N/A
Packaging and transport	SA	SA	SA	SA	SA

FS = fully satisfactory; NA = not available; SA = satisfactory
* There are no safeguard verification activities associated with this facility.

Table C-6: Safety and control area ratings, Nordion (Canada) Inc., 2012–16

Safety and control areas	2012 rating	2013 rating	2014 rating	2015 rating	2016 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	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 Safety and control area ratings, Best Theratronics Ltd., 2014–2016

Safety and control areas	2014 rating	2015 rating	2016 rating
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	SA	SA	SA
Radiation protection	SA	SA	SA
Conventional health and safety	SA	SA	SA
Environmental protection	SA	SA	SA
Emergency management and fire protection	SA	BE	SA
Waste management	SA	SA	SA
Security	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA
Packaging and transport	SA	SA	SA

BE = below expectations; SA = satisfactory

D. Financial guarantees

Table D-1: Financial guarantees, uranium processing facilities

Facility	Canadian dollar amount
Blind River Refinery	$38,600,000
Port Hope Conversion Facility	$128,600,000
Cameco Fuel Manufacturing Inc.	$19,500,000
BWXT Peterborough	$6,803,500
BWXT Toronto	$45,568,100

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

Facility	Canadian dollar amount
SRB Technologies (Canada) Inc.	$652,488
Nordion (Canada) Inc.	$45,124,748
Best Theratronics Ltd.	$1,800,000

E. Worker dose data

Extremity doses: uranium processing facilities

Table E-1: Equivalent (extremity) dose statistics for nuclear energy workers, Blind River Refinery, 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory limit
Average extremity dose (mSv)	11.4	14.1	5.4	1.5	1.2	**N/A**
Maximum individual extremity dose (mSv)	47.6	35.1	48.2	15.3	10.6	**500 mSv/year**

mSv = millisievert; N/A = not available

Table E-2: Equivalent (extremity) dose statistics for nuclear energy workers, Cameco Fuel Manufacturing Inc., 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory limit
Average extremity dose (mSv)	16.5	14.3	15.5	15.5	13.2	**N/A**
Maximum individual extremity dose (mSv)	107.5	87.6	88.4	87.0	98.4	**500 mSv/year**

mSv = millisievert; N/A = not available

Table E-3: Equivalent (extremity) dose statistics for nuclear energy workers, BWXT Peterborough, 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory limit
Average extremity dose (mSv)	11.56	10.47	18.64	12.61	9.78	**N/A**
Maximum individual extremity dose (mSv)	58.82	76.03	98.98	39.34	32.84	**500 mSv/year**

mSv = millisievert; N/A = not available

Table E-4: Equivalent (extremity) dose statistics for nuclear energy workers, BWXT Toronto, 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory limit
Average extremity dose (mSv)	46.41	32.92	31.96	30.30	27.71	**N/A**
Maximum individual extremity dose (mSv)	357.29	143.59	102.44	109.62	119.47	**500 mSv/year**

mSv = millisievert; N/A = not available

Extremity doses: nuclear substance processing facilities

Table E-5: Equivalent (extremity) dose statistics for nuclear energy workers, Nordion (Canada) Inc., 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory limit
Average extremity dose (mSv)	0.54	0.54	0.73	0.46	0.79	**N/A**
Maximum individual extremity dose (mSv)	10.3	7.4	9.5	9.3	8.3	**500 mSv/year**

