Canada's Nuclear Regulator

Regulatory Oversight Report for Nuclear Processing, Small Research Reactor and Class IB Accelerator Facilities: 2015





Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

Canada

Regulatory Oversight Report for Nuclear Processing, Small Research Reactor and Class IB Accelerator Facilities: 2015

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From left to right:

Weighing of uranium concentrate drums before processing
Fuel pellet and fuel bundle
Radiopharmaceuticals
Model of a SlOWPOKE-2- reactor
Inside view of TRIUMF Cyclotron

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EXECUTIVE SUMMARY

This report presents the operating performance of the uranium and nuclear substance processing facilities, small nuclear research reactor facilities and Class IB particle accelerator facilities regulated by the Canadian Nuclear Safety Commission (CNSC). The information provided in this report covers the 2015 calendar year and, when applicable, shows trends and compares information to previous years.

This is the first year that small nuclear research reactor facilities are included in the reporting cycle. To better align the reporting requirements for CNSC-licensed facilities, this is also the first time that Class IB particle accelerator facilities are reported along with uranium and nuclear substance processing facilities. Previously, Class IB particle accelerator facilities were reported in the *Regulatory Oversight Report on the Use of Nuclear Substances in Canada.*

This report focuses on three safety and control areas (SCAs): radiation protection, environmental protection, and conventional health and safety. These three SCAs provide a good overall indication of the safety performance for the facilities discussed in this report. This report also highlights a discussion of public information programs, ratings for all 14 SCAs, reportable events, any significant facility modifications and areas of increased regulatory focus.

For 2015, 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 with the exception of Best Theratronics Ltd., which received a “below expectations” rating in emergency management and fire protection.
- Small nuclear research reactor facilities were rated as “satisfactory” or better.
- Class IB particle accelerator facilities were rated as “satisfactory” or better with the exception of Canadian Light Source Inc., which received a “below expectations” rating in human performance management.

Through their regulatory oversight activities, CNSC staff confirmed that Canada’s uranium and nuclear substance processing facilities, small nuclear research reactor facilities and Class IB particle accelerator facilities continued to operate safely during 2015, despite the “below expectations” ratings mentioned above. The CNSC’s regulatory oversight activities included onsite inspections, reviews of reports submitted by licensees, and event and incident reviews, supported by follow-up and general communication with the licensees.

CNSC staff concluded that, in 2015, each of the regulated facilities discussed in this report made adequate provision for the health and safety of workers as well as the protection of the public and the environment, and for meeting Canada’s international obligations on the peaceful use of nuclear materials.

1 OVERVIEW

1.1 Background

The *Regulatory Oversight Report for Nuclear Processing, Small Research Reactor and Class IB Accelerator Facilities in Canada: 2015* summarizes the Canadian Nuclear Safety Commission (CNSC) staff assessment of the safety performance of the following licensees:

- 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-3631.00/2017)
    - Cameco Fuel Manufacturing Inc. in Port Hope, ON (FFOL-3641.00/2022)
    - GE Hitachi Nuclear Energy Canada Inc. in Peterborough, ON (FFOL-3620.00/2020)
    - GE Hitachi Nuclear Energy Canada Inc. in Toronto, ON (FFOL-3620.00/2020)
- 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)
- small nuclear research reactor facilities
    - McMaster Nuclear Reactor at McMaster University in Hamilton, ON (NPROL-01.00/2024)
    - Safe LOW-Power Kritical Experiment (SLOWPOKE-2) facilities located at:
        - University of Alberta in Edmonton, AB (NPROL-18.00/2023)
        - Saskatchewan Research Council in Saskatoon, SK (NPROL-19.00/2023)
        - Royal Military College of Canada in Kingston, ON (NPROL-20.00/2023)
        - École Polytechnique de Montréal in Montréal, QC (PERFP-9A.01/2023)

  - subcritical assembly at École Polytechnique de Montréal in Montréal, QC (PERFP-9A.01/2023)
- Class IB particle accelerator facilities
  - TRIUMF Accelerators Inc. in Vancouver, BC (PAIOL-01.00/2022)
  - Canadian Light Source Inc. in Saskatoon, SK (PAIOL-02.01/2022)

The assessment aligns with the legal requirements of the *Nuclear Safety and Control Act* (NSCA) and the regulations made under the NSCA, the conditions of facility licences, and applicable standards and regulatory documents.

The report highlights the areas of regulatory focus for CNSC staff – including information on regulatory requirements and expectations in selected areas – and 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 provide a good overall indication of the safety performance for the facilities discussed in this report.

The information covers the 2015 calendar year and, where appropriate, compares information to previous years.

1.2 CNSC regulatory efforts

The CNSC regulates the nuclear sector in Canada, including Canada's uranium and nuclear substance processing facilities, small nuclear research reactors and Class IB particle accelerator facilities, to:

- protect the health, safety and security of Canadians and the environment
- implement Canada's international commitments on the peaceful use of nuclear energy
- disseminate objective scientific, technical and regulatory information to the public

The CNSC regulates these 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.

CNSC staff establish compliance plans for each facility based on risk-informed regulatory oversight of the facility's activities. Compliance plans are continuously reviewed to take into consideration events, facility modifications, changes in licensee performance and lessons learned.

Onsite inspections conducted in 2015 covered various aspects of many SCAs. CNSC staff apply a risk-informed approach for compliance activities, commensurate with the risk associated with these facilities. In 2015, CNSC staff conducted 35 onsite inspections at uranium and nuclear substance processing facilities, small nuclear research reactors and Class IB particle accelerator facilities in Canada. A breakdown of the number of inspections is provided in each industry's respective sections.

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:

- 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 with meetings, presentations and facility visits.

1.3 Ratings and performance

CNSC staff use the SCA Framework in evaluating each licensee's safety performance. The framework includes 14 SCAs, each sub-divided into specific areas that define its key components. (See appendix A for a complete list of the SCAs and specific areas used in this report.)

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

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

A full definition of the four ratings is provided in appendix B. Ratings are provided for each applicable SCA. The ratings are derived from the compliance activities that CNSC staff conduct in the various SCAs.

To ensure each licensee is operating safely, CNSC staff apply a risk-informed approach to the compliance oversight of a facility. CNSC staff determine the type and level of review, inspection and testing in a manner that is consistent with the risk posed by the regulated activities. The CNSC recognizes that the level of risk must be considered to ensure resources are appropriately allocated and controls are applied based on the complexity of the facility, the hazards and magnitude of the potential risks associated with the activities at the facility.

A licensee's performance is measured by the 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, CNSC staff rating input is the information provided by the licensees in their annual compliance reports.

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

1.4 CNSC Independent Environmental Monitoring Program

Under the NSCA, the licensee of each nuclear facility is required 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 licensed activities. The results of these monitoring programs are submitted to the CNSC to ensure compliance with applicable guidelines and limits, as set out in regulations that oversee Canada's nuclear industry.

The CNSC has implemented 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 taking samples from public areas around the facilities, then measuring and analyzing the amount of radiological (nuclear) and hazardous substances in those samples.

In 2015, CNSC staff conducted independent environmental monitoring at the Cameco Port Hope Conversion Facility, Cameco Fuel Manufacturing and SRB Technologies. The 2015 IEMP results, which can be found on the CNSC's IEMP Web page, indicate that the public and the environment in the vicinity of these facilities are protected and safe, and that there are no adverse environmental or health effects as a result of site operations. These results are consistent with the results submitted by the licensees, demonstrating that their environmental protection programs are protecting the health and safety of people and the environment.

SECTION I: URANIUM PROCESSING FACILITIES

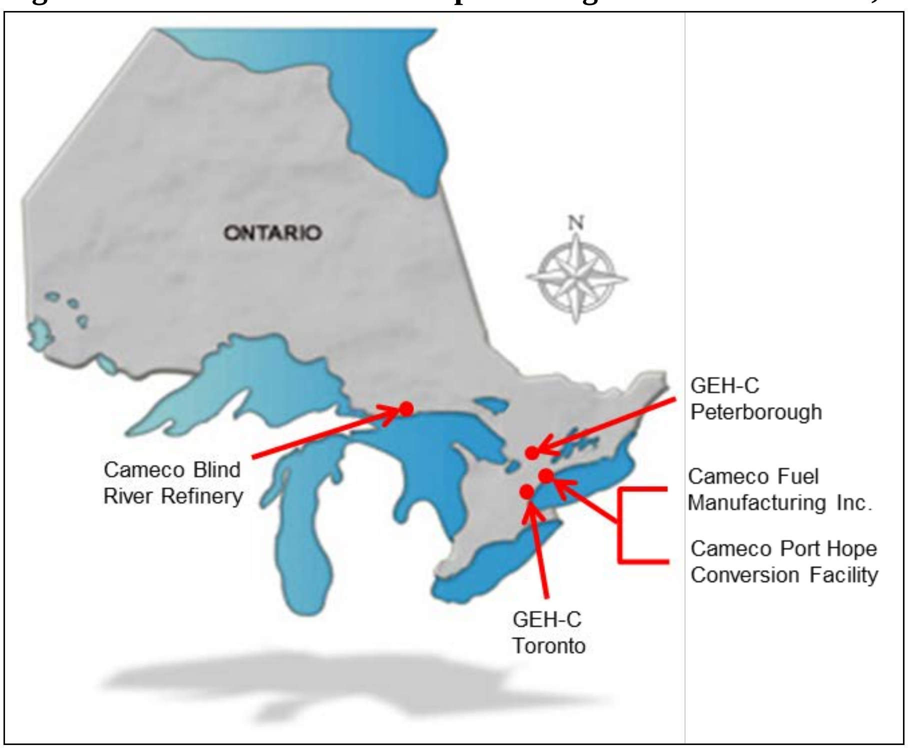
2 OVERVIEW

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

- Cameco Corporation (Cameco) 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
- GE Hitachi Nuclear Energy Canada Inc. (GEH-C) Facility in Peterborough, ON
- GE Hitachi Nuclear Energy Canada Inc. facility in Toronto, ON

The three Cameco facilities operate under separate operating licences, which were issued in March 2012. The licenses for the BRR and CFM facilities expire in February 2022, while the PHCF licence expires in February 2017. In November 2015, Cameco submitted its application to renew its PHCF operating licence. The licence renewal hearing is scheduled the week of November 9, 2016 in the community of Port Hope, ON. The two GEH-C facilities operate under a combined licence issued in January 2011 that expires in December 2020. All five facilities are located in the province of Ontario, as shown in figure 2-1.

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 2015. Table 2-1 presents the licensing and compliance effort for uranium processing facilities during the reporting period.

Table 2-1: CNSC regulatory oversight licensing and compliance activities, uranium processing facilities, 2015

Facility	Number of onsite inspections	Person days for compliance	Person days for licensing activities
Blind River Refinery	3	217	32
Port Hope Conversion Facility	5	533	148
Cameco Fuel Manufacturing	3	237	6
GEH-C Toronto and Peterborough	4	282	25

In 2015, CNSC staff performed 15 onsite inspections at the uranium processing facilities. All the findings resulting from these onsite inspections were provided to the licensees in a detailed inspection report. All regulatory enforcement actions arising from the findings were recorded in the CNSC regulatory information bank to ensure all enforcement actions are tracked to completion.

Each uranium processing facility licensee is required, per their operating licences, to submit an annual compliance report by March 31. 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 their regulatory requirements and are operating safely. The full versions of these reports are available on the licensees' websites, as provided in appendix H.

The SCA performance ratings of uranium processing facilities are presented in table 2-2. For 2015, CNSC staff ratings for all individual SCAs were "satisfactory" for the uranium processing facilities, except for Blind River Refinery, which was given a "fully satisfactory" rating in the conventional health and safety SCA. Appendix C contains the SCA ratings from 2011 to 2015 for each facility.

Table 2-2: SCA performance ratings, uranium processing facilities, 2015

Safety and control area	Blind River Refinery	Port Hope Conversion Facility	Cameco Fuel Manufacturing	GEH-C 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

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

2.1 Radiation protection

This SCA covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations*. The program must ensure contamination levels and radiation doses received by individuals are monitored, controlled and maintained as low as reasonably achievable (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

The 2015 rating for the radiation protection SCA for all uranium processing facility licensees was "satisfactory," unchanged from the previous year.

Ratings for radiation protection SCA, uranium processing facilities, 2015

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

Application of ALARA

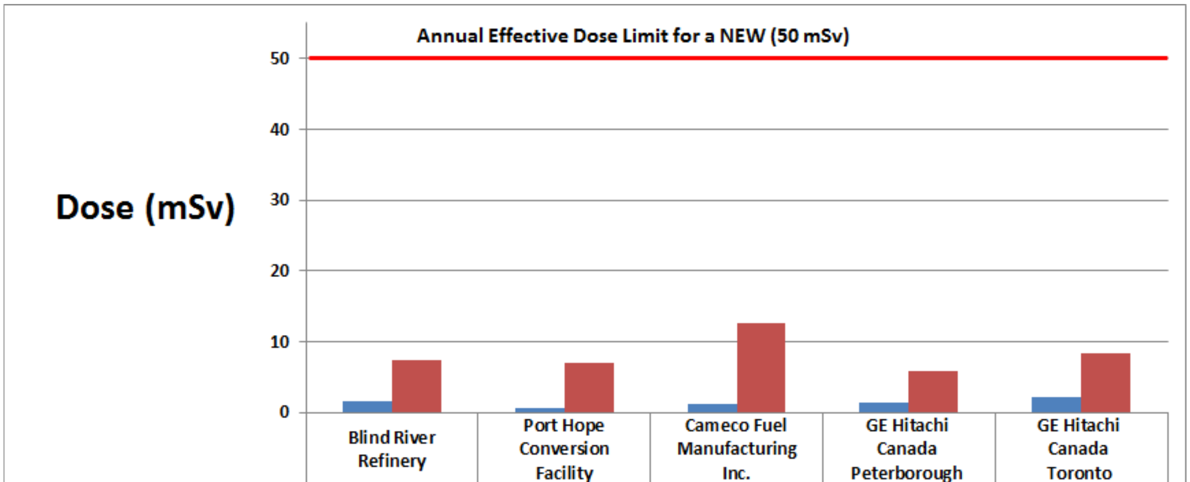
During 2015, all uranium processing facility licensees continued to implement radiation protection measures to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. The CNSC requirement to apply the ALARA principle has consistently resulted in doses to persons to be 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 between 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 2015, the maximum individual effective dose received by a NEW at all facilities ranged from 5.8 millisieverts (mSv) to 12.6 mSv, which is well below the regulatory dose limit of 50 mSv/year for a NEW.

Figure 2-2: Average and maximum effective doses to nuclear energy workers, uranium processing facilities, 2015



	Blind River Refinery	Port Hope Conversion Facility	Cameco Fuel Manufacturing Inc.	GE Hitachi Canada Peterborough	GE Hitachi Canada Toronto
Average effective dose (mSv)	1.7	0.6	1.2	1.4	2.1
Maximum effective dose (mSv)	7.4	7.0	12.6	5.8	8.4

During 2015, 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. Radiological hazards in the uranium processing facilities vary due to the complex and differing work environments. Therefore, direct comparison of doses received by NEWs between 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 regulatory oversight activities at all uranium processing facilities during 2015 to verify compliance of the licensees' radiation protection programs 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 facilities have effectively implemented their radiation protection programs to control occupational exposures to workers.

Action levels for radiological exposures are established as part of the licensees' radiation protection programs. Licensees are responsible for identifying the parameters of their program that represent timely indicators of potential losses of control of the program. For this reason, action levels are licensee-specific and may change over time depending on operational and radiological conditions. If an action level is reached, it triggers the licensee to establish the cause, notify the CNSC and, if applicable, 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 the emergence of 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 how the licensee responds and identifies corrective actions to enhance program performance and prevent reoccurrence. In 2015, there were a total of four radiological action level exceedances across all uranium processing facility licensees. In all instances, the exceedances were reported to the CNSC, investigated and corrective actions established to the satisfaction of CNSC staff.

Radiological hazard control

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 in-plant air-monitoring systems. All uranium processing facility licensees continued to implement their workplace monitoring programs to protect workers and have demonstrated that, in 2015, 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 take corrective actions whenever action levels are exceeded.

Table 2-3 provides a comparison of estimated public doses from 2011 to 2015 for the uranium processing facility licensees. Estimated doses to the public from all uranium processing facility 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, 2011–15

Facility	Year					Regulatory limit
	2011	2012	2013	2014	2015	
Blind River Refinery	0.006	0.012	0.012	0.005	0.005	**1 mSv/year**
Port Hope Conversion Facility	0.019	0.029	0.021	0.012	0.006	
Cameco Fuel Manufacturing	0.042	0.031	0.013	0.018	0.025	
GEH-C Toronto	0.0008	0.0011	0.0006	**0.0055	0.010	
GEH-C Peterborough	*<0.00001	<0.001	<0.001	<0.001	<0.001	

*GEH-C did not report public dose results prior to 2012. The values reported here are based on CNSC staff calculations of GEH-C emissions for the derived release limits (DRL).
**Beginning in 2014, GEH-C Toronto implemented environmental gamma-exposure monitoring using licensed dosimeters and began to include this result in its estimated annual public dose.

The uranium processing facility licensees effectively implemented and maintained their radiation protection programs during 2015 to ensure the health and safety of persons working in their facilities.

2.2 Environmental protection

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

It encompasses the following specific areas:

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

The 2015 rating for the environmental protection SCA for all uranium processing facility licensees was “satisfactory.”

Ratings for environmental protection SCA, uranium processing facilities, 2015

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

The uranium processing facilities are also regulated by Ontario's Ministry of the Environment and Climate Change (MOECC). Environmental protection is, therefore, a shared federal and provincial responsibility. The CNSC avoids or minimizes any duplication of regulatory oversight, including MOECC's requirements, by working cooperatively and inclusively whenever possible.

State of receiving environment

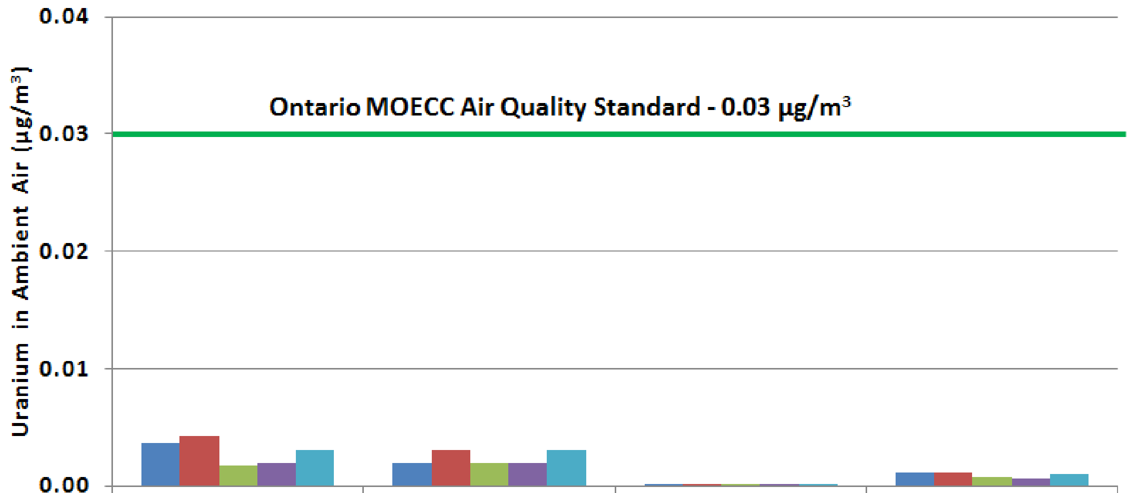
Uranium in ambient air

All the uranium processing licensees, except GEH-C Peterborough, operate high-volume air samplers at the perimeter of their facilities to confirm the effectiveness of emission abatement systems and to monitor the impact of uranium emissions on the environment. GEH-C Peterborough does not use fence-line air samplers, as stack emissions at the point of release already meet MOECC air standard for uranium.

The results from high-volume air samplers with the highest values near a facility (maximum annual average) for 2011 through 2015 are provided in figure 2-3. These values are measured as total suspended particulate representing the total amount of uranium in air.

As shown in figure 2-3, the maximum annual average concentration of uranium in ambient air is below the MOECC air standard for uranium (0.03 $\mu g/m^3$). This new standard for uranium takes effect in 2016.

Figure 2-3: Uranium concentration in ambient air (maximum annual average), uranium processing facilities, 2011–2015



	Blind River Refinery	Port Hope Conversion Facility	Cameco Fuel Manufacturing Inc.	GE Hitachi Canada Toronto
2011	0.0036	0.0020	0.0001	0.0011
2012	0.0042	0.0030	0.0000	0.0011
2013	0.0017	0.0020	0.0001	0.0007
2014	0.0020	0.0020	0.0000	0.0006
2015	0.0031	0.0030	0.0001	0.0010

Note: The maximum annual average concentration for BRR in 2012 was 0.0042 µg/m³, previously reported as 0.0030 µg/m³. This is a correction to the results reported in *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2014*.

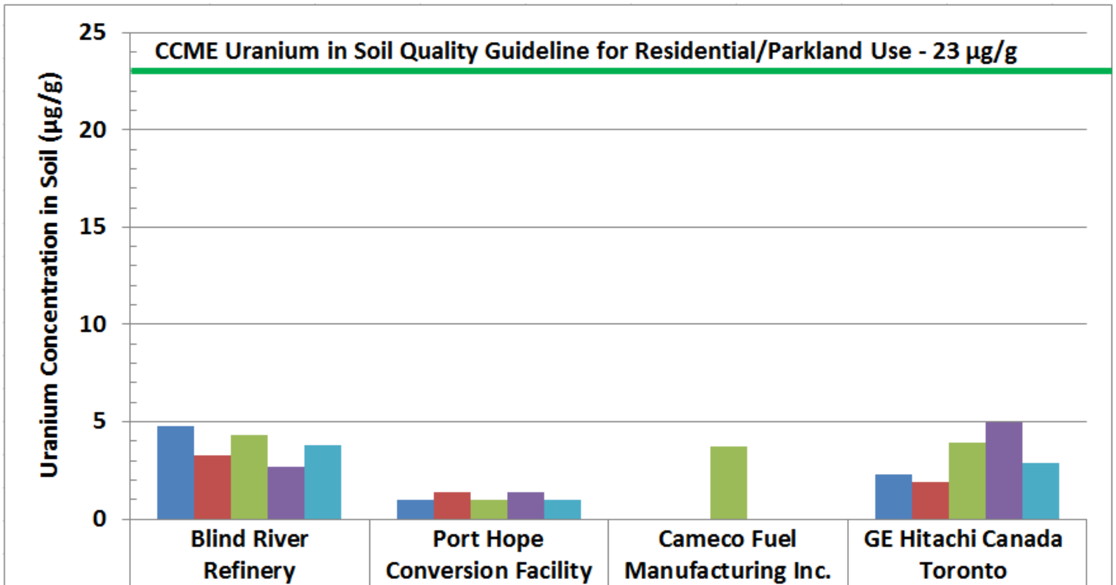
Uranium in soil

The three Cameco facilities and GEH-C Toronto have soil monitoring programs. Uranium releases from the GEH-C Peterborough facility are negligible because the fuel pellets received from the Toronto facility are in solid form and uranium releases to air are very low. This is confirmed by monitoring in the stack; as such, uranium-in-soil monitoring is not warranted at GEH-C Peterborough.

Soil monitoring programs are intended to monitor the long-term effects of air emissions to show whether there is accumulation of uranium in soil in the vicinity of the facility. Soil sampling results in 2015 continue to indicate that current uranium emissions from the uranium processing facilities have no measurable impacts on soil.

Figure 2-4 provides the annual average uranium concentrations in soil results for 2011 through 2015. In Ontario, natural background levels of uranium in soil are generally below 2.5 µg/g. The annual average concentrations of uranium in soil are similar to natural background levels and well below the applicable guideline value for the land-use type, as described by the Canadian Council of Ministers of the Environment (CCME) soil quality guideline for residential and parkland use, which is 23 µg/g.

Figure 2-4: Uranium concentration in soil (annual average), uranium processing facilities, 2011–15



	Blind River Refinery	Port Hope Conversion Facility	Cameco Fuel Manufacturing Inc.	GE Hitachi Canada Toronto
2011	4.8	1.0	N/A	2.3
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

Uranium in the soil at CFM is a result of historic uranium contamination, which is common to the Port Hope area. The sampling frequency at CFM is every three years. The next soil sampling for CFM is scheduled for 2016 and the results will be provided in the next issue of this report.

The uranium processing facility licensees implemented their environmental protection programs satisfactorily during 2015, and their programs are effective in protecting the health and safety of persons working in their facilities.

2.3 Conventional health and safety

This 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

The 2015 rating for the conventional health and safety SCA for all uranium processing facility licensees in 2015 was “satisfactory,” except for Blind River Refinery, which was given a “fully satisfactory” rating. This is unchanged from the previous year.

Ratings for conventional health and safety SCA, uranium processing facilities, 2015

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

Each licensee is responsible for developing and implementing a conventional health and safety program for the protection of its staff and contract workers, which must comply with Part II of the *Canada Labour Code.*

The regulation of conventional health and safety at uranium processing facilities involves both Employment and Social Development Canada (ESDC) and the CNSC. CNSC staff monitor compliance with regulatory reporting requirements. When a concern is identified, ESDC staff are consulted and asked to take appropriate action. Licensees submit hazardous occurrence investigation reports to both ESDC and the CNSC, in accordance with their respective reporting requirements.

As summarized in table 2-4, the number of recordable lost-time injuries (LTIs) reported by all facilities has remained low from 2011 to 2015. Further information is provided in facility-specific sections as well as appendix G.

Table 2-4: Lost-time injuries, uranium processing facilities, 2011–15

Facility	2011	2012	2013	2014	2015
Blind River Refinery	0	0	0	0	0
Port Hope Conversion Facility	3	1	0	1	2
Cameco Fuel Manufacturing Inc.	2	0	0	0	1
GEH-C Toronto and Peterborough	0	1	0	1	0

The uranium processing facility licensees implemented their conventional health and safety programs satisfactorily during 2015, and their programs are effective in protecting the health and safety of persons working in their facilities.

2.4 Public information and disclosure programs

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

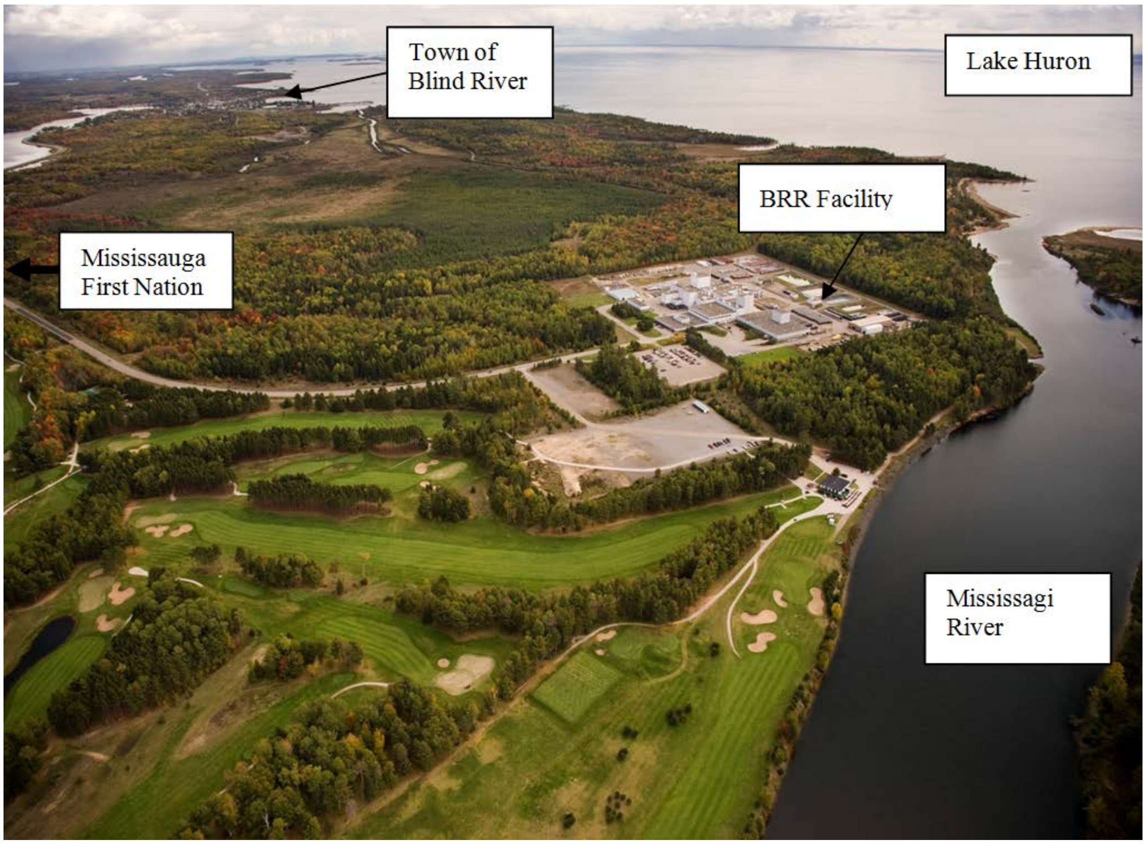
In 2015, CNSC staff evaluated licensees’ implementation of their public information and disclosure programs and determined that all licensees were in compliance with RD/GD-99.3 by providing information on the status of their facilities through numerous activities. CNSC staff reviewed the communications activities during this period and noted that licensees used a variety of methods to share information with the public, including regular updates to elected officials, public information sessions, facility tours, participation in community events, newsletters, and ongoing website and social media updates. Licensees also issued information in accordance with their public disclosure protocols.

The uranium processing facility licensees implemented their public information and disclosure programs satisfactorily during 2015, and their programs are effective at communicating information about the health, safety and security of persons and the environment and other issues associated with their facilities.

3 CAMECO BLIND RIVER REFINERY

Cameco owns and operates a Class IB nuclear fuel facility in Blind River, ON, under an operating licence that expires in February 2022. The Blind River Refinery (BRR) is located about five kilometers 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 kilometer from the facility.

Figure 3-1: Aerial view of the Cameco 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 the PHCF.

In 2015, there were no licence amendments to BRR; however, there was one revision to the BRR licence conditions handbook, as described in table I-2, appendix I.

Figure 3-2: Shipping totes used to transfer UO_3 from Blind River Refinery to the Port Hope Conversion Facility

3.1 Performance

For 2015, CNSC staff rated BRR's performance as "satisfactory" in all SCAs except conventional health and safety, which was rated as "fully satisfactory." The BRR facility ratings from 2011 to 2015 are provided in table C-1, appendix C.

In 2015, CNSC staff conducted three onsite inspections at BRR to ensure compliance with the *Nuclear Safety and Control Act* (NSCA) and its regulations, Cameco's operating licence and the programs used to meet regulatory requirements. The inspections focused on the management system, emergency management, waste management, radiation protection, environmental protection, and conventional health and safety SCAs. None of the findings from these inspections presented an immediate risk to the health, safety and security of workers, Canadians or the environment.

In 2015, there were no major modifications to the BRR facility that required Commission approval. BRR made improvements to the site by constructing a berm around the facility for flood protection. The berm was designed to mitigate the impact of a flood caused by severe weather. The flood scenario was identified following Cameco's Fukushima defence-in-depth review against external hazards, severe accident scenarios and emergency preparedness procedures.

There were no action level exceedances involving radiation protection or environmental protection in 2015. There was one radiation protection-related incident reported to the CNSC per the Cameco BRR radiation protection program requirements. Details are provided in section 3.2 under the "Radiation protection program performance" heading.

On October 6, 2015, CNSC staff met with the MFN Lands and Resource Committee as well as MFN staff and community elders. CNSC staff gave a presentation that included information on BRR's operational performance for 2014 and the facility's results from the 2013 and 2014 IEMP. Many questions were asked during this meeting, particularly regarding the IEMP results, how the IEMP sampling locations were determined and the possibility of MFN participating in future IEMP sampling campaigns.

On request, CNSC staff held a meeting with MFN on February 2, 2016 to discuss MFN's current air quality sampling program and its capabilities for interpreting the program's results, MFN's concerns regarding sampling locations and the changes to Ontario's ambient air quality standard for uranium. Following the meeting, CNSC staff and MFN discussed ideas for future sampling campaigns that would include MFN's traditional lands, and committed to continuing the dialogue and exploring opportunities with MFN to inform the sampling campaign and increase MFN's understanding of the results.

CNSC's Participant Funding Program provided financial support to MFN for all meetings mentioned above.

3.2 Radiation protection

Overall compliance ratings for radiation protection SCA, Blind River Refinery, 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA
For 2015, CNSC staff continued to rate the radiation protection SCA at Cameco's BRR as "satisfactory." Cameco has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations*.				

Application of ALARA

Annually, Cameco establishes radiation protection objectives and targets at BRR with the goal to reduce worker doses and in-plant uranium-in-air concentrations, as examples. A separate ALARA committee is also in place at BRR, which meets regularly to review and discuss issues related to radiation protection and to make recommendations for improving radiation protection at the facility. In 2015, Cameco completed all radiation safety objectives established for the year, including a review to identify opportunities for improving the respiratory protection program for workers.

Worker dose control

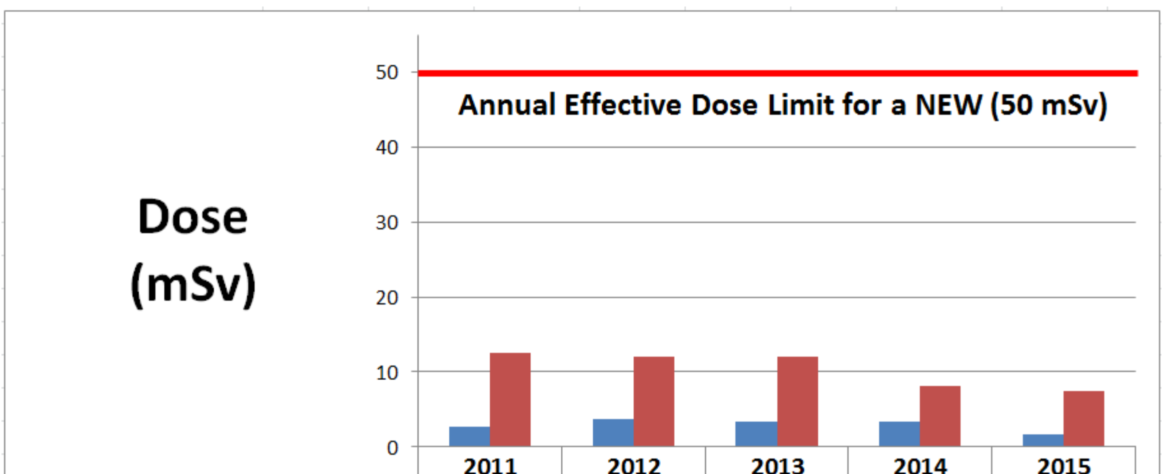
Radiation exposures are monitored to ensure compliance with the CNSC's regulatory dose limits and to maintain radiation doses ALARA. In 2015, no worker's radiation exposure reported by BRR exceeded the CNSC's regulatory dose limits.

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

At BRR, all Cameco employees are identified as NEWs. Contractors at BRR may also be identified as NEWs if the nature of their work activities and time spent onsite presents a reasonable probability of them receiving an occupational dose greater than 1 mSv. In 2015, total effective dose was assessed for 155 NEWs at BRR, consisting of 142 Cameco employees and 13 contractors. The maximum effective dose received by a NEW in 2015 was 7.4 mSv, or approximately 15 percent of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period. For the five-year dosimetry period from 2011–2015, the maximum individual effective dose to a NEW at BRR was 41 mSv. This radiation dose result represents approximately 41 percent of the regulatory dose limit of 100 mSv per five-year dosimetry period.

Figure 3-3 provides the average and maximum effective doses to NEWs at BRR between 2011 and 2015.

Figure 3-3: Average and maximum effective doses to nuclear energy workers, Blind River Refinery, 2011–15



	2011	2012	2013	2014	2015
Average effective dose (mSv)	2.7	3.7	3.3	3.3	1.7
Maximum effective dose (mSv)	12.6	12.0	12.1	8.2	7.4
Number of NEWs monitored	170	173	162	150	155

The average and maximum effective doses at BRR were relatively stable between 2011 and 2015, with a decreasing trend emerging in 2015, likely due to the decrease in UO_3 production compared to previous years.

Annual average and maximum equivalent (extremity) and equivalent (skin) dose results from 2011 to 2015 are provided in tables E-7 and E-15 in appendix E. In 2015, the maximum skin dose received by a NEW at BRR was 28.1 mSv, which is approximately six percent 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 15.3 mSv, which is approximately three percent 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 2011 and 2015, with a decreasing trend emerging in 2015, again likely due to the decrease in UO_3 production compared to previous years.

Site visitors and non-NEW contractors' doses are monitored at BRR using whole body dosimetry. In 2015, the maximum effective dose for a non-NEW was 0.1 mSv and averaged less than 0.1 mSv, which is well below the annual regulatory dose limit of 1 mSv.

Radiation protection program performance

CNSC staff assessed the performance of BRR's radiation protection program in 2015 through various compliance activities. Cameco's compliance with the *Radiation Protection Regulations* and CNSC licence requirements at BRR was acceptable. In addition, action levels for radiological exposures have been established as part of the Cameco BRR radiation protection program. If an action level is reached, it triggers Cameco staff to establish the cause, notify the CNSC and, if applicable, restore the effectiveness of the radiation protection program. In 2015, no radiological action levels were reached at BRR.

In 2015, one radiation protection-related incident was reported to the CNSC per the Cameco BRR radiation protection program requirements. In February 2015, four Cameco workers received uranium intakes while performing a work activity; this was caused by deficiencies in work planning, communication and administrative controls, coupled with complacency toward the radiological hazards posed by uranium dust. The work activity was conducted in the calcination area baghouse, which contains uranium concentrates from the front end of the BRR circuit – specifically, uranium concentrates (yellowcake) received from suppliers for processing into UO_3. The baghouse is an air-collection device that contains 252 Nomex® filter bags that collect and filter the uranium concentrate dust from the dust-collection system, allowing clean air to exhaust out the dust-collection exhaust vent. Over time, these filter bags must be replaced due to dust loading. As a result of this particular work, four of 11 workers involved in performing the baghouse filter replacement received uranium intakes, necessitating dose assessments and the temporary placement of these workers on restricted status. The maximum internal dose assigned to a worker as a result of this incident was 3.7 mSv. Cameco carried out an investigation into the incident that included a root-cause analysis.

Cameco identified a number of corrective actions, including mandating the use of powered air-purifying respirators by workers when performing this task, along with other improvements to work practices and procedures. In March 2016, CNSC staff performed a radiation protection-focused onsite inspection at BRR, which included extensive follow-up on the implementation of these corrective actions. CNSC staff confirmed that Cameco has effectively implemented measures that improved the radiation protection of workers during the conduct of similar work activities.

Radiological hazard control

Radiation and contamination control programs are established at BRR per regulatory requirements 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. BRR staff conducted in-plant air monitoring, contamination monitoring and radiation dose rate surveys in 2015, and did not identify any adverse trends. This is consistent with expected radiological conditions within the facility.

Estimated dose to the public

The 2011 to 2015 maximum effective doses to a member of the public are shown in table 3-1. Dose to the public remains well below the CNSC regulatory dose limit of 1 mSv/year.

Table 3-1: Maximum effective dose to a member of the public, Blind River Refinery, 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Maximum effective dose (mSv)	0.006	0.012	0.012	0.005	0.005	**1 mSv/year**

3.3 Environmental protection

Overall compliance ratings for environmental protection SCA, Blind River Refinery, 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA
For 2015, CNSC staff continued to rate 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 MOECC’s applicable regulations and Environmental Compliance Approvals. All the releases to the environment were well below regulatory limits during 2015. 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.				

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

Atmospheric emissions

Cameco monitors uranium, nitrogen oxides (NO_x) and particulates released from the BRR stacks on a daily basis. The monitoring data in table 3-2 demonstrate that stack emissions from the facility in 2015 continued to be effectively controlled as they were consistently well below their respective licence limits. No action levels were exceeded at any time in 2015.

Table 3-2: Air emissions monitoring results (annual averages), Blind River Refinery, 2011–15

Parameter	2011	2012	2013	2014	2015	Licence limit
Dust collection and exhaust ventilation stack: uranium (kg/h)	0.00010	0.00006	0.00004	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**
Absorber stack: nitrogen oxides (NO_X) + nitric acid (HNO_3) (kg NO_2/h)	3.9	3.3	3.4	2.0	2.5	**56.0**
Particulate (kg/h)	0.027	0.024	0.014	0.009	0.006	**11.0**

Note: Results less than detection limit are denoted with the "<" symbol.

Liquid effluent

There are three sources of allowable liquid effluent from the BRR facility: plant effluent, stormwater runoff and sewage treatment plant effluent. These effluents are collected in lagoons and treated, as required, prior to being discharged 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 2011 to 2015 are summarized in table 3-3. For 2015, the liquid discharges from the facility continued to be below their respective licensed limits. No action levels were exceeded at any time in 2015.

Table 3-3: Liquid effluent monitoring results (annual averages), Blind River Refinery, 2011–15

Parameter	2011	2012	2013	2014	2015	Licence limit
Uranium (mg/l)	0.02	0.01	0.01	0.02	0.02	**2**
Nitrates (mg/l)	30	28	26	17	13	**1,000**
Radium-226 (Bq/l)	<0.01	<0.01	0.01	0.01	<0.01	**11**
pH (min)	7.1	7.2	7.1	7.1	7.2	**6.0**
pH (max)	8.2	8.2	8.4	8.4	8.4	**9.5**

Note: Results less than detection limit are denoted with the "<" symbol.

Environmental managements system

Cameco has developed and maintains an environmental management system (EMS) that provides a framework for integrated activities with respect to the protection of the environment at the BRR facility. The EMS, which is described in Cameco's Environmental Management Program Manual, includes activities such as establishing annual environmental objectives and targets that are reviewed by CNSC staff through compliance verification activities. Cameco holds an annual safety meeting in which environmental protection issues are discussed. CNSC staff, as part of their compliance verification activities, review these minutes and follow up with BRR staff on any outstanding issues. The results of this review demonstrate that Cameco is conducting an annual management review in accordance with CNSC requirements and identified issues are being addressed.

Assessment and monitoring

Cameco's environmental monitoring programs serve to demonstrate that emissions of nuclear and hazardous materials from BRR are properly controlled. The program also provides data for estimates of annual radiological dose to the public to make sure the public dose attributable to BRR's operations is ALARA and well below the annual regulatory dose limit of 1 mSv. The principal monitoring activities are focused on monitoring the air, groundwater, surface water, soil and gamma radiation around the facility.

Uranium in ambient air

The concentrations of uranium in the ambient air as monitored by Cameco's sampling network around the BRR facility continue to be consistently low. In 2015, the highest annual average concentration (among the sampling stations) of uranium in ambient air measured was 0.0031 $\mu g/m^3$, which is well below the MOECC's standard for uranium in ambient air of 0.03 $\mu g/m^3$.

Groundwater monitoring

A total of 43 monitoring wells currently exist in and around the BRR facility (17 wells inside the perimeter fence and 26 wells outside the fence).

Based on the groundwater sampling data presented in Cameco's annual compliance reports, the refinery operations are not causing any adverse impact to groundwater quality. The average uranium concentration in groundwater, however, appears to be increasing. Cameco attributes the increase to one specific monitoring well, BH #22, located just south of the main UO_3 plant building and adjacent to the digestion and calcination process areas. The maximum sampled uranium concentration in the groundwater for this well was 18.5 µg/L in 2015, 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). The maximum individual result from the other monitoring wells was 4.4 µg/L. Further, the average uranium result from all other monitoring wells at BRR, if BH #22 is removed from the calculation, was 0.6 µg/L, the same as in 2014.

The reason for the increase in concentration at BH #22 is not definitively known but may be attributable to slightly contaminated surface water run-off in the vicinity of the monitoring well. This location was used for temporary storage of empty uranium concentrate drums, prior to them being grit blasted. The historical inventory of empty concentrate drums, which originally numbered more than 100,000, has now been eliminated so this location is no longer used for the storage of empty drums. A number of cracks and openings in the asphalt around this monitoring well were sealed as a preventive measure last summer. Cameco is continuing to investigate and monitor results from this location.

CNSC staff concur with Cameco's conclusions on the likely cause for the elevated concentrations as well as its path forward to address this matter. CNSC staff will continue to monitor the situation.Groundwater monitoring results are provided in table F-1, appendix F.

Surface water monitoring

Cameco continues to monitor surface water for uranium and other parameters at the location of the BRR outfall diffuser in Lake Huron. The concentration of uranium in the lake remains well below published federal and provincial guidelines. Surface water monitoring results are provided in table F-2, appendix F.

Soil monitoring

Cameco continues to collect soil samples on an annual basis, monitoring uranium concentrations in the upper layer of surface soil (i.e., 15 cm) to demonstrate that there are no long-term effects of its air emissions because there is no accumulation of uranium in the soil around the BRR facility. The results in 2015 remained consistent with the uranium soil concentrations detected in previous years. The average uranium soil concentrations observed near the facility were well below 23 μg/g, which is the most restrictive CCME soil quality guideline for residential and parkland use. Overall, uranium soil concentrations do not appear to increase in the area surrounding the facility, confirming that current BRR operations have no effects on soil quality. Soil sampling results are provided in table F-3, appendix F.

Gamma monitoring

A significant portion of radiological public dose in the town of Blind River attributable to BRR operations is due to gamma radiation sources. Therefore, it is essential to monitor gamma radiation effective dose rates at the fenceline of the BRR main site and the nearby golf course (critical receptor location) to ensure levels of gamma radiation are maintained ALARA. The gamma radiation effective dose rates for both locations are measured using environmental dosimeters. The annual average of fenceline gamma measurements at the BRR main site, in microsieverts (µSv), were 0.25 µSv/h (east), 0.26 µSv/h (north), 0.31 µSv/h (south) and 1.53 µSv/h (west) in 2015. The BRR main site sets an action level for gamma dose rates of 1.0 µSv/h at the north fence only. These measurements indicate that gamma dose rates are controlled and the public is protected.

Other monitoring

In 2013 and 2014, CNSC staff collected and analyzed a number of environmental samples in publicly accessible areas outside the perimeter of the facility under the IEMP. The results can be found on the CNSC's IEMP Web page. Results obtained by the CNSC confirmed that the public and the environment in the vicinity of BRR are protected from the releases from the facility.

Protection of the public

Cameco is required to demonstrate that the health and safety of the public are protected from exposures to hazardous substances released from the BRR 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.

CNSC receives reports of discharges to the environment through the reporting requirements outlined in the BRR licence and licence conditions handbook. The review of BRR's hazardous (non-radiological) discharges to the environment indicates that no significant risks to the public or environment have occurred during this period.

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

Environmental risk assessment

Cameco indicated that it would implement three environmental protection standards by the end of 2017: CSA Group standards N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills*; N288.5-11, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills*; and N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills*. CNSC staff will review the respective BRR documents to make sure they address the compliance requirements of the CSA Group standards. Cameco currently has acceptable environmental programs in place to ensure the protection of the public and the environment.

3.4 Conventional health and safety

Overall compliance ratings for conventional health and safety SCA, Blind River Refinery, 2011–15

2011	2012	2013	2014	2015
SA	SA	FS	FS	FS

For 2015, 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 LTIs have occurred for more than nine years.

Performance

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. Per table 3-4, the number of LTIs remained at zero in 2015. BRR has not had an LTI in the past nine years.

Table 3-4: Lost-time injuries, Blind River Refinery, 2011–15

	2011	2012	2013	2014	2015
Lost-time injuries	0	0	0	0	0

Practices

Cameco's activities and operations at BRR are required to comply with not only the NSCA and its associated regulations but also with Part II of the *Canada Labour Code*. As such, Cameco is required to report incidents resulting in an injury to ESDC. CNSC staff receive copies of these reports.

BRR's commitment to safety is captured in a safety charter signed by each employee and displayed at the entrance of the facility. Cameco has a Facility Health and Safety Committee that inspects the workplace and meets monthly to resolve and track any safety issues. CNSC staff frequently review the committee meeting minutes and associated corrective actions to verify that issues are promptly resolved.

Awareness

Cameco continues to develop and maintain a comprehensive occupational health and safety management program for the BRR site. During 2015, Cameco undertook nine initiatives to improve occupational health and safety. Workers are made aware of the conventional health and safety program as well as workplace hazards through training and ongoing internal communications with Cameco. CNSC staff continue to monitor the effectiveness of these improvement initiatives through regular onsite inspections.

4 PORT HOPE CONVERSION FACILITY

Cameco owns and operates the Port Hope Conversion Facility (PHCF) under an operating licence that expires on February 28, 2017. PHCF is located in the municipality of Port Hope, ON, situated on the north shore of Lake Ontario, approximately 100 kilometres east of Toronto. An aerial photograph of the site is shown in figure 4-1.

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

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

In 2015, there were no licence amendments; however, there were two revisions to the PHCF licence conditions handbook, as described in table I-2, appendix I. Cameco submitted an application to renew its operating licence for PHCF in November 2015. The licence renewal hearing is scheduled the week of November 9, 2016 in the community of Port Hope, ON.

4.1 Performance

For 2015, CNSC staff continued to rate PHCF's performance as "satisfactory" in all SCAs. The PHCF performance ratings for 2011 through 2015 are provided in table C-2, appendix C.

In 2015, Cameco made no significant changes to the processes it uses to ensure the physical design of the PHCF site is maintained and made no facility modifications that affected PHCF's safety case. During the summer of 2015, the UO_2 and UF_6 plants underwent scheduled shutdowns to allow for planned maintenance activities and to allow employees to take vacation time. Cameco also started its 2015 clean-up project at PHCF that summer, which covered the removal and processing of obsolete equipment and the demolition of buildings 42 and 43 annex on the Centre Pier. After achieving the annual production targets, the UO_2 and UF_6 plants were safely shutdown in December 2015.

As outlined below, PHCF experienced a number of events or incidents that were reported to CNSC staff in 2015:

- In May 2015, PHCF staff recognized that a small spool section feeding potassium hydroxide should have been treated as a pressure-retaining component. Given that this line was not previously identified or maintained as a pressure retaining component, Cameco conducted a review to determine any other pressure-retaining components not previously identified. Cameco intends to replace the identified piping by the end of December 2015 to ensure that all pressure-retaining components meet the appropriate specifications. CNSC staff are satisfied with the measures taken and corrective actions identified by Cameco. CNSC staff will verify the completion of these corrective actions during an onsite inspection.
- In July 2015, a white, chalky substance was observed over portions of a building rooftop, piping infrastructure and on the ground. The source of the substance was traced to liquid discharges from one of the waste water evaporator stacks. Cameco took immediate actions to prevent further liquid discharges such as installing flow indicators, lowering the operating range of the evaporator level and increasing the frequency of building inspections. CNSC staff are satisfied with the compensatory measures and corrective actions taken by Cameco.
- In November 2015, Cameco reported two action level exceedances: one for a skin dose and the other for a routine uranium-in-urine pre-shift sample. These two action level exceedances are described in more detail in section 4.2 under the "Radiation protection program performance" heading.

In addition to these reportable events or incidents, Cameco notifies CNSC staff of the regulatory reports it makes to Environment and Climate Change Canada, the Ontario MOECC and the Municipality of Port Hope. CNSC staff review these reports and follows up with additional regulatory oversight activities, as appropriate.

Vision in Motion (VIM) is Cameco's project to clean up and renew the PHCF. In 2015, Cameco carried out some clean-up and remediation work to further progress the planning and design development for VIM (e.g., test soil excavations, clean-up projects). In November 2015, Cameco submitted its application to renew its PHCF operating licence, which included information about the VIM project that will be carried out during the next licensing period.

In 2015, CNSC staff conducted five planned compliance inspections at PHCF to verify compliance with the NSCA and its regulations, Cameco's operating licence and the programs used to meet regulatory requirements. These planned onsite inspections focused on the areas of waste management, environmental protection, training. A dedicated onsite inspection was also conducted to follow up on the corrective actions associated with events that occurred in 2014, and CNSC staff reviewed Cameco's common-cause analysis report for the 2014 events. CNSC staff concluded that none of the findings from these regulatory oversight activities presented an immediate or unreasonable risk to the health, safety and security of workers, Canadians or the environment.

4.2 Radiation protection

Overall compliance ratings for radiation protection, Port Hope Conversion Facility, 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA
For 2015, 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*.				

Application of ALARA

As required by the *Radiation Protection Regulations,* Cameco continued to implement radiation protection measures at PHCF in 2015 to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. Cameco establishes radiation protection objectives and ALARA targets on an annual basis. These objectives and targets include worker dose reduction initiatives and other projects that examine ways to reduce in-plant uranium-in-air concentrations. In 2015, Cameco achieved the majority of its ALARA targets at PHCF (which focused on radiation doses to workers) and achieved a high compliance rate for bioassay submissions by workers.

Worker dose control

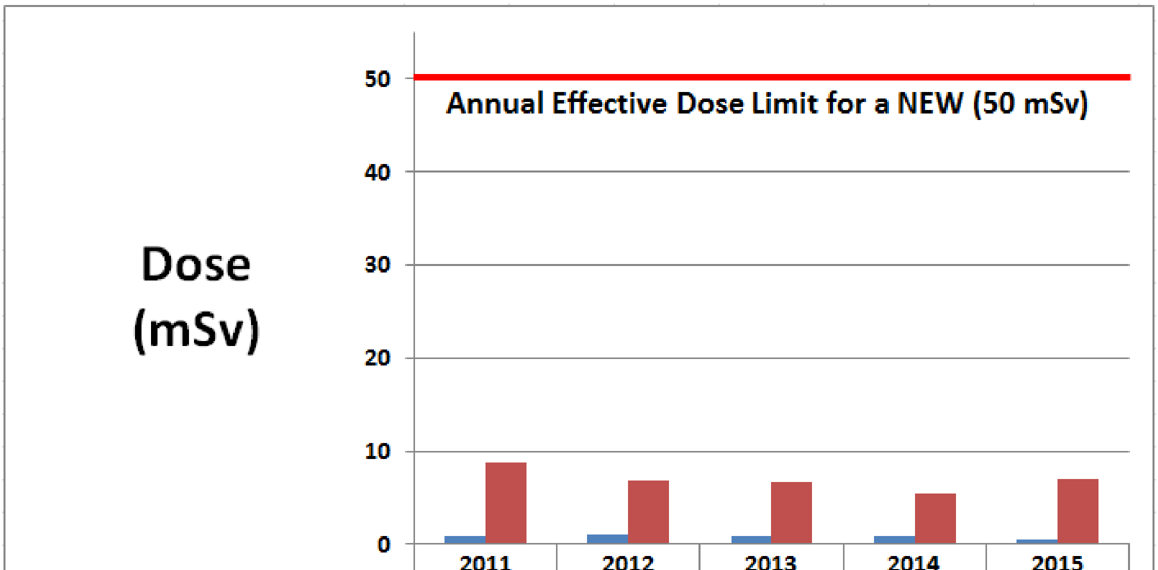
Radiation exposures are monitored to ensure compliance with the CNSC's regulatory dose limits and with keeping radiation doses ALARA. In 2015, radiation exposures at PHCF, as reported by Cameco, were well below the CNSC's regulatory dose limits.

Cameco ascertains external doses using whole body dosimetry. Extremity dosimetry is only used on a case-by-case basis and is 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: urine analysis and lung counting.

Workers (including contractors) conducting work activities that present a reasonable probability of receiving an occupational dose greater than 1 mSv are identified as NEWs at PHCF. In 2015, total effective dose was assessed for 862 NEWs at PHCF, consisting of 422 Cameco employees and 440 contractors. The maximum effective dose received by a NEW in 2015 was 7.0 mSv, or approximately 14 percent of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period. For the five-year dosimetry period from 2011–15, the maximum individual effective dose to a NEW at PHCF was 23.4 mSv. This radiation dose result represents approximately 23 percent of the regulatory dose limit of 100 mSv per five-year dosimetry period.

Figure 4-2 provides the average and maximum effective doses to NEWs at Cameco's PHCF between 2011 and 2015.

Figure 4-2: Average and maximum effective doses to nuclear energy workers, Port Hope Conversion Facility, 2011–15



	2011	2012	2013	2014	2015
Average effective dose (mSv)	0.8	1.1	0.8	0.8	0.6
Maximum effective dose (mSv)	8.8	6.9	6.6	5.4	7.0
Number of NEWs monitored	957	902	793	780	862

Note: The number of NEWs monitored from 2011 to 2014 has been corrected from previously reported values of 442, 450, 823 and 753. This is a correction to the results reported in *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2014*. The average effective doses for the years 2011 to 2013 have also been corrected (previously reported as 1.9, 2.0 and 0.7 mSv), as well as the maximum effective dose value for 2012 (previously reported as 7.0 mSv).

The average and maximum effective doses at PHCF were relatively stable between 2011 and 2015.

Annual average and maximum equivalent (skin) dose results from 2011 to 2015 are provided in table E-16, appendix E. In 2015, the maximum skin dose received by a NEW at PHCF was 23.4 mSv, which is approximately five percent of the regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. The maximum annual equivalent (skin) dose received by a NEW between 2011 and 2015 was 181.4 mSv – the result of a 2011 event where a worker had a finger laceration with contamination due to a maintenance activity. While this value is high in comparison with the routine skin exposures observed over these years, it still only represents approximately 36 percent of the regulatory equivalent dose limit of 500 mSv per year.

The majority of Cameco's administration and technical support staff whose job functions do not require them to be in uranium processing areas, as well as visitors to PHCF, are identified as non-NEWs. In 2015, the maximum effective dose received by a non-NEW was 0.29 mSv and averaged less than 0.1 mSv, which is well below the annual regulatory dose limit of 1 mSv for a member of the public.

Radiation protection program performance

The performance of the PHCF radiation protection program was assessed in 2015 through various CNSC staff compliance activities. Cameco's compliance with the *Radiation Protection Regulations* and CNSC licence requirements at PHCF was found to be acceptable.

Action levels for radiological exposures are established as part of the radiation protection program. If an action level is reached, it triggers Cameco staff to establish the cause, notify the CNSC and, if applicable, restore the effectiveness of the program. In 2015, there were two instances at PHCF where an action level was reached. Cameco completed investigations and established corrective actions in each instance to the satisfaction of CNSC staff.

In the first instance, an operator working in the UF_6 plant submitted a urine sample that was at the action level for uranium in urine: 65 µg of uranium per litre. The committed effective dose assigned to the worker was 0.12 mSv, well below the annual effective dose limit of 50 mSv for a NEW. After an investigation, Cameco suspected that the worker's respirator seal was compromised or the worker removed the respirator too soon after completing work, compromising the respirator's effectiveness in preventing an intake of uranium. In response, the worker was coached on the proper use of personal protective equipment (PPE), including the manner in which PPE should be removed. A safety bulletin was also issued to all onsite workers outlining the proper methods for removing PPE. Cameco has a number of initiatives that are expected to improve protection of workers in the UF_6 plant, including a review of PPE requirements for operators working in the plant's ash can room.

In the second instance, a maintenance employee working in the UF_6 plant recorded a monthly skin dose on his dosimeter of 17.4 mSv, which exceeded the 15 mSv per month action level for skin dose. Still, this dose was well below the annual equivalent dose limit of 500 mSv for a NEW. Cameco completed an investigation and determined that the worker had been part of a non-routine work assignment in which the worker was situated in an area where external dose rates were elevated, thereby contributing to the slightly elevated skin dose. As corrective actions, Cameco highlighted initiatives that were underway to enhance the protection of workers, including a review of safe work practices.

Radiological hazard control

Radiation and contamination control programs have been established at PHCF according to CNSC regulatory requirements 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. In-plant air monitoring and radiation dose-rate surveys conducted in 2015 did not identify any adverse trends and were consistent with expected radiological conditions. Contamination monitoring conducted by PHCF staff did not identify any adverse trends and no instances of contamination were detected in clean areas.

Estimated dose to the public

The maximum effective doses to a member of the public at PHCF for the years 2011 to 2015 are shown in table 4-1. Doses to the public are well below the PHCF operating release level of 0.3 mSv/year. The CNSC 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, 2011–15

Dose Data	2011	2012	2013	2014	2015	Regulatory Limit
Maximum effective dose (mSv)	0.019	0.029	0.021	0.012	0.006	**1 mSv/year**

4.3 Environmental protection

Overall compliance ratings for environmental protection SCA, Port Hope Conversion Facility, 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA

For 2015, CNSC staff continued to rate the environmental protection SCA at Cameco's PHCF as "satisfactory." Uranium releases to the environment continue to be controlled and monitored to comply with the conditions of the facility's operating licence and regulatory requirements. The releases of hazardous substances from the facility to the environment are controlled in accordance with the Ontario MOECC's applicable requirements. All the releases to the environment were well below regulatory limits during 2015. Fenceline gamma measurements, groundwater monitoring, surface water monitoring, soil sampling, vegetation and ambient air data indicate that the public and the environment continue to be protected from facility releases.

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 required to have suitably 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 PHCF. The monitoring data in table 4-2 demonstrates that stack emissions from the facility in 2015 continued to be effectively controlled and remained consistently below their respective licence limits. No action levels were exceeded at any time in 2015.

Table 4-2: Air emissions monitoring results (annual averages), Port Hope Conversion Facility, 2011–15

Location	Parameter	2011	2012	2013	2014	2015	Licence limit
UF_6 plant	Uranium (kg/h)	0.0051	0.0042	0.0051	0.0012	0.0017	**0.290**
	Fluorides (kg/h)	0.0199	0.0160	0.0190	0.0130	0.0170	**0.650**
UO_2 plant	Uranium (kg/h)	0.0013	0.0012	0.0013	0.0012	0.0012	**0.150**
	Ammonia (kg/h)	2.4	1.9	2.0	2.2	2.4	**58**

Liquid effluent

Cameco's operating licence does not allow PHCF to discharge any process waste water effluent. For 2015, there were no process liquid discharges from the facility. Cameco continues to evaporate rather than discharge process liquid effluent.

PHCF does discharge non-process liquid effluent such as cooling water and sanitary sewer discharges. Cameco monitors these releases in compliance with the requirements of other regulators that have jurisdiction. For the current and previous licensing periods, CNSC staff reviewed these monitoring results and found the levels to be consistently low and acceptable, and concluded that the licence requirement not to discharge process waste water effluent has been met.

Environmental management system

Cameco has developed and is maintaining an EMS that provides a framework for integrated activities with respect to the protection of the environment at PHCF. Cameco's EMS is described in its Environmental Management Program Manual and 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 an annual management review by Cameco where minutes and follow-up to outstanding issues are documented. CNSC staff, as part of their compliance verification activities, review these minutes and follow up on any outstanding issues with Cameco staff. The results of this review demonstrate that Cameco is conducting an annual management review per CNSC requirements and identified issues are being addressed.

Assessment and monitoring

Cameco's environmental monitoring programs serve to demonstrate that the site emissions of nuclear and hazardous materials are properly controlled. They also provides data for estimates of annual radiological dose to the public to make sure the public dose attributable to Cameco's PHCF operations is ALARA and below the annual regulatory dose limit of 1 mSv. The principal monitoring activities are focused on monitoring the air, groundwater, surface water, soil, vegetation and gamma radiation around the facility.

Uranium in ambient air

Cameco measures uranium in the ambient air at several locations around the facility to confirm the effectiveness of emission abatement systems and to monitor the impact of the facility on the environment. For 2015, the results from these samples show that uranium in air as suspended particulate has consistently remained very low: the highest annual average concentration (among the sampling stations) of uranium in ambient air measured around the facility in 2015 was 0.003 $\mu g/m^3$, well below the Ontario MOECC's 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
- 67 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, and the groundwater quality across the PHCF site in 2015 has not deteriorated or changed relative to the groundwater quality in previous years.

The mass of contaminants of concern (COC) captured in the pump-and-treat wells and removed before they reached the Port Hope Harbour are provided in table F-4, appendix F. From 2012 to 2015, there was an increase in most of the mass of COC removed due to the addition of four new pump-and-treat wells in October 2011. This result indicates a significant improvement to the pump-and-treat-well performance at PHCF.

Surface water monitoring

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 Port Hope Harbour. Details are provided in table F-5, appendix F. In addition, there is ongoing monitoring of the PHCF's cooling water intake, located in the Port Hope Harbour near the mouth of the Ganaraska River.

The surface water quality in the harbour adjacent to the PHCF has been monitored for uranium since 1977 through the analysis of samples collected from the south cooling water intake. The trend of average uranium concentrations from the south cooling water intake over time shows improvement since 1977, as shown in figure F-1, appendix F.

Soil monitoring

Cameco's soil monitoring program consist of five monitoring locations in the municipality of Port Hope, including 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 has changed compared to previous sample results.

The measured average uranium-in-soil concentrations in 2015 attributable to current PHCF operations have not increased and remained similar to past years. This suggests that uranium emissions from current PHCF operations do not contribute to the accumulation of uranium in soil. Soil sampling results are provided in table F-6, appendix F. These results are well below the 23 µg/g CCME soil quality guideline for residential and parkland use and are within the range of natural background for Ontario.

Fluoride monitoring

The impact of fluoride emissions from PHCF on the environment is determined each growing season (April 15 – October 15), when samples of fluoride-sensitive vegetation are collected and analyzed for fluoride content. The results in 2015 continued to be well below the MOECC's upper limit of 35 parts per million. Details are provided in table F-7, 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. Therefore, it is essential to monitor gamma radiation effective dose rates at the fencelines of the main PHCF site and the Dorset Street site to ensure levels of gamma radiation are maintained ALARA. The gamma radiation effective dose rates for both sites are measured using environmental dosimeters supplied by a CNSC-licensed dosimetry service. The annual average of fenceline gamma measurements at the main PHCF site was 0.007 µSv/h in 2015. The operating release level for the main site sets 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). These measurements indicate that gamma dose rates are controlled and that the public is protected.

Other monitoring

In 2014 and 2015, CNSC staff collected and analyzed a number of environmental samples in publicly accessible areas outside the perimeter of the facility under the CNSC's IEMP. The results can be found on the CNSC's IEMP Web page. Results obtained by the CNSC confirmed that the public and the environment in the vicinity of PHCF are protected from the releases from the facility.

Protection of the public

According to regulatory requirements, licensees must demonstrate that the health and safety of the public are protected from exposures to hazardous substances released from their facilities. The effluent and environmental monitoring programs currently conducted by Cameco are used to verify that releases of hazardous substances do not result in environmental concentrations that may affect public health.

CNSC receives reports of discharges to the environment through the reporting requirements outlined in the PHCF licence and licence conditions handbook. The review of hazardous (non-radiological) discharges to the environment for PHCF in 2015 indicates that no significant risks to the public or environment have occurred during this period.

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

Environmental risk assessment

Cameco submitted PHCF's revised environmental risk assessment (ERA) on January 8, 2016 for CNSC staff review and concurrence. CNSC staff have reviewed the ERA and concluded that the document complies with CSA Group standard N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills*. The ERA conclusions and recommendations, as well as guidance outlined in CSA standards N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills*; and N288.5-11, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills*, 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 conventional health and safety SCA, Port Hope Conversion Facility, 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA
For 2015, CNSC staff continued to rate the conventional health and safety SCA at the PHCF as "satisfactory." Overall, compliance verification activities conducted by CNSC staff at the facility confirmed that Cameco continues to view conventional health and safety as an important consideration. Cameco has demonstrated a satisfactory ability to keep its workers safe from occupational injuries.				

Performance

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. As indicated in table 4-3, over the past five years, the number of LTIs has been fairly consistent at PHCF, with two LTIs occurring in 2015. A description of the 2015 LTIs and the corrective actions taken by PHCF are provided in table G-1, appendix G.

Table 4-3: Lost-time injuries, Port Hope Conversion Facility, 2011–15

	2011	2012	2013	2014	2015
Lost-time injuries	3	1	0	1	2

Practices

Cameco's activities and operations at PHCF must comply with not only the NSCA and its associated regulations but also with Part II of the *Canada Labour Code*.

Conventional health and safety efforts at PHCF are supported by the Conversion Safety Steering Committee, a joint committee that was created in 2013. Cameco uses audits, inspections, evaluations, reviews, benchmarking, training, and employee participation and engagement to evaluate the effectiveness of conventional health and safety practices at PHCF.

All the reported conventional health and safety incidents are tracked and managed as part of PHCF's Cameco Incident Reporting System database.

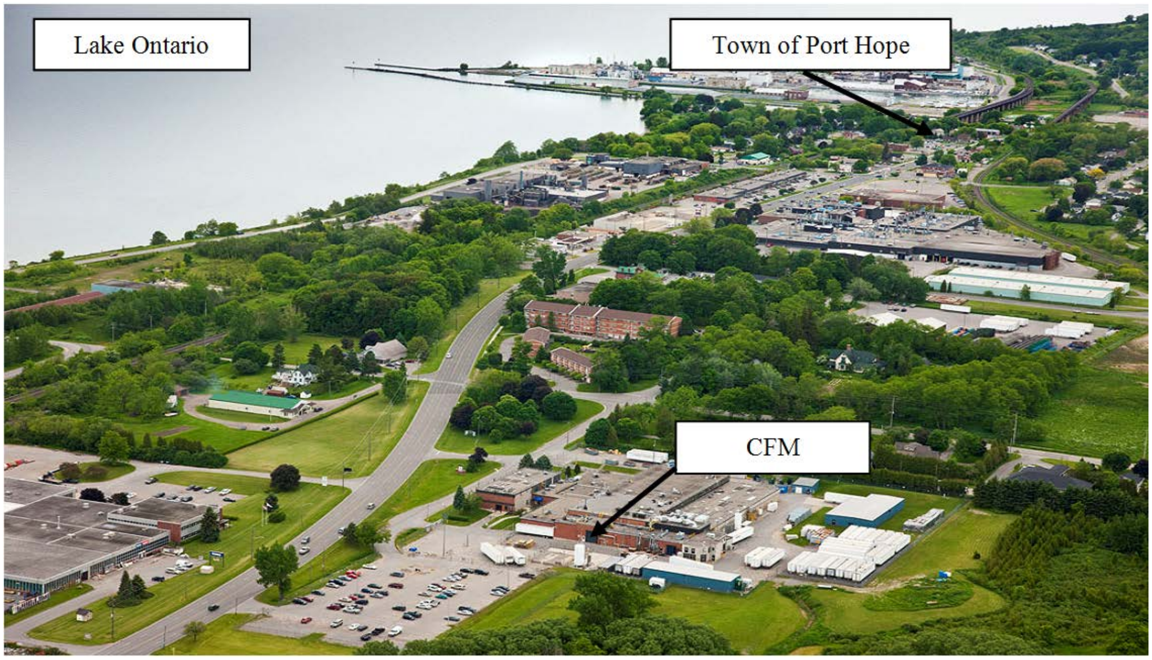
Awareness

Cameco continues to develop and maintain a comprehensive occupational health and safety management program for PHCF. During 2015, Cameco advanced several initiatives to improve occupational health and safety at the facility. Workers are made aware of the conventional health and safety program as well as workplace hazards through training and ongoing internal communications with Cameco. CNSC staff continue to monitor the effectiveness of these improvement initiatives through regular onsite inspections.

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, ON; 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 Cameco Fuel Manufacturing facility



The CFM facility in Port Hope operates under a CNSC licence that expires in 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.

In 2015, there were no licence amendments; however, there was one revision to the CFM licence conditions handbook, as described in table I-2, appendix I.

5.1 Performance

For 2015, CNSC staff rated Cameco's performance at CFM as "satisfactory" in all 14 SCAs. The CFM performance ratings for 2011 to 2015 are found in table C-3, appendix C.

Cameco continued to operate CFM in a safe manner throughout 2015. The facility underwent two planned shutdowns during the course of the year to conduct routine maintenance activities and implement facility upgrades.

In 2015, Cameco implemented several improvements to the CFM facility and its equipment, including improvements to extraction (ventilation) systems, furnace upgrades, and the commissioning of the new powder receiving and preparation area.

All modifications to CFM's buildings, processes, equipment and procedures with a potential impact to safety are evaluated through Cameco's internal change control processes. The 2015 modifications did not alter the licensing basis and were within the safety case described in the licensee's safety analysis report.

In 2015, there were two confirmed instances where action levels for extremity dose and internal dose were exceeded at CFM. Details of the occurrences are provided in section 5.2 under the "Radiation protection program performance" heading.

In 2015, CNSC staff conducted three onsite inspections to verify compliance with the NSCA and its regulations, Cameco's operating licence and the programs used to meet regulatory requirements. These inspections focused on fire protection, packaging and transport, and security. None of the findings from these inspections presented an immediate risk to the health, safety and security of workers, Canadians or the environment.

5.2 Radiation protection

Overall compliance ratings for radiation protection SCA, Cameco Fuel Manufacturing Inc., 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA
For 2015, 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*.				

Application of ALARA

Cameco establishes annual ALARA initiatives and dose targets for the CFM facility. CNSC staff reviewed and tracked CFM's performance against these initiatives and targets in 2015. In addition, CFM has a joint worker–management ALARA Committee at CFM, which aims to implement initiatives to lower worker radiological exposures.

In 2015, the majority of the ALARA dose targets were met at CFM, including the collective ALARA dose targets for the average annual dose per megagram of uranium for whole body, skin and extremity doses.

Worker dose control

Radiation exposures are monitored to ensure compliance with CNSC regulatory dose limits and to maintain radiation doses ALARA. In 2015, no worker's radiation exposure reported by Cameco at CFM exceeded the CNSC's regulatory dose limits.

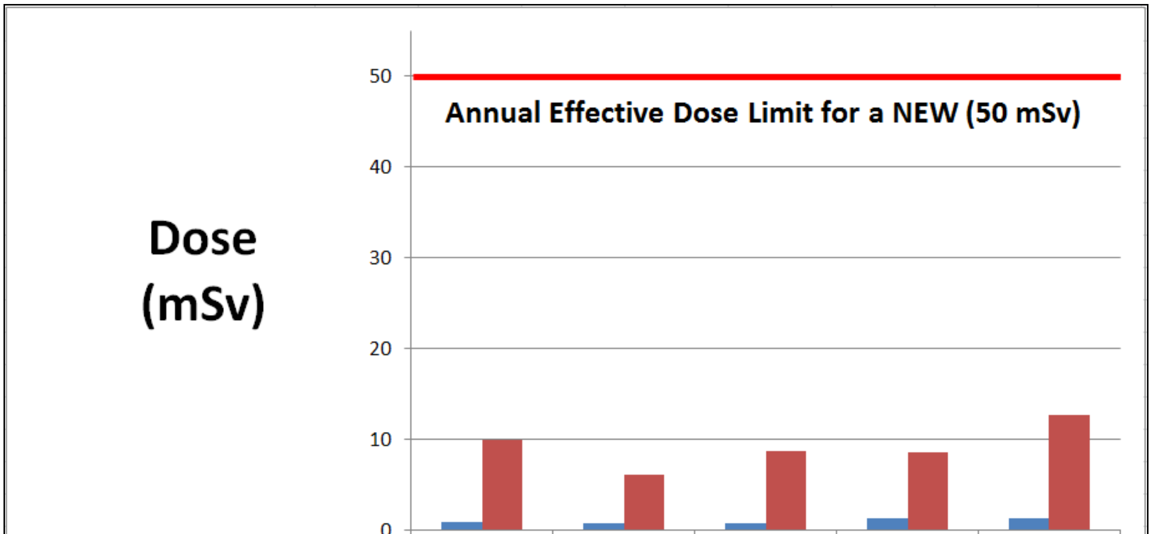
Cameco ascertains external doses using whole body and extremity dosimetry at CFM. For internal radiological exposures, Cameco's Fuel Services Division holds a CNSC dosimetry service licence, which authorizes Cameco to provide in-house internal dosimetry services at CFM. Internal dose is assessed and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

At CFM, all employees are identified as 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, which presents a reasonable probability of receiving an occupational dose greater than 1 mSv.

In 2015, total effective dose was assessed for 336 NEWs at CFM, consisting of 241 CFM employees and 95 contractors. The maximum effective dose received by a NEW in 2015 was 12.6 mSv, or approximately 25 percent of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period. For the five-year dosimetry period from 2011 to 2015, the maximum individual effective dose to a NEW at CFM was 36.2 mSv. This radiation dose result represents approximately 36 percent of the regulatory dose limit of 100 mSv per five-year dosimetry period.