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

Table E-6: Equivalent (extremity) dose statistics for nuclear energy workers, Best Theratronics Ltd., 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory limit
Average extremity dose (mSv)	0.23	0.36	0.37	0.31	1.85	**N/A**
Maximum individual extremity dose (mSv)	2.9	6.1	3.7	2.1	29.9	**500 mSv/year**

mSv = millisievert; N/A = not available

Skin doses: uranium processing facilities

Table E-7: Equivalent (skin) dose statistics for nuclear energy workers, Blind River Refinery, 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory limit
Average skin dose (mSv)	6.0	6.8	5.4	4.0	3.3	**N/A**
Maximum individual skin dose (mSv)	39.2	41.4	41.2	28.1	26.0	**500 mSv/year**

mSv = millisievert; N/A = not available

Table E-8: Equivalent (skin) dose statistics for nuclear energy workers, Port Hope Conversion Facility, 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory limit
Average skin dose (mSv)	0.7	1.7	0.6	0.8	0.8	**N/A**
Maximum individual skin dose (mSv)	16.3	28.6	10.3	23.4	16.9	**500 mSv/year**

mSv = millisievert; N/A = not available

Table E-9: Equivalent (skin) dose statistics for nuclear energy workers, Cameco Fuel Manufacturing Inc., 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory limit
Average skin dose (mSv)	6.5	7.3	8.1	6.3	6.6	**N/A**
Maximum individual skin dose (mSv)	93.2	88.4	108.4	95.6	95.7	**500 mSv/year**

mSv = millisievert; N/A = not available

Table E-10: Equivalent (skin) dose statistics for nuclear energy workers, BWXT Peterborough facility, 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory limit
Average skin dose (mSv)	5.04	3.8	4.75	4.1	2.66	**N/A**
Maximum individual skin dose (mSv)	36.99	31.20	29.91	22.47	21.15	**500 mSv/year**

mSv = millisievert; N/A = not available

Table E-11: Equivalent (skin) dose statistics for nuclear energy workers, BWXT Toronto facility, 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory limit
Average skin dose (mSv)	12.45	10.29	11.08	9.89	10.23	**N/A**
Maximum individual skin dose (mSv)	58.40	52.84	51.67	54.99	74.26	**500 mSv/year**

mSv = millisievert; N/A = not available

Skin doses: nuclear substance processing facilities

Table E-12: Equivalent (skin) dose statistics for nuclear energy workers, Nordion (Canada) Inc., 2012–16

Dose data	2012	2013	2014	2015	2016	Regulatory limit
Average skin dose (mSv)	0.40	0.42	0.46	0.42	0.59	**N/A**
Maximum individual skin dose (mSv)	5.19	6.39	6.11	5.21	5.2	**500 mSv/year**

mSv = millisievert; N/A = not available

F. Environmental data

Blind River Refinery

Table F-1: Annual groundwater monitoring results, 2012–16

Parameter	2012	2013	2014	2015	2016	GCDWQ*
Average uranium concentration (µg/L)	0.3	0.5	0.6	1.7	1.3	**20**
Maximum uranium concentration (µg/L)	2.0	3.7	8.9	18.5	14.0	**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, 2012–16

Parameter	2012	2013	2014	2015	2016	CCME guidelines*
Average uranium concentration (µg/L)	0.2	0.4	<0.2	0.2	<0.8**	**15**
Average nitrate concentration (mg/L as N)	0.1	0.3	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	7.4	7.2	7.6	7.3	8.0	**6.5–9.0**

Bq/l = becquerel per litre; CCME = Canadian Council of Ministers of the Environment; mg/L = milligrams per litre; µg/L = microgram per litre
Note: Results less than 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, 2012–16

Parameter	2012	2013	2014	2015	2016	CCME guidelines*
Minimum uranium concentration (µg/g)	0.1	0.1	0.1	0.1	0.2	**23**
Average uranium concentration (µg/g) (within 1,000 m, 0–5 cm depth)	3.3	4.3	2.7	3.8	1.5	
Maximum uranium concentration (µg/g)	12.1	16.4	7.2	9.7	2.9	

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 of concern removed by pumping wells, 2012–16

COC	2012	2013	2014	2015	2016
Uranium	27.7	28.9	31.0	25.3	22.8
Fluoride	60.4	51.1	53.0	48.3	36.9
Ammonia	34.7	53.0	75.0	63.7	73.6
Nitrate	37.5	41.0	53.0	44.0	42.6
Arsenic	3.1	2.8	2.5	2.6	1.9