Figure 5-2 provides the average and maximum effective doses to NEWs at CFM between 2011 and 2015.

Figure 5-2: Average and maximum effective doses to nuclear energy workers, Cameco Fuel Manufacturing Inc., 2011–15



	2011	2012	2013	2014	2015
Average effective dose (mSv)	0.8	0.7	0.7	1.3	1.2
Maximum effective dose (mSv)	9.9	6.0	8.6	8.5	12.6
Number of NEWs monitored	359	365	330	317	336

In 2015, the average effective dose is in line with the average from 2014. When compared to the other previous years (2011–2013), the average effective dose is slightly higher due to a change in the method of determining internal dose (from urinalysis to lung counting). The maximum individual effective dose in 2015 was higher than previous years. This is directly related to an incident where a worker received an acute, internal dose of 5.7 mSv; this event is discussed in more detail in the following section.

Annual average and maximum equivalent (extremity) and equivalent (skin) dose results from 2011 to 2015 are provided in tables E-8 and E-17, appendix E. In 2015, the maximum skin dose received by a NEW at CFM was 95.6 mSv, which is approximately 19 percent 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 87 mSv, or approximately 17 percent of the regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. Average and maximum equivalent doses to workers have been relatively stable between 2011 and 2015.

Site visitors and non-NEW contractors' doses are monitored at CFM using whole body dosimetry. In 2015, none of the non-NEWs monitored at CFM received any measurable whole body dose (i.e., above the reportable level for the dosimeter type of 0.1 mSv).

Radiation protection program performance

The performance of the radiation protection program at CFM was assessed in 2015 through various CNSC staff compliance activities. Cameco's compliance with the *Radiation Protection Regulations* and CNSC licence requirements at CFM was acceptable.

Action levels for radiological exposures are established as part of the CFM radiation protection program. If an action level is reached, it triggers CFM staff to establish the cause, notify the CNSC and, if applicable, restore the effectiveness of the program.

In 2015, there were two confirmed instances where action levels for extremity dose and internal dose were reached at CFM. The action level exceedances occurred to two different workers with different job functions. Both exceedances were reported to the CNSC and investigated by CFM. Corrective actions were also established.

In the first instance, a worker's extremity dosimeter recorded a dose result of 151 mSv, exceeding the CFM extremity dose action level of 55 mSv/quarter. Further investigation by Cameco and the dosimetry service provider determined that the extremity dosimeter worn by the worker was contaminated, meaning the dose reported was not representative of the actual dose to the worker's extremity. Cameco has planned to initiate a request to revise the worker's dose record with the National Dose Registry.

In the second instance, a worker received an acute, internal dose of 5.7 mSv during the first quarter of 2015, exceeding the CFM internal dose action level of 0.8 mSv/quarter. The worker was removed from further work in production areas to prevent additional exposure while an investigation was conducted. While Cameco's investigation identified a number of potential causes of the intake, it is suspected that the intake was related to deficiencies with the respirator protection program and compliance with the requirement for workers wearing respirators to be clean shaven. The event analysis report was provided to the CNSC, outlining the results of the investigation and the corrective measures that were put into place. One of the corrective measures included a brochure that provided clarification on what is considered acceptable facial hair when using a respirator.

In January 2016, CNSC staff conducted a thorough, reactive onsite inspection focused on this particular incident and the related corrective actions. Based on the findings of the inspection, CNSC staff concluded that CFM is in overall compliance with CNSC regulatory requirements. However, the inspection also identified areas requiring improvements, including the need for the development and documentation of all key processes to adequately support the implementation of the internal dosimetry program at CFM. These deficiencies do not pose a risk to the health and safety of workers; however, improvements are needed to support and improve the management of suspected and confirmed abnormal intakes of uranium by CFM workers. Cameco has provided a response to the inspection report and have committed to implementing corrective actions that adequately address the identified deficiencies by September 30, 2016.

Radiological hazard control

Radiation and contamination control programs have been established 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.

CFM staff conducted in-plant air monitoring, contamination monitoring and radiation dose-rate surveys in 2015, and did not identify any adverse trends. The results were consistent with expected radiological conditions. In 2015, Cameco initiated the installation of continuous air monitors throughout the CFM facility to measure in-plant air concentrations in real time.

Estimated dose to the public

The 2011 to 2015 annual doses to the critical receptor are shown in table 5-1. The public dose to the critical receptor is well below the CNSC regulatory dose limit for a member of the public of 1 mSv/year.

Table 5-1: Maximum effective dose to a member of the public, Cameco Fuel Manufacturing Inc., 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Maximum effective dose (mSv)	0.042	0.031	0.013	0.018	0.025	**1 mSv/year**

5.3 Environmental protection

Overall compliance ratings for environmental protection SCA, Cameco Fuel Manufacturing Inc., 2011–2015

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA

For 2015, CNSC staff continued to rate the environmental protection SCA at the CFM facility as "satisfactory."

Uranium and hazardous substance releases from CFM to the environment continue to be effectively controlled and monitored in 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.

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 required to have suitably 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 CFM facility. The monitoring data in table 5-2 demonstrate that stack and building exhaust ventilation emissions from the facility in 2015 continued to be effectively controlled and remained consistently well below CFM's licence limits. No action levels were exceeded at any time in 2015.

Table 5-2: Air emissions monitoring results, Cameco Fuel Manufacturing Inc., 2011–15

<table>
<tr><th>Parameter</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th><th>Licence limits</th></tr>
<tr><td>Total uranium discharge through stacks (kg/year)</td><td>0.02</td><td>0.02</td><td>0.03</td><td>0.01</td><td>0.01</td><td rowspan="2">14</td></tr>
<tr><td>Total uranium discharge through building exhaust ventilation (kg/year)</td><td>0.57</td><td>0.57</td><td>0.48</td><td>0.40</td><td>0.45</td></tr>
</table>

Liquid effluent

Cameco also continues to monitor uranium released as liquid effluent from the CFM facility. The monitoring data in table 5-3 demonstrate that liquid effluent from CFM in 2015 continued to be effectively controlled as they remained consistently well below CFM's licence limits. No action levels were exceeded at any time in 2015.

Table 5-3: Liquid effluent monitoring results, Cameco Fuel Manufacturing Inc., 2011–15

Parameter	2011	2012	2013	2014	2015	Licence limits
Total uranium discharge to sewer (kg/year)	1.18	0.95	0.83	1.58	1.24	**475**

Environmental management system

Per CNSC regulatory requirements, Cameco has developed and maintains an EMS that provides a framework for integrated activities with respect to the protection of the environment at CFM. The EMS is described in the CFM 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 holds an annual management review meeting in which environmental protection issues are discussed. CNSC staff, as part of their compliance verification activities, review these minutes and follow up with CFM staff on any outstanding issues. The results of this review demonstrate that Cameco is conducting an annual management review per CNSC requirements and identified issues are being addressed.

Assessment and monitoring

Cameco's environmental monitoring programs serve to demonstrate that the emissions of nuclear and hazardous materials from CFM are properly controlled. The program also provides data for estimates of annual radiological dose to the public to make sure the public dose attributable to the CFM operations is ALARA and below the annual regulatory dose limit of 1 mSv. The principal monitoring activities are focused on monitoring the air, groundwater, surface water, soil and gamma radiation around the facility.

Uranium in ambient air

Cameco operates high-volume air samplers at CFM 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 2015, the results from these samplers show that the highest annual average concentration (among the sampling stations) of uranium in ambient air measured around the CFM facility was 0.000056 $\mu g/m^3$, well below the Ontario MOECC's standard for uranium in ambient air of 0.03 $\mu g/m^3$.

Groundwater monitoring

As of the end of 2015, Cameco had a network of 75 groundwater monitoring wells (59 onsite and 16 offsite) within the immediate area of the CFM facility. Some of these wells are screened within the soil and some are screened within the underlying bedrock. The monitoring of these wells has a dual purpose: first, to investigate the extent of historical uranium in groundwater on the licensed property; second, to confirm that current operations are not contributing to the concentrations of uranium in groundwater on the licensed property. The monitoring results indicate that there is no increasing trend in uranium concentration in groundwater.

Surface water monitoring

During 2015, Cameco collected surface water samples at nine locations in June, nine locations in August and nine locations in October. The samples were taken from locations on and adjacent to the facility and were analyzed for uranium.

Uranium concentrations in all surface water samples collected in 2015 met the CCME water quality guideline of 15 µg/L, with the exception of two samples collected at SW-4 (33 µg/L in June and 19 µg/L in August). Sampling station SW-4 is located onsite at the drainage ditch leading to the creek. Uranium concentrations measured in samples collected from two offsite locations (i.e., downstream of CFM) were below the CCME water quality guideline for uranium.

CNSC staff will continue to oversee Cameco's monitoring at locations in the vicinity of CFM to confirm whether there are elevated uranium concentrations in surface water.

Soil monitoring

CFM collects soil samples from 23 locations surrounding the CFM facility on a three-year sampling frequency. Soil samples were last collected in 2013 and analyzed for uranium content. 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 use. A comparison of 2013 results with previous years indicates that there is no increasing trend in uranium concentration in soil.

Cameco did not monitor soil around CFM in 2015. The next soil sampling is scheduled for 2016. Soil sampling results are provided in table F-8, Appendix F.

Gamma monitoring

A significant portion of the radiological public dose in Port Hope attributable to the CFM operations is due to gamma radiation sources. Therefore, it is essential to monitor gamma radiation effective dose rates at the fencelines of the CFM site to ensure levels of gamma radiation are maintained ALARA. The gamma radiation effective dose rates for the site are measured using environmental dosimeters supplied by a licensed dosimeter service. The annual average of fenceline gamma measurements at the CFM site was 0.011 µSv/h in 2015. The derived release limit for the main CFM site sets a licensed limit for fenceline gamma dose rates of 0.35 µSv/h at the critical receptor located at station 1 (along the fenceline of the west side of the site). These measurements indicate that gamma dose rates are effectively controlled and the public is protected.

Other monitoring

In 2014 and 2015, CNSC staff collected and analyzed a number of environmental samples in publicly accessible areas outside the perimeter of the CFM facility under the CNSC's IEMP. The results can be found on the CNSC's IEMP Web page. Results obtained by the CNSC confirmed that the public and the environment in the vicinity of CFM are protected from the releases from the facility.

Protection of the public

According to regulatory requirements, licensees must demonstrate that adequate provision is made for protecting the health and safety of the public from exposures to hazardous substances released from their facilities. The effluent and environmental monitoring programs currently conducted by Cameco 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. The review of hazardous (non-radiological) discharges to the environment from CFM in 2015 indicated that no significant risks to the public or environment have occurred during this period.

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

Environmental risk assessment

In 2015, Cameco indicated that it would implement three environmental protection standards by the end of 2017: CSA Group standards N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills*; N288.5-11, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills*; and N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills*. CNSC staff will review the corresponding CFM documents to confirm they address the compliance requirements from the CSA Group standards. Cameco currently has acceptable environmental programs in place to ensure the protection of the public and the environment.

5.4 Conventional health and safety

Overall compliance ratings for conventional health and safety SCA, Cameco Fuel Manufacturing Inc., 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA
For 2015, CNSC staff continued to rate the conventional health and safety SCA at CFM as "satisfactory." Cameco has implemented and maintained a conventional health and safety program at CFM as required by the NSCA and Part II of the *Canada Labour Code*.				

Performance

Cameco uses a variety of key performance indicators (KPI) to measure the effectiveness of its conventional health and safety program at CFM. Among these KPIs, CNSC staff review the number of LTIs that occur per year as well as their severity. An LTI is an injury that takes place at work and results in the worker being unable to return to work for their scheduled shift or carry out their regular duties for a period of time.

As indicated in table 5-4, three LTIs were recorded at CFM over the past five years, with one occurring in 2015. A description of the 2015 LTI is provided in table G-2, appendix G.

Table 5-4: Lost-time injuries, Cameco Fuel Manufacturing Inc., 2011–15

	2011	2012	2013	2014	2015
Lost-time injuries	2	0	0	0	1

Practices

Cameco's activities and operations at CFM must comply with the NSCA and Part II of the *Canada Labour Code*. Cameco achieves this through a comprehensive Environmental and Occupational Health and Safety program that is consistent with Cameco's corporate policy and is modelled on the Occupational Health and Safety Assessment Series (OHSAS) 18001 standard.

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 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. It emphasizes proactive safety measures by regularly performing risk analyses of various operations throughout the facility and implementing alternate strategies to reduce the risk to the workers.

Awareness

Cameco continues to develop and maintain a comprehensive occupational health and safety management program, and tracks both leading and lagging safety indicators such as safety meeting attendance, percentage of monthly safety inspections completed, the performance of the Joint Health and Safety Committee, and a variety of other safety statistics. Workers are made aware of the conventional health and safety program as well as workplace hazards through training and ongoing internal communications with Cameco.

CNSC staff will continue to monitor CFM's performance related to conventional health and safety during onsite inspections and through event report review.

6 GE HITACHI NUCLEAR ENERGY CANADA INC.

GE Hitachi Nuclear Energy Canada Inc. (GEH-C) operates two Class IB nuclear facilities under a single licence (FFOL-3620.00/2020) to manufacture nuclear reactor fuel bundles for use at Ontario Power Generation's Pickering and Darlington nuclear generating stations. One site in Toronto produces uranium dioxide fuel pellets and the other site in Peterborough manufactures fuel bundles using the fuel pellets from Toronto together with zircaloy tubes manufactured in-house. The Peterborough site also operates a fuel services business involved with the manufacture and maintenance of equipment for use in nuclear power plants. A small quantity of fuel pellets are also fabricated at the Toronto facility for GEH-C's parent company in Wilmington, North Carolina.

Apart from conventional industrial hazards, the primary hazard at these facilities is the inhalation of airborne UO_2 particles. A lesser hazard exists in the form of low-level external gamma and beta doses to employees. The Peterborough facility also processes beryllium that poses inhalation hazards. Apart from various safety features in place to reduce occupational exposure to employees, all personnel working in potentially hazardous areas are monitored for exposure to whole body, skin and extremity doses with action levels to ensure proper monitoring and oversight. The facility operations have low environmental releases, which are controlled, monitored and reported per regulatory requirements.

Figures 6-1 and 6-2 show an aerial view of GEH-C's Toronto and Peterborough facility, respectively.

Figure 6-1: Aerial view of the GEH-C Toronto facility

Figure 6-2: Aerial view of the GEH-C Peterborough facility

In 2015, CNSC staff initiated a project to update GEH-C's licence conditions handbook to incorporate written notification requirements to align its regulatory oversight with those of peer facilities. On CNSC staff request, GEH-C reviewed the applicable CSA standards and CNSC regulatory documents, performed a gap analysis of existing programs and developed an action plan with a due date for compliance. This action plan has been accepted by CNSC staff. The revised licence conditions handbook, which incorporates the described changes (including written notification requirements and due dates for compliance of the notified regulatory documents), was signed in June 2016.

There were no amendments to GEH-C's licence, which expires on December 31, 2020. However, at the time of writing this report in August 2016, GEH-C has submitted a request to transfer the current licence due to the sale of GEH-C to BWXT Nuclear Energy Canada Inc. CNSC staff are in the process of evaluating this request with a recommendation to the Commission expected by the end of 2016.

6.1 Performance

For 2015, CNSC staff rated GEH-C's performance as "satisfactory" in all SCAs. The GEH-C performance ratings for 2011 through 2015 are provided in table C-4, appendix C.

In April 2015, GEH-C notified CNSC staff of the retirement of its president and chief executive officer, resulting in a new appointment to the same position. Several appointments were also made in 2015 to key management positions, including a new plant manager for the Toronto facility.

In March 2015, CNSC staff directed GEH-C management to address identified deficiencies related to its public information program. In June 2015, GEH-C provided a 29-point improvement plan to ensure adequate engagement and communications with the local community near its Toronto and Peterborough facilities. A new position (senior manager of community relations and communications) was created as part of this improvement plan and all improvement activities were completed by December 2015. CNSC staff continue to maintain increased oversight on GEH-C's progress, including participation in its Community Liaison Committee meetings and its presence during community outreach events in 2016. For 2015, CNSC staff determined that GEH-C's implementation of its improvement plan for public information and disclosure is satisfactory and is commensurate with its operations.

Production operations at both GEH-C facilities continued in a safe manner without any significant challenges. Major engineering projects and equipment maintenance were completed during planned shutdowns of the two facilities in each quarter during the reporting period. In 2015, GEH-C completed the implementation of a new systematic approach to training (SAT) process and associated procedures, and is in compliance with REGDOC-2.2.2, *Personnel Training*. GEH-C also conducted 19 internal audits to ensure compliance and the safe conduct of its operations.

In 2015, improvements to plant equipment and processes included upgrades to the loading dock in the Peterborough facility as well as natural gas supply upgrades, including header and piping replacements, in the Toronto facility. All changes were made through GEH-C's change control system to ensure they were within GEH-C's licensing basis and had no impact to the health and safety of personnel and the environment. All changes at GEH-C's facilities were minor in nature and did not alter the licensing basis, and no changes were made to the facility safety analysis reports during this reporting period.

In February 2015, GEH-C reported an event where a sprinkler water pipe burst, resulting in the dousing of certain sections of the warehouse at the Toronto facility. No nuclear material was involved. GEH-C conducted a root-cause analysis of the event and determined the pipe's fracture was a result of ice buildup due to unusually cold weather. GEH-C has implemented several corrective actions associated with this event, which were reviewed and accepted by CNSC staff.

In October 2015, GEH-C reported an event where a partial skid of nuclear material was shipped from its Peterborough facility back to its Toronto facility with improper shipping documents. The shipment was made in a dedicated truck between the two facilities and there was no risk to the public. Once the error was identified, GEH-C took actions to inform CNSC staff of this error and provided a corrected inventory of nuclear material. A root-cause analysis was completed and seven corrective actions were put in place to address this event. These corrective actions were reviewed and accepted by CNSC staff.

In December 2015, GEH-C reported a minor change to the reported annual effective dose for NEWs in its Toronto facility for the years 2013, 2014 and 2015. This change was a result of the correction of a software error discovered by the CNSC during a radiation protection onsite inspection the previous month. GEH-C performed a root-cause analysis of the error and reviewed the method by which radiation doses were calculated and reported. GEH-C is in the process of implementing these corrective actions.

There were no action level exceedances related to radiation protection and environmental protection, as well no lost-time injuries reported for 2015.

In 2015, CNSC staff conducted four inspections at GEH-C facilities to verify compliance with the NSCA and its regulations, GEH-C's operating licence and the programs used to meet regulatory requirements. The inspections focused on conventional health and safety, environmental protection, the transport of nuclear material and radiation protection. GEH-C has addressed the majority of non-compliances from these inspections in 2015 and has submitted acceptable plans to address the remaining non-compliances. None of the findings made during these inspections presented an immediate or unreasonable risk to the health, safety and security of workers, Canadians and the environment.

6.2 Radiation protection

Overall compliance ratings for radiation protection SCA, GE Hitachi Nuclear Energy Canada Inc., 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA
For 2015, CNSC staff continued to rate the radiation protection SCA at GEH-C as "satisfactory." GEH-C has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations*.				

Application of ALARA

As required by the *Radiation Protection Regulations*, GEH-C continued to implement radiation protection measures in 2015 to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. GEH-C establishes annual goals and initiatives for its radiation protection program, and GEH-C's ALARA Committee meets quarterly (at a minimum) to discuss dose and internal audit results as well as employee concerns related to radiation protection. The ALARA Committee also sets annual ALARA goals, such as worker dose reductions. In 2015, GEH-C met its ALARA goals for maintaining uranium in air concentrations below target values in Toronto, and achieved more than 95 percent compliance with respect to surface contamination swipes below the internal control levels in Peterborough.

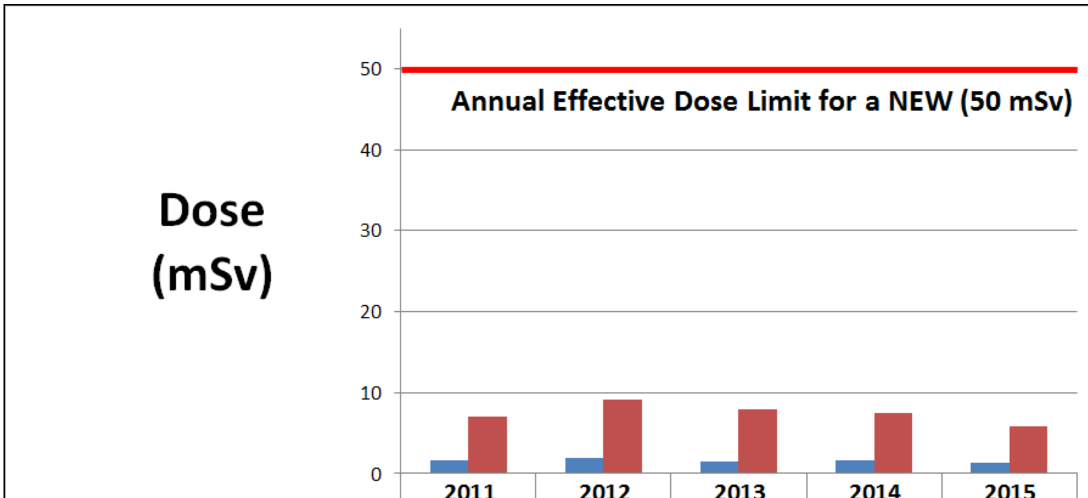
Worker dose control

GEH-C's workers are exposed externally to uranium dioxide pellets. At the Toronto facility, they are also exposed internally to uranium dioxide powder. External whole body and equivalent doses are ascertained using dosimeters. Internal dose is assessed and assigned at GEH-C Toronto through a uranium-in-air breathing zone monitoring program.

At GEH-C, most employees are identified as NEWs. Radiation exposures to NEWs are monitored to ensure maintain radiation doses ALARA and to ensure compliance with the CNSC's regulatory dose limits. In 2015, no worker's radiation exposure reported by GEH-C exceeded the CNSC regulatory dose limits.

Annual average and maximum effective dose results from 2011 to 2015 for the Peterborough facility are provided in figure 6-3. The maximum effective dose received by a NEW in 2015 at the Peterborough facility was 5.77 mSv, or approximately 12 percent of the regulatory effective dose limit of 50 mSv for NEWs in a one-year dosimetry period.

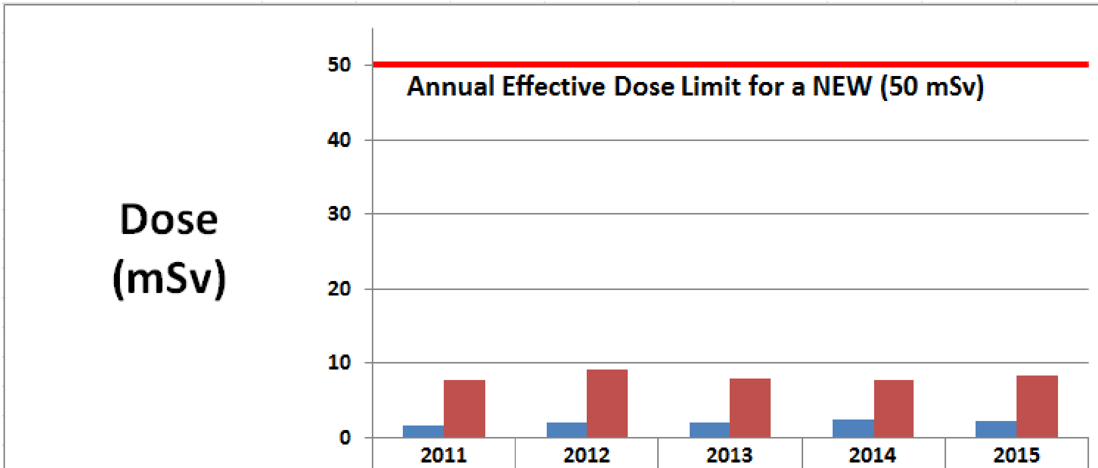
Figure 6-3: Average and maximum effective doses to nuclear energy workers, GEH-C Peterborough facility, 2011–15



	2011	2012	2013	2014	2015
Average effective dose (mSv)	1.71	1.97	1.51	1.67	1.35
Maximum effective dose (mSv)	7.06	9.16	7.96	7.55	5.77
Number of NEWs monitored	80	76	82	78	75

Annual average and maximum effective dose results from 2011 to 2015 for the Toronto facility are provided in figure 6-4. The maximum effective dose received by a NEW in 2015 at the Toronto facility was 8.38 mSv, or approximately 17 percent of the regulatory effective dose limit of 50 mSv for NEWs in a one-year dosimetry period.

Figure 6-4: Average and maximum effective doses to nuclear energy workers, GEH-C Toronto facility, 2011–15



	2011	2012	2013	2014	2015
Average effective dose (mSv)	1.62	1.98	1.95	2.39	2.14
Maximum effective dose (mSv)	7.78	9.22	8.03	7.80	8.38
Number of NEWs monitored	59	61	67	67	69

Note: The maximum effective doses for 2013 and 2014 were 8.03 and 7.80 mSv, respectively (previously reported as 7.80 and 7.62 mSv). The average effective worker dose values have also been corrected from the results reported in *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2014*.

For both facilities, non-NEWs and contractors (which are all identified as non-NEWs) are not directly monitored. Doses are estimated based on in-plant radiological conditions and occupancy factors to ensure radiation doses are controlled well below the public dose limit of 1 mSv/year.

The maximum five-year effective dose received by a NEW at the Peterborough facility for the 2011–15 five-year dosimetry period was 35.61 mSv, or approximately 36 percent of the regulatory effective dose limit of 100 mSv. The maximum five-year effective dose received by a worker at the Toronto facility for the 2011–15 five-year dosimetry period was 39.1 mSv, or approximately 39 percent of the regulatory effective dose limit of 100 mSv.

Annual average and maximum equivalent dose results for skin and extremity from 2011 to 2015 are also provided in tables E-9, E-10, E-18 and E-19, appendix E. The maximum equivalent skin dose for either facility in 2015 was 54.99 mSv (Toronto), while the maximum equivalent extremity dose was 109.62 mSv (also in Toronto). 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; in comparison, this practice is considered routine at the Toronto facility. At the Peterborough facility, with the exception of 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 GEH-C radiation protection program. If reached, it triggers GEH-C staff to establish the cause for reaching the action level, notify the CNSC and, if applicable, restore the effectiveness of the program. In 2015, there were no action level exceedances at either GEH-C facility.

Radiological hazard control

Radiation contamination controls have been established at GEH-C according to regulatory requirements to control and minimize the spread of radioactive contamination. Methods of contamination control include the use of a radiation zone control program and monitoring using surface contamination swipes to confirm the effectiveness of the program. In 2015, the number of swipe locations remained relatively constant. CNSC staff confirmed that no adverse trends were identified in the monitoring results for 2015.

Estimated dose to the public

The 2011–15 maximum effective doses to a member of the public are shown in table 6-1. These doses are for the Toronto facility only; the Peterborough facility reported doses of 0.00000 mSv for 2013, 2014 and 2015. The public dose to the critical receptor is well below the CNSC regulatory dose limit for a member of the public of 1 mSv/year.

Table 6-1: Maximum effective dose to a member of the public, GEH-C Toronto facility, 2011–2015

Dose data	2011	2012	2013	2014	2015	Regulatory dose limit
Maximum effective dose (mSv)	0.0008	0.0011	0.0006	*0.0055	0.010	**1 mSv/year**

Note: The values for public dose have been corrected from those reported in the *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2014*. The data reflects updated values provided by GEH-C in response to a 2015 inspection finding related to air emissions. The previously reported values for public dose for 2011 to 2014 were 0.0006, 0.0008, 0.0004 and 0.0052 mSv, respectively. Additional details are provided in Section 6.3 under the “Atmospheric emissions” heading.
* Beginning in 2014, GEH-C Toronto implemented 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 environmental protection SCA, GE Hitachi Nuclear Energy Canada Inc., 2011–15

2011	2012	2013	2014	2015
FS	FS	FS	FS	SA

For 2015, CNSC staff rated the environmental protection SCA at the GEH-C facilities as "satisfactory." Per regulatory requirements, GEH-C maintains an excellent record of low atmospheric emissions and liquid effluent releases that are filtered, sampled and recorded before release to the environment. Additional details related to the change in ratings are provided below under the "Atmospheric emissions" heading.

All uranium and hazardous substance releases from GEH-C facilities to the environment continued to be well below regulatory limits during 2015. Fenceline gamma measurements, soil sampling and ambient air data indicate that the public and the environment continue to be protected from facility releases.

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 required to have suitably 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 GEH-C facilities is filtered and sampled prior to its release to the atmosphere. In 2015, the annual releases of uranium from the GEH-C facilities in Toronto and Peterborough were 0.0098 kg and 0.000003 kg, respectively. GEH-C's annual uranium emissions from the Toronto and Peterborough facilities from 2011 to 2015 are provided in tables F-9 and F-13, 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 the GEH-C facilities. No action levels were exceeded at any time in 2015.

In April 2015, CNSC staff conducted an inspection focused on environmental protection at GEH-C's Toronto and Peterborough facilities. A significant inspection finding was that GEH-C had not been reporting on all total uranium released to atmosphere from its Toronto facility. Three stacks from which furnace emissions are released to the environment at the Toronto facility were not being monitored for uranium. As well, the uranium emissions from these stacks were also not being estimated and reported per regulatory requirements. CNSC staff directed GEH-C to address this deficiency. GEH-C submitted an acceptable corrective action plan and CNSC staff are monitoring its implementation. Although this was an identified deficiency in the GEH-C Toronto atmosphere emissions monitoring program, due to the low emissions from the facility, there is no impact on the health and safety of the public and the environment.

Liquid effluent

To ensure compliance with licence limits, waste water from the GEH-C facilities is collected, filtered and sampled prior to its release to the sanitary sewers in Toronto and Peterborough. In 2015, the annual release of uranium from the GEH-C Toronto and Peterborough facilities were 0.4 kg and 0.0001 kg, respectively. GEH-C's annual uranium effluent releases from its Toronto and Peterborough facilities for 2011 to 2015 are provided in tables F-9 and F-13, appendix F. In 2015, the releases continued to be well below the licence limit. The results demonstrate that liquid effluent releases are being controlled effectively at the GEH-C facilities. No action levels were exceeded at any time in 2015.

Environmental management system

GEH-C maintains an EMS that provides a framework for integrated activities with respect to the protection of the environment at its facilities. As described in GEH-C's Environmental Management Program Manual, this EMS includes activities such as establishing annual environmental objectives and targets, which are reviewed and assessed by CNSC staff through compliance verification activities.

GEH-C holds regular safety meetings in which environmental protection issues are discussed and minutes are issued. As part of their compliance verification activities, CNSC staff review the safety meeting minutes and follow up on any outstanding issues with GEH-C staff. CNSC staff have confirmed that GEH-C is conducting an annual management review per CNSC requirements and identified issues are being addressed.

Assessment and monitoring

GEH-C's environmental monitoring program serves to demonstrate that emissions of nuclear and hazardous materials from its facilities are properly controlled. The program also provides data for estimates of annual radiological dose to the public to make sure the public dose attributable to GEH-C's Toronto and Peterborough operations are ALARA and well below the annual regulatory dose limit of 1 mSv. The principal monitoring activities are focused on monitoring the air and soil at GEH-C Toronto as well as gamma radiation around both the Toronto and Peterborough facilities.

Uranium in ambient air

GEH-C 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 (among the sampling stations) of uranium in ambient air measured around the facility in 2015 was 0.001 $\mu g/m^3$, well below the MOECC's standard for uranium in ambient air of 0.03 $\mu g/m^3$. Air monitoring results for GEH-C Toronto are provided in table F-10, appendix F.

Soil monitoring

GEH-C conducts soil sampling at its Toronto facility as part of its environmental monitoring program. In 2015, samples were taken from 49 locations (on the GEH-C site, on commercial property located along the south border of the site and in the nearby residential neighbourhood) and then analyzed for uranium. In 2015, the average soil concentration of uranium for the residential locations was 0.7 µg/g while the maximum concentration of uranium in the soil at these locations was 2.1 µg/g. These values are in the range of natural background for Ontario and well below the most restrictive CCME soil quality guidelines for residential and parkland (23 µg/g). Soil sampling results are provided in tables F-11 and F-12, appendix F.

Gamma monitoring

For GEH-C Toronto, a significant portion of radiological public dose is due to gamma radiation sources. It is therefore essential to monitor gamma radiation effective dose rates at the fencelines of the GEH-C Toronto site to ensure levels of gamma radiation are maintained ALARA. Starting in 2014, the gamma radiation effective dose rate for the site has been measured using environmental dosimeters. The estimated effective dose as a result of gamma radiation during 2015 was 9.4 µSv for a total estimated dose of 9.8 µSv to a member of the public. This is well below the regulatory dose limit of 1 mSv (1,000 µSv) per year to a member of the public. These measurements indicate that gamma dose rates are controlled and the public is protected.

For GEH-C Peterborough, environmental dosimeters were put in place at the plant boundary in 2016. The results will be incorporated into the 2016 annual public dose estimation.

Other monitoring

In 2014, CNSC staff collected and analyzed a number of environmental samples in publicly accessible areas outside the perimeter of both GEH-C facilities under the CNSC's IEMP. The results can be found on the CNSC's IEMP Web page. Results obtained by the CNSC confirmed that the public and the environment in the vicinity of GEH-C Toronto and GEH-C Peterborough are protected from the releases from the facility.

Protection of the Public

According to regulatory requirements, CNSC licensee must demonstrate that the health and safety of the public are protected from exposures to hazardous substances released from their facilities. They are also required to ensure adequate provision is made for protecting the health and safety of the public. The effluent and environmental monitoring programs currently conducted by GEH-C 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 GEH-C licence and licence conditions handbook. The review of hazardous (non-radiological) discharges to the environment for GEH-C in 2015 indicates that these discharges do not pose significant risks to the public or the environment during this period.

Based on their reviews of the programs at the GEH-C Toronto and Peterborough facilities, CNSC staff concluded that the public continues to be protected from facility emissions.

Environmental risk assessment

GEH-C indicated that both the Toronto and Peterborough sites are working toward program improvements to achieve compliance with three environmental protection standards by the end of 2016: CSA Group standards N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills*; N288.5-11, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills*; and N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills*. CNSC staff will review the respective GEH-C documents to make sure they address the compliance requirements of the CSA Group standards. CNSC staff actively maintain oversight on GEH-C's progress related to its commitments on the implementation of the above CSA Group standards.

6.4 Conventional health and safety

Overall compliance ratings for conventional health and safety SCA, GE Hitachi Nuclear Energy Canada Inc., 2011–15

2011	2012	2013	2014	2015
FS	SA	SA	SA	SA
For 2015, CNSC staff continued to rate the conventional health and safety SCA at GEH-C as “satisfactory.” Overall, the compliance verification activities conducted by CNSC staff confirmed that GEH-C continues to view conventional health and safety as an important consideration.				

Performance

GEH-C’s conventional health and safety program incorporates elements such as training, contractor safety, fall protection, electrical safety, hot work, cranes and hoists, and chemical management. GEH-C staff conduct routine self-assessments and program evaluations are conducted to ensure compliance.

For 2015, both the Toronto and Peterborough facilities reported zero LTIs. Tables 6-2 and 6-3 show the trend of LTIs for both facilities for 2011 through 2015.

Table 6-2: Lost-time injuries, GEH-C Toronto, 2011–15

	2011	2012	2013	2014	2015
Lost-time injuries	0	1	0	1	0

Table 6-3: Lost-time injuries, GEH-C Peterborough, 2011–15

	2011	2012	2013	2014	2015
Lost-time injuries	0	0	0	0	0

Practices

During this reporting period, GEH-C's program practices were being transitioned to GE's new environment health and safety framework, which covers all aspects of worker safety and environmental protection, including leadership and accountability; regulatory applicability; environment, health and safety processes and systems; emergency preparedness and response; risk assessment; highly hazardous processes; safety defenses and exposure defenses. GEH-C must comply with the NSCA and its regulations and Part II of the *Canada Labour Code*. GEH-C 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

To ensure compliance and continuous improvement in its conventional health and safety program, GEH-C conducted 31 WSC inspections and investigations at its Toronto facility and 66 WSC inspections and investigations at its Peterborough facility in 2015. Performance metrics are regularly reviewed by management for each facility and these are summarized in the GEH-C's annual report. The major findings from the WSC inspections in Peterborough were related to equipment safety, emergency response/preparedness, housekeeping, documents and fall protection. The top five findings emerging from the Toronto WSC inspections pertained to housekeeping, personal protective equipment, facilities, emergency response/preparedness and potential unsafe conditions. CNSC staff will continue to monitor the effectiveness of GEH-C's program through onsite inspections.

SECTION II: NUCLEAR SUBSTANCE PROCESSING FACILITIES

7 OVERVIEW

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

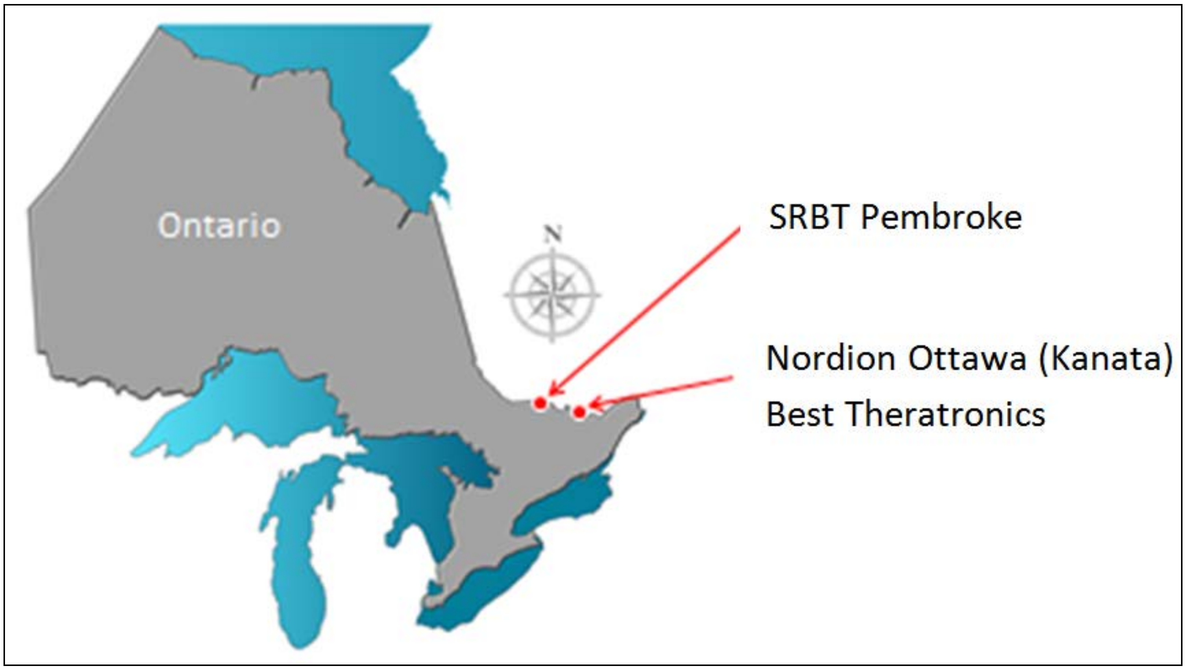
- SRB Technologies (Canada) Inc. (SRBT) in Pembroke, ON
- Nordion (Canada) Inc. in Ottawa, ON
- Best Theratronics Ltd. (BTL) in Ottawa, ON

The Commission renewed the operating licences for both SRBT and Nordion following public hearings held in 2015. SRBT's licence was issued in July 2015 and expires in June 2022; Nordion's licence was issued in November 2015 and expires in October 2025.

The Commission issued BTL a Class IB licence in July 2014 after a hearing held in May 2014. The BTL licence expires in June 2019.

All three facilities are located in the province of Ontario, as shown in figure 7-1.

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 2015. Table 7-1 presents the licensing and compliance effort from CNSC staff for these facilities during 2015.

Table 7-1: CNSC regulatory oversight licensing and compliance activities, nuclear substance processing facilities, 2015

Facility	Number of onsite inspections	Person days for compliance	Person days for licensing activities
SRBT	2	239	193
Nordion	4	173	330
BTL	3	87	43

CNSC staff performed two onsite inspections at SRBT, four onsite inspections at Nordion and three onsite inspections at BTL in 2015. All non-compliances identified during these inspections have been addressed by the respective licensees.

Each nuclear substance processing facility licensee is required to submit annual reports on the operations of their facilities by March 31 of each year. These reports must contain all environmental, radiological and safety-related information, including events and associated corrective actions taken. The full versions of these reports are available on the licensees' websites, provided in appendix H.

Combined with the observations made during their onsite inspections, CNSC staff reviewed these annual compliance reports, the revisions to the licensee's programs, and the licensee's responses to events and incidents to compile the 2015 performance ratings for the nuclear substance processing facilities. CNSC staff rated most safety and control areas (SCAs) for SRBT, Nordion and BTL as "satisfactory" with the following exceptions:

- SRBT's performance in the fitness for service and 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."
- BTL's performance in the emergency management and fire protection SCA was rated as "below expectations."

The 2015 performance ratings for the nuclear substance processing facilities are presented in table 7-2.

Table 7-2: SCA performance ratings, nuclear substance processing facilities, 2015

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	BE*
Waste management	SA	SA	SA
Security	SA	FS	SA
Safeguards and non-proliferation	N/A**	SA	SA
Packaging and transport	SA	SA	SA

*This rating is discussed in section 10.1.

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

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

7.1 Radiation protection

This SCA covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations*. The program must ensure contamination levels and radiation doses received by individuals are monitored, controlled and maintained as low as reasonably achievable (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

The 2015 rating for the radiation protection SCA for all nuclear substance processing facility licensees was “satisfactory,” unchanged from the previous year.

Ratings for radiation protection SCA, nuclear substance processing facilities, 2015

SRBT	Nordion	BTL
SA	SA	SA

Application of ALARA

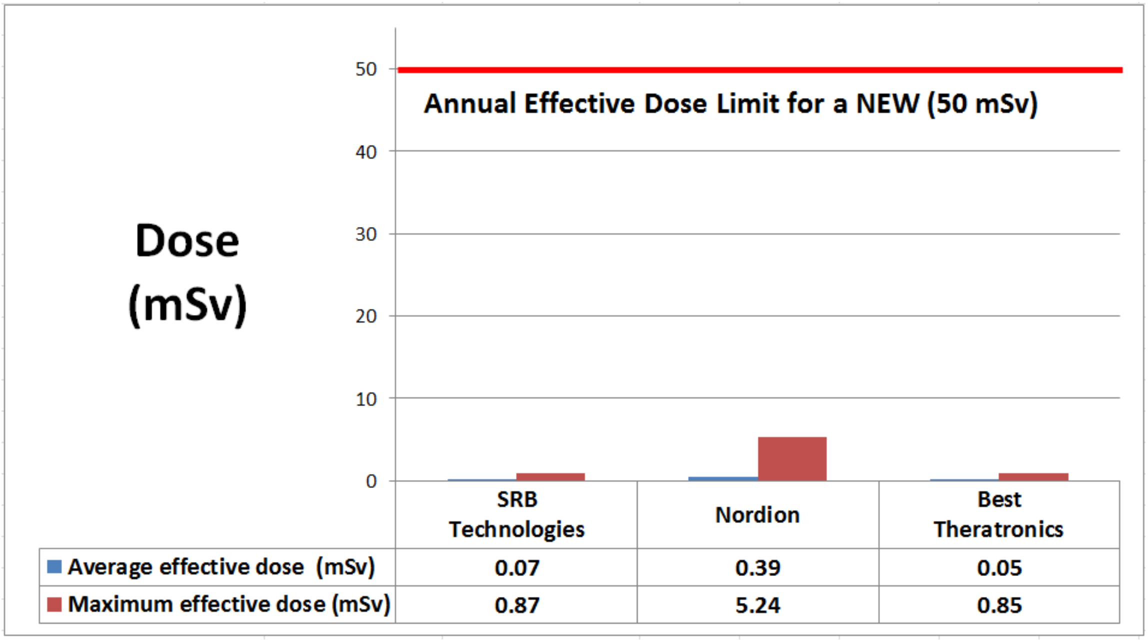
During 2015, all nuclear substance processing facility licensees continued to implement radiation protection measures to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. The CNSC requirement to apply the ALARA principle has consistently resulted in doses to persons to be 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 between 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 nuclear substance processing facilities are provided in figure 7-2. In 2015, the maximum individual effective dose received by a NEW at all facilities ranged from 0.85 millisieverts (mSv) to 5.24 mSv, which are 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 facility licensees, 2015



	SRB Technologies	Nordion	Best Theratronics
Average effective dose (mSv)	0.07	0.39	0.05
Maximum effective dose (mSv)	0.87	5.24	0.85

During 2015, 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. Radiological hazards across nuclear substance processing facilities vary due to the complex and differing work environments. Therefore, direct comparison of doses to NEWs between 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 2015 to verify compliance of the licensees' radiation protection programs 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 nuclear substance processing facilities have effectively implemented their radiation protection programs to control occupational exposures to workers.

Action levels for radiological exposures are established as part of the licensees' radiation protection programs. Licensees are responsible for identifying the parameters of their program that represent timely indicators of potential losses of control of the program. For this reason, action levels are licensee-specific and may change over time depending on operational and radiological conditions. If an action level is reached, it triggers the licensee to establish the cause, notify the CNSC and, if applicable, 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 the emergence of 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 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 2015.

Radiological hazard control

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. All nuclear substance processing facility licensees continued to implement their workplace monitoring programs to protect workers and have demonstrated that, in 2015, levels of radioactive contamination were controlled within their facilities.

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 take corrective actions whenever action levels are exceeded.

Table 7-3 provides a comparison of estimated public doses from 2011 to 2015 for the nuclear substance processing facility licensees. Estimated doses to the public from all nuclear substance processing facility licensees continued to be well below the regulatory annual public dose limit of 1 mSv/year.

Table 7-3: Public dose comparison table (mSv), nuclear substance processing facilities, 2011–15

Facility	Year					Regulatory limit
	2011	2012	2013	2014	2015	
SRBT	0.0050	0.0049	0.0068	0.0067	0.0068	**1 mSv/year**
Nordion	0.015	0.020	0.022	0.010	0.0056	
BTL	N/A	N/A	N/A	N/A	N/A	

The nuclear substance processing facility licensees effectively implemented and maintained their radiation protection programs during 2015 to ensure the health and safety of persons working in their facilities.

7.2 Environmental protection

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

It encompasses the following specific areas:

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

The 2015 rating for the environmental protection SCA for all nuclear substance processing facility licensees was “satisfactory” with the exception of Nordion, which was given a “fully satisfactory” rating. These ratings are unchanged from the previous year.

Ratings for environmental protection SCA, nuclear substance processing facilities, 2015

SRBT	Nordion	BTL
SA	FS	SA

To control the release of radioactive and hazardous substances into the environment, 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 suitably trained and qualified staff to effectively develop, implement and maintain their environmental protection programs.

The nuclear substance processing facilities implemented their environmental programs satisfactorily during 2015, and their programs are effective in protecting the health and safety of persons working in their facilities. There were no exceedances of licence limits for any nuclear substance processing facilities in 2015.

7.3 Conventional health and safety

This 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

The 2015 rating for the conventional health and safety SCA for all nuclear substance processing facility licensees was “satisfactory,” unchanged from the previous year

Ratings for conventional health and safety, nuclear substance processing facilities, 2015

SRBT	Nordion	BTL
FS	**SA**	**SA**

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. When a concern is identified, ESDC staff are consulted and asked to take appropriate action. 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*. These reports include serious illnesses or injuries incurred or possibly incurred as a result of a licensed activity. The number of recordable lost-time injuries (LTIs) reported by all facilities remained low in 2015. Table 7-4 summarizes the number of recordable LTIs reported by nuclear substance processing facilities from 2011 to 2015. Further information is provided in facility-specific sections as well as appendix G.

Table 7-4: Lost-time injuries, nuclear substance processing facilities, 2011–15

Facility	2011	2012	2013	2014	2015
SRBT	1	0	0	0	0
Nordion	0	0	1	3	0
BTL	N/A*	N/A*	N/A*	1	1

*BTL was not required to report LTI statistics prior to 2014 under its previous licence.

The nuclear substance processing facility licensees implemented their conventional health and safety programs satisfactorily during 2015, and 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 facilities are required to maintain and implement public information and disclosure programs per RD/GD-99.3, *Public Information and Disclosure*. These programs are supported by disclosure protocols that outline the type of information on the facility and its activities to be shared with the public (e.g., incidents, major changes to operations, periodic environmental performance reports) and how that information will be shared. This ensures timely information about the health, safety and security of persons and the environment and other issues associated with the lifecycle of nuclear facilities are effectively communicated.

In 2015, 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 by providing information on the status of their facilities through numerous activities. CNSC staff reviewed the communications activities during this period and noted that licensees used a variety of methods to share information about their activities and license renewal processes with the public, including regular updates to elected officials, facility tours, and ongoing website and social media updates. Licensees also issued information in accordance with their public disclosure protocols.

The nuclear substance processing facility licensees implemented their public information and disclosure programs satisfactorily during 2015, and their programs are effective at communicating information about the health, safety and security of persons and the environment and 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 in Pembroke, ON, approximately 150 km northwest of Ottawa. Figure 8-1 shows an aerial view of the SRBT facility.

Figure 8-1: Aerial view of the SRBT facility

The facility has been in operation since 1990. It processes tritium gas to produce GTLS and manufactures radiation devices containing the GTLS. Figure 8-2 shows an example of a GTLS sign produced at SRBT.

Figure 8-2: GTLS sign produced at the SRBT facility

In 2015, there were no licence amendments to SRBT; however, there was one revision to the SRBT licence conditions handbook, as described in table I-2, appendix I.

8.1 Performance

For 2015, CNSC staff rated SRBT's performance as "fully satisfactory" in the conventional health and safety and fitness for service SCAs, and "satisfactory" in all other SCAs. The SRBT performance ratings for 2011 through 2015 are provided in table C-5, appendix C.

In 2015, SRBT processed a total of 27,989,832 gigabecquerels (GBq) of tritium, resulting in 1,150 shipments of self-luminous products to customers in 16 countries including Canada. SRBT also receives expired self-luminous products for reuse and disposal. In 2015, it received 598 consignments comprising a total of 20,200 returned devices, containing 4,715 terabecquerels (TBq) of tritium activity. Any GTLS from expired products that are not reused by SRBT are packaged, secured and sent to a Canadian Nuclear Laboratories waste management facility located in Chalk River, ON.

There was one action level exceedance in 2015 relating to a weekly atmospheric tritium release. The exceedance was caused by the failure of a valve on tritium-processing equipment during operations. SRBT took corrective actions that were accepted by CNSC staff to prevent recurrence. The details on the action level exceedance are further described in section 8.3.

In 2015, CNSC staff conducted two onsite inspections at SRBT to ensure compliance with the *Nuclear Safety and Control Act* (NSCA) and its regulations, SRBT's operating licence and the programs used to meet regulatory requirements. The onsite inspections focused on human performance management, personnel training, emergency management and fire protection, and waste management. None of the findings from these inspections presented an immediate risk to the health, safety and security of workers, Canadians or the environment.

Import and export

SRBT is required to apply for and obtain licences for the import and export of tritium, pursuant to the requirements of the *Nuclear Non-proliferation Import and Export Control Regulations.* In December 2015, CNSC staff conducted an onsite inspection of records pertaining to import and export of tritium held by SRBT. CNSC staff observed that, on two occasions, SRBT shipments of tritium light sources authorized for export to the European Union (EU) had been retransferred subsequent to their arrival in the EU to a third country outside of the EU (specifically, India). CNSC staff consider that this represented a discrepancy with SRBT's export application and a non-compliance with the terms of SRBT's licence for exports to the EU.

As a result of these findings, CNSC staff directed SRBT to review and revise its shipping and management oversight procedures to ensure shipments of tritium light sources are consistent with the end-use locations identified in CNSC export licences. In addition, CNSC staff directed SRBT to review its export records since the beginning of 2013, as well as the annual reports submitted to CNSC staff, to determine if similar retransfers had been conducted in the past. SRBT confirmed that there were no other occasions of such retransfers.

CNSC staff reviewed and accepted the actions and information provided by SRBT and were satisfied with the corrective measures taken by SRBT to prevent shipment irregularities from reoccurring. CNSC staff will be conducting a follow-up onsite inspection in 2016 to verify the implementation and effectiveness of SRBT's revised shipping and oversight procedures. Apart from the non-compliance identified above, SRBT was found to be compliant with the import and export licensing requirements pursuant to the *Nuclear Non-proliferation Import and Export Control Regulations.*

8.2 Radiation protection

Overall compliance ratings for radiation protection SCA, SRB Technologies (Canada) Inc., 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA
For 2015, 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*.				

Application of ALARA

As required by the *Radiation Protection Regulations*, SRBT continued to implement radiation protection measures at its facility in 2015 to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. SRBT makes improvements to its radiation protection program annually and its 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 sets annual ALARA targets for the average and maximum effective doses to workers, continuously working toward reducing the already very low doses to workers. In 2015, SRBT performed better than its established occupational dose targets for average and maximum effective dose.

Worker dose control

Radiation exposures are monitored to ensure compliance with the CNSC's regulatory dose limits and to maintain radiation doses ALARA. In 2015, radiation exposures at SRBT were well below CNSC regulatory dose limits.

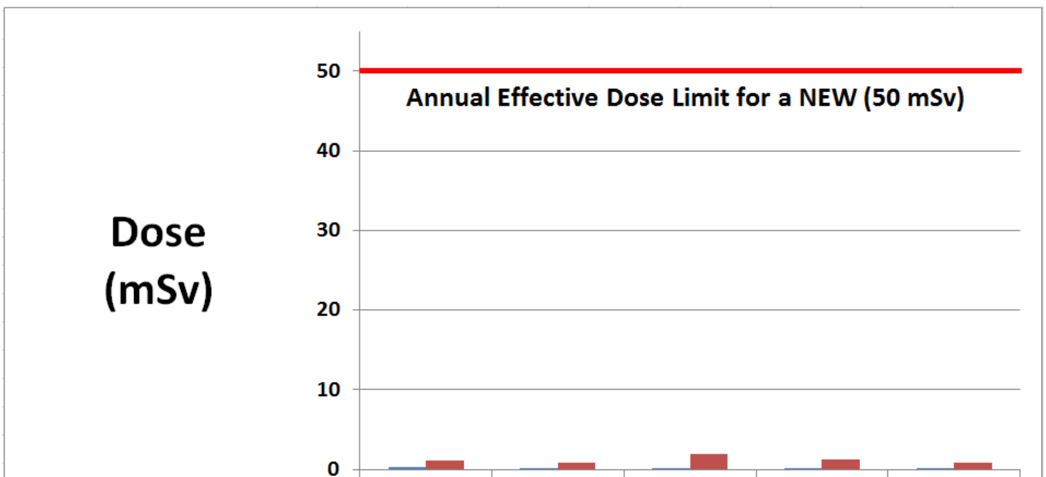
Inhalation, ingestion or absorption of tritium are the main radiological hazards faced by SRBT workers. SRBT ascertains internal tritium exposures through a urine analysis program that is part of its CNSC-licensed internal dosimetry service.

All workers employed at SRBT are identified as NEWs. Contractors are not identified as NEWs as they do not perform radiological work; however, they are monitored per regulatory requirements and provided with training as necessary to ensure doses remain ALARA and below the public dose limit of 1 mSv/year.

In 2015, none of the radiation exposures reported by SRBT for its 47 NEWs exceeded the CNSC's regulatory dose limits, and none of the three contractors working at SRBT in 2015 received a recordable dose. The maximum effective dose received by a NEW in 2015 was 0.87 mSv, or approximately two percent of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period. For the five-year dosimetry period from 2011 to 2015, the maximum individual effective dose received by a NEW at SRBT was 4.36 mSv. This radiation dose result represents approximately four percent of the regulatory dose limit of 100 mSv per five-year dosimetry period.

Figure 8-3 provides the average and maximum effective doses to NEWs at SRBT between 2011 and 2015.

Figure 8-3: Average and maximum effective doses to nuclear energy workers, SRB Technologies (Canada) Inc., 2011–15



	2011	2012	2013	2014	2015
Average effective dose (mSv)	0.25	0.11	0.21	0.10	0.07
Maximum effective dose (mSv)	1.15	0.80	1.93	1.29	0.87
Number of NEWs monitored	18	24	38	48	47

Average doses were relatively stable between 2011 and 2015, with a slight downward trend since 2013. The maximum dose also experienced a downward trend since 2013.

Due to the nature of tritium, exposures are distributed uniformly throughout the body. As such, equivalent skin doses are the same as the effective whole body dose. For this same reason, extremity doses are not ascertained for workers at SRBT.

Radiation protection program performance

CNSC staff assessed the performance of SRBT's radiation protection program in 2015 through various compliance verification activities and desktop reviews. SRBT's compliance with the *Radiation Protection Regulations* and CNSC licence requirements was acceptable.

Action levels for effective doses to workers and urine bioassay are established as part of SRBT's radiation protection program. If 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 2015.

Although the total amount of tritium processed by SRBT decreased by only 2.5 percent in 2015, improvements in the performance of its radiation protection program led to a 35 percent decrease in collective dose.

Radiological hazard control

Contamination controls have been established at SRBT per CNSC regulatory requirements to control and minimize the spread of radioactive contamination. These controls include the use of a radiation zone control program and the monitoring of surface and airborne tritium concentrations to confirm the effectiveness of that program. CNSC staff did not identify any adverse trends in monitoring results in 2015.

Estimated dose to the public

The 2011 to 2015 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, SRB Technologies (Canada) Inc., 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Maximum effective dose (mSv)	0.0050	0.0049	0.0068	0.0067	0.0068	**1 mSv/year**

8.3 Environmental protection

Overall compliance ratings for environmental protection SCA, SRB Technologies (Canada) Inc., 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA

For 2015, CNSC staff continued to rate the environmental protection SCA at SRBT as “satisfactory.” Radioactive releases to the environment continue to be effectively controlled and consistently well below the release limits prescribed in SRBT’s operating licence. There were no releases of hazardous substances (non-radiological) to the environment from SRBT that would pose a risk to the public or the environment. SRBT continues to maintain an effective environmental monitoring program per regulatory requirements, with principal monitoring activities focusing on the air and groundwater around the facility. This program provides data to estimate the annual dose to the public. The calculated maximum dose to a member of the public from SRBT’s licensed activities remains very low: approximately 0.7 percent of the public dose limit of 1 mSv/year.

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

Atmospheric emissions

SRBT’s tritium releases to the atmosphere continue to be effectively controlled and are consistently well below the release limits prescribed in its operating licence. This information is provided in table F-14, appendix F.

The relative increase in total tritium released into the air between 2012 and 2013 is due to a three-fold increase in tritium processing at SRBT (10,224 TBq in 2012 versus 30,544 TBq in 2013) during the same period.

The total tritium released into the air decreased from 66.16 TBq in 2014 to 56.24 TBq in 2015. The percent of tritium released relative to tritium processed also decreased – from 0.23 percent in 2014 to 0.20 percent in 2015 – due to effective emission-reduction initiatives put in place by SRBT.

There was a gaseous tritium release action level exceedance the week of May 26, 2015. The weekly action level for total tritium released is 7.753 TBq; during this particular week, 16.947 TBq was released to the atmosphere, equivalent to 3.78 percent of the annual release limit for total tritium. SRBT conducted an investigation into this exceedance to identify contributing and root causes. It concluded that the higher tritium emissions were caused by a service-related degradation of the packing on a process valve and the operation of that valve during an inappropriate point in the process. SRBT's corrective actions included increasing the preventative maintenance frequency on process valves as well as incorporating procedural changes into their systematic approach to training (SAT) system. CNSC staff reviewed SRBT's investigation report and proposed corrective actions and found both to be acceptable.

Liquid effluent

SRBT continues to monitor and control tritium released as liquid effluent from its facility. The monitoring data for 2011 through 2015, provided in table F-15, appendix F, show that liquid effluent from the facility continues to be effectively controlled and tritium releases are consistently well below the licence limit of 200 GBq/year. Tritium effluent releases decreased from 12.5 GBq in 2014 to 6.5 GBq in 2015. This decrease was achieved by reducing the number of failed leak tests on the manufactured light sources and by implementing process improvements to reduce indoor air concentrations, which helps to reduce air conditioner and dehumidifier drain water concentrations.

Environmental management system

SRBT maintains an environmental management system (EMS) that describes the integrated activities associated with the protection of the environment at its facility according to CNSC regulatory requirements. SRBT's EMS includes activities such as establishing annual environmental objectives and targets that are reviewed and assessed by CNSC staff through compliance verification activities.

SRBT completed a gap analysis of its EMS in 2015 to bring itself into compliance with REGDOC-2.9.1, *Environmental Protection: Policies, Programs and Procedures*. In the analysis, SRBT identified areas for improvement and developed an action plan for making those improvements. The CNSC continues to monitor the implementation of the action plan through the review of key documents and site inspections.

SRBT staff hold an annual safety meeting during which environmental protection issues are discussed. CNSC staff, as part of their compliance verification activities, review the minutes of these meetings and follow up on any outstanding issues with SRBT staff.

Assessment and monitoring

SRBT's environmental monitoring program serves to demonstrate that radiological emissions from the site are properly controlled. The program also provides monitoring data for estimates of annual radiological dose to the public to ensure the public dose attributable to SRBT's operations is ALARA and in compliance with the regulatory dose limit. The principal monitoring activities are focused on monitoring the air and groundwater around the SRBT facility.

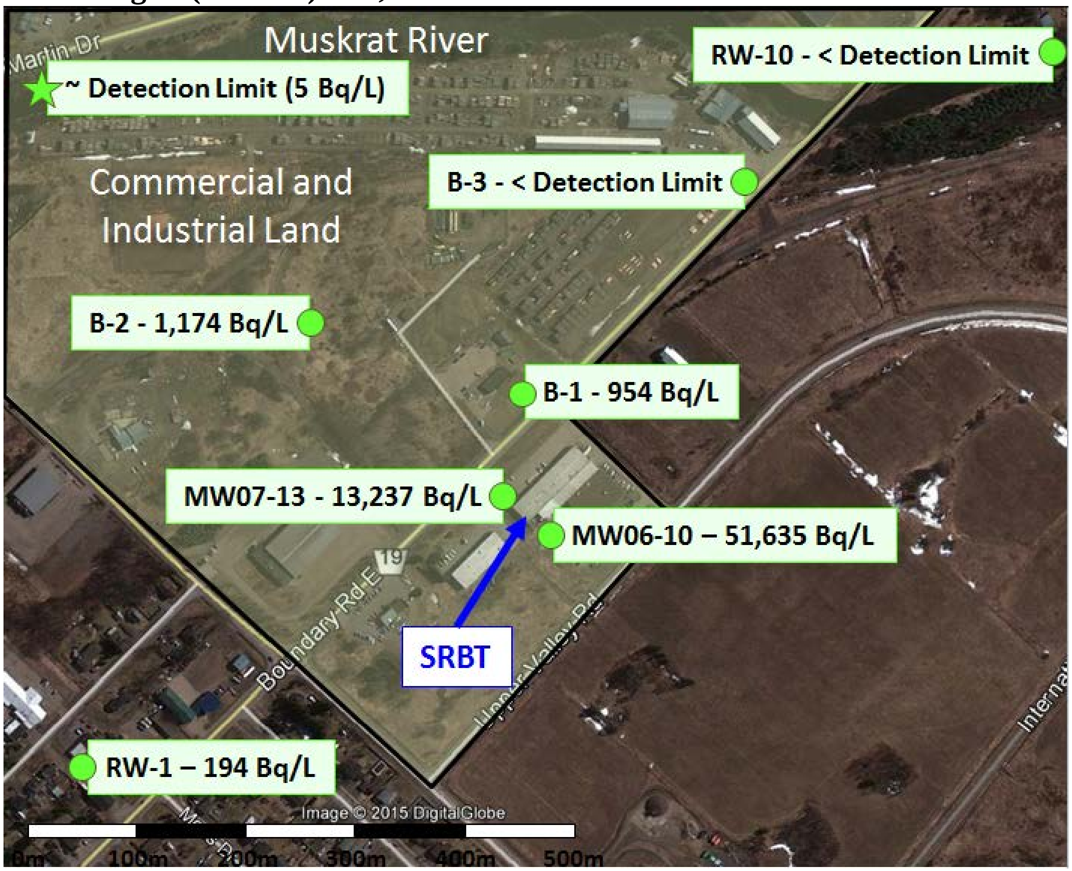
Tritium in ambient air

SRBT has a total of 40 passive air samplers located within a two-kilometre radius of its facility. The passive air samplers represent tritium exposure pathways for inhalation and skin absorption and are used in the calculations to determine public dose. The samples are collected and analyzed by a qualified third-party laboratory. Based on CNSC staff review, the air monitoring results from these samplers demonstrates that tritium levels in air are low, which is consistent with the atmospheric emissions measured in 2015.

Groundwater monitoring

Groundwater is sampled in 34 monitoring wells around the facility along with an additional 15 residential and business wells. At the end of 2015, only two monitoring wells showed tritium concentrations above Ontario's drinking water quality standard of 7,000 Bq/L: MW06-10 and MW07-13, both of which are located on the SRBT site, had average concentrations of 51,635 Bq/L and 13,237 Bq/L, respectively. Neither well is used for drinking water. Tritium concentrations decreased significantly at locations farther away from SRBT. Figure 8-4 shows locations of the groundwater monitoring wells near the SRBT facility in 2015.

Figure 8-4: Annual average tritium concentrations in groundwater, SRB Technologies (Canada) Inc., 2015



SRBT's groundwater study, which has been conducted annually since 2010, confirmed that the nearby residential wells (highest tritium concentration of 194 Bq/L for 2015) and Muskrat River (highest detectable tritium concentration of 7 Bq/L for 2015) are not at risk of exceeding Ontario's drinking water quality standard. The highest tritium concentration in a potential drinking water well was found in business well B-2, which averaged 1,174 Bq/L in 2015. Even though the tritium concentrations are well below the Ontario drinking water quality standard, SRBT continues to provide bottled drinking water to the affected business.

The monitoring results to date, combined with a 2010 CNSC staff independent modelling assessment, agree with SRBT's conclusion that the elevated tritium concentrations at MW06-10 were caused primarily by high tritium concentrations in the soil due to historical practices. Overall, CNSC staff concluded that the tritium inventory in the groundwater system around the facility has been decreasing since 2006.

Other monitoring

To complement its principal air and groundwater monitoring activities, SRBT engages a qualified third party to perform monitoring and analysis of precipitation, runoff, surface water, produce, milk and wine. SRBT also analyzed soil and sludge samples in 2015. The results from this monitoring are included in SRBT's annual compliance report that is submitted to and reviewed by CNSC staff.

In 2013, 2014 and 2015, CNSC staff collected and analyzed a number of environmental samples in publicly accessible areas outside the perimeter of the SRBT facility under the CNSC's Independent Environmental Monitoring Program (IEMP). The results can be found on the CNSC's IEMP Web page. Results obtained by the CNSC confirmed that the public and the environment in the vicinity of SRBT are protected from the releases from the facility.

Protection of the public

According to regulatory requirements, licensees shall demonstrate that adequate provision is made for protecting the health and safety of the public from exposures to hazardous substances released from their facilities.

There were no releases of hazardous substances (non-radiological) to the environment in 2015 from SRBT that would pose a risk to the public or environment.

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

Environmental risk assessment

In March 2015, a letter was sent from CNSC staff to SRBT indicating that several environmental management standards would need to be included as part of the future licensing basis for the facility. The letter directed SRBT to provide implementation dates along with a gap analysis documenting the areas where its 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 Group standard N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills*. SRBT indicated that it anticipates conducting an environmental risk assessment after a number of program updates have been completed in advance of its next licence renewal application.

In general, CNSC staff found the gap analysis conducted by SRBT for CSA Group standard N288.6-12 to be acceptable. SRBT provided an action plan and a timeframe for when the items listed in the action plan would be implemented.

8.4 Conventional health and safety

Overall compliance ratings for conventional health and safety SCA, SRB Technologies (Canada) Inc., 2011–15

2011	2012	2013	2014	2015
SA	FS	FS	FS	FS
For 2015, CNSC staff continued to rate the conventional health and safety SCA at SRBT as "fully satisfactory." 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.				

Performance

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. Per table 8-2, the number of LTIs remained at zero in 2015.

Table 8-2: Lost-time injuries, SRB Technologies (Canada) Inc., 2011–15

	2011	2012	2013	2014	2015
Lost-time injuries	1	0	0	0	0

Practices

SRBT's activities and operations must comply with not only the NSCA and its associated regulations but also with Part II of the *Canada Labour Code.* As such, SRBT is required to report incidents resulting in an injury to ESDC.

The SRBT Workplace Health and Safety Committee inspects the workplace and meets monthly to resolve and track any safety issues. This committee met 12 times in 2015. CNSC staff review the monthly meeting minutes and associated corrective actions to ensure issues are 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. CNSC staff continue to monitor the effectiveness of this program through regular onsite inspections.

9 NORDION (CANADA) INC.

Nordion (Canada) Inc. is located adjacent to industrial and residential property in Ottawa, ON and is licensed to operate a Class IB nuclear substance processing facility. 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, and manufactures sealed radiation sources for industrial applications. Nordion's application to renew its Class IB nuclear substance processing facility operating licence was heard by the Commission in August 2015. The Commission renewed Nordion's licence for a period of 10 years with an expiry date of October 31, 2025.

In its 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 has been determined.

Nordion is currently working with Energy Solutions, which is able to receive and dispose of these neutron sources. The CNSC requires Nordion to submit an application to obtain approval to transport these sources to Energy Solutions for disposal. Nordion has committed to providing the CNSC with its application by August 15, 2016 and CNSC staff issued a certificate for the transport package to be used for the transfer of the sources. Nordion now has an acceptable disposal pathway for the neutron sources.

Figure 9-2 shows a Nordion employee performing an inspection above a cobalt storage pool.

Figure 9-2: Nordion employee working above a cobalt storage pool

9.1 Performance

CNSC staff rated all of Nordion's SCAs as "satisfactory" for 2015 with the exception of environmental protection and security, both of which were rated as "fully satisfactory." The Nordion facility ratings for 2011 to 2015 are provided in table C-6, appendix C.

For 2015, no significant changes were made to the design of the Nordion facility. Some upgrades to existing systems were completed as part of facility maintenance and continuous improvement.

There were no instances in which there was the potential to exceed a regulatory limit or to reach or exceed an action level in 2015. All measurable doses received by workers and the public were within the regulatory limits and no internal dose levels or limits were exceeded.

On August 6, 2015, Nordion notified the CNSC of a fire on the roof of its facility. This event was reported to the Commission as an event initial report on August 19, 2015 and a status update was provided to the Commission on September 30, 2015 (Commission member document 15-M39.A). The fire started as a result of roof repair work. Nordion implemented its emergency response plan and was in direct contact with the CNSC once emergency measures were initiated. A CNSC inspector was also onsite to observe Nordion's emergency response to this event. Ottawa Fire Services arrived quickly on scene and extinguished the fire, with Nordion ensuring the building was safe before permitting staff to re-enter. Nordion also confirmed that all ventilation and safety systems, including radiation protection monitoring equipment, security and fire protection systems, were functioning and performing as required before recommencing operations. There was no impact to persons or the environment, and no injuries as a result of the fire. The air and water samples collected after the event confirmed that no nuclear substances were released during the fire. Nordion investigated the incident and identified corrective actions, all of which have been implemented. All actions related to this fire are closed and CNSC staff are satisfied with the measures Nordion has put in place.

As required by the NSCA, its associated regulations and Nordion's licence, Nordion submitted a total of 22 reports to the CNSC on events or incidents that occurred in 2015. CNSC staff reviewed these reports and concluded that none of the events of incidents compromised the health and safety of persons or the environment. Of the 22 reports, 17 were related to packaging and transport (largely due to the fact that Nordion transports approximately 10,000 packages containing nuclear substances per year). The majority of the packaging and transport reports were related to low-risk items such as incorrect shipping documents, errors in labelling, and incorrect activity listed on labels or documents. The other five reports that were not related to packaging and transport pertained to the fire described above, export-related administrative issues and the timely submission of investigation reports following an event. CNSC staff have reviewed and are satisfied with the corrective actions taken by Nordion for all of the reports submitted in 2015.

In 2015, CNSC staff conducted four 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. The inspections focused on the management system, fire protection, security, operating performance, radiation protection, environmental protection, and conventional health and safety SCAs. None of the findings from these inspections presented an immediate risk to the health, safety and security of workers, Canadians or the environment.

9.2 Radiation protection

Overall compliance ratings for radiation protection SCA, Nordion (Canada) Inc., 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA
For 2015, 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*.				

Application of ALARA

As required by the *Radiation Protection Regulations*, Nordion continued to implement radiation protection measures at its facility in 2015 to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. Nordion makes annual improvements to its radiation protection program and its 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. This committee also sets annual performance targets to maintain doses to workers ALARA. Nordion performed better than its established occupational dose targets for average and maximum dose in 2015. However, it did not achieve its newly established internal target for thyroid monitoring compliance. Nordion reports that compliance in this area is continuously improving and will continue to be monitored.

Worker dose control

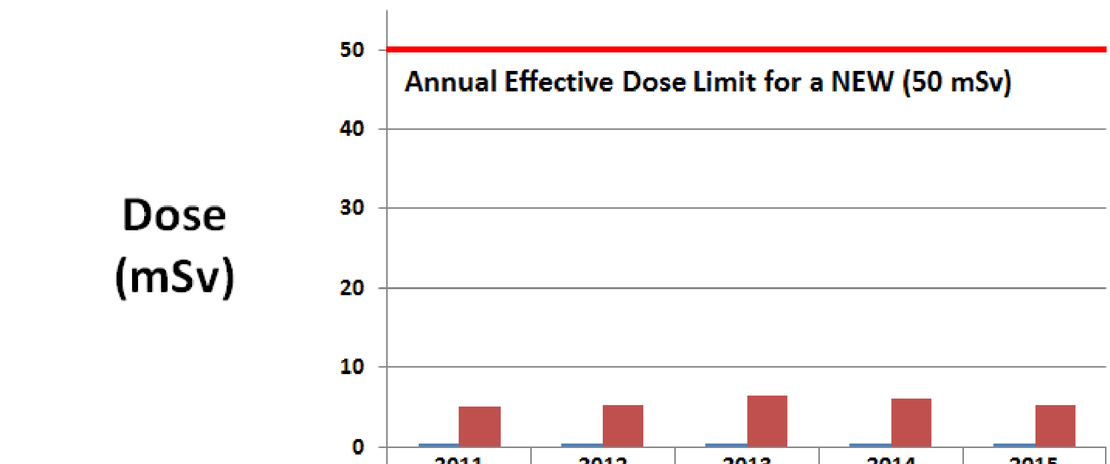
Radiation exposures are monitored to ensure compliance with the CNSC's regulatory dose limits and with keeping radiation doses ALARA. In 2015, radiation exposures at Nordion were well below CNSC regulatory dose limits.

The main radiological hazards faced by Nordion workers include external exposure to alpha, beta and gamma radiation emitted from the radioisotopes processed for medical diagnostic and radiopharmaceuticals, 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 or urine analysis for dose determination should elevated air and/or contamination monitoring indicates a need. CNSC staff confirmed that there were no internal doses recorded in 2015.

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

In 2015, the total effective dose was assessed for 264 NEWs at Nordion, consisting of 150 workers working in the active area and 114 workers who work primarily in the non-active area but may perform some work duties in the active area. All of the NEWs are Nordion employees. The maximum effective dose received by a NEW in 2015 was 5.24 mSv, or approximately 10 percent of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period. For the five-year dosimetry period from 2011 to 2015, the maximum individual effective dose received by a NEW at Nordion was 16.11 mSv. This represents approximately 16 percent of the regulatory effective dose limit of 100 mSv per five-year dosimetry period. Figure 9-3 provides the average and maximum effective doses to NEWs at Nordion between 2011 and 2015.

Figure 9-3: Average and maximum effective doses to nuclear energy workers, Nordion (Canada) Inc., 2011–15



	2011	2012	2013	2014	2015
Average effective dose (mSv)	0.43	0.40	0.36	0.44	0.39
Maximum effective dose (mSv)	5.08	5.19	6.39	6.03	5.24
Number of NEWs monitored	311	293	284	269	264

Note: The data for average worker doses from 2011 to 2014 was previously reported as 0.6, 0.6, 0.6, and 0.4 mSv and included only NEWs working in active areas. The data now reflects average doses for all NEWs working at Nordion. This is a correction to the results reported in *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2014.*

Average and maximum effective doses were relatively stable between 2011 and 2015.