COC = contaminants of concern; kg = kilogram

Table F-5: Harbour water quality, 2012–16

Parameter	Value	2012	2013	2014	2015	2016	CCME* guidelines
Uranium (µg/L)	Average	3.7	3.3	3.3	2.9	2.6	**15**
	Maximum	10	8.3	7.6	6.6	10	
Fluoride (mg/L)	Average	0.099	0.10	0.11	0.13	0.15	**0.12**
	Maximum	0.14	0.18	0.39	0.17	0.22	
Nitrate (mg/L)	Average	0.83	0.84	0.86	0.89	0.85	**13**
	Maximum	1.5	1.6	1.5	1.7	1.6	
Ammonia + Ammonium (mg/L)	Average	0.10	0.11	0.23	0.20	0.16	**0.3**
	Maximum	0.40	0.35	0.52	0.66	0.58	

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), 2012–16

Soil depth (cm)	2012	2013	2014	Soil depth (cm)	2015	2016	CCME guidelines *
0–2	1.4	1.0	1.4	**0–5**	1.0	1.2	**23**
2–6	1.1	0.9	1.2				
6–10	1.3	1.0	1.1	**5–10**	1.0	1.1	
10–15	1.5	1.0	1.1	**10–15**	1.2	1.0	
70 cm composite	1.2	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, 2012–16

Parameter	2012	2013	2014	2015	2016	MOECC guidelines*
Fluoride in vegetation (ppm)	2.1	5.6	2.6	3.2	3.0	**35**

MOECC = Ontario Ministry of the Environment and Climate Change; ppm = parts per million
***** MOECC's upper limit of normal guidelines

Table F-8: Gamma monitoring results, annual average, 2012–16

Parameter	2012	2013	2014	2015	2016	Licence limit
Site 1 (µSv/h)	0.011	0.007	0.003	0.007	0.005	**0.14**
Site 2 (Dorset Street)) (µSv/h)	0.056	0.058	0.054	0.044	0.054	**0.40**

µSv = microsievert

Cameco Fuel Manufacturing Inc.

Table F-9: Soil monitoring results*

Parameter	2010	2013	2016	CCME guidelines**
Average uranium concentration (µg/g)	4.5	3.7	2.5	**23**
Maximum uranium concentration (µg/g)	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-10: Air emission and liquid effluent monitoring results, 2012–16

Parameter	2012	2013	2014	2015	2016	Licence limit
Uranium discharged to air (kg/year)	0.0172	0.0104	0.0109	0.0108	0.0108	**0.76**
Uranium discharged to sewer (kg/year)	0.90	0.83	0.72	0.39	0.65	**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-11: Uranium in boundary air monitoring results, 2012–16

Parameter	2012	2013	2014	2015	2016
Average concentration (µg/m^3)	0.001	0.001	0.001	0.001	0.001

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

Table F-12: Uranium in soil monitoring results, 2012–14

Parameter	BWXT property			Industrial/commercial lands			Residential locations		
	2012	2013	2014	2012	2013	2014	2012**	2013	2014
Number of samples	–	1	1	–	24	34	49	24	14
Average uranium concentration (µg/g)	–	2.3	2.3	–	3.9	5.0	1.9	1.1	0.6
Maximum uranium concentration (µg/g)	–	2.3	2.3	–	24.9	22.1	10.8	3.1	2.1
CCME guidelines (µg/g)*	300			33			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*

****** In 2012 there was no distinction among the three CCME property uses. All results were compared with the most stringent use, residential, which is 23 µg/g.