Nordion ascertained the total effective dose for 48 contractors (non-NEWs) in 2015. The maximum effective dose received by a contractor in 2015 was 0.13 mSv, or approximately 13 percent of the regulatory effective dose limit of 1 mSv in a one-year dosimetry period. The average effective dose for contractors in 2015 was 0.03 mSv.

Annual average and maximum equivalent dose results from 2011 to 2015 are also provided in tables E-11 and E-20, appendix E. The maximum equivalent skin dose for all NEWs monitored at Nordion in 2015 was 5.21 mSv. The maximum equivalent extremity dose for workers in the active area was 9.3 mSv. These represent approximately one and two percent respectively, of the 500 mSv equivalent dose limits for the skin and extremities. Over the past five years, average equivalent extremity and skin doses have been relatively stable.

Radiation protection program performance

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* and CNSC licence requirements was acceptable.

Action levels for effective doses to workers are established as part of Nordion's radiation protection program. If reached, Nordion must establish the cause, notify the CNSC and, if applicable, restore the effectiveness of the program. There were no action level exceedances reported by Nordion in 2015.

Radiological hazard control

Radiation and contamination control programs have been established at Nordion per CNSC regulatory requirements 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 2015.

Estimated dose to the public

The 2011 to 2015 maximum effective doses to a member of the public are shown in table 9-1. In 2015, the public dose to a member of the public was well below the CNSC regulatory dose limit of 1 mSv/year.

Table 9-1: Maximum effective dose to a member of the public, Nordion (Canada) Inc., 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Maximum effective dose (mSv)	0.015	0.020	0.022	0.010	0.0056	**1 mSv/year**

9.3 Environmental protection

Overall compliance ratings for environmental protection SCA, Nordion (Canada) Inc., 2011–15

2011	2012	2013	2014	2015
FS	FS	FS	FS	FS

For 2015, 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 last five years, the gaseous emissions and liquid effluents were well below the derived release limits and no action levels were exceeded. Groundwater monitoring, soil sampling and gamma exposure measurements indicate that the public and the environment continue to be protected from facility releases.

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 required to have suitably 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 the facility to prevent unnecessary releases of radioisotopes to the atmosphere. CNSC staff confirmed that the radiological air emissions from the facility in 2015 continued to be effectively controlled as they were consistently well below the derived release limits prescribed in Nordion's operating licence. No action levels were exceeded at any time in 2015. See table F-16, appendix F for Nordion's radiological air emissions monitoring results from 2011 to 2015.

Liquid effluent

Nordion continues to monitor all liquid effluent releases prior to discharging them into the municipal sewer system. CNSC staff confirmed that the radiological liquid effluent releases from the facility in 2015 continued to be effectively controlled as releases were consistently well below the derived release limits prescribed in Nordion's operating licence. No action levels were exceeded in 2015. See table F-17, appendix F, for Nordion's radiological liquid emissions monitoring results from 2011 to 2015.

Environmental management system

Per CNSC regulatory requirements, Nordion has developed and maintains an EMS to describe the integrated activities associated with the protection of the environment at its facility. As described in its Environmental Management System Manual, Nordion'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 Nordion's annual management review, which involves the evaluation of the company's Environmental Health & Safety Policy (and related objectives and targets), the adequacy of the company's resources to meet those targets, actions taken since the previous annual review, changing circumstances related to environmental health and safety, and recommendations for improvement. CNSC staff, as part of its compliance verification activities, review the results of the annual review and follows up with Nordion staff on any outstanding issues.

Assessment and monitoring

Nordion's environmental monitoring program serves to demonstrate that the site emissions of nuclear and hazardous materials are properly controlled. To show that emissions from its facility do not pose a risk to public health or the environment, Nordion conducts groundwater monitoring, collects soil samples and measures environmental gamma radiation using thermoluminescent dosimeters. The results from these monitoring activities are described below.

Groundwater monitoring

A total of nine monitoring wells currently exist around the Nordion site. Four of the wells are sampled for non-radiological parameters and the remaining five wells are sampled for radiological parameters.

Nordion has been monitoring groundwater for hazardous substances such as ammonia, nitrate, dissolved organic carbon, total dissolved solids, iron and total petroleum hydrocarbons since 2005. The monitoring is done at least once per year to ensure there are no significant changes in the results. CNSC staff confirmed that the monitoring results for 2011 through 2015 demonstrated that there were no significant changes in the concentrations of hazardous substances in the groundwater relative to the 2005 results, which were near the background levels or detection limit.

Nordion began radiological sampling for groundwater in 2013. The results since 2013 have shown that only naturally occurring radionuclides that are not processed at the Nordion facility have been detected in the groundwater. Based on CNSC staff assessments, these results indicate that releases of radioactive and hazardous substances from the Nordion facility have had no measurable impact on groundwater quality.

Soil sampling

Nordion conducts soil sampling every two years to monitor concentrations of radiological materials in the soil. Soil sampling was performed in 2012 and 2014, and CNSC staff confirmed that no radioactive substances attributable to Nordion's licensed activities were detected in the soil.

Gamma monitoring

Nordion monitors environmental gamma radiation using thermoluminescent dosimeters deployed both onsite and offsite. The dosimeters are deployed in all directions around the facility but mostly to the east of the facility, which is the direction of the prevailing winds. Dosimeters are also placed in the residences of Nordion employees. Based on CNSC staff assessments, the annual monitoring results showed the levels of gamma radiation at offsite monitoring locations are in the range of natural background. The results indicated that Nordion is not contributing to dose at and beyond the perimeter of the facility.

Protection of the public

According to regulatory requirements, licensees must demonstrate that the health and safety of the public are protected from exposures to hazardous substances released from their facilities. There are no releases of non-radiological hazardous substances to the environment from Nordion that would pose a risk to the public or environment.

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

Environmental risk assessment

Nordion indicated it would implement three environmental protection standards by May 31, 2016: CSA Group standards N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills*; N288.5-11, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills*; and N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills*. Nordion submitted documents to support the implementation of these standards on June 2, 2016. CNSC staff continue to review these documents to ensure they address the compliance requirements of the CSA Group standards.

9.4 Conventional health and safety

Overall compliance ratings for conventional health and safety SCA, Nordion (Canada) Inc., 2011–15

2011	2012	2013	2014	2015
FS	FS	FS	SA	SA
For 2015, 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.				

Performance

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 to carry out their duties for a period of time. As indicated in table 9-2, there were no LTIs at Nordion in 2015.

Table 9-2: Lost-time injuries, Nordion (Canada) Inc., 2011–15

	2011	2012	2013	2014	2015
Lost-time injuries	0	0	1	3	0

Practices

Nordion's activities and operations must comply with not only the NSCA and its regulations but also Part II of the *Canada Labour Code*.

Nordion's conventional health and safety program is under the oversight of Nordion's Workplace Health and Safety Committee, which met nine times in 2015. In addition, Nordion's Health and Safety Policy Committee met five times in 2015. Based on the CNSC staff assessment of the meeting minutes for these committees, Nordion continues to develop and maintain a comprehensive conventional health and safety management program. As operational ergonomics are important to Nordion's operations, CNSC staff noted that the Policy Committee has made ergonomics a standing agenda item at each of its meetings.

Awareness

Nordion sets annual objectives related to its conventional health and safety management program, including targets for occupational incidents and LTIs. For 2015, Nordion set a target of six occupational incidents; this target was achieved as only four incidents were reported over the course of the year. These incidents were mostly related to ergonomics in lifting practices or working with manipulators.

Nordion also made several improvements to its conventional health and safety program in 2015, including improvements to back safety training and creating new videos of stretches employees can perform during their shifts.

10 BEST THERATRONICS LTD.

Best Theratronics Ltd. (BTL) owns and operates a manufacturing facility under a Class IB operating licence that expires in 2019. Figure 10-1 shows an aerial view of the BTL facility in Ottawa, ON. BTL manufactures medical equipment, including cobalt-60 (Co-60) radiation therapy units and cesium-137 blood irradiators. Figure 10-2 shows an image of a radiation therapy (Co-60 teletherapy) unit manufactured by BTL.

Figure 10-1: Aerial view of the Best Theratronics Ltd. facility

Figure 10-2: Teletherapy unit manufactured by Best Theratronics Ltd.

BTL's licensed activities include the operation of a nuclear substance processing facility and a radioactive source teletherapy machine. The use of a cyclotron above 1 megaelectronvolt (MeV) has been restricted due to a Designated Officer order.

On August 24, 2015, the CNSC issued an order to BTL. The order was issued following BTL's failure to comply with a condition of the Commission-issued licence NSPFOL-14.01/2019 that imposed requirements on BTL to provide an acceptable financial guarantee by July 31, 2015. The intent of the order was to ensure there are sufficient funds available for the future decommissioning of the BTL facility.

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. BTL was also required to report monthly to the CNSC on the disposal status and provide the CNSC with a revised preliminary decommissioning plan and financial guarantee update. The order was amended by the Commission in September 2015 (CMD 15-H114) and February 2016 (CMD 16-H110). At the time of writing this report, there was no update to the order. BTL is making progress on the disposal of sealed sources, prescribed equipment and depleted uranium.

There was one licence amendment in 2015 and two revisions to the licence conditions handbook. Further information is provided in tables I-1 and I-2, appendix I.

10.1 Performance

For 2015, CNSC staff rated BTL's performance as "satisfactory" in all SCAs except emergency management and fire protection, where the company's performance was "below expectations." The BTL performance ratings from 2014 to 2015 are provided in table C-7, appendix C.

In 2015, CNSC staff conducted three onsite inspections at the BTL facility to verify compliance with the NSCA and its regulations, BTL's operating licence, and programs used to meet regulatory requirements. During one onsite inspection, CNSC staff found non-compliances with the *National Fire Code of Canada* (NFCC) with respect to a dust collector machine. This is the basis for the "below expectations" rating for the emergency management and fire protection SCA.

An order was issued to BTL on October 6, 2015 to cease operation of the dust collector and to ensure it complied with the NFCC prior to its future use. On November 17, 2015, the CNSC confirmed that BTL had complied with all the terms and conditions of the order. The corrective measures implemented by the company were reviewed and found to be satisfactory by CNSC staff.

There were no reportable action level exceedances in 2015. There was one lost-time injury in 2015.

10.2 Radiation protection

Overall compliance ratings for radiation protection SCA, Best Theratronics Ltd., 2014–15

2014	2015
SA	SA
For 2015, 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*.	

Application of ALARA

As required by the *Radiation Protection Regulations*, BTL continued to implement radiation protection measures in 2015 to keep radiation exposures and doses to persons ALARA, 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 dose trend analysis.

Worker dose control

Radiation exposures are monitored to ensure compliance with CNSC regulatory dose limits and to maintain radiation doses ALARA. In 2015, radiation exposures at BTL were well below the CNSC's regulatory dose limits.

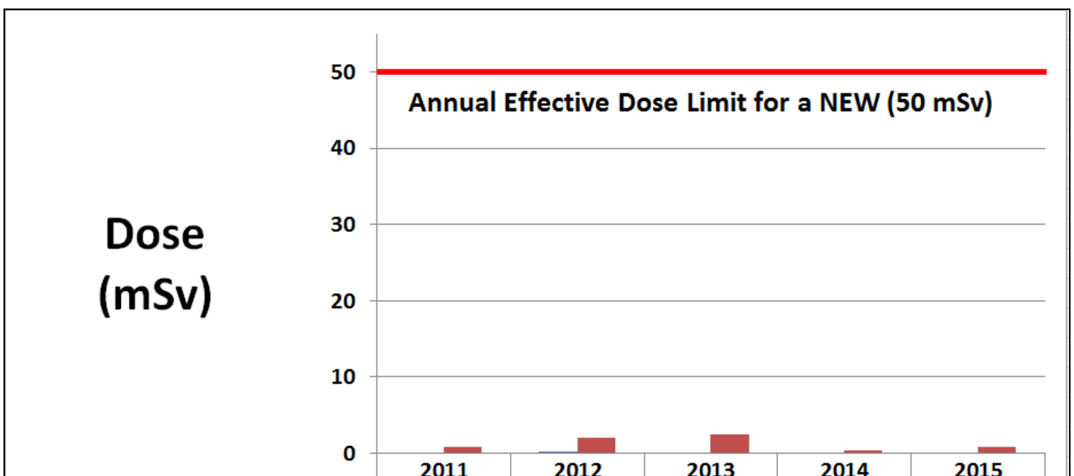
External exposure to sealed sources of radiation is the main radiological hazard to BTL workers. External whole body and equivalent doses are ascertained using dosimetry.

At BTL, employees are identified as NEWs if they are expected to have a reasonable probability of receiving an occupational dose greater than 1 mSv. Such workers include service technicians, source handlers and dosimetry personnel. The maximum effective dose received by a NEW in 2015 at BTL was 0.85 mSv, or approximately 1.7 percent of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period. Other workers identified as non-NEWs, such as administrative staff, did not receive any reportable doses during the same period and are not directly monitored. Therefore, non-NEWs do not contribute to the dose statistics reported below.

For the five-year dosimetry period from 2011 to 2015, the maximum individual effective dose received by a NEW at BTL was 3.2 mSv, or approximately 3.2 percent of the regulatory dose limit of 100 mSv per five-year dosimetry period.

Figure 10-3 provides the average and maximum effective doses to NEWs over the years 2011 to 2015 at BTL.

Figure 10-3: Average and maximum effective doses to nuclear energy workers, Best Theratronics Ltd., 2011–15



	2011	2012	2013	2014	2015
Average effective dose (mSv)	0.13	0.18	0.07	0.09	0.05
Maximum effective dose (mSv)	0.91	2.01	2.47	0.46	0.85
Number of NEWs monitored	80	81	86	74	92

Over the past five years, maximum annual effective doses at BTL have remained stable and very low: between approximately 1 mSv and 2.5 mSv.

Annual average and maximum equivalent (extremity) dose results from 2011 to 2015 are provided in table E-12, appendix E. The maximum equivalent extremity dose for 2015 was 2.1 mSv. Over the past five years, maximum extremity equivalent doses have been relatively stable: between approximately 1 mSv and 6 mSv. Although equivalent skin doses are ascertained, due to the nature of exposure, they are essentially equal to the effective dose and not included in this report.

Radiation protection program performance

CNSC staff assessed the performance of BTL's radiation protection program in 2015 through various compliance activities and desktop reviews. BTL's compliance with the *Radiation Protection Regulations* and CNSC licence requirements was acceptable.

Action levels for effective dose for various categories of workers have been established to alert BTL management of a potential loss of control of the radiation protection program. If reached, it triggers BTL staff to establish the cause for reaching the action level, notify the CNSC and, if applicable, restore the effectiveness of the program. In 2015, there were no action level exceedances at BTL.

Radiological hazard control

BTL's radiation protection program ensures measures are in place to monitor and control radiological hazards according to regulatory requirements. This includes contamination and radiation dose rate monitoring and controls.

As the majority of the radioisotopes in use at BTL are sealed sources, the potential for contamination is very low. However, the licensee has still implemented a thorough procedure to monitor any potential surface contamination at its facility. Contamination checks are performed monthly in designated areas where radioactive materials may be handled or following work where the potential for contamination exists. CNSC staff confirmed that there has been no indication of contamination from routine contamination swipes at the BTL facility over the last five years.

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

Estimated dose to the public

There are no activities that occur inside the BTL facility that result in the release of radioactive materials to the environment. In addition, gamma radiation is kept ALARA to protect staff within the BTL facility. Consequently, there is insignificant and unmeasurable dose impact to members of the public due to BTL's current and proposed licensed activities.

10.3 Environmental protection

Overall compliance ratings for environmental protection SCA, Best Theratronics Ltd., 2014–15

2014	2015
SA	SA

For 2015, 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. The risk of radiation exposure to members of the public from normal operations is very low. There were no releases of hazardous substances (non-radiological) 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 a new EMS to conform to REGDOC-2.9.1, *Environmental Protection Policies, Programs and Procedures*. The new program was submitted to the CNSC in January 2016. CNSC staff have requested further information to evaluate the system.

Effluent and emissions control (releases)

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

There are also 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 the BTL facility are related to the exhausting of the lead pouring area, paint booth, fire torching areas and sand blasting. Engineering controls (e.g., filters, ventilation) are in place to reduce or eliminate emissions generated during operations.

Environmental management system

As a requirement of its Class IB licence, in 2015, BTL implemented a new EMS to conform to REGDOC-2.9.1, *Environmental Protection Policies, Programs and Procedure*. CNSC staff verified that BTL's EMS is in compliance with the requirements listed in REGDOC-2.9.1 and find the documents submitted by BTL to be acceptable. CNSC staff have planned an onsite environmental protection inspection for the fall of 2016.

Assessment and monitoring

There is no environmental monitoring conducted around the BTL facility. Waste water released to the sewer system is monitored by the City of Ottawa approximately twice a year.

Protection of the public

According to regulatory requirements, licensees must demonstrate that the health and safety of the public are protected from exposures to hazardous substances released from their facilities. As 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 commissioned an environmental assessment in 2011, identifying potential environmental risks in areas within and outside the facility and then putting in place mitigation measures as appropriate. CNSC staff reviewed 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 the facility's Environmental Compliance Approval application with Ontario's Ministry of the Environment and Climate Change. CNSC staff reviewed the model and the results indicate 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 conventional health and safety, Best Theratronics Ltd., 2014–15

2014	2015
SA	SA
For 2015, 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 the implementation of an effective occupational health and safety management program, which has resulted in the ability to keep its workers safe from occupational injuries.	

Performance

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 was one LTI reported at the BTL facility in 2015. The injury resulted in one day of lost time. Details are provided in table G-3, appendix G.

Table 10-1: Lost-time injuries, Best Theratronics Ltd., 2014–15

	2014	2015
Lost-time injuries	1	1

Practices

BTL's activities and operations must comply with not only the NSCA and its associated regulations but also Part II of the *Canada Labour Code*. 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 associated corrective actions to ensure issues are promptly resolved. 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. CNSC staff continue to monitor the effectiveness of this program through regular onsite inspections.

SECTION III: SMALL NUCLEAR RESEARCH REACTOR FACILITIES

11 OVERVIEW

This section of the report deals with small nuclear research reactor facilities:

- McMaster Nuclear Reactor (MNR) located at McMaster University in Hamilton, ON
- Four Safe LOW-Power Kritical Experiment (SLOWPOKE-2) facilities located at:
  - University of Alberta (U of A) in Edmonton, AB
  - Saskatchewan Research Council (SRC) in Saskatoon, SK
  - Royal Military College of Canada (RMCC) in Kingston, ON
  - École Polytechnique de Montréal (ÉPM) in Montréal, QC
- Subcritical assembly located at ÉPM in Montréal, QC

To provide consistent reporting across CNSC-licensed facilities, this is the first time that small nuclear research reactor facilities have been included in the regular reporting cycle.

The small nuclear research reactor facilities discussed in this report are low power reactors with thermal capacities ranging from 0.02 megawatts (MW) for the SLOWPOKE-2 reactors to 5 MW for the MNR. ÉPM's subcritical assembly has a near-zero energy output (approximately 3×10^{-5} W) and is used for academic purposes. These reactors are designed with inherent safety characteristics and pose a very low risk to the health and safety of persons and the environment.

The SLOWPOKE-2 reactors are self-limiting in power and temperature, without the need for operator intervention or actuation of automatic trip systems. They also use natural circulation for cooling. While relatively larger, the MNR is a pool-type reactor using light water to moderate and cool the fuel, meaning the live core can be observed safely from the top of the pool without any special protection. The MNR is one of many pool reactors built and operated around the world, known for their robust design and flexible operating capability.

The small nuclear research reactors do not release liquid effluents. A conservative evaluation puts the dose to the public through airborne releases at less than 1 microsievert (µSv) per year, which is less than a thousandth of the regulatory limit of 1 mSv for a member of the public for any of these facilities. With their inherent safety characteristics and low power, these reactors present very low risk among nuclear reactors in Canada, below the National Research Universal reactor (100 MW) and at a fraction of power reactors producing over 600 MW.

The small nuclear research reactors discussed in this report have been used by the academic community for decades and have received broad public acceptance due to their low-risk nature and benefits toward promoting research. Their designs have not changed, their usage and operations have remained consistent over the years, and overall performance has been consistently satisfactory.

Although CNSC staff assess all 14 safety and control areas (SCAs) on a continuous basis, this report focuses on the areas of particular relevance for small research reactors, such as radiation protection, environmental protection, and conventional health and safety. It also highlights any significant developments and issues of particular interest. Figure 11-1 shows the location of small nuclear research reactor facilities in Canada.

Figure 11-1: Location of small nuclear research reactors in Canada

The MNR licence was issued by the Commission in 2014 for a 10-year duration, expiring in June 2024. The operating licences for the four SLOWPOKE-2 facilities were issued by the Commission in 2013 for a 10-year duration, expiring in June 2023. The ÉPM subcritical assembly has an operating licence that was granted in 2006 for a 10-year duration, expiring in June 2016. ÉPM has requested to revoke the licence for the subcritical assembly (PERFP-9.00/2016) and amend its SLOWPOKE-2 licence (PERFP-9A.00/2023) to incorporate the operation of the subcritical assembly. This request was processed and approved by the Commission through an abridged Commission hearing, consisting of a panel of one, held on June 30, 2016 (CMD 16-H107).

CNSC staff provided consistent and risk-informed regulatory oversight at the small nuclear research reactor facilities in 2015. Table 11-1 below presents the licensing and compliance effort from CNSC staff for the small nuclear research reactor facilities during the reporting period.

Table 11-1: CNSC regulatory oversight licensing and compliance activities, small nuclear research reactor facilities, 2015

Facility	Number of inspections	Person days for compliance	Person days for licensing activities
McMaster University, McMaster Nuclear Reactor	2	138	19
University of Alberta, SLOWPOKE-2	1	31	17
Saskatchewan Research Council, SLOWPOKE-2	1	60	12
Royal Military College of Canada, SLOWPOKE-2	1	81	27
École Polytechnique de Montréal, SLOWPOKE-2	1	89	16
École Polytechnique de Montréal, subcritical assembly	1	6	6

During the review period, CNSC staff conducted seven onsite inspections at the small nuclear research reactor facilities. Findings from these inspections were provided to the licensees in detailed inspection reports. None of the findings presented an immediate or unreasonable risk to the health, safety and security of workers, Canadians or the environment.

Licensees are required to submit annual reports on the operations of their facilities by March 31 of each year. The annual reports contain all environmental, radiological and safety-related information, including events and associated corrective actions taken.

CNSC staff reviewed these annual reports as well as the revisions made to the licensees' programs and their responses to events and incidents at their facilities, together with observations noted during onsite inspections, to compile the 2015 performance ratings for the small nuclear research reactor facilities. CNSC staff gave these facilities a "satisfactory" rating for all SCAs, with the MNR receiving a "fully satisfactory" rating in the security SCA.

The 2015 performance ratings for the small nuclear research reactor facilities are presented in table 11-2.

Table 11-2: SCA performance ratings, small nuclear research reactor facilities, 2015

Safety and control area	MNR	U of A	SRC	RMCC	ÉPM	ÉPM subcritical
Management system	SA	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA	SA
Security	FS	SA	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA	SA

Each facility is required to develop decommissioning plans that are then reviewed and approved by CNSC staff. Each plan is accompanied by a financial guarantee that provides the funding necessary to complete the decommissioning work. The financial guarantees for the facilities are listed in appendix D.

11.1 Radiation protection

This SCA covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations*. The program must ensure contamination levels and radiation doses received by individuals are monitored, controlled and maintained as low as reasonably achievable (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

The 2015 rating for the radiation protection SCA for all small nuclear research reactor facility licensees was “satisfactory,” unchanged from the previous year.

Ratings for radiation protection SCA, small nuclear research reactor facilities, 2015

MNR	U of A	SRC	RMCC	ÉPM	ÉPM subcritical
SA	SA	SA	SA	SA	SA

Application of ALARA

During 2015, all small nuclear research reactor facility licensees continued to implement radiation protection measures to keep radiation exposures and doses to persons ALARA, 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 CNSC 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.

The maximum and average effective doses for workers at small nuclear research reactor facilities are provided in table 11-3. Taking into consideration the inherent differences in the design of each licensee's radiation protection program, the dose statistics in table 11-3 are provided separately for NEWs and non-NEWs. In 2015, the maximum individual effective dose received by a NEW at all facilities ranged from zero to 3.22 millisieverts (mSv), well below the regulatory dose limit of 50 mSv/year for a NEW. The maximum individual effective dose received by a non-NEW working at the facilities ranged from zero to 0.16 mSv, well below the regulatory dose limit of 1 mSv/year for a non-NEW.

Table 11-3: Average and maximum effective doses to workers, small nuclear research reactor facilities, 2015

Dose statistics	Non-NEWs			NEWs		
	SRC	ÉPM	RMCC	MNR	U of A	RMCC
Average effective dose (mSv)	0.01	0	0	0.38	0	0.02
Maximum individual effective dose (mSv)	0.16	0	0	3.22	0	0.29
Total persons monitored	23	5	13	112	2	13
Regulatory limit	1 mSv			50 mSv		

During 2015, all small nuclear research reactor facility licensees monitored and controlled the radiation exposures and doses received by all persons present at their licensed facilities, including workers, contractors and visitors.

Radiation protection program performance

CNSC staff performed regulatory oversight activities at all small nuclear research reactor facilities during 2015 to verify compliance of the licensees' radiation protection programs 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 small nuclear research reactor facilities have effectively implemented their radiation protection programs to control occupational exposures to workers.

Action levels for radiological exposures are established as part of the licensees' radiation protection programs. Licensees are responsible for identifying the parameters of their program that represent timely indicators of potential losses of control of the program. For this reason, action levels are licensee-specific and may change over time depending on operational and radiological conditions. If an action level is reached, it triggers the licensee to establish the cause, notify the CNSC and, if applicable, 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. There were no action level exceedances reported by small nuclear research reactor licensees during 2015.

Radiological hazard control

All small nuclear research reactor facility licensees continued to implement adequate measures to monitor and control radiological hazards in their facilities according to regulatory requirements. These measures include zoning for contamination control purposes (for all facilities) and in-plant air monitoring systems (for the MNR specifically). All licensees continued to implement their workplace monitoring programs to protect workers and have demonstrated that, in 2015, levels of radioactive contamination were controlled within their facilities.

Estimated dose to the public

The CNSC's requirements to apply ALARA principles ensure that licensees monitor their facilities and take corrective actions whenever action levels are exceeded. Calculations to conservatively estimate the public dose have been conducted and were assessed to be less than 1 µSv/year, which is less than a thousandth of the regulatory dose limit of 1 mSv/year for a member of the public

The small nuclear research reactor facility licensees effectively implemented and maintained their radiation protection programs during 2015 to ensure the health and safety of persons working in their facilities.

11.2 Environmental protection

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

For small nuclear research reactor facilities, this SCA encompasses the following specific areas:

- effluent and emissions control (releases)
- assessment and monitoring

CNSC staff gave all small nuclear research facilities a "satisfactory" rating for the environmental protection SCA in 2015, unchanged from the previous year.

Ratings for environmental protection SCA, small nuclear research reactor facilities, 2015

MNR	U of A	SRC	RMCC	ÉPM	ÉPM subcritical
SA	SA	SA	SA	SA	SA

To control the release of radioactive and hazardous substances into the environment, 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 suitably trained and qualified staff to effectively develop, implement and maintain their environmental protection programs.

The small nuclear research reactor facilities satisfactorily implemented their environmental programs during 2015, and their programs are effective in protecting the health and safety of persons working in their facilities.

11.3 Conventional health and safety

This 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

The rating for the conventional health and safety SCA for all small nuclear research reactor facility licensees in 2015 was “satisfactory,” unchanged from the previous year.

Ratings for conventional health and safety SCA, small nuclear research reactor facilities, 2015

MNR	U of A	SRC	RMCC	ÉPM	ÉPM subcritical
SA	SA	SA	SA	SA	SA

The regulation of conventional health and safety at these facilities involves both Employment and Social Development Canada (ESDC) and the CNSC. CNSC staff monitor compliance with regulatory reporting requirements. When a concern is identified, ESDC staff are consulted and asked to take appropriate action. 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*. These reports include serious illnesses or injuries incurred or possibly incurred as a result of licensed activity.

Table 11-4 shows that there has not been a lost-time injury at any of the small nuclear research reactor facilities from 2011 to 2015.

Table 11-4: Lost-time injuries, small nuclear research reactor facilities, 2011–15

Facility	2011	2012	2013	2014	2015
McMaster University, McMaster Nuclear Reactor	0	0	0	0	0
University of Alberta, SLOWPOKE-2	0	0	0	0	0
Saskatchewan Research Council, SLOWPOKE-2	0	0	0	0	0
Royal Military College of Canada, SLOWPOKE-2	0	0	0	0	0
École Polytechnique de Montréal, SLOWPOKE-2	0	0	0	0	0
École Polytechnique de Montréal, subcritical assembly	0	0	0	0	0

The small nuclear research reactor facility licensees implemented their conventional health and safety programs satisfactorily during 2015, and their programs are effective in protecting the health and safety of persons working in their facilities.

11.4 Public information and disclosure programs

Small nuclear research reactor facilities are required to maintain and implement public information and disclosure programs per RD/GD-99.3, *Public Information and Disclosure*. These programs are supported by disclosure protocols that outline the type of information on the facility and its activities to be shared with the public (e.g., incidents, major changes to operations, periodic environmental performance reports) and how that information will be shared. This ensures timely information about the health, safety and security of persons and the environment and other issues associated with the lifecycle of nuclear facilities are effectively communicated.

As small nuclear research reactors are low-risk facilities, CNSC staff recognize that a full-scale public information program, as undertaken by larger nuclear facilities, is not warranted. However, the CNSC does require research reactor licensees to implement the elements of RD/GD-99.3 to increase public awareness and understanding of their facilities and operations. Licensees are continuing to improve their public information programs and disclosure protocols to better align with RD/GD-99.3.

In 2015, all licensees actively provided information on the operations of their nuclear research reactor on their websites, some of which include informative videos. Examples of other communications activities undertaken include open houses, facility tours and participation in community events.

The small nuclear research reactor facility licensees implemented their public information and disclosure programs satisfactorily during 2015, and their programs are effective at communicating information about the health, safety and security of persons and the environment and other issues associated with their facilities.

12 MCMASTER UNIVERSITY

McMaster Nuclear Reactor (MNR) is a 5 MW research reactor located on the campus of McMaster University in Hamilton, ON. Operated by McMaster University, this pool-type reactor uses low-enriched uranium as a fuel and has the added safety feature of a full containment building. Figure 12-1 shows an aerial view of the MNR facility and figure 12-2 shows a ground-level view of the facility.

Figure 12-1: Aerial view of the McMaster Nuclear Reactor facility

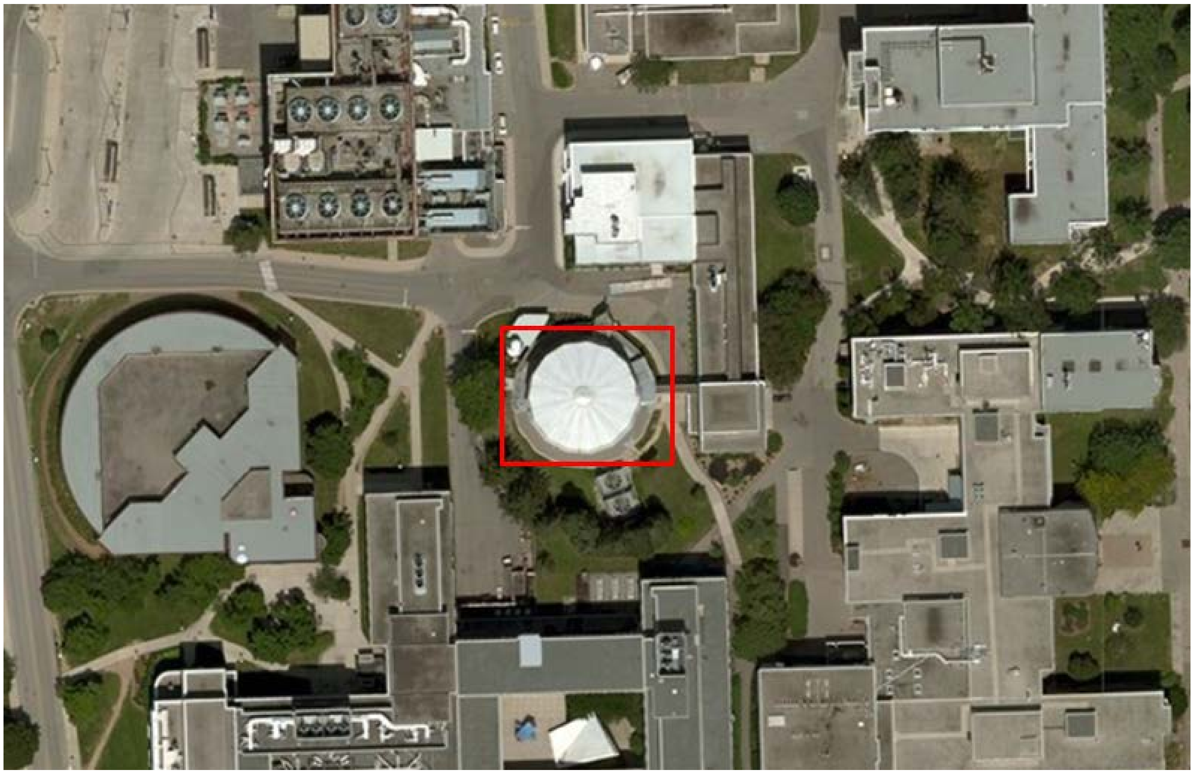


Figure 12-2: Ground-level view of the McMaster Nuclear Reactor facility

The MNR has been in operation since 1959 and is used for research, materials testing, teaching and isotope production. The reactor produces iodine-125 (I-125) for medical use in Canada as well as for export to the United States and other countries. The MNR is also used for neutron radiography, which is performed on a daily basis for the testing of aircraft engine components. In addition to supporting the research work of McMaster University physics and engineering undergraduate and post-graduate students, the MNR is also used for the irradiation of more than 10,000 mineral and other samples every year for various applications such as biomedical research, material science and geological surveys.

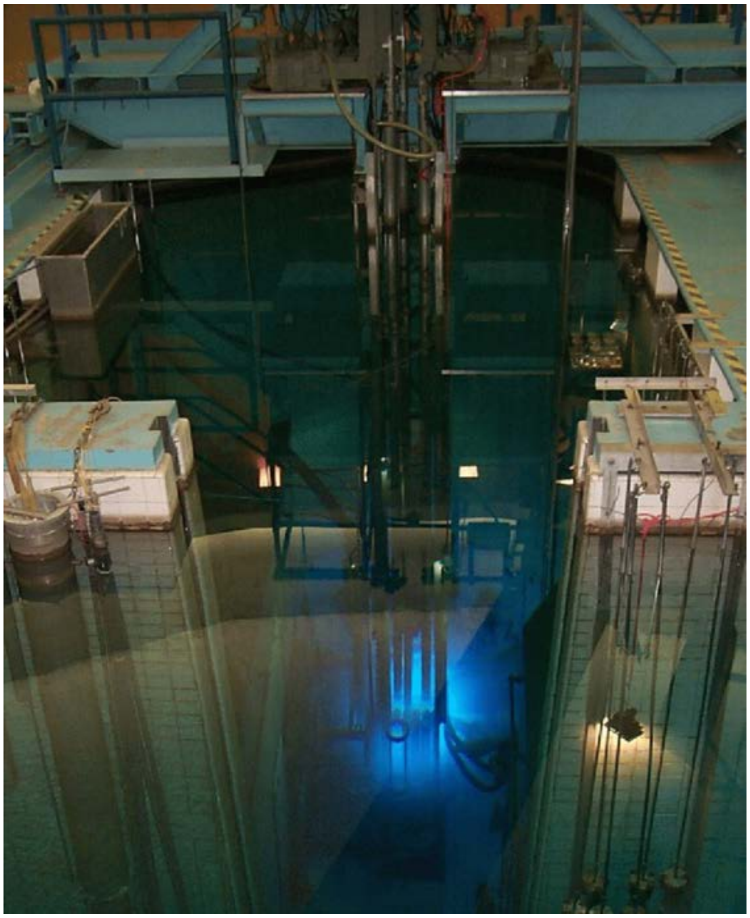
The current MNR licence was issued by the Commission on July 1, 2014 for a period of 10 years further to a Commission hearing held on May 8, 2014.

12.1 Performance

For 2015, CNSC staff continued to rate the MNR's performance as "satisfactory" in all SCAs except security, where it was given as "fully satisfactory" rating. The MNR maintains a strong security culture and provides an effective program to control access to facilities, nuclear material and prescribed/classified information. The MNR performance ratings for 2011 through 2015 are provided in table C-8, appendix C.

In 2015, the MNR operated on a normal schedule of 16 hours per day, Monday through Friday, with a few exceptions for holidays, maintenance outages and fueling activities. Figure 12-3 shows an overhead view of the MNR.

Figure 12-3: Overhead view of the McMaster Nuclear Reactor



During the annual maintenance outage, McMaster University inspected the MNR's primary system piping and secondary tubes of the heat exchangers, with no abnormal degradation observed. The university also performed the annual containment building leakage rate test, which confirmed that the building continues to meet its design specifications and is fit for service. Over the review period, quarterly shim rod drop-time tests were performed successfully, ensuring the continued reliability of the MNR's safety shutdown system. MNR staff inspected the reactor pool and no abnormal degradation was detected.

McMaster University reported one event during 2015, where limit switches for three shim rods were found inoperable as part of routine verification checks. The role of these limit switches is to warn the operator should a guide tube not be fully inserted, which could prevent the normal operation of adjuster rods. There were no consequences to this event and no safety systems were impaired. CNSC staff followed up through desktop reviews of the information provided, compliance meetings and an onsite inspection in September 2015. CNSC staff verified that the corrective actions developed to prevent recurrence of the event have been implemented.