Table F-13: Uranium in soil monitoring results, 2015–16

Parameter	BWXT property		Industrial/commercial lands		Residential locations	
	2015	2016	2015	2016	2015	2016
Number of samples	1	1	30	34	18	14
Average uranium concentration (µg/g)	1.4	1.2	2.9	2.7	0.7	0.5
Maximum uranium concentration (µg/g)	1.4	1.2	8.7	13.6	2.1	0.7
CCME guidelines (µg/g)*	**300**		**33**		**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-14: Air emissions and liquid effluent monitoring results, 2012–16

Parameter	2012	2013	2014	2015	2016	Licence limit
Uranium discharged to air (kg/year)	0.000005	0.000013	0.000003	0.000003	0.000004	**0.55**
Uranium discharged to sewer (kg/year)	0.0001	0.0002	0.0001	0.0001	0.0001	**760**

kg = kilogram

SRB Technologies (Canada) Inc.

Table F-15: Atmospheric emissions monitoring results, 2012–16

Parameter	2012	2013	2014	2015	2016	Licence limit (TBq/year)
Tritium as tritium oxide (HTO), TBq/year	8.36	17.82	10.71	11.55	6.29	**67**
Total tritium as HTO + HT, TBq/year	29.90	78.88	66.16	56.24	28.95	**448**

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

Table F-16: Liquid effluent monitoring results, 2012–16

Parameter	2012	2013	2014	2015	2016	Licence limit (TBq/year)
Tritium-water soluble, TBq/year	0.012	0.009	0.013	0.007	0.005	**0.200**

TBq = terabecquerel

Nordion (Canada) Inc.

Table F-17: Air emissions monitoring results, 2012–16

Parameter	2012	2013	2014	2015	2016	Licence limit (DRL) (GBq/year)
Cobalt-60	0.006	0.005	0.005	0.005	0.006	70.1
Iodine-125	0.46	0.23	0.14	0.12	0.21	4,880
Iodine-131	0.40	0.39	0.46	0.15	0.35	3,790
Xenon-133	36,153	30,735	15,018	11,916	7,277	61,200,000
Xenon-135	23,943	28,193	13,075	8,237	4,299	7,660,000
Xenon-135m	39,498	43,383	18,170	10,758	5,421	4,600,000

DRL = derived release limit; GBq = gigabecquerel

Table F-18: Liquid effluent monitoring results, 2012–16

Parameter	2012	2013	2014	2015	2016	Licence limit (DRL) (GBq/year)[1]
β < 1 MeV	0.261	0.288	0.209	0.191	0.222	66,000
β > 1 MeV	0.060	0.065	0.050	0.044	0.051	210,000
Iodine-125	0.005	0.005	0.051	0.111	0.144	73,600
Iodine-131	0.009	0.009	0.006	0.006	0.006	23,300
Molybdenum-99	0.075	0.077	0.055	0.06	0.052	1,120,000
Cobalt-60	0.017	0.022	0.018	0.019	0.026	155,000
Niobium-95	0.0002	0.0006	0.0007	0.0010	0.001	558,000
Zirconium-95	0.0003	0.0006	0.0005	0.0010	0.0015	749,000
Cesium-137	0.0004	0.0005	0.0004	0.0004	0.0007	137,000

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

G. Lost-time injuries in 2016

Table G-1: Lost-time injuries, Port Hope Conversion Facility, 2016

Lost-time injury	Action taken
An employee was cutting a piece of steel in the cutting booth. Their left hand was placed on the ground clip that was installed on the cutting table. A cut to the final piece of steel caused it to fall over, crushing the end of the employee's finger between the ground clip and the piece of steel. This injury led to a lost-time incident with four days of lost time.	As a result of this event, Cameco implemented the following corrective actions: • developed a new procedure for safe use and operation of the plasma cutter • completed training needs analysis for the cutting procedure • conducted a lighting survey of the cutting booth • linked the plasma cutting activity to a process hazard analysis • moved the plasma cutter grounding clamp to another location (the leg of the work table) • installed an additional clamp to hold materials during the cutting process, thus moving employees' hands away from the object • purchased a new lens for welding/cutting helmets, which transitions more quickly to minimize the time of reduced visibility for employees when plasma cutting stops
An employee working in the UF_6 plant rolled their ankle and required medical attention. A medical assessment confirmed that the employee broke a bone in their leg. This injury resulted in four days of lost time.	Cameco reviewed this event and determined that there were no known causal factors (i.e., no slip or trip hazards were present and all personal protective equipment was in good condition). The employee did not move their feet while turning, resulting in the lost-time incident.

Lost-time injury	Action taken
	As a result of this event, Cameco issued a safety bulletin to staff to provide awareness.
An employee required medical treatment for a sprained left ankle. The employee was working in the cylinder filling area and standing on the cylinder trolley. When the employee turned to complete a task, they rolled their ankle and fell. This injury resulted in one day of lost time.	As a result of this event, Cameco implemented the following corrective actions: • installed an articulating arm with a light in the work area instead of manually placing the light in position • designed and installed an alternative platform in the affected area to provide more space for workers • reviewed the incident for process hazard analysis inclusion

Table G-2: Lost-time injuries, Nordion (Canada) Inc., 2016

Lost-time injury	Action taken
An employee sustained a severe allergic reaction from multiple wasp stings. This injury resulted in 1.25 days of lost time.	A pest control company was hired to eliminate the wasp nest.
An employee slipped while wearing clean room booties that were not fitted properly. The employee sustained a lower back injury and was assigned modified duties upon returning. This injury resulted in 18 days of lost time.	The incident was reviewed and a corrective action was taken to replace the booties with a different type of bootie.
An employee sustained a right shoulder injury after using an Allen key to loosen a socket head cap screw. Modified duties were assigned following the injury; however, the employee later required surgery resulting in 71 days of lost time. The employee returned to work on restricted duties.	A root-cause analysis was performed. Corrective actions are underway.

Table G-3: Lost-time injuries, Best Theratronics Ltd., 2016

Lost-time injury	Action taken
An employee twisted and scraped their thumb trying to lift heavy equipment. This injury resulted in 0.5 days of lost time. The employee returned to work with adjusted duties.	The employee was reminded to work within limits and be aware of surroundings.
An employee was hurt when a steel part was dropped onto their finger. This injury resulted in 0.5 days of lost time.	The employee was reminded to use caution and work within limits.
An employee fell and broke their wrist. This injury resulted in two days of lost time. The employee returned to work with adjusted duties.	The employee was reminded to be aware of their surroundings and to act in a safe manner.

H. Links to licensee websites

Licensee	Website
Cameco Blind River Refinery	cameco.com/fuel_services/blind_river_refinery
Cameco Port Hope Conversion Facility	cameco.com/fuel_services/port_hope_conversion
Cameco Fuel Manufacturing Inc.	cameco.com/fuel_services/fuel_manufacturing
BWXT Nuclear Energy Canada Inc.	nec.bwxt.com
SRB Technologies (Canada) Inc.	srbt.com
Nordion (Canada) Inc.	nordion.com
Best Theratronics Ltd.	theratronics.ca

I. Significant changes to licence and licence conditions handbooks

Table I-1: Changes to the licence by the Commission

Facility	Date	Facility licence	Description of change
BWXT Nuclear Energy Canada Inc.	December 2016	FFOL-3620.01/2020	The licence was transferred from GE Hitachi Nuclear Energy Canada Inc. (GEH-C) to BWXT Nuclear Energy Canada Inc. as a result of an application from GEH-C. The Commission approved the transfer along with a new financial guarantee from BWXT. For additional details on the transfer and associated changes, refer to CMD 16-H113.