McMaster University also completed the root-cause analysis and corrective actions related to a 2014 incident where a fuel assembly was inadvertently left in a position of the core with no forced cooling. This event was presented to the Commission as an Event Initial Report on November 5, 2014 and the results of the analysis were presented at an update to the Commission on June 18, 2015. McMaster University developed a corrective action plan that included several changes to procedures, independent verification during fueling, human performance improvement tools, increased lighting in the pool, and the installation of an underwater camera and jib crane to facilitate fuel handling. CNSC staff observed the fueling process in March 2015 and performed an onsite inspection of that process in September 2015. Corrective actions were verified as completed and no additional actions were required.

Design and preliminary construction work have progressed toward the installation of the new Positron and Small Angle Neutron Scattering facilities for which a grant was awarded from the Canadian Foundation for Innovation. McMaster University expects to install these new experimental facilities between 2016 and 2017. These facilities are authorized under the provisions of the current MNR licence and the MNR’s engineering change control. CNSC staff are monitoring the progress and will be reviewing the safety documents associated with these new facilities once completed by McMaster University.

12.2 Radiation protection

Overall compliance ratings for radiation protection SCA, McMaster Nuclear Reactor, 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA
For 2015, CNSC staff continued to rate the radiation protection SCA for the MNR as “satisfactory.” McMaster University has implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations*.				

Application of ALARA

Annually, McMaster University establishes goals related to radiation protection and measures are taken to enhance the MNR’s performance in this area. Examples of radiation protection goals established in 2015 include the establishment of collective dose targets for different work groups and maximum permissible airborne concentrations at some locations. Examples of measures taken in 2015 to reduce doses to workers included the installation of an automated chemical control/addition station for the secondary water system in a low dose-rate area and the transfer of active waste to less occupied areas for storage.

Worker dose control

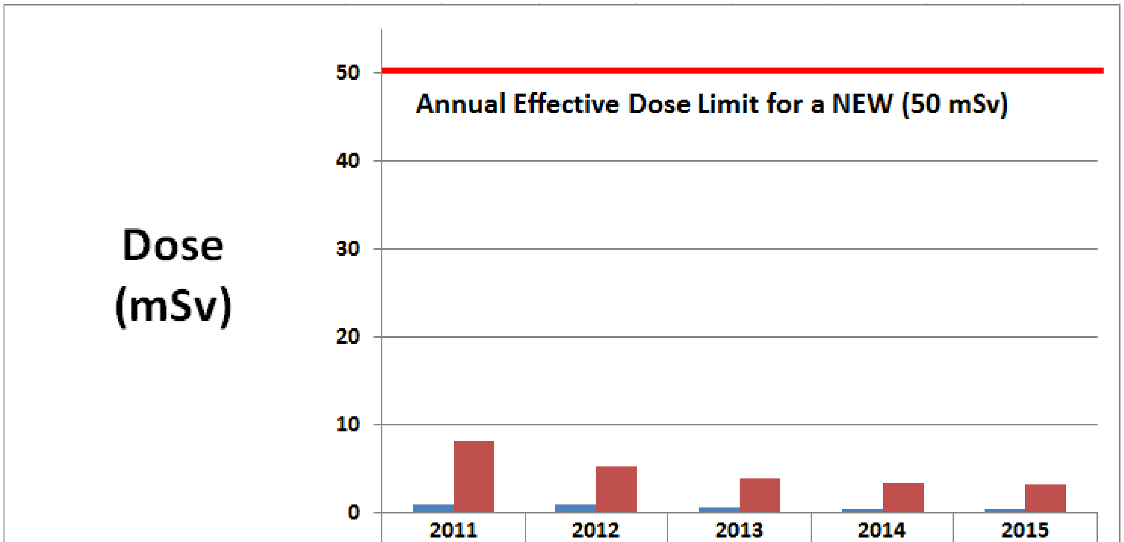
Radiation exposures are monitored to ensure compliance with CNSC's regulatory dose limits and to maintain doses ALARA, taking social and economic factors into account. In 2015, no worker received a radiation exposure in excess of the regulatory dose limits or action levels established in the MNR's radiation protection program.

McMaster University ascertains external doses using whole body and extremity dosimeters. In addition, electronic personnel dosimeters are used to monitor doses on a daily basis. Internal exposure is assessed through routine thyroid screening for individuals working with volatile I-125. Internal dose to workers exposed to other radionuclides is assessed though the review of results from contamination monitoring of surfaces, airborne contamination monitoring and personnel contamination monitoring. In 2015, CNSC staff confirmed that no internal doses were recorded from extensive facility air and surface contamination monitoring, personnel contamination monitoring or thyroid screening.

At the MNR, employees and contractors conducting work activities that present a reasonable probability of receiving an occupational dose greater than 1 mSv/year are identified as NEWs. Site visitors and some contractors who do not present a reasonable probability of receiving an occupational dose greater than 1 mSv/year are identified as non-NEWs.

Figure 12-4 provides the average effective doses, maximum effective doses to an individual and number of NEWs monitored from 2011 to 2015 at the MNR. In 2015, total effective dose was assessed for 112 NEWs, consisting of 96 MNR employees and 16 contractors. The maximum effective dose received by a NEW in 2015 was 3.22 mSv, or approximately six percent of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period. For the five-year dosimetry period from 2011 to 2015, the maximum individual effective dose received by a NEW at McMaster was 20.39 mSv, or approximately 20 percent of the regulatory effective dose limit of 100 mSv per five-year dosimetry period.

Figure 12-4: Average and maximum effective doses to nuclear energy workers, McMaster Nuclear Reactor, 2011–15



	2011	2012	2013	2014	2015
Average effective dose (mSv)	1.01	0.87	0.54	0.39	0.38
Maximum effective dose (mSv)	8.15	5.31	3.93	3.34	3.22
Number of NEWs monitored	82	79	87	119	112

During the years 2011 to 2015, the average and maximum effective doses at MNR show a decreasing trend. The dose fluctuations from year to year are attributed to the type and scope of work being performed.

Annual average and maximum equivalent (extremity and skin) dose results from 2011 to 2015 are provided in tables E-13 and E-21, appendix E. In 2015, the maximum skin dose received by a NEW at the MNR was 4.70 mSv and the maximum extremity dose was 36.39 mSv. These represent approximately one percent and seven percent, respectively, of the 500 mSv annual regulatory equivalent dose limits for the skin and extremities.

In 2015, the total effective dose was assessed for 2,205 non-NEWs, consisting of site visitors and some contractors. In 2015, the maximum effective dose received by a non-NEW was 0.02 mSv, or approximately two percent of the regulatory effective dose limit of 1 mSv in a one-year dosimetry period.

Radiation protection program performance

CNSC staff assessed the performance of the MNR radiation protection program in 2015 through compliance activities and desktop reviews. McMaster University's compliance with the *Radiation Protection Regulations* and CNSC licence requirements was satisfactory.

Action levels for radiological exposures are established as part of the radiation protection program. If an action level is reached, it triggers MNR staff to establish the cause, notify the CNSC and, if applicable, restore the effectiveness of the program. In 2015, no action levels were reached.

Radiological hazard control

Radiation and contamination control programs have been established at the MNR to control and minimize radiological hazards and the spread of radioactive contamination. Methods of control include the use of radiation zone controls, surface contamination monitoring, in-plant air monitoring and radiological dose-rate surveys.

The radiological hazard surveys conducted in 2015 did not identify any adverse trends and the findings were consistent with expected radiological conditions.

Estimated dose to the public

Pursuant to the *Radiation Protection Regulations*, a licensee is required to ensure the regulatory public dose limit of 1 mSv/year as a result of its licensed activity is not exceeded. Calculations to conservatively estimate the public dose have been conducted by comparing emission monitoring results to the derived release limit (DRL). The two radionuclides released to the environment from the MNR facility in any measureable quantities are I-125 and argon-41 (Ar-41). In 2015, the maximum possible dose to a member of the public, assuming a person would stand for an entire year at the ground location of the highest release concentration for I-125 and Ar-41, was assessed by CNSC staff as 0.72 µSv. This dose is less than a thousandth of the regulatory limit of 1 mSv/year.

The annual doses to a member of the public for 2011 to 2015 are shown in table 12-1. The public dose is well below the CNSC regulatory dose limit for a member of the public of 1 mSv/year.

Table 12-1: Maximum effective dose to a member of the public, McMaster Nuclear Reactor, 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Maximum effective dose (mSv)	0.00067	0.00053	0.00070	0.00074	0.00072	**1 mSv/year**

12.3 Environmental protection

Overall compliance ratings for environmental protection SCA, McMaster Nuclear Reactor, 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA

For 2015, CNSC staff continued to rate the environmental protection SCA for the MNR as “satisfactory.” McMaster University continues to implement and maintain an environmental protection program as required by its licence.

Effluent and emissions control (releases)

The MNR's effluent and emissions monitoring program consists of monitoring exhaust ventilation for I-125 and Ar-41, which are the only nuclear substances routinely released to the environment in measurable quantities (i.e., above detection limits). Radioactive particulates are also monitored for gross beta to ensure no unexpected radionuclides are present in the air stream.

There are no liquid releases to the environment; the MNR captures, reprocesses or evaporates any liquid waste within the facility. Weekly assessments are done on the secondary side of the heat exchanger to ensure no leakage occurs.

Controls are in place to ensure airborne releases of nuclear substances to the environment are minimized. These controls include the use of activated charcoal filters to minimize the release of radioiodines and the use of absolute filters to ensure releases of radioactive particulates are controlled.

DRLs have been established for airborne releases of I-125 and Ar-41 based on the regulatory public dose limit of 1 mSv/year. The maximum effective dose to the public, as reported above, was estimated at 0.72 µSv in 2015. This is less than 0.1 percent of the regulatory public dose limit of 1 mSv/year.

The MNR also maintains environmental action levels corresponding to a small fraction of the DRL. Exceedance of an action level triggers a notification to the CNSC and an investigation that may result in corrective actions or preventative measures being put in place. The action level for Ar-41 is 1.6E+13 Bq/year and results in a dose equivalent to 0.012 mSv/year. The action level for I-125 is 1.0E+10 Bq/year and results in a dose equivalent to 0.001 mSv/year. There were no exceedances of any environmental action level or regulatory limit at the MNR over the past five years. Table 12-2 shows the annual releases of Ar-41 and I-125 from 2011 to 2015.

Table 12-2: Air emissions monitoring results, McMaster Nuclear Reactor, 2011–2015

Parameter	2011	2012	2013	2014	2015	Action level (Bq/year)	DRL (Bq/year)
Ar-41	9.89E+11	8.33E+11	1.05E+12	9.30E+11	8.40E+11	**1.6E+13**	**1.3E+15**
I-125	4.68E+07	1.49E+08	1.80E+08	1.70E+08	1.70E+08	**1.0E+10**	**9.4E+12**

Releases of Ar-41 in 2015 were similar to the previous year, corresponding to approximately 0.06 percent of the DRL and five percent of the action level. Releases of I-125 in 2015 were also similar to the previous year, corresponding to approximately 0.002 percent of the DRL and two percent of the action level.

Assessment and monitoring

The MNR environmental monitoring program includes three monitoring stations located around the facility. Samples are collected weekly and analyzed for gross beta activity. Charcoal cartridges are collected and sampled monthly for I-125 via gamma spectrometry. There were no liquid releases during the review period. The gaseous effluent monitors and environmental monitoring results did not indicate any radiological releases from the MNR facility that could compromise the health and safety of persons or the environment.

12.4 Conventional health and safety

Overall compliance ratings for conventional health and safety SCA, McMaster Nuclear Reactor, 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA
For 2015, CNSC staff continued to rate the conventional health and safety SCA for the MNR as “satisfactory.” McMaster University has implemented and maintained a conventional health and safety program as required by its licence.				

Performance

A key performance measure for conventional health and safety SCA is the number of long-term 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 12-3, there have been no LTIs at the MNR facility over the past five years.

Table 12-3: Lost-time injuries, McMaster Nuclear Reactor, 2011–15

	2011	2012	2013	2014	2015
Lost-time injuries	0	0	0	0	0

Practices

McMaster University has a comprehensive conventional health and safety program that complies with the requirements of Ontario’s *Occupational Health and Safety Act*. A central committee monitors activities and programs for the entire campus. A local committee, comprising workers and managers, promotes and provides a safe work environment in the MNR facility. Compliance with fire code requirements are also verified as part of this program. CNSC staff have reviewed McMaster University’s conventional health and safety program and concluded that the program meets the compliance requirements.

Awareness

McMaster University continues to maintain an effective conventional health and safety program. Workers are made aware of the program as well as workplace hazards through training and ongoing internal communications with the university. CNSC staff continue to monitor the effectiveness of this program through regular onsite inspections.

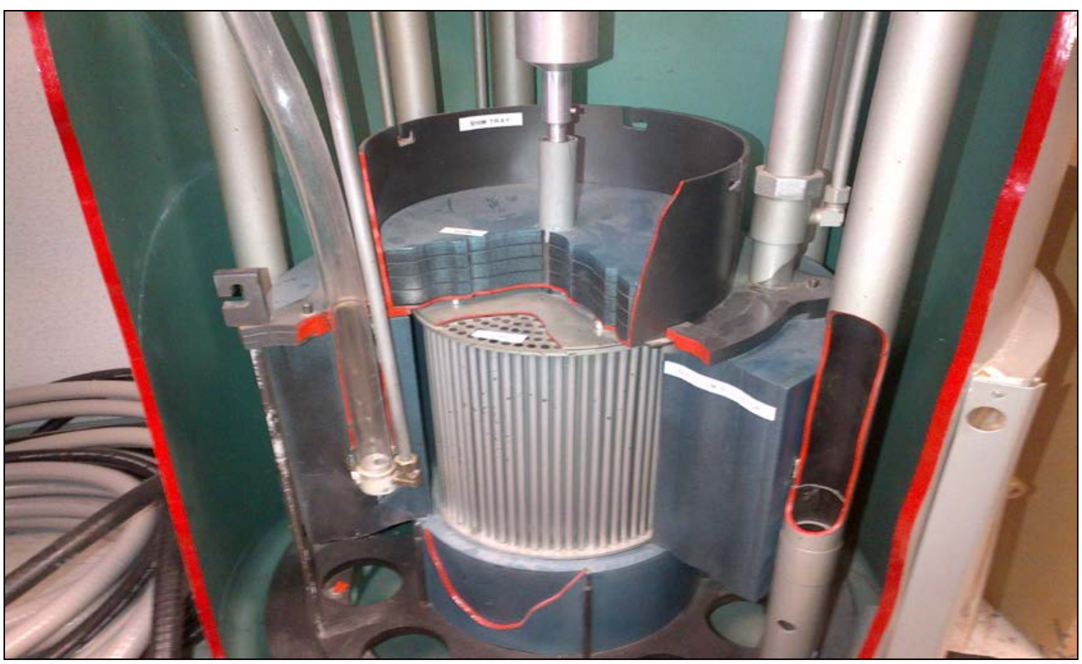
13 SLOWPOKE-2 FACILITIES

SLOWPOKE-2 reactors use sealed container-in-pool designs with a nominal power of 20 kilowatt (kW) thermal. The reactor is housed in a closed container suspended in a water pool, which restricts access to the core and provides for limited and controlled release of fission products.

Figure 13-1 shows a model of a SLOWPOKE-2 reactor core. The reactors are cooled and moderated by light water (reactor container water) and fueled with either highly enriched uranium (in the case of the U of A and SRC reactors) or low-enriched uranium (in the case of the RMCC and ÉPM reactors).

SLOWPOKE-2 reactors provide a source of neutrons to carry out neutron activation analysis, delayed neutron counting, radioisotope production, and radiography and radioscopy. They also support post-graduate education and research in physics and engineering. The operating licences for all four SLOWPOKE-2 facilities in Canada were renewed by the Commission in 2013 for a period of 10 years ending June 30, 2023.

Figure 13-1: Model of SLOWPOKE-2 reactor core



The following three subsections discuss the performance of all SLOWPOKE-2 facilities as it relates to the radiation protection, environmental protection, and conventional health and safety SCAs.

13.1 Radiation protection

Overall compliance ratings for radiation protection SCA, SLOWPOKE-2 facilities, 2015

U of A	SRC	RMCC	ÉPM
SA	SA	SA	SA
In 2015, CNSC staff continued to rate the radiation protection SCA at the SLOWPOKE-2 facilities as "satisfactory." The SLOWPOKE-2 facilities have implemented and maintained a radiation protection program as required by the *Radiation Protection Regulations*.			

Application of ALARA

In 2015, all SLOWPOKE-2 facilities continued to apply measures to keep doses received by workers ALARA. Examples of ALARA measures included appropriate use of shielding and personal protective equipment, minimization of time on radiological areas, and maximizing of distances from radioactive sources.

Worker dose control

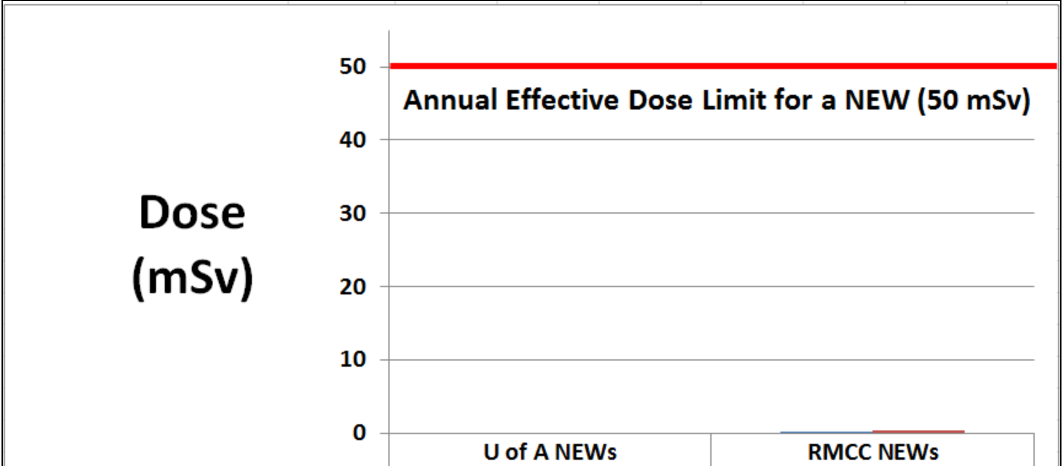
Radiation exposures are monitored by licensees to ensure compliance with the CNSC's regulatory dose limits and to maintain radiation doses ALARA. In 2015, no worker received a radiation exposure in excess of the regulatory dose limits or action levels established in each facility's radiation protection program.

At the SLOWPOKE-2 facilities, employees and contractors conducting activities which present a reasonable probability of receiving an occupational dose greater than 1 mSv/year are identified as NEWs. Individuals who do not present a reasonable probability of receiving an occupational dose greater than 1 mSv/year are identified as non-NEWs.

Based on the specific requirements of the worker's position, SRC and ÉPM made the decision to identify their workers as non-NEWs while U of A identified its workers as NEWs. RMCC has both NEWs and non-NEWs at its facility.

Figure 13-2 provides the average effective doses, maximum effective doses to an individual and number of NEWs monitored for 2015 at the SLOWPOKE-2 facilities. In 2015, the maximum effective dose received by a NEW was 0.29 mSv, or approximately 0.5 percent of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period.

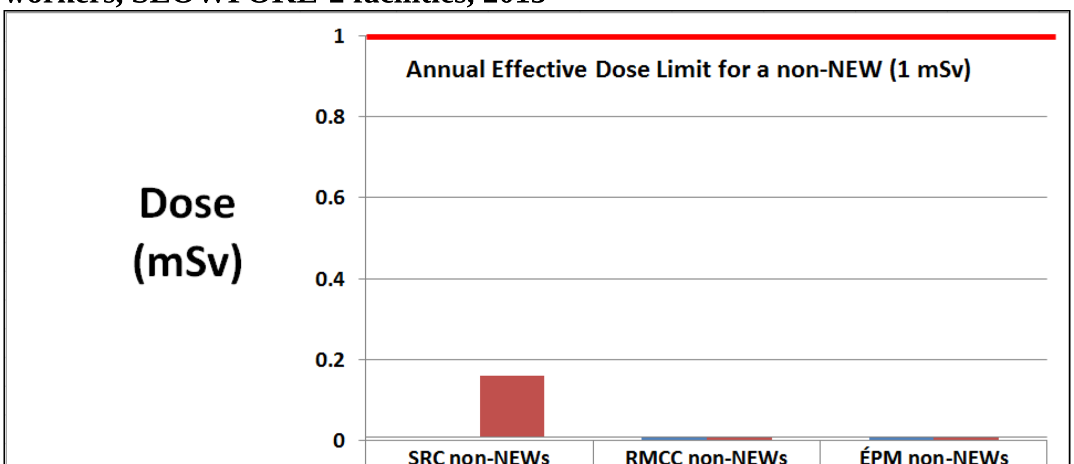
Figure 13-2: Average and maximum effective doses to nuclear energy workers, SLOWPOKE-2 facilities, 2015



	U of A NEWs	RMCC NEWs
Average effective dose (mSv)	0	0.02
Maximum effective dose (mSv)	0	0.29
Number of NEWs monitored	2	13

Figure 13-3 provides the average effective doses, maximum effective doses to an individual and number of non-NEWs monitored for 2015 at the SLOWPOKE-2 facilities. In 2015, the maximum effective dose received by a non-NEW was 0.16 mSv, or 16 percent of the regulatory effective dose limit of 1 mSv in a one-year dosimetry period.

Figure 13-3: Average and maximum effective doses to non-nuclear energy workers, SLOWPOKE-2 facilities, 2015



	SRC non-NEWs	RMCC non-NEWs	ÉPM non-NEWs
Average effective dose (mSv)	0.01	0	0
Maximum effective dose (mSv)	0.16	0	0
Total Persons monitored	23	13	5

The average effective doses, maximum effective doses to an individual and number of persons monitored from 2011 to 2015 at each SLOWPOKE-2 facility are presented in tables E-1 through E-6, appendix E. Doses remained low and relatively stable during those years.

All NEWs and non-NEWs at the SLOWPOKE-2 facilities wear dosimeters, issued by a CNSC-licensed dosimetry provider, to measure the whole-body and skin doses they may receive. No equivalent skin and extremity doses were received by workers in 2015.

Radiation protection program performance

CNSC staff assessed the performance of the radiation protection programs at the SLOWPOKE-2 facilities was assessed in 2015 through compliance activities and desktop reviews. Compliance with the *Radiation Protection Regulations* and CNSC licence requirements was satisfactory.

Action levels for radiological exposures are established as part of the facilities' radiation protection programs. If an action level is reached, it triggers staff to establish the cause, notify the CNSC and, if applicable, restore the effectiveness of the program. No action levels were reached in 2015.

Radiological hazard control

The SLOWPOKE-2 facilities have measures in place to monitor and control radiological hazards. These measures include, but are not limited to, access control, fixed area alarming radiation monitors, and the routine monitoring of radiological dose rates and radioactive contamination.

Radiological dose rate and contamination monitoring measurements conducted by all SLOWPOKE-2 facilities in 2015 did not identify any adverse trends and were consistent with expected radiological conditions.

Estimated dose to the public

CNSC staff performed an independent assessment of the public dose due to all gaseous releases from the SLOWPOKE-2 facilities. A very conservative evaluation of the dose to the public gives an estimate below 0.085 μSv/year, which is well below the regulatory limit of 1 mSv/year for a member of the public.

13.2 Environmental protection

Overall compliance ratings for environmental protection SCA, SLOWPOKE-2 facilities, 2015

U of A	SRC	RMCC	ÉPM
SA	SA	SA	SA
In 2015, CNSC staff continued to rate the environmental protection SCA at the SLOWPOKE-2 facilities as “satisfactory.” The SLOWPOKE-2 licensees continued to ensure there were no hazardous liquid releases from their facilities and to limit releases to the air during the review period.			

Effluent and emissions control (releases)

The SLOWPOKE-2 facilities release very small quantities of radioactive noble gases, mainly xenon-133 (Xe-133) and xenon-135 (Xe-135) resulting from the weekly purges of reactor head space, and argon-41 (Ar-41) resulting from irradiation activities. The releases take place through absolute filters and a dedicated facility stack.

At each facility, the reactor container headspace is purged weekly to avoid hydrogen buildup from the radiolysis of reactor water. The weekly purges take place 48 to 72 hours after reactor shutdown to provide time for the gaseous radionuclides to decay. Therefore, small concentrations of Xe-133 and Xe-135 will be left in the headspace before purges. Ar-41 is produced by the activation of air in the pneumatic transfer system and very low quantities are vented during normal irradiation operations.

Most irradiated samples are stored until they decay to background levels and disposed of as non-radioactive material. Any irradiated samples with long-lived radionuclides are either returned to the client or transported to a licensed facility for disposal.

The SLOWPOKE-2 facilities do not release liquid effluents.

13.3 Conventional health and safety

Overall compliance ratings for conventional health and safety SCA, SLOWPOKE-2 facilities, 2015

U of A	SRC	RMCC	ÉPM
SA	SA	SA	SA
In 2015, CNSC staff continued to rate the conventional health and safety SCA at the SLOWPOKE-2 facilities as “satisfactory.” Compliance verification activities conducted by CNSC staff at the facilities confirmed that the licensees continue to implement effective conventional health and safety programs.			

Performance

The conventional health and safety hazards at SLOWPOKE-2 facilities include hazards related to activities similar to those expected in any laboratory performing elemental analyses.

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 to carry out their duties for a period of time. During the review period, there were no injuries or illnesses of any person as a result of the licensed activities at the SLOWPOKE-2 facilities. As shown in table 13-1, there were no LTIs at the SLOWPOKE-2 facilities from 2011 to 2015.

Table 13-1: Lost-time injuries, SLOWPOKE-2 facilities, 2011–15

Facility	2011	2012	2013	2014	2015
University of Alberta	0	0	0	0	0
Saskatchewan Research Council	0	0	0	0	0
Royal Military College of Canada	0	0	0	0	0
École Polytechnique de Montréal	0	0	0	0	0

Practices

Conventional health and safety at the SLOWPOKE-2 facilities is based on minimizing the risk to the health and safety of workers posed by conventional hazards. The health and safety committees at each facility are charged with reviewing incidents, conducting safety inspections, evaluating safety programs, and recommending health and safety improvements.

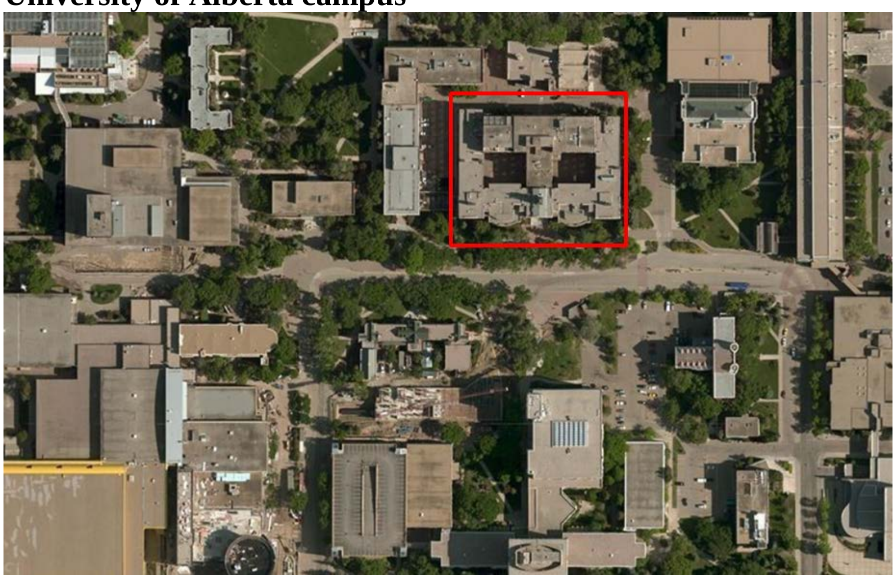
Awareness

The SLOWPOKE-2 facilities maintain effective conventional health and safety programs. Workers are made aware of theses program as well as workplace hazards through training and ongoing internal communications with their employers. CNSC staff continue to monitor the effectiveness of these programs through regular onsite inspections.

13.4 University of Alberta

The U of A SLOWPOKE-2 reactor is located in the Dentistry/Pharmacy Building on the university's campus in Edmonton, AB. The facility consists of a reactor room and an underground vault below the west courtyard of the building, with the reactor itself located in a concrete well underneath the floor of the vault. Figure 13-4 shows an aerial view of the Dentistry/Pharmacy Building that houses the U of A SLOWPOKE-2 facility.

Figure 13-4: Aerial view of the Dentistry/Pharmacy Building on the University of Alberta campus



The SLOWPOKE-2 facility is used for neutron activation analysis, isotope production, and teaching and research programs of the university's departments and affiliated teaching hospitals. The reactor has been in operation since 1977. The core is fuelled with highly enriched uranium. Figure 13-5 shows the top of the SLOWPOKE-2 reactor covered by concrete blocks.

Figure 13-5: Top of the University of Alberta SLOWPOKE-2 reactor, covered with concrete blocks

Performance

For 2015, CNSC staff continued to rate U of A's performance as "satisfactory" in all SCAs. The U of A performance ratings for 2011 through 2015 are provided in table C-9, appendix C.

During the review period, U of A was compliant with the *Nuclear Safety and Control Act* (NSCA) and its associated regulations as well as the conditions of the U of A non-power reactor operating licence (NPROL-18.00/2023). The U of A SLOWPOKE-2 reactor operated in a safe and reliable way and did not require unplanned maintenance, and no operational challenges were reported. There were no changes that affected systems, structures and components (SSCs) in meeting and maintaining their design requirements.

The review of the records by CNSC staff showed that the licensee performed scheduled inspections and maintenance and non-routine maintenance to ensure the SSCs remain effective over time and continue to effectively fulfill their intended purpose.

In November 2015, CNSC staff conducted an onsite inspection at the U of A SLOWPOKE-2 facility to verify compliance with the NSCA and its regulations, U of A's operating licence and the programs used to meet regulatory requirements. The inspection focused on radiation protection, environmental protection, conventional health and safety, and security. None of the findings from this inspection presented an immediate or unreasonable risk to the health, safety and security of workers, Canadians or the environment.

Facility operations, equipment, procedures, usage and organization are expected to remain unchanged in 2016.

13.5 Saskatchewan Research Council

The SRC SLOWPOKE-2 facility is located within SRC's Environmental Analytical Laboratories in Saskatoon, SK. An aerial view of the facility is shown in figure 13-6. The facility consists of a reactor room (with the reactor located within a concrete well), uranium analysis and neutron activation laboratories, and a waste storage room.

The SLOWPOKE-2 facility is used for neutron activation analysis, delayed neutron counting of uranium and teaching in conjunction with the University of Saskatchewan. The reactor has been in operation since 1981. The core is fueled with highly enriched uranium.

At the current rate of fuel use, SRC expects that re-shimming (i.e., adding excess reactivity to compensate for fuel burnup) will be required in about two years. A refuelling of the core may not be required for up to 20 years.

Figure 13-6: Aerial view of the SRC Environmental Analytical Laboratories

Performance

For 2015, CNSC staff continued to rate SRC's performance as "satisfactory" in all SCAs. The SRC performance ratings for 2011 through 2015 are provided in table C-10, appendix C.

During the review period, SRC was compliant with the NSCA and its associated regulations as well as the conditions of the SRC non-power reactor operating licence (NPROL-19.00/2023). The SRC SLOWPOKE-2 reactor operated in a safe and reliable way and did not require unplanned maintenance, and no operational challenges were reported. CNSC staff's review of records showed that SRC performed scheduled routine inspections and maintenance activities to ensure that SSCs remain effective over time and continue to effectively fulfill their intended purpose.

In November 2015, CNSC staff conducted one onsite inspection at the SRC SLOWPOKE-2 facility to verify compliance with the NSCA and its regulations, SRC's operating licence and the programs used to meet regulatory requirements. The inspection focused on radiation protection, environmental protection, conventional health and safety, and security. None of the findings from this inspection presented an immediate or unreasonable risk to the health, safety and security of workers, Canadians or the environment.

Facility operations and usage remained the same as in previous years and no changes are expected in 2016.

13.6 Royal Military College of Canada

The RMCC SLOWPOKE-2 facility is located within the RMCC complex in Kingston, ON. Figure 13-7 provides an aerial view of the complex. The facility is housed in the Sawyer Science and Engineering Building, Module 5. It includes the reactor room (with the reactor located in a steel-lined concrete well), a control room on the first floor, and laboratories on the first and second floors.

Figure 13-7: Aerial view of the Royal Military College of Canada complex

The RMCC SLOWPOKE-2 facility is used for neutron activation analysis, analysis of fissile materials, neutron radiography and radioscopy, and education in radiation protection at the post-graduate level. The reactor has been in operation since 1985. The core is fuelled with low-enriched uranium.

RMCC submitted a business plan for refuelling the SLOWPOKE-2 reactor to the Department of National Defence for funding. If the funding is approved, the target completion date for refuelling is December 2018.

Performance

For 2015, CNSC staff continued to rate RMCC's performance as "satisfactory" in all SCAs. The RMCC performance ratings for 2011 through 2015 are provided in table C-11, appendix C.

During the review period, RMCC was compliant with the NSCA and its associated regulations as well as the conditions of the RMCC non-power reactor operating licence (NPROL-20.00/2023). The RMCC SLOWPOKE-2 reactor operated in a safe and reliable way and did not require unplanned maintenance, and no operational challenges were reported. There were no changes that affected SSCs in meeting and maintaining their design requirements. CNSC staff's review of records showed that RMCC performed scheduled routine inspections and maintenance activities to ensure the SSCs remain effective over time and continue to effectively fulfill their intended purpose.

In November 2015, CNSC staff conducted one onsite inspection at the RMCC SLOWPOKE-2 facility to verify compliance with the NSCA and its regulations, RMCC's operating licence and the programs used to meet regulatory requirements. The inspection focused on radiation protection, environmental protection, conventional health and safety, and security. None of the findings from this inspection presented an immediate or unreasonable risk to the health, safety and security of workers, Canadians or the environment.

The type of operations remained the same during the review period and no changes are expected in 2016, with the exception that RMCC is planning to improve the quality of its radiography operations.

13.7 École Polytechnique de Montréal

The ÉPM SLOWPOKE-2 facility is located on the campus of the Université de Montréal in Montréal, QC. Specifically, the reactor is located on the ground floor of the main building of ÉPM, as shown in figure 13-8. The reactor is used for research, teaching, neutron analysis and isotope production, and has been in operation since 1976. The reactor core is fuelled with low-enriched uranium.

Figure 13-8: Aerial view of the École Polytechnique de Montréal campus

Performance

For 2015, CNSC staff continued to rate ÉPM's performance as "satisfactory" in all SCAs. The ÉPM performance ratings for 2011 through 2015 are provided in table C-12, appendix C.

During the review period, ÉPM was in compliance with the NSCA and its associated regulations as well as the conditions of the ÉPM non-power reactor operating licence (PERFP-9A.01/2023). During the same period, the SLOWPOKE-2 reactor was operated safely and reliably, and no operational issues were reported. Operational activities and use of the facility were the same as in previous review periods.

In September 2015, CNSC staff conducted one onsite inspection at the ÉPM SLOWPOKE-2 facility to verify compliance with the NSCA and its regulations, ÉPM's operating licence and the programs used to meet regulatory requirements. The inspection focused on management system, training, radiation protection, conventional health and safety, and environmental protection. None of the findings from this inspection presented an immediate or unreasonable risk to the health, safety and security of workers, Canadians or the environment.

ÉPM submitted an updated preliminary decommissioning plan and financial guarantee. CNSC staff have reviewed and accepted the preliminary decommissioning plan and are in the process of reviewing the financial guarantee.

13.8 École Polytechnique de Montréal subcritical assembly

The ÉPM subcritical assembly is also located on the campus of the Université de Montréal in Montréal, QC. It is surrounded by a corridor, a neutron activation analysis laboratory, a radiochemistry laboratory, a classroom and the building foundations. The assembly consists of natural uranium bars inserted into graphite blocks. The subcritical assembly is used only for teaching and research purposes. During periods when the assembly is inactive, the uranium bars are returned to a locked shielded storage box, and the neutron sources are stored and locked in shielded containers. Use of the subcritical assembly is very limited (approximately once every five years) and poses a very low risk.

On July 2, 2015, ÉPM requested the revocation of its non-power subcritical assembly operating licence (PERFP-9.00/2016) and the amendment of its SLOWPOKE-2 reactor operating licence (PERFP-9A.00/2023) to include the operation of the non-power subcritical assembly. This request has been processed and approved by the Commission through an abridged Commission hearing, consisting of a panel of one, held on June 30, 2016 (CMD 16-H107). The authorization to operate this low-risk subcritical assembly is now consolidated into the SLOWPOKE-2 reactor operating licence (PERFP-9A.01/2023).

Performance

For 2015, CNSC staff continued to rate the performance of the ÉPM subcritical assembly as “satisfactory” in all SCAs. The performance ratings for 2011 through 2015 are provided in table C-13, appendix C.

For this type of low-risk facility, compliance onsite inspections are normally performed once every five years and only while the facility is in operation. The facility was last operated on March 2012, at which time CNSC staff conducted an onsite inspection.

ÉPM is required to notify CNSC staff of its intention to operate the facility with sufficient advance notice, allowing adequate coordination of the inspection by CNSC staff. There have been no changes in the performance of the facility since the renewal of its licence or the integration of the facility into the SLOWPOKE-2 operating licence.

SECTION IV: CLASS IB PARTICLE ACCELERATOR FACILITIES

14 OVERVIEW

This section of the report deals with Class IB particle accelerator facilities:

- TRIUMF Accelerators Inc. in Vancouver, BC
- Canadian Light Source Inc. (CLS) in Saskatoon, SK

To provide consistent reporting across CNSC-licensed facilities, this is the first time the Class IB particle accelerator facilities are reported along with similar Class I facilities. Previously, the Class IB particle accelerator facilities were reported on in the *Regulatory Oversight Report on the Use of Nuclear Substances in Canada.*

The TRIUMF operating licence was issued by the Commission in 2012 for a 10-year duration, expiring in June 2022. The CLS operating licence was issued by the Commission in 2012 for a 10-year duration, expiring in May 2022. Figure 14-1 shows the location of Class IB particle accelerator facilities in Canada.

Figure 14-1: Location of Class IB particle accelerator facilities in Canada

CNSC staff conducted consistent and risk-informed regulatory oversight at the Class IB particle accelerator facilities in 2015. Table 14-1 presents the licensing and compliance effort from CNSC staff for these facilities during the reporting period.

Table 14-1: CNSC regulatory oversight licensing and compliance activities, Class IB particle accelerator facilities, 2015

Facility	Number of onsite inspections	Person days for compliance	Person days for licensing activities
TRIUMF Accelerators Inc.	2	209	6
Canadian Light Source Inc.	2	94	14

During the review period, CNSC staff conducted four onsite inspections at the Class IB particle accelerator facilities. Findings from these inspections were provided to the licensees in detailed inspection reports and were tracked by CNSC staff until adequately addressed by the licensee. None of these findings represented in immediate or unreasonable risk to the health, safety and security of workers, Canadians or the environment.

The Class IB particle accelerator facilities are required, as part of their operating licences, to submit an annual compliance report by March 31 each year. These reports contain facility performance information in all safety and control areas (SCAs), including details related to radiological, environmental and safety performance. CNSC staff review these reports as part of their normal regulatory compliance oversight to verify that licensees are complying with their regulatory requirements and are operating safely.

For 2015, CNSC staff ratings for all individual SCAs were either “satisfactory” or “fully satisfactory” for the Class IB particle accelerator facilities, with the exception of a “below expectations” rating for CLS in the human performance management SCA. This rating is discussed in detail in the performance section for CLS. Appendix C contains the SCA ratings from 2011 to 2015 for each facility. The 2015 performance ratings for the Class IB particle accelerator facilities are presented in table 14-2.

Table 14-2: SCA performance ratings, Class IB particle accelerator facilities, 2015

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

*This is further discussed in section 16.1.
**N/A: There are no safeguard verification activities associated with this facility.

Each facility is required to develop decommissioning plans that are then reviewed and approved by CNSC staff. Each plan is accompanied by a financial guarantee that provides the funding necessary to complete the decommissioning work. The financial guarantees for the facilities are listed in appendix D.

14.1 Radiation protection

This SCA covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations*. The program must ensure contamination levels and radiation doses received by individuals are monitored, controlled and maintained as low as reasonably achievable (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

The 2015 rating for the radiation protection SCA for all Class IB particle accelerator facility licensees was “fully satisfactory,” unchanged from the previous year.

Ratings for radiation protection SCA, Class IB particle accelerator facilities, 2015

TRIUMF	CLS
FS	FS

Application of ALARA

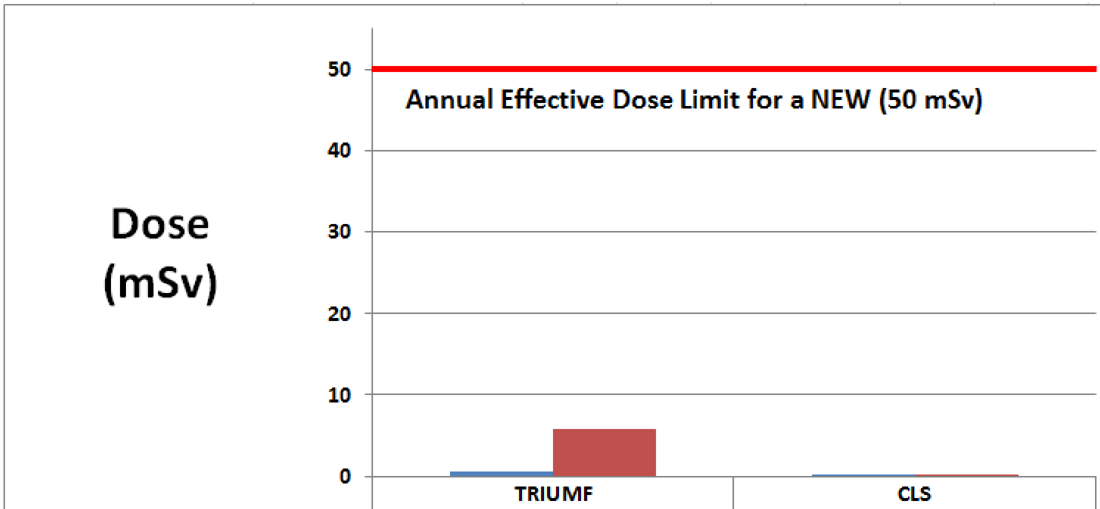
During 2015, CNSC staff determined that all Class IB particle accelerator facility licensees were very effective at implementing measures to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. The CNSC requirement to apply the ALARA principle has consistently resulted in doses to persons to be well below CNSC 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 each licensee’s radiation protection program, 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 Class IB particle accelerator facilities are provided in figure 14-2. In 2015, the maximum individual effective dose received by a NEW at all facilities ranged from 0.19 millisieverts (mSv) to 5.87 mSv, well below the regulatory dose limit of 50 mSv/year for a NEW.

Figure 14-2: Average and maximum effective doses to nuclear energy workers, Class IB particle accelerator facilities, 2015



	TRIUMF	CLS
Average effective dose (mSv)	0.49	0.01
Maximum effective dose (mSv)	5.87	0.19

During 2015, all Class IB particle accelerator facility licensees monitored and controlled the radiation exposures and doses received by all persons present at their licensed facilities, including workers, contractors and visitors. Radiological hazards in the Class IB particle accelerator facilities vary due to the complex and differing work environments. Therefore, direct comparison of doses to NEWs among the facilities does not necessarily provide an appropriate measure of how effective the licensees are in implementing their radiation protection programs.

Radiation protection program performance

CNSC staff conducted regulatory oversight activities at all Class IB particle accelerator facility licensees during 2015 to verify compliance of the licensees' radiation protection programs 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 Class IB particle accelerator facilities have effectively implemented their radiation protection programs to control occupational exposures to workers.

Action levels for radiological exposures are established as part of the licensees' radiation protection programs. Licensees are responsible for identifying the parameters of their program that represent timely indicators of potential losses of control of the program. For this reason, action levels are licensee-specific and may change over time depending on operational and radiological conditions. If an action level is reached, it triggers the licensee to establish the cause, notify the CNSC and, if applicable, 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 the emergence of 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 how the licensee responds and identifies corrective actions to enhance program performance and prevent reoccurrence. There was one action level exceedance at TRIUMF reported to the CNSC in 2015. The exceedance was investigated and corrective actions were established to the satisfaction of CNSC staff.

Radiological hazard control

All Class IB particle accelerator facility licensees continued to implement adequate measures to monitor and control radiological hazards in their facilities, including the delineation of zones for contamination control purposes. All Class IB particle accelerator facility licensees continued to implement their workplace monitoring programs to protect workers and have demonstrated that, in 2015, levels of radioactive contamination were controlled within their facilities.

Estimated dose to the public

The maximum dose to the public from licensed activities for TRIUMF is calculated using monitoring results from air emissions and liquid effluent releases. There are no airborne or effluent releases from CLS. The CNSC's requirements to apply ALARA principles ensure that licensees monitor their facilities and take corrective actions whenever action levels are exceeded.

Estimated doses to the public from all Class IB accelerator facility licensees continued to be low and well below the regulatory annual public dose limit of 1 mSv/year.

CNSC staff concluded that the Class IB particle accelerator facility licensees effectively implemented and maintained their radiation protection programs during 2015 to ensure the health and safety of persons working in their facilities.

14.2 Environmental protection

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

It encompasses the following specific areas:

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

The 2015 rating for the environmental protection SCA was “satisfactory” for TRIUMF and “fully satisfactory” for CLS, both of which are unchanged from the previous year.

Ratings for environmental protection SCA, Class IB particle accelerator facilities, 2015

TRIUMF	CLS
SA	FS

To control the release of radioactive and hazardous substances into the environment, 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 suitably trained and qualified staff to effectively develop, implement and maintain their environmental protection programs.

The Class IB particle accelerator facility licensees implemented their environmental programs satisfactorily during 2015, and their programs are effective in protecting the health and safety of persons working in their facilities. There were no exceedances of licence limits for any Class IB particle accelerator facility in 2015.

14.3 Conventional health and safety

This 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

The rating for the conventional health and safety SCA for all Class IB particle accelerator facility licensees in 2015 was “satisfactory,” unchanged from the previous year.

Ratings for conventional health and safety SCA, Class IB particle accelerator facilities, 2015

TRIUMF	CLS
SA	SA

The regulation of conventional health and safety at Class IB particle accelerator facilities involves both Employment and Social Development Canada (ESDC) and the CNSC. CNSC staff monitor compliance with CNSC regulatory reporting requirements. When a concern is identified, ESDC staff are consulted and asked to take appropriate action. The 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*. These reports include serious illnesses or injuries incurred or possibly incurred as a result of licensed activity. The number of recordable lost-time injuries (LTIs) reported by all facilities has remained low over the past five years.

Table 14-3 summarizes the number of LTIs reported by Class IB particle accelerator facilities from 2011 to 2015. Further information is provided in facility-specific sections as well as appendix G.

Table 14-3: Lost-time injuries, Class IB particle accelerator facilities, 2011–15

Facility	2011	2012	2013	2014	2015
TRIUMF	4	4	3	0	4
CLS	1	2	2	0	1

The Class IB particle accelerator facility licensees implemented their conventional health and safety programs satisfactorily during 2015, and their programs are effective in protecting the health and safety of persons working in their facilities.

14.4 Public information and disclosure programs

Class IB particle accelerator facility licensees have a responsibility to inform the public about their nuclear facilities and activities. CNSC staff recognize that Class IB particle accelerators are low-risk facilities and that a full-scale public information program, as undertaken by larger nuclear facilities, is not warranted. However, the CNSC requires these licensees to provide open and transparent information to the public, and to transition to the requirements of regulatory document RD/GD-99.3, *Public Information and Disclosure*. Doing so will ensure timely information about the health, safety and security of persons and the environment and other issues associated with the nuclear facility are effectively communicated.

CLS and TRIUMF are currently transitioning from guidance document G-217, *Public Information Programs*, to RD/GD-99.3. In 2015, both licensees upheld the spirit and intent of RD/GD-99.3 by providing ongoing information about their nuclear activities through informative website content, videos, social media updates, facility tours and participation in community events.

The Class IB particle accelerator facility licensees implemented their public information and disclosure programs satisfactorily during 2015, and their programs are effective at communicating information about the health, safety and security of persons and the environment and other issues associated with their facilities.

15 TRIUMF ACCELERATORS INC.

TRIUMF Accelerators Inc. is Canada’s national laboratory for nuclear and particle physics research and related sciences. It is also a major producer of radioisotopes used for medical diagnostic procedures. Located on the University of British Columbia campus in Vancouver, BC, TRIUMF is owned and operated as a joint venture by a consortium of 18 Canadian universities. An aerial view of the TRIUMF site is shown in figure 15-1. TRIUMF operates one 520 megaelectronvolt (MeV) cyclotron accelerator facility, shown in figure 15-2, as well as four smaller cyclotrons facilities and three linear accelerator facilities. The MeV cyclotron accelerator has been in operation for over 40 years.

Figure 15-1: Aerial view of the TRIUMF site

Figure 15-2: Inside view of the TRIUMF 520 MeV cyclotron

In 2015, there were no licence amendments or changes to the TRIUMF licence conditions handbook. TRIUMF had no changes in operations, organization or operating policies in 2015.

15.1 Performance

For 2015, CNSC staff continued to rate TRIUMF's performance as "satisfactory" in all SCAs except radiation protection, where it received a "fully satisfactory" rating. The TRIUMF performance ratings for 2011 through 2015 are provided in table C-14, appendix C.

There were two reportable events in 2015. One was for a non-NEW who incurred a dose in excess of TRIUMF's quarterly action level while carrying out work during shutdown. The other event was an accidental release from a rubidium target. TRIUMF investigated both events to determine their root causes and implemented corrective actions. CNSC staff have reviewed and accepted the corrective actions implemented by TRIUMF. There were four LTIs at the TRIUMF site in 2015.

In 2015, CNSC staff conducted two compliance onsite inspections to verify compliance with the *Nuclear Safety and Control Act* (NSCA) and its regulations, TRIUMF's operating licence and programs used to meet regulatory requirements. None of the findings made during the onsite inspection presented an immediate or unreasonable risk to the health, safety, and security of workers, Canadians or the environment.

15.2 Radiation protection

Overall compliance ratings for radiation protection SCA, TRIUMF Accelerators Inc., 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	FS	FS
For 2015, CNSC staff continued to rate the radiation protection SCA at TRIUMF as "fully satisfactory." TRIUMF continues to excel at maintaining a radiation protection program as required by the *Radiation Protection Regulations*.				

Application of ALARA

As required by the *Radiation Protection Regulations*, TRIUMF continued to implement radiation protection measures in 2015 to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors.

Worker dose control

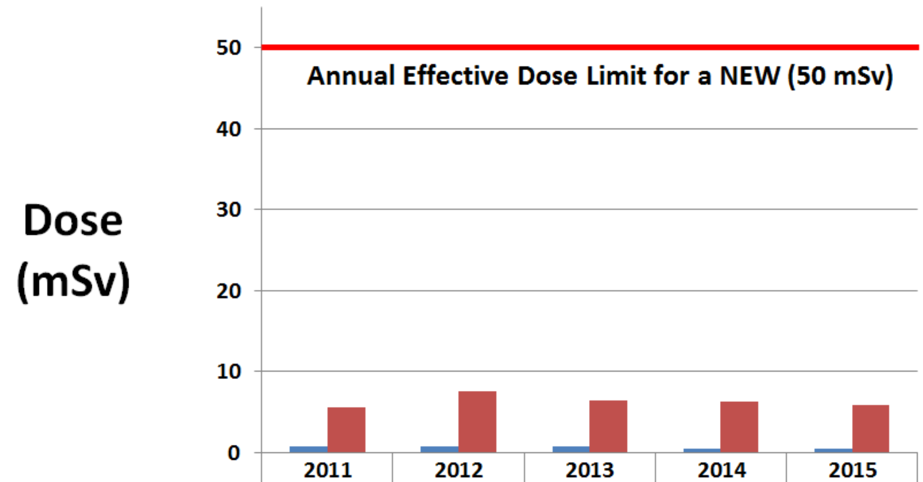
Radiation exposures are monitored to ensure compliance with the CNSC's regulatory dose limits and to maintain radiation doses ALARA. In 2015, radiation exposures at TRIUMF were well below CNSC regulatory dose limits.

TRIUMF's workers are primarily exposed externally to a wide variety of radionuclides generated by the use of the cyclotron. External whole body and equivalent doses are ascertained using dosimeters. For internal exposures, TRIUMF has specific internal monitoring protocols for workers depending on the type of research project. There were no internal doses recorded in 2015.

At TRIUMF, employees are identified as NEWs if there is a reasonable probability of receiving an occupational dose greater than 1 mSv/year. The maximum effective dose received by a NEW in 2015 was 5.87 mSv, or approximately 12 percent of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period. For the five-year dosimetry period from 2011 to 2015, the maximum individual effective dose received by a NEW at TRIUMF was 29.2 mSv, or approximately 29 percent of the regulatory effective dose limit of 100 mSv per five-year dosimetry period.

Figure 15-3 provides the average and maximum effective doses to NEWs at TRIUMF between 2011 and 2015.

Figure 15-3: Average and maximum effective doses to nuclear energy workers, TRIUMF Accelerators Inc., 2011–15



	2011	2012	2013	2014	2015
Average effective dose (mSv)	0.74	0.75	0.77	0.52	0.49
Maximum effective dose (mSv)	5.60	7.50	6.49	6.32	5.87
Number of NEWs monitored	254	259	183	275	280

Effective doses were also monitored for 1,137 non-NEWs in 2015, with a maximum effective dose of 0.67 mSv. This includes employees that do not perform radiological work as well as visitors and contractors.

Annual average and maximum equivalent dose results from 2011 to 2015 are provided in tables E-14, appendix E. The maximum equivalent extremity dose in 2015 was 27.5 mSv. Over the past five years, average equivalent extremity doses have remained relatively stable. Although equivalent skin doses are ascertained, due to the nature of exposure, they are essentially equal to the effective dose and not included in the report.

Radiation protection program performance

In accordance with regulatory requirements, action levels for radiological exposures are established as part of the TRIUMF radiation protection program. An action level, if reached, triggers TRIUMF staff to establish the cause for reaching the action level, notify the CNSC and, if applicable, restore the effectiveness of the radiation protection program. There was one action level exceedance at TRIUMF in 2015, with a non-NEW worker receiving a dose of 0.7 mSv, exceeding the quarterly action level for effective dose of 0.5 mSv. TRIUMF performed a root-cause analysis and implemented corrective and preventative actions, including clear marking on TRIUMF access cards to indicate NEW status, to avoid the potential for non-NEWs to gain access to or work on projects with higher dose potential. TRIUMF also acknowledged that the affected worker be recognized as a NEW. CNSC staff have reviewed and accepted the corrective actions implemented by TRIUMF.

Radiological hazard control

A thorough radiation dose area monitoring program has been established at TRIUMF. CNSC staff routinely verify the results of this program and compare them to those of previous years. No unusual results were detected in 2015.

Estimated dose to the public

The 2011 to 2015 maximum effective doses to a member of the public are shown in table 15-1. The main reason for the variation of these values is the annual delivered beam charge of the TRIUMF 520 MeV cyclotron. Reduced cyclotron operations during 2011 and 2012 resulted in lower dose values to the public. Normal operation of the cyclotron resumed in 2013. During the last five years, the public dose to a member of the public was well below the CNSC regulatory dose limit for a member of the public of 1 mSv/year.

Table 15-1: Maximum effective dose to a member of the public, TRIUMF Accelerators Inc., 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Maximum effective dose (mSv)	0.003	0.005	0.012	0.016	0.011	**1 mSv/year**

15.3 Environmental protection

Overall compliance ratings for environmental protection SCA, TRIUMF Accelerators Inc., 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA

For 2015, CNSC staff continued to rate the environmental protection SCA at TRIUMF as “satisfactory.”

Radiological releases from the TRIUMF facility to the environmental continue to be effectively controlled and monitored to comply with the conditions of its operating licence and regulatory requirements. All releases to the environment were well below regulatory limits during 2015. There were no releases of hazardous (non-radiological) substances to the environment in 2015. Environmental monitoring of water, vegetation and gamma/beta radiation at the site boundary indicates that the public and the environment continue to be protected from facility releases.

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

Atmospheric emissions

TRIUMF monitors airborne radiological releases of beta plus (β^+) emitters, noble gases, and volatile and particulate matter from its facility. In 2015, the total releases of all airborne effluents from the TRIUMF facility represented a combined total of 0.94 percent of the derived release limit (DRL). TRIUMF's airborne emissions from 2011 to 2015 are provided in table F-18, appendix F. The annual airborne emissions remained well below the DRLs for the TRIUMF facility. The results demonstrate that the air emissions are being controlled effectively at the TRIUMF facility. No action levels were exceeded at any time in 2015.

Liquid effluent

TRIUMF monitors radiological liquid effluent releases to the sanitary sewer via the various holding tanks and sumps from the TRIUMF facility. In 2015, the total release of liquid effluents represent a combined total of 0.000000381 percent of the DRL. TRIUMF's liquid effluent releases from 2011 to 2015 are provided in table F-19, appendix F. The liquid effluent releases remained well below the DRLs for the TRIUMF facility. The results demonstrate that the liquid effluent releases are being controlled effectively at the TRIUMF facility. No action levels were exceeded at any time in 2015.

Environmental management system

TRIUMF has developed and maintains an environmental management system (EMS) that provides a framework for integrated activities with respect to the protection of the environment at the TRIUMF facility. The TRIUMF EMS includes activities such as establishing annual environmental objectives and targets, and conducting internal audits and an annual management review. In 2015, CNSC staff conducted an onsite inspection of the TRIUMF facility that focused specifically on environmental protection. It was identified that some EMS elements, such as the internal audits and annual management review, had not been implemented at the TRIUMF facility. CNSC staff continue to monitor TRIUMF's implementation of corrective actions to address the inspection findings.

Assessment and monitoring

TRIUMF's environmental monitoring program serves to demonstrate that emissions of nuclear materials from its facility are properly controlled. The principal monitoring activities are focused on monitoring storm sewer water, radio-assays of building drains and vegetation samples, and gamma/beta measurements at the site boundary. Due to the low levels of emissions from the TRIUMF facility, very little is detected in the environmental monitoring program.

Water monitoring

TRIUMF conducts periodic sampling of building drains and storm sewer water. Radio-assays of building drains were completed in July 2015 and only natural background radioactive isotopes were detected. Storm sewer water was sampled in March and November 2015 at two locations (one upstream and one downstream of the TRIUMF site) and only natural background radioactive isotopes were detected.

Vegetation monitoring

TRIUMF conducts vegetation sampling at 11 locations twice per year. The only radionuclide detected that may be attributed to TRIUMF's operations was beryllium-7, but its concentration was at such a low level that it may be due to cosmic radiation. Cesium-137 (Cs-137) was also detected at low levels in some vegetation samples beyond the TRIUMF site perimeter. This is very likely attributable to residual levels from the Fukushima nuclear incident in Japan due to a consistent reduction of Cs-137 concentrations over time.

Gamma/beta monitoring

TRIUMF conducts gamma/beta dose monitoring at nine locations along the facility's security fence. The gamma/beta radiation effective dose rates are measured using Landauer environmental dosimeters. In 2015, the highest six-month average of fenceline gamma/beta measurements at the TRIUMF site was 0.11 microsieverts (µSv) per hour above background on the east side of the site. As there are no human receptors in close proximity to the TRIUMF site, fenceline gamma/beta radiation is not a contributor to the dose to the public.

Protection of the public

TRIUMF must demonstrate that the health and safety of the public are protected from exposures to hazardous substances released from its facility. There were no releases of hazardous (non-radiological) substances to the environment in 2015 from the TRIUMF facility that would pose a risk to the public or environment

Based on their reviews of the programs at the TRIUMF, CNSC staff concluded that the public continues to be protected from facility emissions.

Environmental risk assessment

Following a recent compliance onsite inspection, CNSC staff requested TRIUMF to conduct a screening-level environmental risk assessment (ERA) in accordance with CSA Group standard N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills*. ERAs provide the basis for the scope and complexity of the monitoring programs covered by CSA Group standards N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills*, and N288.5-11 *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills*. This ERA was requested by CNSC staff to ensure TRIUMF's existing programs adequately account for the 2012, 2015 and 2016 updates to the requirements contained in these standards. TRIUMF submitted an initial plan for its ERA on June 30, 2016, with a completion date of December 2016. CNSC staff will monitor the plan progress to ensure TRIUMF adequately addresses the compliance requirements of the CSA Group standards.

15.4 Conventional health and safety

Overall compliance ratings for conventional health and safety SCA, TRIUMF Accelerators Inc., 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA
For 2015, CNSC staff continued to rate the conventional health and safety SCA at TRIUMF as "satisfactory." TRIUMF has implemented and maintained a conventional health and safety program as required by the NSCA and Part II of the *Canada Labour Code*.				

Performance

TRIUMF uses a variety of key performance indicators (KPIs) to measure the effectiveness of its conventional health and safety program. Among these KPIs, CNSC staff review the number of LTIs that occur per year and their severity. An LTI is an injury that takes place at work and results in the worker being unable to return to work for their scheduled shift or carry out their regular duties for a period of time.

As shown in table 15-2, four LTIs were reported by TRIUMF in 2015. This is well below the average for the WorkSafeBC[1] category, which includes TRIUMF. Details on the LTIs are provided in table G-4, appendix G.

[1] WorkSafeBC is dedicated to promote workplace health and safety for the workers and employers of the province of British Columbia. WorkSafeBC consults with and educates employers and workers, and enforces the provincial *Occupational Health and Safety Regulation*.

Table 15-2: Lost-time injuries, TRIUMF Accelerators Inc., 2011–15

	2011	2012	2013	2014	2015
Lost-time injuries	4	4	3	0	4

Practices

TRIUMF's activities and operations must comply with not only the NSCA and its associated regulations but also Part II of the *Canada Labour Code* and British Columbia's *Occupational Health and Safety Regulation* (OHSR).

In 2015, TRIUMF revised its safety note on personal protective equipment to align with Part 8 of the OHSR as well as its safety note on its work permit system, which included revised training for workers.

TRIUMF continued to dialogue with WorkSafeBC about the improvements implemented on access control systems for exclusion areas. WorkSafeBC specialists visited TRIUMF and additional information was provided on these access control systems. TRIUMF and WorkSafeBC expect to converge in 2016 on any additional approvals that may be required for the access control systems.

Awareness

TRIUMF continues to develop and maintain a comprehensive occupational health and safety management program. In 2015, TRIUMF advanced some initiatives to improve occupational health and safety, such as improvements to the work permit system and the revision of all safety-related signage to align with the International Organization for Standardization (ISO) 7010 standard. CNSC staff will continue to monitor the effectiveness of the improvement initiatives through regular onsite inspections.

16 CANADIAN LIGHT SOURCE INC.

Canadian Light Source Inc. (CLS) operates a synchrotron facility on the University of Saskatchewan campus in Saskatoon, SK. Figure 16-1 shows an aerial view of the CLS facility.

Figure 16-1: Aerial view of Canadian Light Source Inc. facility

The facility consists of three major accelerator systems: a 300 MeV linear accelerator, a booster ring that accelerates electrons up to 2.9 gigaelectronvolts (GeV) and a storage ring that keeps electrons circulating at this energy for several hours. Figure 16-2 shows an inside look of the CLS facility.

The CLS facility produces synchrotron radiation that is used as a light source for experiments in diverse fields such as biology, materials research, atomic and molecular science, earth sciences, pharmaceuticals, biomedical research and electronics. Synchrotron radiation is electromagnetic radiation produced by magnetic bending of high-energy electrons in a storage ring by different devices (magnets, wigglers and undulators). The light ranges from infrared through the visible spectrum to ultraviolet and X-rays. The experiments take place in optical beam lines tangential to the storage ring. The facility has been in operation since 2005.

Figure 16-2: Inside view of the Canadian Light Source Inc. facility

There was one licence amendment in 2015. Further information is provided in table I-1, appendix I.

16.1 Performance

For 2015, CNSC staff rated CLS' performance as "satisfactory" or better in all SCAs except for the human performance management SCA, where it received a "below expectations" rating. This rating was based on an onsite inspection in May 2015 that found that there had been no progress on the implementation of a training system based on the systematic approach to training (SAT). Per the requirements of REGDOC-2.2.2, *Personnel Training*, licenses are required to conduct an analysis to identify all performance requirements of a job or duty area related to licensed activities. During their inspection, CNSC staff noted that CLS had not performed the required analysis and its training system was not adequately reflected in an overarching training system manual with supporting procedures. In April 2016, CLS submitted a status update to the CNSC, including updated programs that addressed the non-compliances. CNSC staff reviewed and accepted the updated programs, which demonstrated significant progress in addressing this issue. CNSC staff will verify the implementation of the SAT through an onsite inspection scheduled for the fourth quarter of 2016 and will inform the Commission of the results in the 2016 edition of this report.

The CLS performance ratings for 2011 through 2015 are provided in table C-15, appendix C. CLS had no changes in its operations, organization or operating policies in 2015.

There were no reportable action level exceedances in 2015. One LTI was reported in 2015.

In 2015, CNSC staff conducted two onsite inspections of the CLS facility to verify compliance with the NSCA and its regulations, CLS' operating licence and programs used to meet regulatory requirements. None of the findings made during the inspection presented an immediate or unreasonable risk to the health, safety, and security of workers, Canadians or the environment.

16.2 Radiation protection

Overall compliance ratings for radiation protection SCA, Canadian Light Source Inc., 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	FS	FS
For 2015, CNSC staff rated the radiation protection SCA at CLS as "fully satisfactory." CLS continues to implement and maintain a radiation protection program as required by the *Radiation Protection Regulations*.				

Application of ALARA

As required by the *Radiation Protection Regulations*, CLS continued to implement radiation protection measures in 2015 to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. CLS planned a number of ALARA initiatives in 2014, including the addition of local shielding to reduce gamma and neutron exposures, which were then implemented in 2015.

Worker dose control

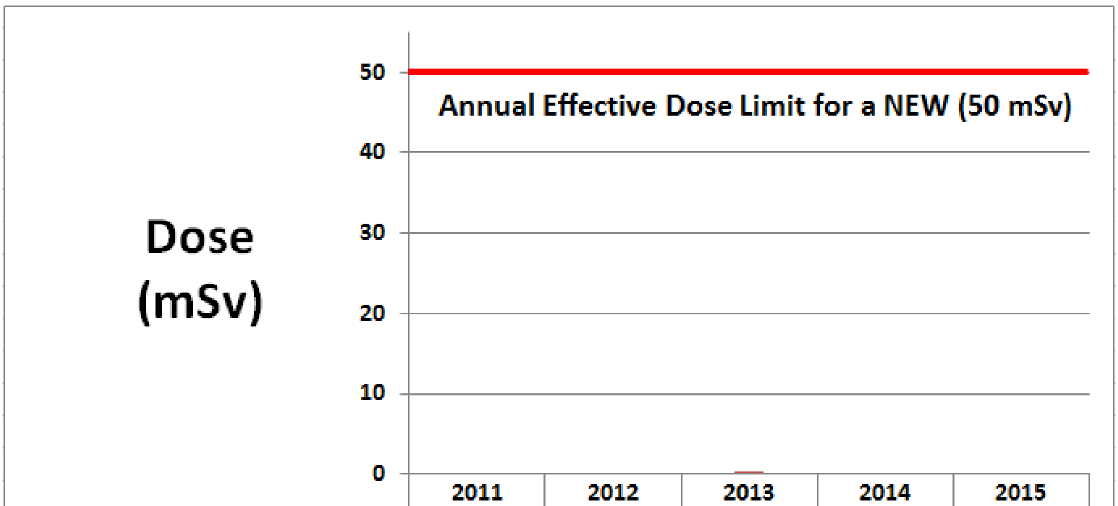
Radiation exposures are monitored to ensure compliance with the CNSC's regulatory dose limits and to maintain radiation doses ALARA. In 2015, radiation exposures at CLS were well below CNSC regulatory dose limits.

CLS workers are exposed externally to activation products associated with the use of the beam line. External whole body doses are ascertained using dosimeters. At CLS, employees are identified as either NEWs or non-NEWs.

The maximum effective dose received by a NEW in 2015 was 0.19 mSv, or approximately 0.4 percent of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period. For the five-year dosimetry period from 2011 to 2015, the maximum individual effective dose received by a NEW at CLS was 0.53 mSv, or approximately 0.53 percent of the regulatory dose limit of 100 mSv per five-year dosimetry period.

Figure 16-3 provides the average and maximum effective doses to NEWs at CLS between 2011 and 2015.

Figure 16-3: Average and maximum effective doses to nuclear energy workers, Canadian Light Source Inc., 2011–15



	2011	2012	2013	2014	2015
Average effective dose (mSv)	0.01	0.04	0.06	0.01	0.01
Maximum effective dose (mSv)	0.08	0.23	0.31	0.14	0.19
Number of NEWs monitored	155	152	151	154	165

Effective doses were also monitored for 113 non-NEW employees in 2015, with a maximum effective dose of 0.08 mSv. There were also 649 visiting users monitored in 2015, with a maximum dose 0.04 mSv, as well as 82 monitored contractors, with a maximum dose of 0.06 mSv. All were identified as non-NEWs and subject to the dose limit of 1 mSv/year.

Due to the nature of the work performed at CLS, equivalent extremity doses are not ascertained. Although equivalent skin doses are ascertained, due to the nature of exposure, they are essentially equal to the effective dose and not included in this report.

Radiation protection program performance

Action levels for radiological exposures are established as part of the CLS radiation protection program. An action level, if reached, triggers CLS staff to establish the cause for reaching the action level, notify the CNSC and, if applicable, restore the effectiveness of the program. In 2015, there were no action level exceedances at CLS.

Radiological hazard control

A thorough radiation dose area monitoring program has been established at CLS. Results are verified routinely and compared to those of previous years. No unusual results were detected in 2015. In addition, routine surface contamination measurements (swipes) are made at various locations. In 2015, there were no swipes that measured above background.

Estimated dose to the public

There are no airborne or liquid effluent releases of radioactive materials or hazardous substances from CLS. In addition, CLS monitors the environmental radiation levels outside its main building; in 2015, these levels were at ambient background radiation levels. Therefore, the estimated dose to the public is at natural radiation background levels.

16.3 Environmental protection

Overall compliance ratings for environmental protection SCA, Canadian Light Source Inc., 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	FS	FS
For 2015, CNSC staff rated the environmental protection SCA at CLS as “fully satisfactory.” CLS runs an accelerator that does not produce any emissions. As there are no releases to the environment, there are no data to present in this section.				

16.4 Conventional health and safety

Overall compliance ratings for conventional health and safety SCA, Canadian Light Source Inc., 2011–15

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA
For 2015, CNSC staff continued to rate the conventional health and safety SCA at CLS as “satisfactory.” CLS has implemented and maintained a conventional health and safety program as required by the NSCA and Part II of the *Canada Labour Code*.				

Performance

CLS uses a variety of KPIs to measure the effectiveness of its conventional health and safety program. Among these KPIs, CNSC staff review the number of LTIs that occur per year and their severity. An LTI is an injury that takes place at work and results in the worker being unable to return to work for their scheduled shift or carry out their regular duties for a period of time.

As indicated in table 16-1, CLS reported one LTI in 2015. Details on the LTI are provided in table G-5, appendix G.

Table 16-1 Lost-time injuries, Canadian Light Source Inc., 2011–15

	2011	2012	2013	2014	2015
Lost-time injuries	1	2	2	0	1

Practices

CLS' activities and operations must comply with not only the NSCA and its associated regulations but also Part II of the *Canada Labour Code*.

The CLS Occupational Health and Safety Committee inspects the facility as required by the *Canada Occupational Health and Safety Regulations*. These inspections serve to identify health and safety hazards as well as the controls to mitigate those hazards. CLS has reduced the number of items on its inspection list. In December 2014, there were 18 items requiring attention on the inspection list; this number was reduced to four prior the December 2015 inspection.

An independent external review of the CLS occupational health and safety program was completed in April 2015, which involved safety professionals from TRIUMF, the Louisiana State University Center for Advanced Microstructures and Devices, and the Australian Synchrotron. The review found that CLS runs a safe operation and has a strong commitment to safety. A number of recommendations from the review have been or are being implemented.

Awareness

CLS continues to develop and maintain a comprehensive occupational health and safety management program. CLS is already implementing a number of the recommendations from the independent external review of April 2015. CNSC staff will continue to monitor the effectiveness of the improvement initiatives through regular onsite inspections.

17 OVERALL CONCLUSIONS

This report summarizes the Canadian Nuclear Safety Commission (CNSC) staff assessment on the performance of uranium and nuclear substance processing facilities, small nuclear research reactor facilities and Class IB particle accelerator facilities in 2015. CNSC staff concluded that these facilities operated safely during 2015. 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 follow-up and general communication with the licensees.

For 2015, the performance in all 14 safety and control areas (SCAs) for the facilities are as follows:

- Uranium processing facilities were rated as “satisfactory” or better.
- Nuclear substance processing facilities were rated as “satisfactory” or better with the exception of Best Theratronics Ltd., which received a “below expectations” rating in the emergency management and fire protection SCA.
- Small nuclear research reactor facilities were rated as “satisfactory” or better.
- Class IB particle accelerator facilities were rated as “satisfactory” or better with the exception of Canadian Light Source Inc., which received a “below expectations” rating in the human performance management SCA.

CNSC staff’s compliance activities confirmed that:

- radiation protection programs at all facilities adequately controlled radiation exposures, keeping doses as low as reasonably achievable
- environmental protection programs at all facilities were effective in protecting the environment
- conventional health and safety programs at all facilities continue to protect workers

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

APPENDIX 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), which are grouped according to their functional areas of management, facility and equipment, and core control processes. These SCAs are further divided into specific areas that define the key components of the SCA. The following table shows the CNSC's 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 ▪ 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 as well as other activities that enable effective performance.	▪ conduct of licensed activity ▪ procedures ▪ reporting and trending ▪ outage management performance ▪ safe operating envelope ▪ severe accident management and recovery ▪ accident management and recovery

Functional area	Safety and control area	Definition	Specific areas
Facility and equipment	Safety analysis	Covers maintenance of the safety analysis that supports the overall safety case for a facility. Safety analysis involves 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, taking into account new information as it arises and changes in the external environment.	▪ 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. 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*. This program must ensure that contamination levels and radiation doses received by individuals are monitored, controlled and maintained as low as reasonably achievable (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
	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

Functional area	Safety and control area	Definition	Specific areas
	Emergency management and fire protection	Covers emergency plans and emergency preparedness programs that exist for emergencies and for non-routine conditions (including 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. 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, 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 to successfully implement the obligations arising from the Canada's safeguards agreement with the International Atomic Energy Agency (IAEA) 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	Covers the programs that relate to the safe packaging and transport of nuclear substances to and from the licensed facility.	▪ package design and maintenance ▪ packaging and transport ▪ registration for use

Other matters of regulatory interest

- environmental assessment
- CNSC consultation (Aboriginal)
- CNSC consultation (other)
- cost recovery
- financial guarantees
- improvement plans and significant future activities
- licensee public information program
- nuclear liability insurance

APPENDIX B: PERFORMANCE RATING 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.

APPENDIX C: SAFETY AND CONTROL AREA RATINGS

Table C-1: Safety and control area ratings, Blind River Refinery, 2011–15

Safety and control areas	2011 rating	2012 rating	2013 rating	2014 rating	2015 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	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

Table C-2: Safety and control area ratings, Port Hope Conversion Facility, 2011–15

Safety and control areas	2011 rating	2012 rating	2013 rating	2014 rating	2015 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

Table C-3: Safety and control area ratings, Cameco Fuel Manufacturing Inc., 2011–15

Safety and control areas	2011 rating	2012 rating	2013 rating	2014 rating	2015 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

Table C-4: Safety and control area ratings, GEH-C Toronto and Peterborough facilities, 2011–15

Safety and control areas	2011 rating	2012 rating	2013 rating	2014 rating	2015 rating
Management system	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA	SA
Conventional health and safety	FS	SA	SA	SA	SA
Environmental protection	FS	FS	FS	FS	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

Table C-5: Safety and control area ratings, SRB Technologies (Canada) Inc., 2011–15

Safety and control areas	2011 rating	2012 rating	2013 rating	2014 rating	2015 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	FS	FS
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	NA	NA	NA	NA	NA
Packaging and transport	SA	SA	SA	SA	SA

NA: There are no safeguard verification activities associated with this facility.