Table I-2: Changes to the licence conditions handbook

Facility	Date	Revision number	Description of change
BWXT Nuclear Energy Canada Inc.	June 2016	Revision 2	In June 2016, GEH-C's licence conditions handbook (LCH) was updated to the latest format. The improvements included: • additional clarity on the licensing basis • written notification requirements (prior and non-prior) for GEH-C's program documents that form part of the licensing basis • inclusion of several compliance verification criteria including all commitments by GEH-C to implement new regulatory documents in 2014 and 2015 • additional clarity on reporting requirements and inclusion of program documents related to each safety and control area • updated list of action levels
BWXT Nuclear Energy Canada Inc.	January 2017	Revision 3	A revised LCH was issued to reflect changes due to the transfer of the licence to BWXT.

J. CNSC inspections

CNSC inspections: Uranium processing facilities

Table J-1: Inspections, Blind River Refinery, 2016

Inspection title	Safety and control areas covered	Inspection report sent date
Security Inspection	Security	February 22, 2016
BRR Type II Inspection NPFD-BRR-2016-03-08	Radiation protection, public information and disclosure program*	May 2, 2016
BRR Type II Inspection NPFD-BRR-2016-05-02	Fire protection	July 7, 2016
BRR Type II Inspection BRR-2016-04	Management system, radiation protection, conventional health and safety, emergency management and fire protection	January 26, 2017

* Not a safety and control area.

Table J-2: Inspections, Port Hope Conversion Facility, 2016

Inspection title	Safety and control areas covered	Inspection report sent date
PHCF Type II Inspection NPFD-PHCF-2016-02-24	Fire protection	May 20, 2016
Security Inspection	Security	July 26, 2016
PHCF Type II Inspection NPFD-PHCF-2016-06-09	Radiation protection	August 11, 2016
PHCF Type II Inspection Cameco-PHCF-2016-04	Environmental protection	October 7, 2016

Table J-3: Inspections, Cameco Fuel Manufacturing Inc., 2016

Inspection title	Safety and control areas covered	Inspection report sent date
CFM Type II Inspection NPFD-CFM-2016-01-18	Radiation protection	March 18, 2016
CFM Type II Inspection NPFD-CFM-2016-06-14	Environmental protection	September 22, 2016
CFM Type II Inspection Cameco-CFM-2016-03	Emergency management and fire protection	March 9, 2017

Table J-4: Inspections, BWXT Nuclear Energy Canada Ltd., 2016

Inspection title	Safety and control areas covered	Inspection report sent date
BWXT Type II Routine Inspection GEHC-2016-02-24	Fire protection, waste management, conventional health and safety, fitness for service, and safety analysis	May 20, 2016
BWXT Type II Reactive Inspection GEHC-2016-02	Radiation protection: internal dosimetry	November 3, 2016
BWXT Type II Emergency Response Inspection GEHC-2016-03	Emergency management and fire protection	March 27, 2017

CNSC inspections: Nuclear substance processing facilities

Table J-5: Inspections, SRB Technologies Inc., 2016

Inspection title	Safety and control areas covered	Inspection report sent date
SRBT Type II Inspection SRBT-2016-01	Environmental protection	December 16, 2016

Table J-6: Inspections, Nordion (Canada) Inc., 2016

Inspection title	Safety and control areas covered	Inspection report sent date
EMPD-NORDION-2016-T01	Emergency management and fire protection	September 13, 2016
NORDION-2016-02	Operating performance, fitness for service, radiation protection, environmental protection, conventional health and safety, waste management, packaging and transport	December 07, 2016
NORDION-2016-03	Operating performance (import and export)	December 28, 2016

Table J-7: Inspections, Best Theratronics Ltd., 2016

Inspection title	Safety and control areas covered	Inspection report sent date
Monthly Reporting Inspection	Operating performance	April 29, 2016
Radiation Protection Type II Inspection NPFD-BEST-2016-06-21	Radiation protection	September 7, 2016
Export Inspection BT-2016-03	Operating performance (export)	January 9, 2017
Environmental Inspection BT-2016-04	Environmental protection	February 28, 2017

Note: The implementation of the revised DNCFR Conduct of Inspection process in July 2016 resulted in a change in inspection numbering. Security and safeguard inspection reports contain sensitive information and will not be made public.