Table C-6: Safety and control area ratings, Nordion (Canada) Inc., 2011–15

Safety and control areas	2011 rating	2012 rating	2013 rating	2014 rating	2015 rating
Management system	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA	SA
Conventional health and safety	FS	FS	FS	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	SA	FS	FS	FS	FS
Safeguards and non-proliferation	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA

Table C-7 Safety and control area ratings, Best Theratronics Ltd., 2014–15

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

Table C-8: Safety and control area ratings, McMaster Nuclear Reactor, 2011–15

Safety and control areas	2011 rating	2012 rating	2013 rating	2014 rating	2015 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	FS	FS	FS	FS	FS
Safeguards and non-proliferation	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA

Table C-9: Safety and control area ratings, University of Alberta SLOWPOKE-2 facility, 2011–15

Safety and control areas	2011 rating	2012 rating	2013 rating	2014 rating	2015 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

Table C-10: Safety and control area ratings, Saskatchewan Research Council SLOWPOKE-2 facility, 2011–15

Safety and control areas	2011 rating	2012 rating	2013 rating	2014 rating	2015 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

Table C-11: Safety and control area ratings, Royal Military College of Canada SLOWPOKE-2 facility, 2011–15

Safety and control areas	2011 rating	2012 rating	2013 rating	2014 rating	2015 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

Table C-12: Safety and control area ratings, École Polytechnique de Montréal SLOWPOKE-2 facility, 2011–15

Safety and control areas	2011 rating	2012 rating	2013 rating	2014 rating	2015 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

Table C-13: Safety and control area ratings, École Polytechnique de Montréal subcritical assembly, 2011–15

Safety and control areas	2011 rating	2012 rating	2013 rating	2014 rating	2015 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

Table C-14: Safety and control area ratings, TRIUMF Accelerators Inc., 2011–15

Safety and control areas	2011 rating	2012 rating	2013 rating	2014 rating	2015 rating
Management system	SA	SA	SA	BE	SA
Human performance management	SA	SA	SA	BE	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	BE	SA	SA
Radiation protection	SA	SA	SA	FS	FS
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	BE	SA	SA	SA	SA
Security	SA	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	FS	FS
Packaging and transport	SA	SA	SA	SA	SA

Table C-15: Safety and control area ratings, Canadian Light Source Inc., 2011–15

Safety and control areas	2011 rating	2012 rating	2013 rating	2014 rating	2015 rating
Management system	SA	SA	BE	SA	SA
Human performance management	SA	SA	BE	SA	BE
Operating performance	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	FS	FS
Physical design	SA	SA	SA	FS	FS
Fitness for service	SA	SA	SA	FS	FS
Radiation protection	SA	SA	SA	FS	FS
Conventional health and safety	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	FS	FS
Emergency management and fire protection	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	FS	FS
Security	SA	SA	SA	FS	FS
Safeguards and non-proliferation	NA	NA	NA	NA	NA
Packaging and transport	SA	SA	SA	FS	FS

NA: There are no safeguard verification activities associated with this facility.

APPENDIX D: FINANCIAL GUARANTEES

The following tables outline the current financial guarantees for the uranium processing, nuclear substance processing, small nuclear research reactor and Class IB particle accelerator facilities in Canada.

Table D-1: Financial guarantees, uranium processing facilities

Facility	Canadian dollar amount
Blind River Refinery	$38,600,000
Port Hope Conversion Facility	$101,700,000[1]
Cameco Fuel Manufacturing Inc.	$19,500,000
GEH-C Peterborough	$3,027,000
GEH-C Toronto	$30,052,000

1. A revised amount will be recommended to the Commission at PHCF’s licence renewal hearing.

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.	$4,005,963

Table D-3: Financial guarantees, small nuclear research reactor facilities

Facility	Canadian dollar amount
McMaster University	$10,800,000
University of Alberta	$5,750,000
Saskatchewan Research Council	$8,700,000
Royal Military College of Canada	NA[1]
École Polytechnique de Montréal	$2,800,000[2]

1. The RMCC SLOWPOKE-2 facility is owned by the Department of National Defence (DND) and is therefore the property of the Crown. The costs associated with the future decommissioning of this facility will be paid by DND.
2. Under review.

Table D-4: Financial guarantees, Class IB particle accelerator facilities

Facility	Canadian dollar amount
TRIUMF Accelerators Inc.	$10,800,000
Canadian Light Source Inc.	$7,500,300

APPENDIX E: WORKER DOSE DATA

Effective doses – SLOWPOKE-2 facilities

The following tables show the maximum and average effective doses for the SLOWPOKE-2 facilities from 2011 to 2015.

Table E-1: Effective dose statistics for non-nuclear energy workers, Saskatchewan Research Council, 2011–15

Dose statistics	2011	2012	2013	2014	2015	Regulatory limit
Number of non-nuclear energy workers monitored	14	13	19	16	23	**NA**
Average effective dose (mSv)	0.013	0	0	0.01	0.01	**NA**
Maximum individual effective dose (mSv)	0.14	0	0	0.11	0.16	**1 mSv**

Table E-2: Effective dose statistics for nuclear energy workers, Royal Military College of Canada, 2011–15

Dose statistics	2011	2012	2013	2014	2015	Regulatory limit
Number of nuclear energy workers monitored	11	10	13	13	13	**NA**
Average effective dose (mSv)	0.09	0	0	0.032	0.02	**NA**
Maximum individual effective dose (mSv)	0.63	0	0	0.42	0.29	**50 mSv**

Table E-3: Effective dose statistics for non-nuclear energy workers, Royal Military College of Canada, 2011–15

Dose statistics	2011	2012	2013	2014	2015	Regulatory limit
Number of non-nuclear energy workers monitored	10	16	14	10	13	**NA**
Average effective dose (mSv)	0	0	0	0.01	0	**NA**
Maximum individual effective dose (mSv)	0	0	0	0.11	0	**1 mSv**

Table E-4: Effective dose statistics for nuclear energy workers, University of Alberta, 2011–15

Dose statistics	2011	2012	2013	2014	2015	Regulatory dose limit
Number of nuclear energy workers monitored	2	3	3	2	2	**NA**
Average effective dose (mSv)	0.24	0.04	0	0	0	**NA**
Maximum individual effective dose (mSv)	0.48	0.13	0	0	0	**50 mSv**

Table E-5: Effective dose statistics for non-nuclear energy workers, École Polytechnique de Montréal, 2011–15

Dose statistics	2011	2012	2013	2014	2015	Regulatory dose limit
Number of non-nuclear energy workers monitored	5	5	5	5	5	**NA**
Average effective dose (mSv)	0.08	0.03	0	0	0	**NA**
Maximum individual effective dose (mSv)	0.24	0.14	0	0	0	**1 mSv**

Table E-6: Effective dose for non-nuclear energy workers, École Polytechnique de Montréal, 2011–15

Dose statistics	2011	2012	2013	2014	2015	Regulatory dose limit
Number of non-nuclear energy workers monitored	NA*	1	NA*	NA*	NA*	**NA**
Average effective dose (mSv)	0	0	0	0	0	**NA**
Maximum individual effective dose (mSv)	0*	0	0*	0*	0*	**1 mSv/year**

* Not in operation.

Extremity doses – uranium processing facilities

Table E-7: Equivalent (extremity) dose statistics for nuclear energy workers, Blind River Refinery, 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Average extremity dose (mSv)	10.2	11.4	14.1	5.4	1.5	**NA**
Maximum individual extremity dose (mSv)	49.0	47.6	35.1	48.2	15.3	**500 mSv/year**

Table E-8: Equivalent (extremity) dose statistics for nuclear energy workers, Cameco Fuel Manufacturing Inc., 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Average extremity dose (mSv)	23.4	16.5	14.3	15.5	15.5	**NA**
Maximum individual extremity dose (mSv)	111.3	107.5	87.6	88.4	87.0	**500 mSv/year**

Table E-9: Equivalent (extremity) dose statistics for nuclear energy workers, GEH-C Peterborough facility, 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Average extremity dose (mSv)	9.36	11.56	10.47	18.64	12.61	**NA**
Maximum individual extremity dose (mSv)	56.12	58.82	76.03	98.98	39.34	**500 mSv/year**

Table E-10: Equivalent (extremity) dose statistics for nuclear energy workers, GEH-C Toronto facility, 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Average extremity dose (mSv)	40.02	46.41	32.92	31.96	30.30	**NA**
Maximum individual extremity dose (mSv)	160.64	357.29	143.59	102.44	109.62	**500 mSv/year**

Extremity doses – nuclear substance processing facilities

Table E-11: Equivalent (extremity) dose statistics for nuclear energy workers, Nordion (Canada) Inc., 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Average extremity dose (mSv)	0.71	0.54	0.54	0.73	0.46	**NA**
Maximum individual extremity dose (mSv)	12.3	10.3	7.4	9.5	9.3	**500 mSv/year**

*Only the workers who routine work in the active area are monitored for extremity dose at Nordion.

Table E-12: Equivalent (extremity) dose statistics for nuclear energy workers, Best Theratronics Ltd., 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Average extremity dose (mSv)	0.19	0.23	0.36	0.37	0.17	**NA**
Maximum individual extremity dose (mSv)	0.9	2.9	6.1	3.7	2.1	**500 mSv/year**

Extremity doses – small nuclear research reactor facilities

Table E-13: Equivalent (extremity) dose statistics for nuclear energy workers, McMaster Nuclear Reactor, 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Average equivalent dose (mSv)	14.6	8.1	5.9	5.9	6.2	**NA**
Maximum individual equivalent dose (mSv)	190*	35.3	22.5	27.3	36.4	**500 mSv/year**

* The 2011 maximum extremity dose resulted from an event where a worker had a finger laceration with contamination due to an operation activity. This resulted in two action level exceedances and an early notification report was presented to the Commission in September 2011. CNSC staff determined that appropriate corrective actions were taken to prevent a recurrence.

Extremity doses – Class IB particle accelerator facilities

Table E-14: Equivalent (extremity) dose statistics for nuclear energy workers, TRIUMF Accelerators Inc., 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Average equivalent dose (mSv)	6.52	6.6	6.03	4.42	5.00	**NA**
Maximum individual equivalent dose (mSv)	69.2	59.8	52.2	46.2	27.5	**500 mSv/year**

Skin doses – uranium processing facilities

Table E-15: Equivalent (skin) dose statistics for nuclear energy workers, Blind River Refinery, 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Average skin dose (mSv)	5.5	6.0	6.8	5.4	4.0	**NA**
Maximum individual skin Dose (mSv)	48.8	39.2	41.4	41.2	28.1	**500 mSv/year**

Table E-16: Equivalent (skin) dose statistics for nuclear energy workers, Port Hope Conversion Facility, 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Average skin dose (mSv)	0.8	0.7	1.7	0.6	0.8	**NA**
Maximum individual skin dose (mSv)	181.4*	16.3	28.6	10.3	23.4	**500 mSv/year**

* The 2011 maximum skin dose resulted from an event where a worker had a finger laceration with contamination due to a maintenance activity.

Table E-17: Equivalent (skin) dose statistics for nuclear energy workers, Cameco Fuel Manufacturing Inc., 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Average skin dose (mSv)	6.9	6.5	7.3	8.1	6.3	**NA**
Maximum individual skin dose (mSv)	95.4	93.2	88.4	108.4	95.6	**500 mSv/year**

Table E-18: Equivalent (skin) dose statistics for nuclear energy workers, GEH-C Peterborough facility, 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Average skin dose (mSv)	4.54	5.04	3.8	4.75	4.1	**NA**
Maximum individual skin dose (mSv)	22.62	36.99	31.20	29.91	22.47	**500 mSv/year**

Table E-19: Equivalent (skin) dose statistics for nuclear energy workers, GEH-C Toronto facility, 2011-15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Average skin dose (mSv)	10.81	12.45	10.29	11.08	9.89	**NA**
Maximum individual skin dose (mSv)	55.48	58.40	52.84	51.67	54.99	**500 mSv/year**

Note: The reason for the consistently lower skin and extremity doses at the GEH-C Peterborough facility is the low likelihood of direct pellet handling, a practice considered routine at the Toronto facility. Except for in the end cap welding station, all pellets at the Peterborough facility are shielded in zirconium tubes, bundles or boxes.

Skin doses – nuclear substance processing facilities

Table E-20: Equivalent (skin) dose statistics for nuclear energy workers, Nordion (Canada) Inc., 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Average skin dose (mSv)	0.50	0.40	0.42	0.46	0.40	**NA**
Maximum individual skin dose (mSv)	6.09	5.19	6.39	6.11	5.21	**500 mSv/year**

Skin doses – small nuclear research reactor facilities

Table E-21: Equivalent (skin) dose statistics for nuclear energy workers, McMaster Nuclear Reactor, 2011–15

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Average equivalent dose (mSv)	1.25	1.00	0.61	0.46	0.45	**NA**
Maximum individual equivalent dose (mSv)	13.11	6.80	4.26	4.18	4.70	**500 mSv/year**

APPENDIX F: ENVIRONMENTAL DATA

Blind River Refinery

Table F-1: Annual groundwater monitoring results, 2011–15

Parameter	2011	2012	2013	2014	2015	Health Canada guidelines*
Average uranium concentration (μg/L)	0.4	0.3	0.5	0.6	1.7	20
Maximum uranium concentration (μg/L)	4.1	2.0	3.7	8.9	18.5	20

* Health Canada *Guidelines for Canadian Drinking Water Quality*, which note that none of the groundwater wells monitored are used for drinking water.

Table F-2: Lake Huron annual average results at diffuser, 2011–15

Parameter	2011	2012	2013	2014	2015	CCME guidelines*
Average uranium concentration (μg/L)	0.4	0.2	0.4	< 0.2	0.2	**15**
Average nitrate concentration (mg/L as N)	0.1	0.1	0.3	0.2	0.2	**13**
Average radium-226 concentration (Bq/L)	0.006	< 0.005	< 0.005	< 0.005	< 0.005	**1**
Average pH	7.9	7.4	7.2	7.6	7.3	**6.5-8.5**

*****Canadian Council of Ministers of the Environment (CCME) *Canadian Water Quality Guidelines for the Protection of Aquatic Life*.

Table F-3: Soil monitoring results, 2011–15

Parameter	2011	2012	2013	2014	2015	CCME guidelines*
Minimum uranium concentration (µg/g)	0.2	0.1	0.1	0.1	0.1	**23**
Average uranium concentration (µg/g) (within 1,000 m, 0–5 cm depth)	4.8	3.3	4.3	2.7	3.8	
Maximum uranium concentration (µg/g)	18.0	12.1	16.4	7.2	9.7	

*Canadian Council of Ministers on the Environment (CCME), *Soil Quality Guidelines for the Protection of Environment and Human Health* (for residential/parkland land use).

Port Hope Conversion Facility

Table F-4: Mass of contaminants of concern removed by pumping wells, 2011–15

Mass of contaminants of concern (kg)	2011	2012	2013	2014	2015
Uranium	19.7	27.7	28.9	31.0	25.3
Fluoride	38.6	60.4	51.1	53.0	48.3
Ammonia	20.9	34.7	53.0	75.0	63.7
Nitrate	41.2	37.5	41.0	53.0	44.0
Arsenic	2.6	3.1	2.8	2.5	2.6

Table F-5: Harbour water quality, 2011–15

Parameter	Value	2011	2012	2013	2014	2015	CCME guidelines*
Uranium (µg/L)	Average	4.1	3.7	3.3	3.3	2.9	**15**
	Maximum	9.2	10	8.3	7.6	6.6	
Fluoride (mg/L)	Average	0.078	0.099	0.10	0.11	0.13	**0.12**
	Maximum	0.60	0.14	0.18	0.39	0.17	
Nitrate (mg/L)	Average	0.88	0.83	0.84	0.86	0.89	**13**
	Maximum	1.5	1.5	1.6	1.5	1.7	
Ammonia + Ammonium (mg/L)	Average	0.11	0.10	0.11	0.23	0.20	**0.3**
	Maximum	0.33	0.40	0.35	0.52	0.66	

*Canadian Council of Ministers of the Environment (CCME), *Canadian Water Quality Guidelines for the Protection of Aquatic Life*.

Figure F-1: Average uranium concentrations from the south cooling water intake, 1977–2015

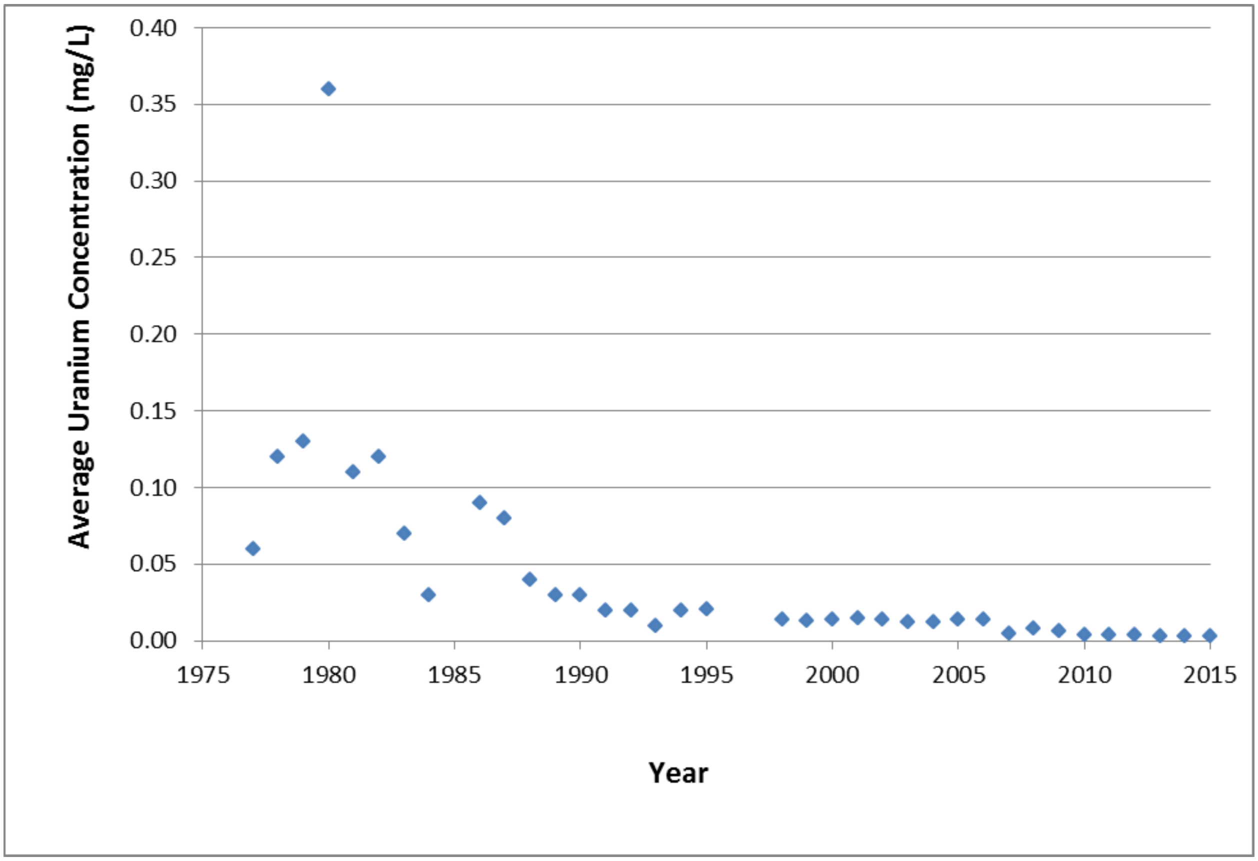


Table F-6: Uranium concentrations at waterworks side yard remediated with clean soil (µg/g), 2011–15

<table>
<tr><th>Soil depth (cm)</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th><th>Soil depth (cm)</th><th>2015</th><th>CCME guidelines*</th></tr>
<tr><td>0–2</td><td>1.0</td><td>1.4</td><td>1.0</td><td>1.4</td><td rowspan="2">0–5</td><td rowspan="2">1.0</td><td rowspan="5">23</td></tr>
<tr><td>2–6</td><td>0.7</td><td>1.1</td><td>0.9</td><td>1.2</td></tr>
<tr><td>6–10</td><td>0.3</td><td>1.3</td><td>1.0</td><td>1.1</td><td>5–10</td><td>1.0</td></tr>
<tr><td>10–15</td><td>0.8</td><td>1.5</td><td>1.0</td><td>1.1</td><td rowspan="2">10–15</td><td rowspan="2">1.2</td></tr>
<tr><td>70 cm composite</td><td>1.3</td><td>1.2</td><td>1.5</td><td>1.4</td></tr>
</table>

*Canadian Council of Ministers on the Environment (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, 2011–15

Parameter	2011	2012	2013	2014	2015	MOECC guidelines*
Fluoride in vegetation (ppm)	3.6	2.1	5.6	2.6	3.2	**35**

***Ontario Ministry of the Environment and Climate Change (MOECC) upper limit of normal guidelines.

Cameco Fuel Manufacturing Inc.

Table F-8: Soil monitoring results, 2010 and 2013*

Parameter	2010	2013	CCME guidelines**
Average uranium concentration (µg/g)	4.5	3.7	**23**
Maximum uranium concentration (µg/g)	21.1	17.4	**23**

*Cameco Fuel Manufacturing Inc. implements a three-year soil monitoring program. It did not monitor soil in 2011, 2012, 2014 or 2015.
**Canadian Council of Ministers on the Environment (CCME), *Soil Quality Guidelines for the Protection of Environmental and Human Health* (for residential/parkland land use).

GEH-C Toronto

Table F-9: Air emission and liquid effluent monitoring results, 2011–15

Parameter	2011	2012	2013	2014	2015	Licence limit
Uranium discharged to air (kg/year)	0.0129	0.0163	0.0094	0.0099	0.0098	**0.76**
Uranium discharged to sewer (kg/year)	1.1	0.9	0.8	0.7	0.4	**9,000**

Note: The values for uranium discharged to air have been corrected from those reported in the *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2014*. The data reflect updated values provided by GEH-C in response to a 2015 inspection finding related to air emissions. The previously reported values for uranium discharged to air from 2011 to 2014 were 0.009, 0.013, 0.006 and 0.006 grams of uranium, respectively. Additional details are provided in Section 6.3 under the “Atmospheric emissions” heading.

Table F-10: Uranium in boundary air monitoring results, 2011–15

Parameter	2011	2012	2013	2014	2015
Average concentration (μg/m^3)	0.001	0.001	0.001	0.001	0.001
Maximum concentration (μg/m^3)	0.005	0.008	0.003	0.003	0.003

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

Table F-11: Uranium in soil monitoring results, 2011–12

Parameter	2011	2012
Average concentration (μg/g)	2.3	1.9
Maximum concentration (μg/g)	14.8	10.8

Table F-12: Uranium in soil monitoring results, 2013–15

Parameter	GEH-C property			Industrial/commercial lands			Residential locations		
	2013	2014	2015	2013	2014	2015	2013	2014	2015
Number of samples	1	1	1	24	34	30	24	14	18
Average uranium concentration (μg/g)	2.3	2.3	1.4	3.9	5.0	2.9	1.1	0.6	0.7
Maximum uranium concentration (μg/g)	2.3	2.3	1.4	24.9	22.1	8.7	3.1	2.1	2.1
CCME guidelines (μg/g)*	**300**			**33**			**23**		

*Canadian Council of Ministers on the Environment (CCME), *Soil Quality Guidelines for the Protection of Environmental and Human Health*.

GEH-C Peterborough

Table F-13: Air emissions and liquid effluent monitoring results, 2011–15

Parameter	2011	2012	2013	2014	2015	Licence limit
Uranium discharged to air (kg/year)	0.000011	0.000005	0.000013	0.000003	0.000003	**0.55**
Uranium discharged to sewer (kg/year)	0.0001	0.0001	0.0002	0.0001	0.0001	**760**

SRB Technologies (Canada) Inc.

Table F-14: Atmospheric emissions monitoring results, 2011–15

Parameter	2011	2012	2013	2014	2015	Licence limit
Tritium as tritium oxide (TBq/year)	12.50	8.36	17.82	10.71	11.55	**67**
Total tritium as tritium oxide + tritium gas (TBq/year)	55.68	29.90	78.88	66.16	56.24	**448**

Table F-15: Liquid effluent monitoring results, 2011–15

Parameter	2011	2012	2013	2014	2015	Licence limit
Tritium (water soluble) (GBq/year)	8	12	9	13	7	**200**

Nordion (Canada) Inc.

Table F-16: Air emissions monitoring results, 2011–15

Parameter (GBq/year)	2011	2012	2013	2014	2015	Derived release limit
Cobalt-60	0.006	0.006	0.005	0.005	0.005	**78**
Iodine-125	0.38	0.46	0.23	0.14	0.12	**990**
Iodine-131	0.29	0.40	0.39	0.46	0.15	**1,110**
Xenon-133	34,967	36,153	30,735	15,018	11,916	**29,000,000**

Table F-17: Liquid effluent monitoring results, 2011–15

Parameter (GBq/year)	2011	2012	2013	2014	2015	Licence limit
β (<1 MeV)	0.395	0.261	0.288	0.209	0.191	**7,780**
Β (>1 MeV)	0.088	0.060	0.065	0.050	0.044	**105,000**
Iodine-125	0.007	0.005	0.005	0.051	0.111	**14,700**
Iodine-131	0.013	0.009	0.009	0.006	0.006	**10,800**
Molybdenum-99	0.116	0.075	0.077	0.055	0.06	**467,000**
Cobalt-60	0.027	0.017	0.022	0.018	0.019	**64,100**
Niobium-95	0.001	0.0002	0.0006	0.0007	0.0010	**64,100**
Zirconium-95	0.001	0.0003	0.0006	0.0005	0.0010	**64,100**
Cesium-137	0.0004	0.0004	0.0005	0.0004	0.0004	**64,100**

TRIUMF Accelerators Inc.

Table F-18: Air emission results, 2011–15

Parameter	2011 (% DRL)[b]	2012 (% DRL)	2013 (% DRL)	2014 (% DRL)	2015 (% DRL)
Beta plus emitters and argon-41[a]	0.24	0.448	1.15	1.58	0.929
Tritium	0.000088	0.000220	0.000769	0.00112	0.000971
Noble gases	0.0095	0.00655	0.0126	0.00346	0.00712
Volatile and particulate	0.00659	0.0000760	0.0000584	0.0000543	0.000037
Total	0.26	0.45	1.16	1.58	0.94

a. Beta plus emitters are short-lived positron emitting radionuclides (carbon-11, nitrogen-13 and oxygen-15) as well as argon-41.
b. One hundred percent of the derived release limit (DRL) equals one mSv annual dose (regulatory limit for member of the public).

Table F-19: Liquid effluent results, 2011–15

Parameter	2011 (% DRL)[a]	2012 (% DRL)	2013 (% DRL)	2014 (% DRL)	2015 (% DRL)
Total of various isotopes	0.000000318	0.0000004	0.00000379	0.00000121	0.000000381

a. One hundred percent of the derived release limit (DRL) equals one mSv annual dose (regulatory limit for member of the public).

APPENDIX G: LOST-TIME INJURIES

Table G-1: Lost-time injuries, Port Hope Conversion Facility, 2015

Lost-time injury	Action taken
In June 2015, an employee was injured when taking a shortcut between a piece of equipment and a wall. The employee had his head down and struck his head on a screw conveyor that is approximately four feet above the floor. The employee immediately experienced tingling and numbness throughout his left hand. This injury resulted in three days of lost time.	As a result of this event, Cameco has painted the screw conveyor and the floor surrounding it with a high-visibility paint to notify employees to take caution when walking under the conveyor.
In August 2015, a Cameco corporate employee working in the science and technology lab appeared in distress after dropping a bottle of potassium chloride. Cameco emergency response team was immediately called for support. The potassium chloride spill was secured in a safe manner with barrier tape and the employee was attended to by the emergency response team. This individual was then transported by ambulance to the hospital in Coburg for further assessment. After this medical situation was addressed, the potassium chloride spill was cleaned up. This injury resulted in four days of lost time.	As a result of this event, Cameco reviewed the topic of heat stress with the science and technology group at its next toolbox meeting and at its next safety meeting to remind employees: • what heat stress symptoms to look for in themselves and coworkers • to drink water before, during and after shifts • that people experience heat stress differently due to a variety of factors

Table G-2: Lost-time injuries, Cameco Fuel Manufacturing Inc., 2015

Lost-time injury	Action taken
In January 2015, an electrical contractor was working in a tight space (not a normal working space) and was bent down pulling an Ethernet cable. As the individual stood up from the crouched position, he struck his right shoulder and neck on a metal bar. There was no open wound. However, the individual's neck and shoulder areas were sore. The individual reported the incident to his company's supervisor. The contracting company supervisor released the electrician to seek medical attention. The individual visited a physician who prescribed medication for the pain. The individual missed his next scheduled shift. The contracting company supervisor did not inform CFM of the incident until the next morning, when it was too late to arrange for modified work for the injured individual. This injury resulted in one day of lost time.	After the event, caution tape was hung around the area in question until the incident investigation was complete. A safety stand-down was held with all contractors, which stressed the importance of maintaining awareness of their surroundings at all times, as well as the need to report any incidents immediately to both their supervisor and their CFM contact.

Table G-3: Lost-time injuries, Best Theratronics Ltd., 2015

Lost-time injury	Action taken
An employee twisted his knee when walking in the kitchen and supply area. This injury resulted in one day of lost time.	The incident was reviewed and no further action was taken.

Table G-4: Lost-time injuries, TRIUMF Accelerators Inc., 2015

Lost-time injury	Action taken
An employee was splashed in the eyes with a small amount of isopropyl alcohol while draining equipment, causing redness to the eyes. This injury resulted in one day of lost time.	A root-cause analysis was performed. Corrective actions relating to procedure, protective equipment and training were completed in 2015.
An employee experienced back spasms and leg soreness as a result of lowering a heavy panel. This injury resulted in one day of lost time.	The incident was reviewed and no further action was taken.
An employee standing five feet away from a fume hood was sprayed with a few drops of hydrofluoric acid, causing mild redness of the skin. The spray occurred where the line enters the side of the fume hood. This injury resulted in one day of lost time.	A root-cause analysis was performed. Corrective actions relating to procedure, protective equipment and training were completed in 2015.
An employee sprained their ankle while stepping down the stairs. This injury resulted in six days of lost time.	The incident was reviewed and no further action was taken.

Table G-5: Lost-time injuries, Canadian Light Source Inc., 2015

Lost-time injury	Action taken
An employee was attending a meeting in a CLS meeting room. While standing and reaching to pass documents across the table, the employee bumped their chair backwards slightly. When the employee went to resume sitting down, they contacted just the front edge of their seat. The chair then rocked forward slightly, causing the employee to fall on the floor. This injury resulted in two and a half days of time lost from work.	The incident was reviewed and no further action was taken.

APPENDIX H: LINKS TO LICENSEES 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
GE Hitachi Nuclear Energy Canada Inc.	nec.bwxt.com (formerly geh-canada.ca)
SRB Technologies (Canada) Inc.	srbt.com
Nordion (Canada) Inc.	nordion.com
Best Theratronics Ltd.	theratronics.ca
McMaster University	mnr.mcmaster.ca
University of Alberta	ehs.sitecore.ualberta.ca/MICF%20and%20SLOWPOKE%20Facility/SLOWPOKE
Saskatchewan Research Council	src.sk.ca/industries/environment/pages/slowpoke-2.aspx
Royal Military College of Canada	rmcc-cmrc.ca
École Polytechnique de Montréal	polymtl.ca/nucleaire/en/LTN/SLP.php
TRIUMF Accelerators Inc.	triumf.ca
Canadian Light Source Inc.	lightsource.ca

APPENDIX I: CHANGES TO LICENCES AND LICENCE CONDITIONS HANDBOOKS

Table I-1: Changes to the licence (amendments) – by the Commission

Facility	Date	Facility licence	Description of change
Best Theratronics Ltd.	January 2015	NSPFOL-14.01/2019	The licence was amended to direct BTL to provide an acceptable financial guarantee for the future decommissioning of its facility.
Canadian Light Source Inc.	March 2015	PAIOL-02.01/2022	The operating licence was amended to allow CLS to process nuclear substances, typically mine tailing containing uranium, to be used for experiments on the synchrotron beamlines and to allow CLS to recover non-radioactive molybdenum-100 from previously irradiated targets. CLS also requested to update the address on its licence (CMD 15-H106).

Table I-2: Changes to the licence conditions handbook (revisions) – by delegated authorities

Facility	Date	Revision number	Description of change
Blind River Refinery	April 2015	Revision 2	Updated to provide greater clarity on the licensing basis and to incorporate written notification requirements. Also incorporated licensee commitments with respect to CSA standards N288.3, N288.4 and N288.6. Made general formatting and editing changes to correct document titles, as appropriate, and to improve readability.
Port Hope Conversion Facility	March 2015	Revision 1	Updated to provide greater clarity on the licensing basis and to incorporate improved written notification requirements. Also incorporated licensee commitments with respect to CSA standards N288.4, N288.5 and N288.6. Made general formatting and editing changes.
Port Hope Conversion Facility	May 2015	Revision 2	Updated to describe Site 1 as two properties and to recognize the physical addresses for both properties and for Site 2. Also updated to replace the licence conditions handbook change request form.

Facility	Date	Revision number	Description of change
Cameco Fuel Manufacturing Inc.	August 2015	Revision 1	Updated to provide greater clarity on licensing basis and to incorporate improved written notification requirements. Also updated to incorporate licensee commitments with respect to CSA standards N288.4, N288.5 and N288.6. CFM anticipates that it will be in full compliance with these standards by December 31, 2017. Made general formatting and editing changes.
SRB Technologies (Canada) Inc.	December 2015	Revision 1	Updated to incorporate licensee commitments and target dates for compliance with respect to CSA standard N393 and CNSC REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*. Made general formatting and editing changes to correct errors.
Best Theratronics Ltd.	January 2015	Revision 1	Updated to reflect a new date for the implementation of BTL's financial guarantee.
Best Theratronics Ltd.	March 2015	Revision 2	Revised to include a funding schedule for the implementation of BTL's financial guarantee.

ACRONYMS AND ABBREVIATIONS

ALARA	As low as reasonably achievable
Ar-41	Argon-41
β^+	Beta plus
Bq/L	Becquerel per litre
BRR	Blind River Refinery
BTL	Best Theratronics Ltd.
CCME	Canadian Council of Ministers of the Environment
CFM	Cameco Fuel Manufacturing Inc.
CLS	Canadian Light Source Inc.
CMD	Commission member document
CNSC	Canadian Nuclear Safety Commission
Co-60	Cobalt-60
COC	Contaminants of concern
Cs-137	Cesium-137
CSA	Canadian Standards Association (now CSA Group)
DRL	Derived release limit
EMS	Environmental management system
ÉPM	École Polytechnique de Montréal
ESDC	Employment and Social Development Canada (formerly Human Resources and Skills Development Canada)
ERA	Environmental risk assessment
EU	European Union
GBq	Gigabecquerel
GEH-C	GE Hitachi Nuclear Energy Canada Inc.
GeV	Gigaelectronvolt
GTLS	Gaseous tritium light source
I-125	Iodine-125
IAEA	International Atomic Energy Agency
IEMP	Independent Environmental Monitoring Program
ISO	International Organization for Standardization

KPI	Key performance indicator
Kg	Kilogram
kW	Kilowatt
LTI	Lost-time injury
MeV	Megaelectronvolt
mg/L	Milligram per litre
MFN	Mississauga First Nation
MNR	McMaster Nuclear Reactor
mSv	Millisievert
MOECC	Ontario Ministry of the Environment and Climate Change
MW	Megawatt
NEW	Nuclear energy worker
NFCC	*National Fire Code of Canada*
NO_x	Nitrogen oxide
Nordion	Nordion (Canada) Inc.
NSCA	*Nuclear Safety and Control Act*
OHSAS	Occupational Health and Safety Assessment Series
OHSR	British Columbia *Occupational Health and Safety Regulation*
PHCF	Port Hope Conversion Facility
PPE	Personal protective equipment
ppm	Parts per million
RMCC	Royal Military College of Canada
SAT	Systematic approach to training
SCA	Safety and control area
SLOWPOKE	Safe Low-Power Critical Experiment
SRBT	SRB Technologies (Canada) Inc.
SRC	Saskatchewan Research Council
SSC	Systems, structures and components
TBq	Terabecquerel
TRIUMF	TRIUMF Accelerators Inc.
µg	Microgram
µSv	Microsievert

U of A	University of Alberta
UF_6	Uranium hexafluoride
UO_2	Uranium dioxide
UO_3	Uranium trioxide
VIM	Vision in Motion
WSC	Workplace Safety Committee
Xe-133	Xenon-133
Xe-135	Xenon-135

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.

Commission

The Canadian Nuclear Safety Commission (CNSC) established by section 8 of the *Nuclear Safety and Control Act* (NSCA). It is a corporate body of not more than seven members, appointed by the Governor in Council. The objects of the Commission are:

a) to regulate the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information in order to:
   - prevent unreasonable risk to the environment and to the health and safety of persons
   - prevent unreasonable risk to national security
   - achieve conformity with measures of control and international obligations to which Canada has agreed

b) to disseminate objective scientific, technical and regulatory information to the public concerning the activities of the CNSC and the effects of nuclear substances, prescribed equipment and prescribed information on the environment and on the health and safety of persons

Commission member document

A document prepared for Commission hearings and meetings by CNSC staff, proponents and interveners. Each Commission member document (CMD) is assigned a specific identification number.

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

As defined in CSA Group standard N288.1, *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities*, the derived release limit (DRL) is the release rate that would cause an individual of the most highly exposed group to receive and be committed to a dose equal to the regulatory annual dose limit due to release of a given radionuclide to air or surface water during normal operation of a nuclear facility over the period of a calendar year.

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 by a specific weighting factor established for each of these organs or tissues.

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 a specific type of radiation by a weighting factor established for that type or radiation.

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 their 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 they may receive a dose of radiation that is greater than the prescribed limit for the general public.

root-cause analysis

An objective, structured, systematic and comprehensive analysis designed to determine the underlying reason(s) for a situation or event. This analysis is conducted with a level of effort consistent with the safety significance of the 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.